Instituto Geográfico Nacional of Spain

Francisco Colomer [1], Pablo de Vicente [2], José Antonio López-Pérez[2], Laura Barbas[2], Félix Tercero[2], Javier López-Ramasco[2], Susana García-Espada[3,2], Rubén Bolaño-González[3,2], Luis R. Santos[4], José Antonio López-Fernández [2], Jesús Gómez-González [1]

Abstract The National Geographic Institute (IGN) of Spain has been involved in space geodesy activities since 1995. The 40-m radio telescope at Yebes Observatory has been a network station for IVS since 2008 and participates regularly in IVS sessions. IGN is developing an Atlantic Network of Geodynamical and Space Stations (project RAEGE). The first antenna saw its first light in 2014 at Yebes Observatory. Commissioning of a second antenna of RAEGE on Santa María island (Azores, Portugal) is being finished. First works for the third antenna in the Canary Islands have been initiated.

1 General Information

The National Geographic Institute of Spain (Instituto Geográfico Nacional, Ministerio de Fomento), has run geodetic VLBI programs at Yebes Observatory since 1995 and nowadays operates a 40-m radio telescope which is a network station for IVS (code "Ys"). IGN Yebes Observatory is also the reference station for the Spanish GNSS network and holds permanent facilities for gravimetry.

A new VGOS-type antenna, 13.2-m in diameter, has been built at Yebes as part of the RAEGE project (the acronym RAEGE stands for "Red Atlántica hispano-portuguesa de Estaciones Geodinámicas y Espaciales"). This antenna is operational and participates in the IVS VLBI broadband test observing under code "Yj" (RAEGYEB), even if not still not formally a network station in IVS. Detailed information on RAEGE is available on the Web at http://www.raege.net/

Since 2014, IGN Yebes Observatory has been a Technology Development Center for IVS. Activities are described in the corresponding contribution in this Biennial Report.

2 Current Status and Activities

Table 1 shows the observational sessions in which the IGN Yebes radio telescopes participated in 2015 (67) and 2016 (72). All the data were routinely transferred by Internet to the IVS correlators.

Table 1 Number of observational sessions at Yebes.

	Yebes 40-m	RAEGE 13.2-m	TOTAL
Sessions 2015	31	36	67
IVS R1	6	20	26
IVS R4	17	15	32
IVS T2	4	1	5
EUROPE	4	0	4
Sessions 2016	31	41	72
IVS R1	0	12	12
IVS R4	21	17	38
IVS T2	4	0	4
EUROPE	6	0	6
VGOS tests	0	12	12

1. Instituto Geográfico Nacional (IGN), Spain
2. IGN Yebes Observatory, Spain
3. IGN RAEGE Santa María, Azores
4. Direção Regional das Obras Públicas e Comunicações (Azores, Portugal)

During 2015 the 13.2-m telescope (Yj) performed 36 regular IVS sessions: 20 R1 sessions, 15 R4 sessions, and one T2 session. Regular observing started in February 2015 and finished in October 2015. Observing was discontinued because the tri-band receiver was dismounted and replaced by a broadband VGOS compatible receiver.

In April 2015, the Yebes 13.2-m antenna also took part in successful VLBI test observing at 32 GHz together with one of the Wettzell Twin radio telescopes [5]. Figure 1 shows the fringe plot of the Wettzell–Yebes baseline.

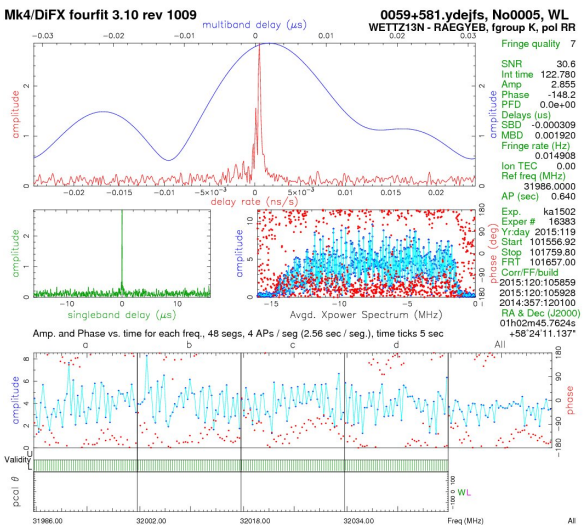

Fig. 1 Fringe plot for the Ws–Yj baseline at 32 GHz. These are the first detected fringes at 32 GHz between Wettzell and Yebes.

The tri-band Yj receiver was used as well to take part in six sessions organized by the Institute of Applied Astronomy in Saint Petersburg together with KVAZAR VGOS antennas between September and November 2015 to test recording rates of 2 Gb/s [4]. This high recording rate was also tested within the FAST project which aimed towards reducing the scan integration time while increasing the bandwidth and the number of scans.

Engineers at IGN Yebes Observatory have developed a VGOS-kind broadband receiver, which is installed and operational at the RAEGE 13.2-m radio telescope. Details may be found in the IGN Technology Development Center report, in this volume.

Once the broadband receiver was installed, in late 2015, first single dish observing was performed in March 2016. On 28 April 2016 the Yj telescope started taking part in test observing together with Wettzell, Westford, Kokee Park, and GGAO. The goal of this observing was to debug the hardware (frontend and backends) and the software at the stations and the correlator and to iron out the observational procedures. The observing required a Mark 6 recorder and one or two DBBC2s, depending on their availability. An internal report with information about the tests is in preparation [3].

Five sessions (ft6118, ft6126, ft6140, ft6161, and ft6188) were performed between April and July 2016. The first sessions with fringes in all four bands were in June 2016. Yj tested the four bands in two runs, because simultaneous bands were not possible because the two DBBC2 backends were not available simultaneously. All of these sessions were performed with one or two DBBC2s as backends. A second set of three experiments (vgt001, vgt002, and vgt003) was observed between July and August 2016 to debug and fix some issues with the DBBC2 firmware. The tests continued with sessions vgp001 and vgp002, but in this case Yj was using two RDBE-G backends mixed with one DBBC2 backend. In the last test performed in 2016, Yj used four RDBE-G backends. The test was fully successful; fringes are shown in Figure 2. The installation procedure and tests for the RDBE-G are summarized in [2].

The backends room, where the VLBI backends for the 40-m and 13.2-m radio telescopes are installed, was equipped, in June 2016, with an accurate air conditioning system that keeps the environment temperature with a precision of 0.2 degrees. That solved problems with the phase stability that had been present for several months. The positive impact on the geodetic observing has been visible since its installation.

The VDIF format started being used for geodetic VLBI on May 2016. Since then the 40-m radio telescope has started using Flexbuff as the recording equipment, and the data have been electronically transferred to the correlators via a Yebes high-speed connection fiber line to the Internet. A report on the usage of VDIF and scripts developed at Yebes for viewing data during experiments is available at our Web site [1].

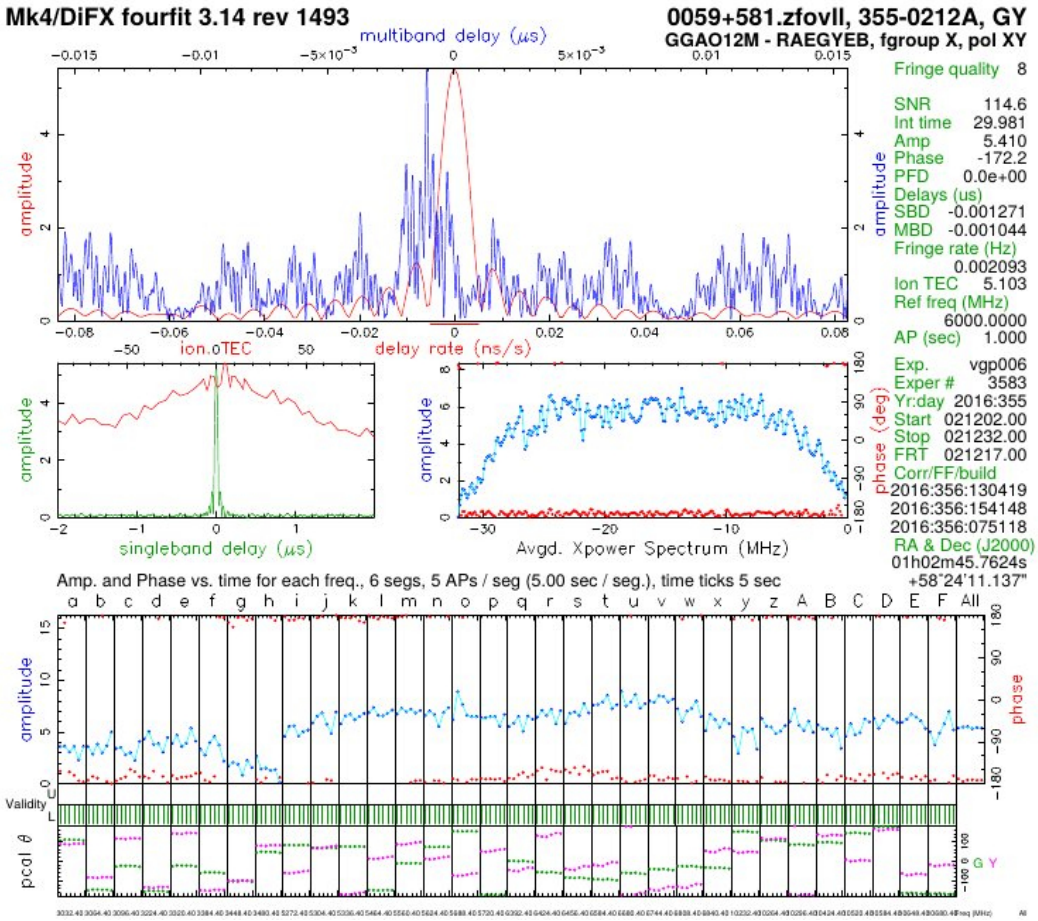

Fig. 2 Fringes in the four IFs of the VGOS broadband receiver with the 13.2-m "Jorge Juan" radio telescope at Yebes Observatory.

3 IGN Staff Working on VLBI Projects

Table 2 lists the IGN staff who are involved in space geodesy studies and operations. The VLBI activities are also supported by other staff members such as receiver engineers, computer managers, telescope operators, secretaries, and students.

Table 2 Staff in the IGN VLBI group (e-mail: **vlbitech@oan.es**).

Name	Role
Rubén Bolaño	Technical expert
Francisco Colomer	VLBI Project coordinator
Pablo de Vicente	VLBI technical coordinator
Susana García–Espada	geoVLBI expert
Jesús Gómez–González	IGN Deputy Director
José Antonio López–Fdez	Yebes Obs. & RAEGE Director
José Antonio López–Pérez	Receivers
Javier López–Ramasco	Geodesist
Félix Tercero	Antennas

4 Future Plans

Commissioning of the RAEGE station in Santa María is being performed, for an expected first light and start of observing in 2017.

Progress on the infrastructure works for the RAEGE station in the Canary Islands has been delayed, due to the need to perform tests for the suitability of the site. The erection of the antenna is expected in 2017, for a start of operations in 2018–2019.

References

1. de Vicente P., Barbas L., González J. *Using VDIF in astronomy VLBI observations at the 40m RT. Flexbuff and e-VLBI operations.* Technical Report CDT 2016-12.
2. de Vicente P., Barbas L., González J. *Setting the RDBEGs at the 13.2 m Yebes VGOS antenna.* Technical Report CDT 2016-21.
3. de Vicente P., Barbas L., González J. *First VLBI pre-VGOS tests with the 13.2m Yebes antenna* Technical Report CDT 2017 (in preparation).
4. Melnikov A., de Vicente P., Kurdubov S., Mikhailov, A. *First 2 Gbps Observations between the KVAZAR VGOS Antennas and the Yebes RAEGE Antenna*. IVS 2016 General Meeting Proceedings, edited by D. Behrend, K. D. Baver, and K. L. Armstrong, NASA/CP-2016-219016, pp. 40–43, 2016.
5. Schuler T., Kronschnabl G., Neidhardt A. et al. *Results from the TWIN Commissioning Phase*. EVGA meeting in Ponta Delgada (Azores, Portugal), 2015.