United Nations

United Nations Global Geodetic Centre of Excellence

POLICY BRIEF NO003

Safeguarding VLBI Radio-Frequencies

Protection of geodetic VLBI observations from radio-frequency interference is crucial to maintaining accurate and reliable satellite services

Authors: Jan Dostal[1], Liubov Poshyvailo-Strube[1], Hayo Hase[2], Nicholas Brown[1]
[1] United Nations Global Geodetic Centre of Excellence, UN DESA; [2] Federal Agency for Cartography and Geodesy (BKG), Germany

INTRODUCTION

Geodetic Very Long Baseline Interferometry (VLBI) plays a critical, yet often unseen, role in modern society. It operates through a worldwide network of radio telescopes that simultaneously observe extremely weak cosmic radio waves from distant galaxies. By precisely measuring the arrival times of these radio waves at different locations, scientists can determine the orientation of the Earth with respect to space, its rotation rate, and the distances between the telescopes with millimetre precision.

These measurements are fundamental for the generation of essential geodetic products, including Earth Orientation Parameters (EOPs) and the maintenance of highly accurate terrestrial and celestial reference frames, the basis for positioning and navigation on Earth and in space. These geodetic products serve a vast array of government, economic, societal, and scientific needs, including the operation of Global Navigation Satellite Systems (GNSS), Earth Observation (EO) satellites and satellite communications which are vital for economic growth, the operation of critical infrastructure, and are a cornerstone of national defence forces.

Of all the different techniques used to create geodetic products, VLBI is crucially important because it is the only one which directly yields Universal Time (UT1), that is, time based on the actual rotation of the Earth, which can slightly vary, as opposed to Coordinated Universal Time (UTC) based on atomic clock time that ticks evenly.

The difference between UT1 and UTC is crucial for many satellites to operate accurately. Inaccuracies in this measurement can result in GNSS positioning and timing errors which could impact the operation of critical infrastructure such as energy grids, financial systems and telecommunications networks.

This policy brief highlights the growing challenges to these vital VLBI observations caused by artificial radio emissions and urges governments to support efforts in preventing harmful disturbances in radio bands used by VLBI to ensure the continued accuracy of geodetic products.

Key messages

- VLBI is a fundamental geodetic technique that underpins high-accuracy positioning by observing weak cosmic radiation using a global network of radio telescopes.
- Continuous high-quality geodetic products derived from VLBI are essential for socio-economic development.
- The increasing demand for active use of the radio spectrum by our modern societies poses a significant challenge to VLBI observations.
- Artificial radio emissions interfere with the natural cosmic radio waves received by VLBI, degrading the accuracy of critical geodetic products such as Earth Orientation Parameters (EOPs) and terrestrial and celestial reference frames.
- Improving the protection of geodetic VLBI observatories is crucial to maintaining high-accuracy positioning capabilities that are vital for a wide range of applications.
- Member States are invited to take steps to safeguard geodetic VLBI through international regulatory frameworks and national policies.

THE RADIO SPECTRUM: A Scarce Resource

Nature has given us a limited radio spectrum, so its use inevitably leads to competing interests among stakeholders. As wireless telecommunications systems—both on the ground and in space—continue to grow and expand, the demand for bandwidth within this finite spectrum is increasing rapidly.

It is a matter of great concern that the radio frequencies currently utilized for geodetic VLBI observations are not adequately protected under the existing Radio Regulations[1] of the International Telecommunication Union (ITU). VLBI operates as a passive service, receiving naturally occurring radio waves without transmitting any signals.

[1] International Telecommunication Union, "Radio Regulations" (2024). Available at https://www.itu.int/pub/R-REG-RR.

Historically, geodetic VLBI made use of unprotected bands outside of the allocations to radio astronomy service, because of the larger bandwidth needed to fulfil the needs of geodetic high-accuracy observations. The increased demand for spectrum and protection makes it necessary, that geodetic VLBI claims its own spectrum for the Radio Astronomy Service.

Without adequate protection of the observatories, the quality of geodetic products derived from VLBI is expected to degrade in the coming years. This degradation will have significant implications for various sectors which rely on satellite services for economic development and the operation of critical infrastructure[2].

CALL TO ACTION: Safeguarding the Future of High-Accuracy Positioning

All stakeholders, including governments, regulatory bodies, the scientific community, and industry, are encouraged to recognize the urgent need for protecting the radio-frequencies essential for geodetic VLBI observations. Sustaining the quality of fundamental geodetic products is crucial for the continued socio-economic development of the UN Member States. To achieve this, the following actions should be considered:

- **Raise Awareness**: It is critical to increase awareness among regulatory spectrum management authorities about the fundamental importance of the Geodetic-VLBI observing technique and its key contributions to a wide range of applications. Decision makers should be provided with the necessary information to understand the societal, environmental, and economic risks associated with the degradation or failure of the global geodesy supply chain[2].
- **Advocate for Protection**: Member States are invited to advocate for the improved recognition and protection of geodetic VLBI activities, as this technique contributes to the successful implementation of the United Nations General Assembly resolution 69/266 "A global geodetic reference frame for sustainable development"[3].
- **Extend Radio Astronomy Service Bands**: Efforts should be made to advocate for the extension of the frequency bands allocated to Radio Astronomy Service (RAS) for observing radio waves to explicitly include the additional bands currently utilized by VLBI. Introduction of new allocations and better protection criteria in the Radio Regulations of the ITU is the best way to immediately improve the protection of geodetic VLBI from active radio applications.
- **Support World Radiocommunication Conference Agenda Item on VLBI**: New allocations and frequency protections can only be initiated at a World Radiocommunication Conferences (WRC), organized every 3-4 years. Administrations and spectrum authorities are asked to work towards an agenda item for the WRC in the year 2031, which could be enacted by the upcoming WRC in 2027. New agenda items are proposed by ITU regions and need to be agreed upon by all Member States. Therefore, a large group of countries all over the world is required to support this strongly, as each WRC can have only limited number of agenda items.
- **Register VLBI Sites**: VLBI geodetic sites should be registered as Earth Stations within the ITU Radiocommunication Sector, following the relevant guidelines. This formal registration can contribute to the recognition and potential protection of these vital observing sites. Furthermore, only registered sites can be considered in the ITU processes and afforded protection (even in allocated frequency bands).
- **Establish national protection areas**: Countries have full sovereignty over the radio spectrum use in their own territory. Thus, national protection or coordination areas could be established around important geodetic observatories with the aim to improve the observation situation.
- **Support International Resolutions**: Member States should support conventions and resolutions of the International Astronomical Union (IAU) and the International Union of Geodesy and Geophysics (IUGG) that advocate for the protection of geodetic observations against radio-frequency interferences. These international scientific bodies play a crucial role in highlighting the importance of this issue.

By taking these crucial steps, Member States can ensure the long-term viability of geodetic VLBI observations and safeguard the continuous supply of high-quality geodetic products.

Protecting these radio frequencies is not merely a scientific endeavour; it is a fundamental requirement for maintaining the accuracy and reliability of a vast array of technologies and services that underpin modern society and drive socio-economic development. The time to act is now to prevent a degradation of our fundamental positioning infrastructure.

[2] United Nations Global Geodetic Centre of Excellence (UN-GGCE), "Hidden Risk. Background report for decision-makers" (2024). Available at https://ggim.un.org/UNGGCE/documents/20240620-Hidden_Risk_Report.pdf (accessed on 1 March 2025).

[3] UN General Assembly resolution 69/266 (2015). Available at https://docs.un.org/en/A/RES/69/266 (accessed on 17 April 2025).