SAFEGUARDING ASTRONOMY & GEODETIC VLBI IN SOUTH AFRICA

South African Geodesy Working Group Workshop
02 OCTOBER 2025

MS TEBOGO MASHILE, MS AUDREY DIKGALE & MR SELAELO MATHLANE

Making sure it's possible

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Department:
Science, Technology and Innovation
REPUBLIC OF SOUTH AFRICA

2030 NDP

Outline

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- International efforts
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- Protection by Regulation
- RFI Levels to achieve VGOS goals
- Difficulties of Spectrum Management for VGOS

BACKGROUND AND CONTEXT

The SKA site is a National Key Point (NKP Act No. 102 of 1980)

- Declared by the Minister of Police in 2010.
- Recognizes the SKA as critical to national security, scientific advancement, and economic development.

Astronomy Geographic Advantage (AGA) Act, 2007 (Act No. 21 of 2007) – 18 years

- **preserve South Africa's geographic advantage** for astronomy by protecting areas with exceptional conditions for optical and radio astronomy.
- **regulate activities** that could interfere with astronomical observations, especially radio frequency interference.
- **support the development** of large-scale astronomy projects like the **Square Kilometre Array (SKA)** and **Southern African Large Telescope (SALT)**.
- empowers the Minister of Science, Technology, and Innovation to declare certain areas as *Astronomy Advantage Areas (AAAs)*—regions uniquely suited for optical and radio astronomy.
- Ministerial powers are delegated to the Astronomy Management Authority (AMA) regulatory unit within the Astronomy Subprogramme.
- Signed Memorandum of Agreements with ICASA (entity of DCDT) for cooperation on telecommunications and radio frequency spectrum

BACKGROUND AND CONTEXT CONT……

Karoo Central Astronomy Advantage Area (KCAAA): MeerKAT/SKA Area

- Regulations published in the Government Gazette No.41321 under Notice No. 1411 on 15 December 2017
- Prohibits and restricts the use of certain radio frequencies and transmissions within the KCAAA.
- Applies to any activity that could cause radio interference, including mobile networks, broadcasting, and certain wireless technologies.
- Regulates electrical activities that could emit electromagnetic noise, such as power lines, transformers, and industrial equipment.
- 1367 permit applications received to date, with 1200 permits issued, with outstanding permits on Transnet

Sutherland Central Astronomy Advantage Area (SCAAA): SALT Telescope Area

- Regulations published in the Gazette No.42492 under Notice No.805 and 806, 29 May 2019
- Protection against light pollution and dust to establish Dark Skies for Optical Telescopes

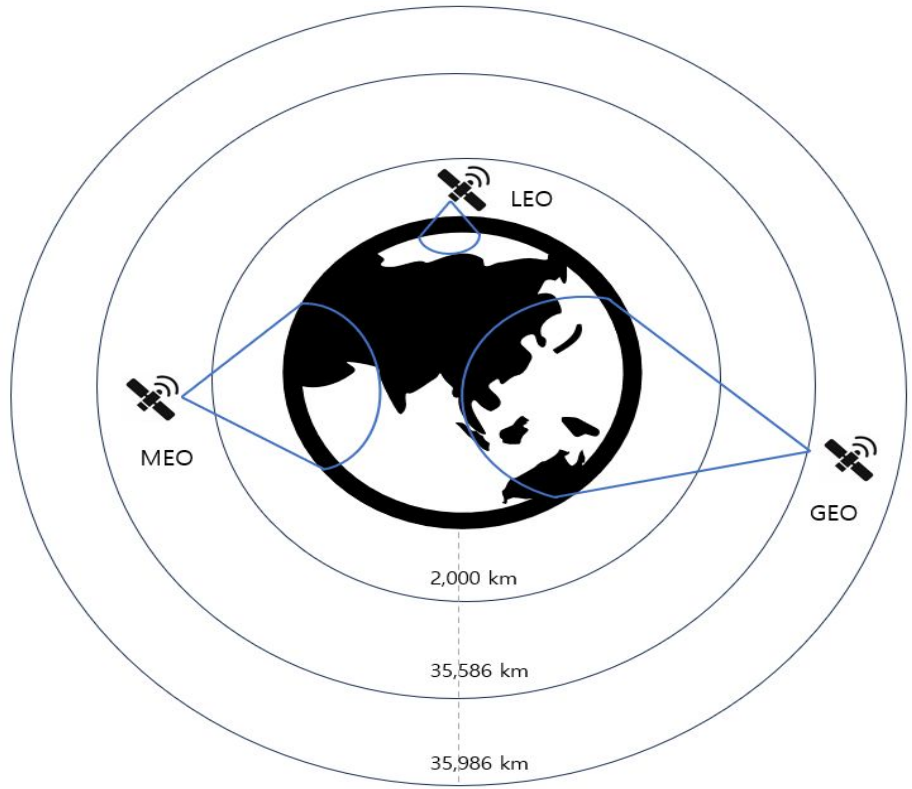
SATELLITES CHALLENGES FOR ASTRONOMY

- The rapid expansion of LEO satellite constellations presents growing challenges for both optical and radio astronomy, especially for the SKA telescope.
- These satellites constitute the biggest threat to astronomical observatories around the world
- These satellites contribute to RFI, leave light trails on astronomical images, and introduce regulatory complications, all of which impact astronomical research worldwide.

SpaceX Starlink (42 000 satellites)

Eutelsat Group's OneWeb (648 satellites)

Amazon Kuiper (3,236 satellites)



INTERNATIONAL EFFORTS

- The global astronomy community took this matter to the UN agencies, the International Telecommunication Union (ITU), and the United Nations Committee on the Peaceful Uses of Outer Space (UN-COPUOS).
- This matter is now being discussed as Agenda Item 1.16 for WRC-27 at Working Party 7D.
- The DSTI, SARAO, SANSA, and ICASA have been participating and working very closely with the DCDT over the years at the International Telecommunication Union (ITU).
- South Africa is a member state of the ITU, represented by the DCDT as the lead department.
- The SKA Observatory (global office) also has a seat in the ITU.
- This issue was tabled and approved for implementation at the 67th session of UNCOPUS in 2024 as a 5-year Agenda item for the Scientific and Technical Subcommittee beginning in February 2025.
- Efforts to protect astronomy facilities from LEO satellites are ongoing, with activities taking place at both the international and national levels to facilitate the coexistence of LEO satellite systems with radio astronomy facilities.

ASTRO-TOURISM IN SA

Protecting our skies is not only about safeguarding science but also about unlocking development opportunities through astro-tourism and dark-sky certification

Policy Anchor

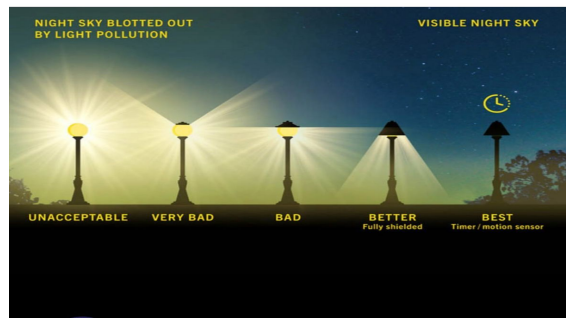
- National Astro-Tourism Strategy (2023–2033), launched in Sept 2024 and gazetted in May 2025.
- Jointly led by DSTI, DT, and Northern Cape DEDAT with NRF facilities (SARAO/SAAO).
- Builds on South Africa's world-class astronomy projects: MeerKAT, SALT, SKA.
- Coordinated and overseen by the multi-stakeholder Astro-Tourism Governance Body.

Opportunities

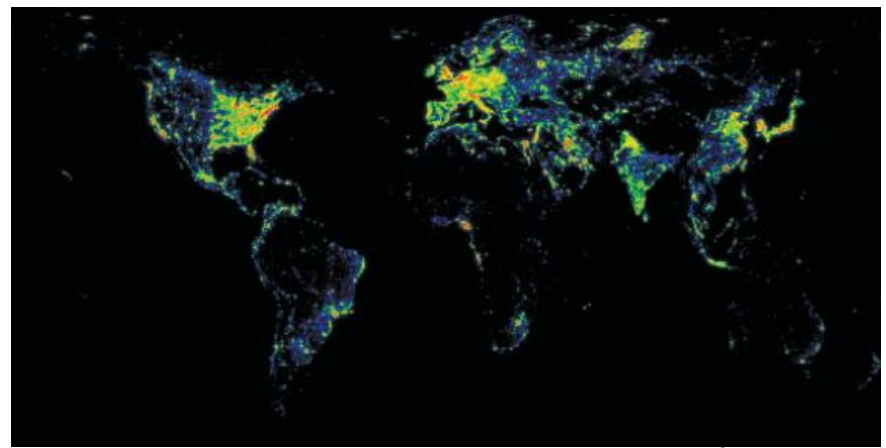
- Growth of the Northern Cape Astro-Tourism Route (Carnarvon, Sutherland, Loxton, Fraserburg)
- SMMEs in accommodation, guiding, cultural heritage products, astrophotography.
- New roles such as astro-tourism guides, night-sky interpreters, and dark-sky auditors.
- Integrates indigenous celestial narratives and science education to enhance cultural value.

DARK-SKIES FOR DEVELOPMENT

- Dark Skies for Development is a DSTI-led initiative with DT, DEDAT, NRF (SARAO/SAAO), SKAO, and DarkSky International.
- Complements AGA Act protections with a voluntary, community-led certification approach.
- DarkSky International recognises landscapes with natural darkness and responsible lighting.
- Protects biodiversity, reduces light pollution, promotes renewable energy-aligned lighting.
- South Africa has only two certified sites (!Xaus Lodge, Kalahari). Certification of areas along the astro-tourism route is underway.
- Certification enhances astro-tourism appeal and will position SA as a continental leader in night-sky conservation.
- Links South Africa to international best practice and boosts tourism competitiveness.
- Advances all three pillars of the National Astro-Tourism Strategy:
  - Indigenous Celestial Narratives & Human Capacity Development
  - Infrastructure Development
  - Inclusive Tourism Growth & Partnerships



Credit: DarkSky Int



Credit http://darksitefinder.com

ITU-Radiocommunication

ITU-R main mission is to facilitate seamless and **interference free** operation of radiocommunication services between member states.

Radio Regulations (RR) Article 4.6 recognizes that the Radio Astronomy Service (RAS) can be regarded as a radiocommunication service within the ITU-R for the purpose of protecting its operation from harmful interference.

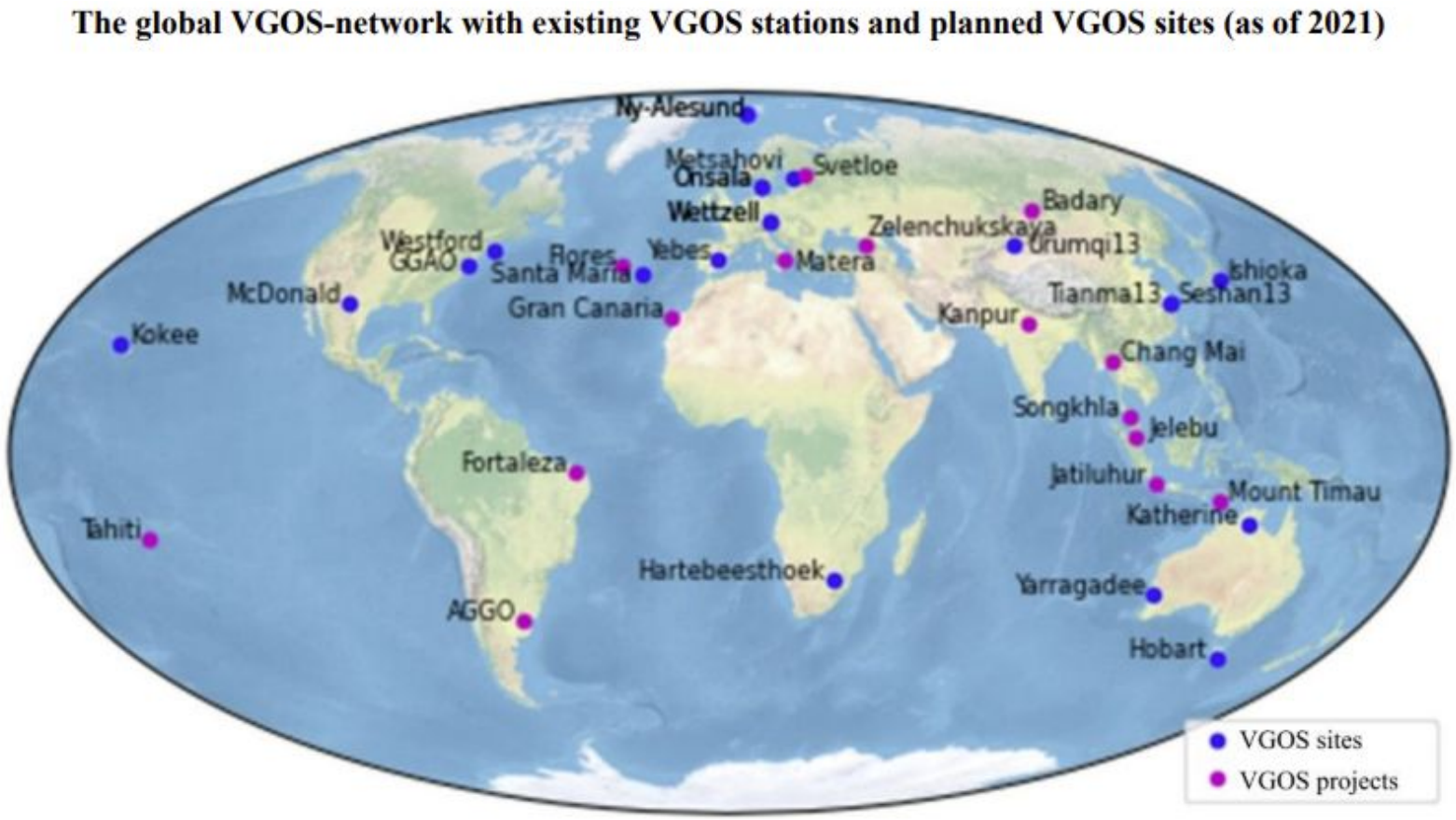
The RR has the status of an international treaty between member states, binding in international law.

ITU-R BR holds the **'Master International Frequency Register' (MIFR)** – or 'Master Register' contains the recorded frequency assignments and a database of the radiocommunication stations.

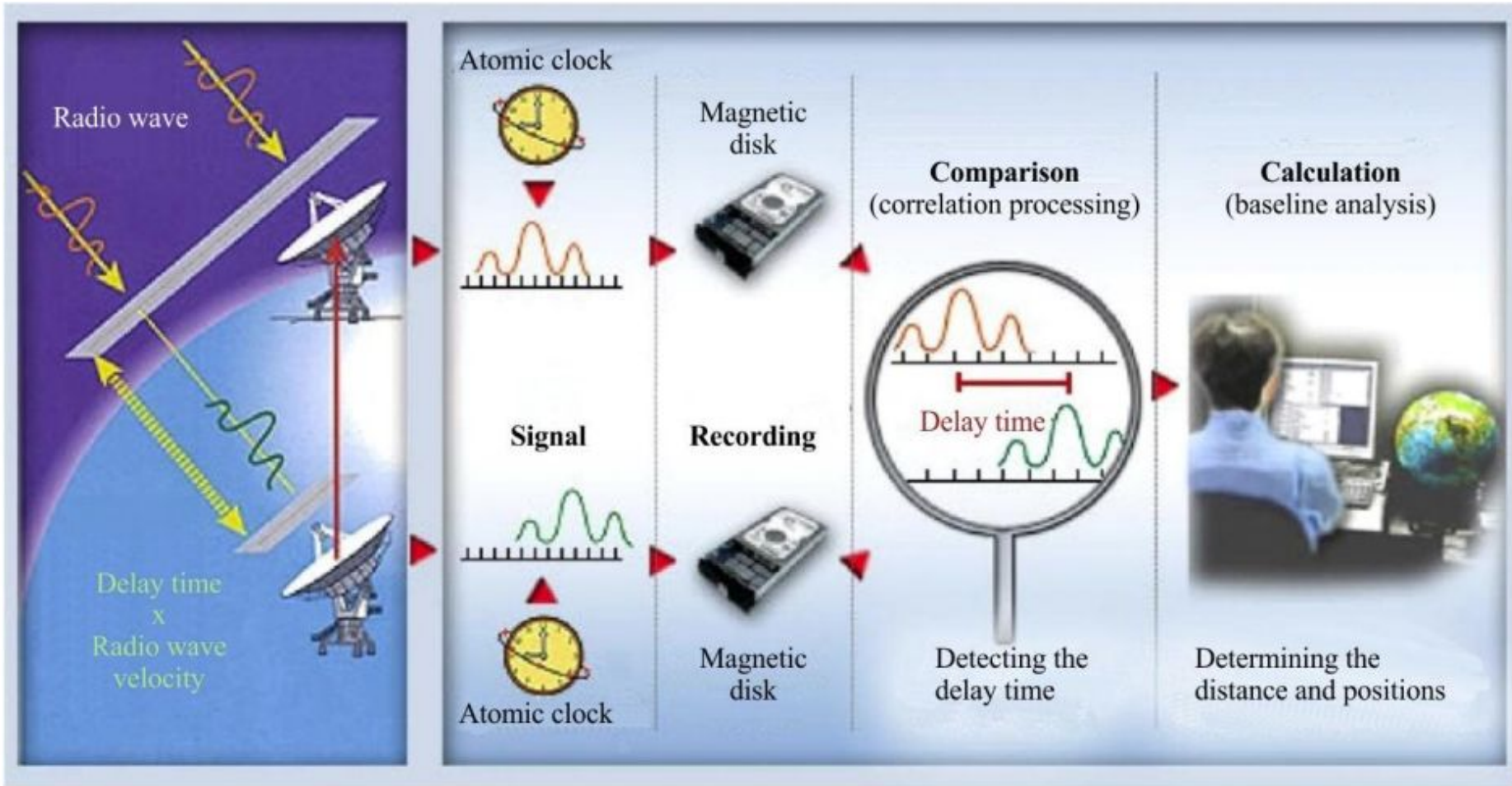
RR, Article 11.12 – Any frequency to be used for reception by a particular radio astronomy station may be notified if it is desired that such data be included in the **Master Register**.

VLBI Global Observing System (VGOS)

- Rep. ITU-R RA.2507 provide the technical and operational characteristics of existing and planned Geodetic Very Long Baseline Interferometry (VLBI) network.
- ‘Geodetic VLBI’ should enter the ITU-R documents as RAS technique

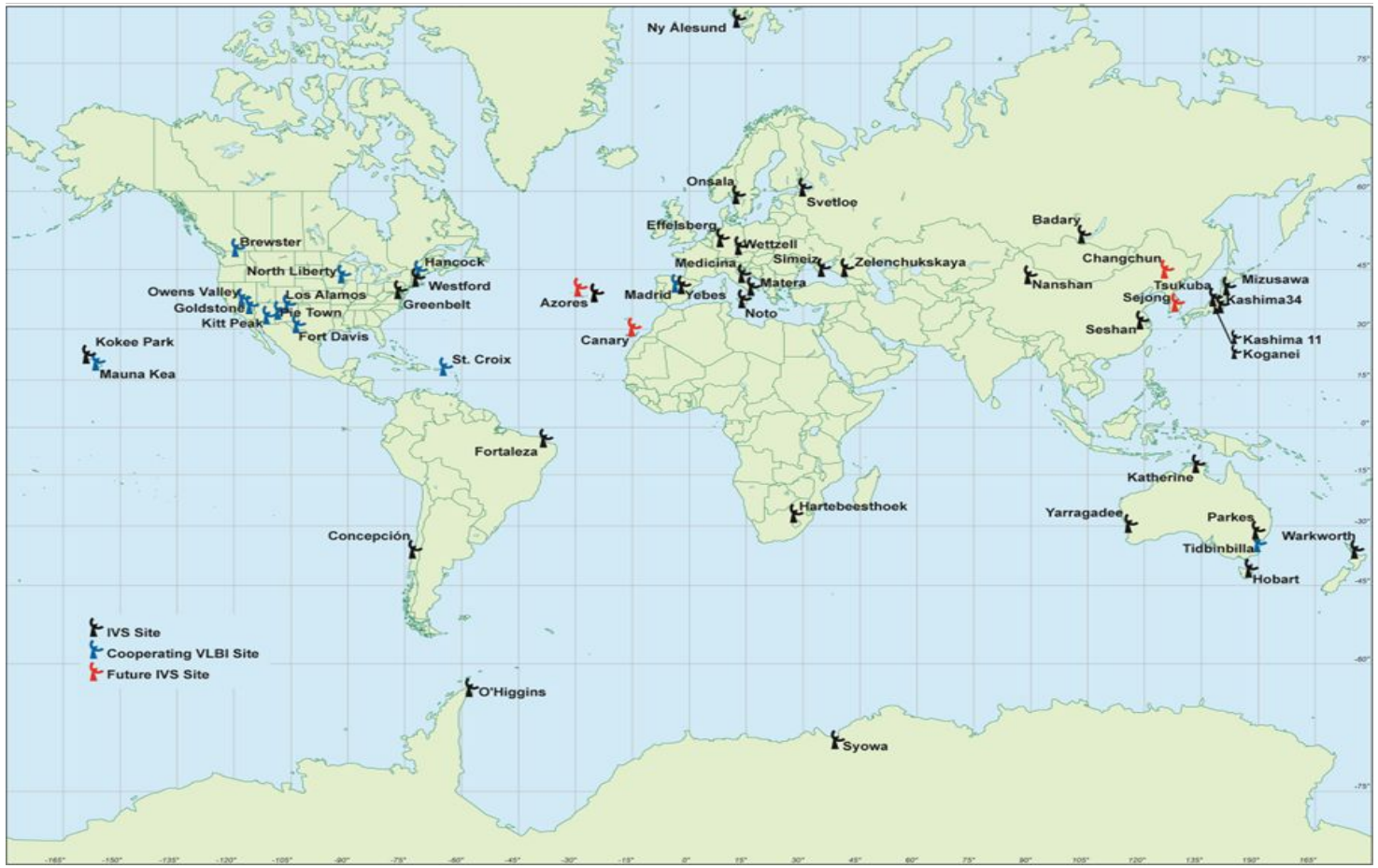


VLBI measurement principle and the processing chain



VLBI is a fundamental geodetic technique that underpins high accuracy positioning by observing weak cosmic radiation using a global network of radio telescopes.

International VLBI Service (IVS)



In 1999, the International VLBI Service for Geodesy and Astrometry (IVS) was accepted as an official service for the International Association of Geodesy (IAG) and for the International Astronomical Union (IAU).

RAS frequency bands within 2 – 14 GHz

Frequency (MHz)	Bandwidth (MHz)	Allocation, Footnote
2 655-2 670	15.0	secondary, No. **5.149**, **5.208B**
2 670-2 690	20.0	secondary, No. **5.149**, **5.208B**
2 690-2 700	10.0	PRIMARY, No. **5.340, 5.413, 5.208B**
3 260-3 270	7.0	No allocation, No. **5.149**
3 332-3 339	7.0	No allocation, No. **5.149**
3 345.8-3 352.5	6.7	No allocation, No. **5.149**
4 800-4 990	190.0	secondary, No. **5.149** applies in the 4 825-4 835 and 4 950-4 990 bands
4 990-5 000	10.0	PRIMARY, No. **5.149, 5.402, 5.443B**
6 650-6 675.2	25.2	No allocation, No. **5.149, 5.458A**
10 600-10 680	80.0	PRIMARY, No. **5.149**
10 680-10 700	20.0	PRIMARY, No. **5.340**

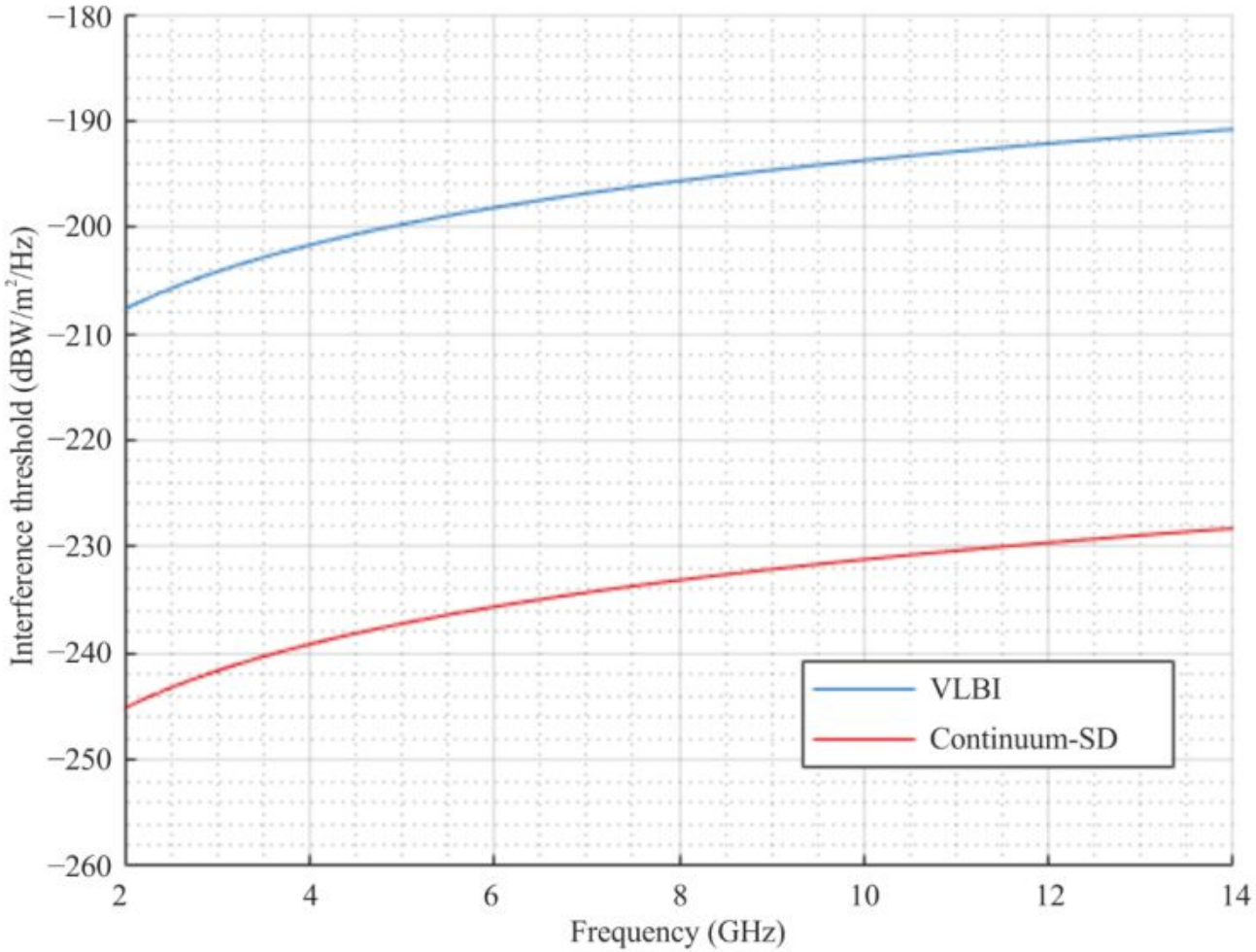
The demand for bandwidth of VGOS is about 5-times higher than what is allocated to RAS.
VGOS is using 32-times 32 MHz bandwidth/channel, Σ= 1024 MHz

Protection by Regulation

- **PRIMARY** allocations give legal protection from interference, but they are not necessarily exclusive.
- **Secondary** allocations do not provide protection from primary users in the same band. Secondary users shall not cause interference to primary users of that band, nor can they claim protection against detrimental interference from primary users of that band.
- **Footnote 5.149** urges administrations to take all practical steps to protect RAS from harmful interference. It notes that emissions from spaceborne and airborne stations can be particularly serious sources of interference to RAS.
- **Footnote 5.340** lists frequency bands in which 'all emissions are prohibited'. This is the maximum protection for the passive RAS
- **Radio Regulations** Article 1, in Nos. 13 and 58 defines radio astronomy and radio astronomy service (RAS) as being astronomy based on the reception of cosmic radio waves.
- **Geodetic VLBI** receives cosmic radio waves.
- Advantage: **ITU-R Recommendation RA.769**: “Protection criteria used for radio astronomical measurements” contains protection levels also for VLBI measurements.

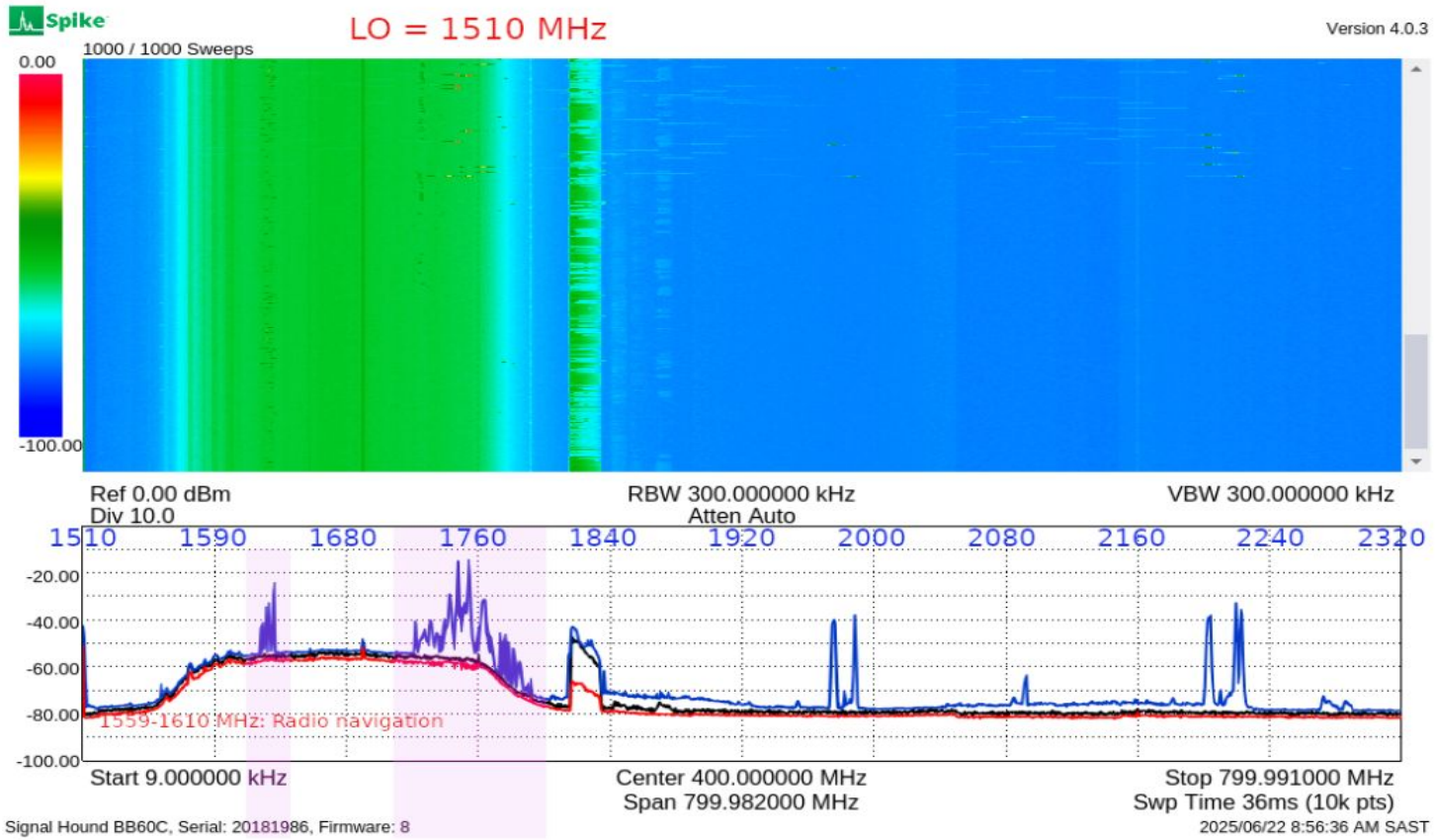
RFI Levels to achieve VGOS goals

Level detrimental to achieving VGOS goals in spectral power flux-density units for the calibration process (continuum-single dish) and interferometric observations



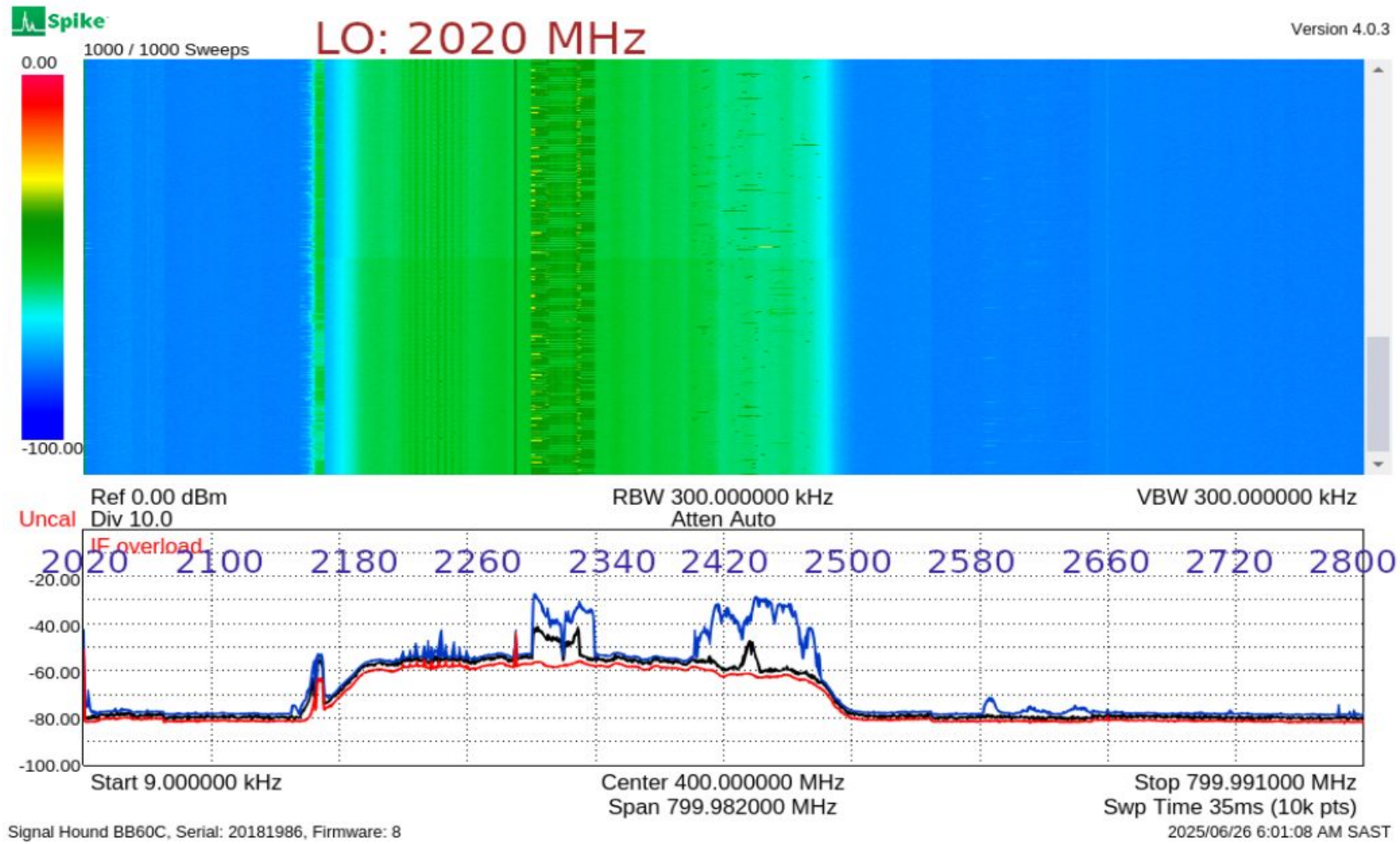
Report RA.2507-16

L-Band receiver



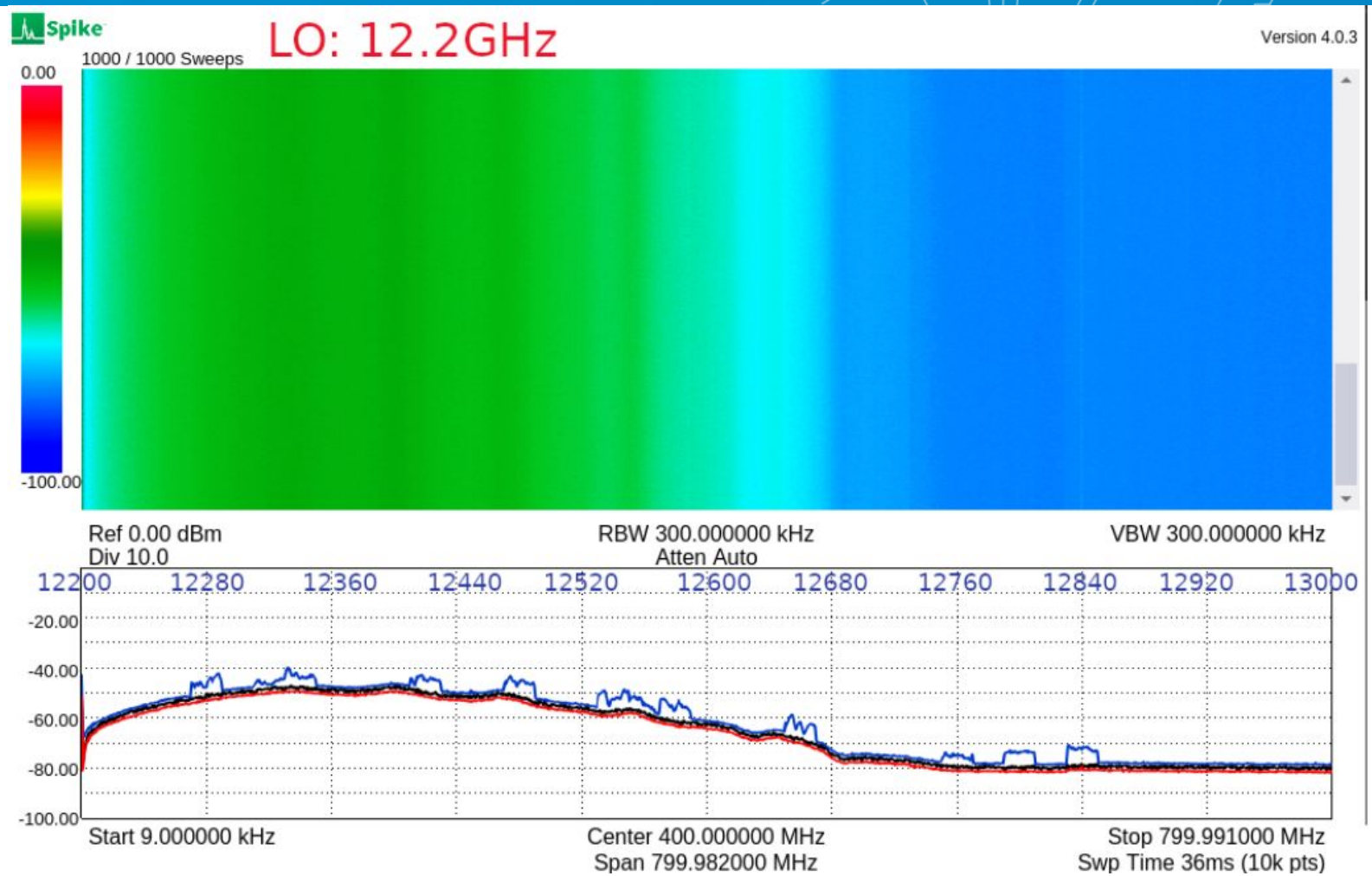
L-Band frequency 1608 - 1727 MHz is allocated to Aeronautical Radionavigation on a primary basis. Radio Astronomy is allocated in the frequency band 1610.6 - 1613.8 MHz. Radio Astronomy is also allocated on a primary basis in the frequency band 1668.4 - 1670 MHz. There is also a lot of Mobile satellites in this frequency band.

S-BAND receiver



S-Band frequency 2210 - 2450 MHz. There might be Fixed links in the band 2400 - 2500 MHz paired with 2300 - 2400 MHz. Additional fixed links might be in the band 2170 - 2300 MHz.

Ku-BAND receiver



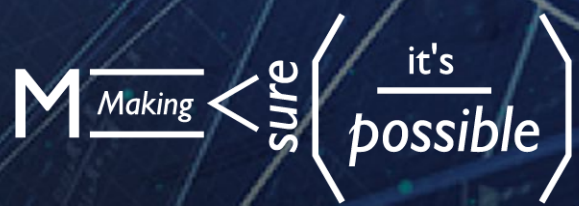
Ku-Band frequency 12048 - 12216 MHz is allocated to Broadcasting satellite service in the band 11.7 - 12.5 GHz

Difficulties of Spectrum Management for VGOS

- VGOS does not make use of allocated RAS spectrum, but asking for more bands.
- VGOS infrastructure cannot be moved to radio quiet zones like SKA
- Commercialization of space will have an impact on VGOS by new missions (Starlink, OneWeb, Kuiper)

Mode	Frequencies (GHz)	Since
Legacy S/X	2.20-2.39 8.20-8.95	1979
S/X/Ka	2.20-2.70 7.50-9.00 28.00-33.00	2014
VGOS	2.00-14.00	2015

Dankie
Enkosi
Ha khensa
Re a leboga
Ro livhuwa
Siyabonga
Siyathokoza
Thank you



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