National Geographic Institute of Spain Analysis Center Report

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Abstract This report provides an overview of the service and research activities carried out by the National Geographic Institute of Spain IVS Analysis Center during the 2023–2024 period. It highlights the center's contributions to geodetic VLBI, including data analysis, antenna performance statistics, and collaborations within the IVS network. In addition, the report outlines ongoing projects and future plans aimed at enhancing the precision and reliability of geodetic observations.

1 General Information

The National Geographic Institute of Spain (IGN Spain, Instituto Geográfico Nacional) is the mapping agency dependent on the Ministry of Transport and Sustainable Mobility. Among several activities such as mapping production, astronomic research, and geophysical monitoring, one of the main activities of IGN Spain is the design and maintenance of the national geodetic networks, together with the exploitation of the data. The geodetic infrastructure managed by IGN Spain currently includes a network of permanent GNSS stations, tide gauges and leveling network, VLBI telescopes, and a new SLR station at Yebes Observatory [1].

In 2018, leveraging 20 years of experience as a GNSS Analysis Center, IGN Spain established an analysis team to become an IVS Analysis Center (AC). As a result, IGN has been submitting regular VLBI solutions since March 2020. A key strength of the center is that its staff works across VLBI, GNSS, and SLR, allowing it to fully exploit and integrate geodetic data, with a strong focus on using data from the Atlantic Network of Geodynamic and Space Stations (RAEGE) project through the RAEGE Analysis Group.

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2 Staff

The VLBI analysis activities are performed by the staff assigned to the Geodesy Department of IGN Spain. Currently, there are three members involved in the IGE AC and one member developing the antenna performance plots, listed in Table 1.

Table 1 VLBI analysis group.

Name and email	Role	Dedication
Clara Pérez becario.cperez@externomf.es	Analyst and Trainee	Part-time
Esther Azcue eazcue@mitma.es	Analyst and Researcher	Part-time
José Carlos Rodríguez jcrodriguez@mitma.es	Analyst and Researcher	Part-time
Andrea Rosillo becario.arosillo@externomf.es	VLBI performance statistics	Part-time

The IGE AC staff regularly collaborates with other organizations through the RAEGE Analysis Group, including the Yebes and Santa Maria observatories, and researchers from the University of Alicante. The aim is to expand and share our research activities within VLBI analysis.

Table 2 RAEGE analysis group.

Name and email	Institution
Santiago Belda santiago.belda@ua.es	University of Alicante
Maria Karbon maria.karbon@ua.es	University of Alicante
Lucía del Nido lucia.delnido@ua.es	University of Alicante
Sonia Guessoum gs74@gcloud.ua.es	University of Alicante
Mariana Moreira mariana.cs.moreira@a-raege-az.pt	Estação RAEGE de Santa Maria

3 Service Activities

The operational processing of IVS R1/R4 and VGOS sessions is fully automatized through Linux scripts, except for the visual inspection of the residuals that is normally needed in VLBI analysis to exclude outliers and to identify clock breaks.

The software package that is used for the operational analysis of the VLBI sessions is Where [2], developed by the Norwegian Mapping Authority. The most recent submitted solutions can be found in the IVS Data Centers with the solution code 2023a.

As part of our commitment to advance geodetic research and maintain accurate global reference frames, the IGE AC contributed to the ITRF2020 update. This project involved collaboration with eleven other Analysis Centers, providing data from 2021 to the end of 2023. The final submission deadline was set for January 31, 2024. The IGE specifically contributed to both types of sessions, legacy S/X and VGOS, maintaining high submission rates in line with the overall averages. The solutions from this collaboration related to IGE AC can be found under the code 2023b, as the effect of atmospheric pressure loading has been removed. This adjustment was set because other space geodetic techniques still do not routinely include this effect.

4 Research and Training Activities: RAEGE Analysis Group

The RAEGE Analysis Group is a research team associated with the RAEGE, dedicated to processing and analyzing geodetic and geodynamic data collected from the network's stations.

The analysis group focuses on interpreting this data for scientific and technical applications, including geodynamics, precise reference frame determination, and climate change studies. The group consists of staff from the IGE AC, the Yebes and Santa Maria observatories, and researchers from the University of Alicante. For research activities, the VieVS software package [3] is also frequently used.

Some of the topics studied are:

- *Simulations of the integration of RAEGE in existing VGOS sessions for EOP estimation, as well as RAEGE-alone performance for coordinates* [4],
- *Exploring the impact of a priori errors on dUT1 estimations from Intensive VLBI sessions* [5],
- *Examinations of the consistency among different terrestrial reference frames (TRFs) in conjunction with Earth Orientation Parameters (EOP)* [6],
- *Exploring the effect of different VLBI networks on estimation of EOPs* [7].

Additionally, EOP prediction and studies on the influence of the correlator on analysis products are being developed. For more information, please refer to the UAVAC report.

The group is also focused on exploring and processing new types of sessions. A recent addition to the 2024 Master Schedule is the VGOS-INT-G session. Furthermore, a joint test involving RAEGE, the Geospatial Information Authority of Japan, and the Shanghai Astronomical Observatory, started on February 15, 2024, is conducted every Thursday at 17:30 UTC (schedule developed by the DACH Operation Center). This test has two main objectives:

- Evaluate the impact on UT1 data quality by increasing VGOS observation frequencies beyond 5 GHz, considering a new range between 4–14 GHz,
- Assess the impact of a very long West-East baseline on UT1, comparing results with the VGOS-INT-A session.

5 Performance Statistics

Visual information summarizing the operational performance of the RAEGE and Yebes VLBI antennas is generated. Between the plots, we can generate:

- A calendar view, indicating whether a station participated in a session and whether it was included in the analysis,
- Another set of graphs illustrating station performance per session, including the percentage of time allocated to different tasks (as shown in the image below),
- A session classification graph categorizing sessions by type, providing a broader perspective on station utilization.

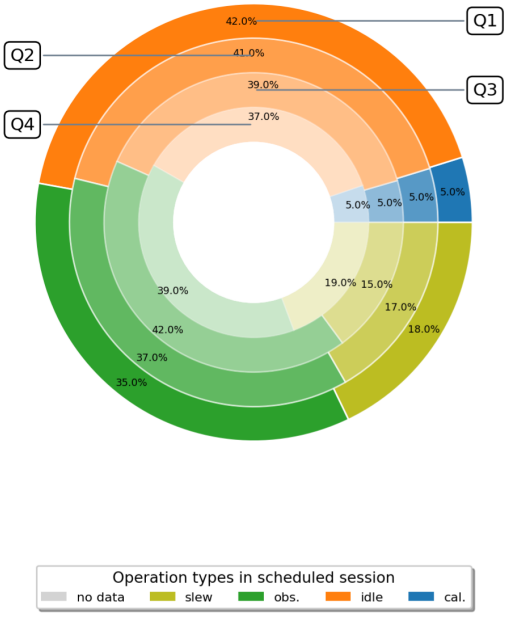

Fig. 1 Percentage of used time in each task by REAGYEB.

6 Future Plans

IGE AC aims to continue collaborations with other organizations and expand its role in research, especially by initiating studies that combine geodetic techniques at the RAEGE observatories. Another key objective is to further explore the potential of the RAEGE network and seek new collaborations in this field, as well as possible observing sessions.

Specific plans include implementing a tracking control system for the operational solution sent to the IVS, ensuring proper monitoring of submission and reception times for our sessions. We are also considering automating the processing of Intensive sessions, contributing to international collaborations, and improving UT1 estimates.

Additionally, the group is strongly involved in GGOS through the affiliated group GGOS IberAtlantic, dedicating significant resources to outreach, promoting scientific results to society, and attracting young talent.

The IGE AC will continue to strengthen its collaborations with international geodetic networks and adapt to emerging challenges in geodesy and space geodynamics.

Acknowledgements

We want to thank the Norwegian Mapping Authority VLBI team for their support in the usage of the Where software package.

References

1. J.C. Rodríguez, E. Azcue, V. Puente et al. Geodetic Analyses at the National Geographic Institute of Spain. *International Association of Geodesy Symposia. Springer, Berlin, Heidelberg*, doi: 10.1007/1345, 182, 2022
2. A.S. Kirkvik, G.A. Hjelle, M. Dähnn, I. Fausk, E. Mysen. Where - A new software for geodetic analysis. *23rd EVGA Working Meeting and 18th IVS Analysis Workshop*, 2017.
3. J. Böhm, S. Böhm, J. Boisits, A. Girdiuk, J. Gruber, A. Hellerschmied, H. Krásná, D. Landskron, M. Madzak, D. Mayer, J. McCallum, L. McCallum, M. Schartner, K. Teke. Vienna VLBI and Satellite Software (VieVS) for Geodesy and Astrometry. *Publications of the Astronomical Society of the Pacific*, Vol. 130(986), 044503, doi: 10.1088/1538-3873/aaa22b, 2018.
4. E. Azcue, M. Karbon, S. Belda, M. Moreira. RAEGE: Exploring Geodetic Capabilities and Applications. *13th General Meeting of the International VLBI Service for Geodesy and Astrometry (IVS)*, 2024.
5. C. Pérez. Exploring the impact of a priori errors on dUT1 estimations from intensive VLBI sessions. *XXXII IAU General Assembly*, 2024. Web document https://astronomy2024.org/wp-content/uploads/posters/1052.pdf.
6. M. Moreira et al. Assessing the Consistency of the Conventional Reference Frames (Terrestrial and Celestial) and Their Impact on Estimated EOP Using VLBI-Based Data. *26th EVGA Working Meeting*, 2023.
7. L. del Nido. Exploring the effect of different VLBI Networks on EOPs estimation. *EGU General Assembly*, 2024. Web document https://ui.adsabs.harvard.edu/abs/2024EGUGA..26.9388D/abstract.