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The Italian VLBI Network: First Results and Future Perspectives

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Abstract A first 24-hour Italian VLBI geodetic experiment, involving the Medicina, Noto, and Matera antennas, shaped as an IVS standard EUROPE, was successfully performed. In 2014, starting from the correlator output, a geodetic database was created and a typical solution of a small network was achieved, here presented. From this promising result we have planned new observations in 2016, involving the three Italian geodetic antennas. This could be the beginning of a possible routine activity, creating a data set that can be combined with GNSS observations to contribute to the National Geodetic Reference Datum. Particular care should be taken in the scheduling of the new experiments in order to optimize the number of usable observations. These observations can be used to study and plan future experiments in which the time and frequency standards can be given by an optical fiber link, thus having a common clock at different VLBI stations.

Keywords VLBI, correlation, time and frequency, local ties, national datum

1 Italian VLBI Network Status

The Italian VLBI network is composed of four antennas. Three of them are part of the IVS [1] network: Medicina, Noto, and Matera. The fourth antenna is the Sardinia Radio Telescope (SRT), recently becoming operational. When not involved in VLBI observations they also work as single dishes and perform a number of VLBI observations including the ones organized internally.

Since 2012, VLBI observations have gained momentum due to the installation of the DiFX [2] software correlator in Bologna. Progressive updates shown in Table 1 have transitioned the antennas from previous Mark IV and VLBA backends to present DBBC ones.

Table 1 Hardware setup of the Italian antennas.

Antenna	Backend	Formatter	Recorder
Medicina - 32 m	DBBC2	Fila10G	Mark 5C
Noto - 32 m	DBBC2	Fila10G + Mark 5B	Mark 5B
SRT - 64 m	DBBC2	Fila10G + Mark 5B	Mark 5B+5C
Matera - 20 m	VLBA	Mark 5B	Mark 5B

Significant advancements have also been made in network connectivity, providing 10-Gbit connections to Noto and Medicina, and the installation of a POP (Point of Presence) by the Italian research provider (GARR) in Bologna. The POP router provides up to 1-Tbit backplane connectivity to the research network, which is currently under major upgrades.

Table 2 Network connectivity.

Facility	Network connection
Medicina	10 Gbit
Noto	10 Gbit
Sardinia	10 Gbit[1]
Matera	500 Mbit
Bologna	10 Gbit

[1]Expected in 2017

All stations are at least co-located with GNSS systems, while at the Matera fundamental geodetic station there is also an SLR system. The relevant local tie vec-

1. IRA - INAF
2. ASI
3. Italian Embassy - Pretoria - South Africa

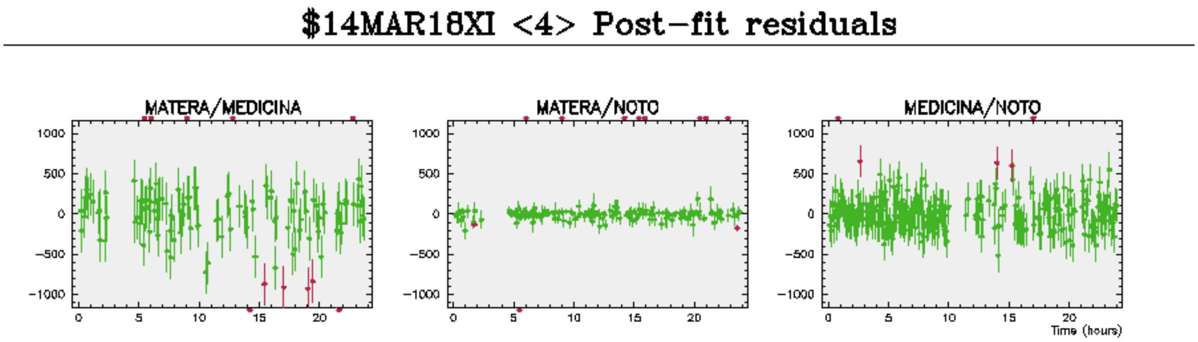

Fig. 1 SOLVE residuals from the first Italian geodetic VLBI experiment.

tors are available. In Italy there are several GNSS networks managed by various institutions, but all of them may benefit from the geodetic VLBI observations. A series of geodetic VLBI experiments has been planned to contribute to realizing an improved national datum.

Table 3 Co-located techniques and their local ties with VLBI.

Antenna	GNSS	DORIS	SLR
Medicina	YES	NO	NO
Noto	YES	NO	NO
Sardinia	YES	NO	NO
Matera	YES	NO	YES

2 Geodetic Experiments

Planning of geodetic experiments followed first fringes obtained with astronomical observations in 2013. The establishment of the experiments pipeline was not straightforward due to the backend transitioning time and working out the processing chain to obtain a dataset which could be analyzed with CALC/SOLVE. The most critical aspects were updating catalogs in SKED that could match the new setups at the antennas, Noto being first in adopting the new DBBC backend and with Medicina following in 2015 (though going directly to VDIF data format). The residuals shown in Figure 1 were obtained after working out the correct definition of Noto station which was scheduled by SKED as having a VLBA backend, but the station at the time was already using a DBBC backend.

3 Time and Frequency

Optical fiber links are beneficial not only for frequency metrology but also for other fields of physical research, such as radio astronomy and geodesy. Within the LIFT Project, the first optical fiber link from the National Institute of Metrology (INRIM) to the Medicina radio telescope was realized [3]. Comparing the hydrogen maser used as a frequency reference at Medicina with the Italian Cs fountain primary frequency standard, it was demonstrated that optical links can provide radio astronomical facilities with very accurate and stable frequency references, potentially better than the currently used hydrogen masers. The investigation experiment EUR137 has seen the participation of Medicina in a double manner [5], utilizing both the local maser clock and the remotely distributed frequency clock. The principal aim of the experiment was to test the accuracy of the remote clock over long periods of time, typically the timescale of a geodetic experiment (24 hours). The experiment was carried out alternating the observation scans between the local clock and the remote clock. This observation strategy was dictated by the fact that it was not possible to observe simultaneously with two different clocks (as this would have required two backends) and by the necessity to observe the same source at least three times for obtaining a single closure within the time of the experiment.

The secondary aim of the experiment was technical: it was the first time Medicina observed using the VDIF data format. The VDIF data format is in fact a more convenient and network-friendly format for VLBI data that can speed up and more reliably enable data transfers over networks rather than disk shipments. The

Fila10G complimentary formatter to the DBBC is able to easily produce this format as network packets output; however, a difficulty for the scheduling and correlation softwares is to interpret this. Table 4 shows the rearranged channels and BBC order for the DiFX software to correctly process the VDIF data.

Table 4 Geodetic VDIF channel and BBC assignment.

GEO VDIF			
CH	**Sideband**	**BBC**	**Pol**
1	U	BBC1	R
2	U	BBC2	R
3	U	BBC3	R
4	U	BBC4	R
5	U	BBC5	R
6	U	BBC6	R
7	U	BBC7	R
8	U	BBC8	R
9	L	BBC1	R
10	L	BBC8	R
11	U	BBC9	R
12	U	BBC10	R
13	U	BBC11	R
14	U	BBC12	R
15	U	BBC13	R
16	U	BBC14	R

4 Conclusions

Recent technical and technological advancements in networks, backends, data formats, and time and frequency distribution contribute to better plan VLBI experiments. The encouraging results shown in this paper could be the first of a series of Italian experiments to be integrated with GNSS solutions through local ties to contribute to a national reference system. The time and frequency distribution opens new perspectives in the ultimate limits of VLBI and a more precise space geodesy. In the framework of this unique opportunity more Italian geodetic experiments have been planned for 2016 and 2017 to reliably test the new VDIF setups at Medicina and Noto and also involving Matera where the next remote time and frequency distribution link will be set up. During these newly planned tests, real-time recording at the correlation facility in Bologna has also been scheduled to significantly reduce the correlation processing time.

References

1. Nothnagel, A., et al,"The IVS data input to ITRF2014". International VLBI Service for Geodesy and Astrometry, http://doi.org/10.5880/GFZ.1.1.2015.002, 2015.
2. A. T. Deller, S. J. Tingay, M. Bailes and C. West, "DiFX: A Software Correlator for Very Long Baseline Interferometry Using Multiprocessor Computing Environments", In Publications of the Astronomical Society of the Pacific, http://www.jstor.org/stable/10.1086/513572, pages 318–336, 2007.
3. C. Clivati, R. Ambrosini, C. Bortolotti, G. A. Costanzo, M. Frittelli, F. Levi, A. Mura, F. Perini, M. Roma, M. E. Zucco, D. Calonico, "The optical fiber link LIFT for Radioastronomy", In Frequency Control Symposium and the European Frequency and Time Forum (FCS), 2015 Joint Conference of the IEEE International, doi: 10.1109/FCS.2015.7138955, pages 769–772, 2015.
4. D. Calonico, C. Clivati, M. Frittelli, A. Mura, M. Zucco, F. Levi, F. Perini, C. Bortolotti, M. Roma, R. Ambrosini, G. A. Costanzo, "Time and frequency optical fiber link for Space Metrology", In 2nd IEEE International Workshop on Metrology for AeroSpace, June 4-5, 2015, Benevento, Italy, 2015 IEEE, doi: 10.1109/MetroAeroSpace.2015.7180654, pages 204–208, 2015.
5. F. Perini, C. Bortolotti, M. Roma, R. Ambrosini, M. Negusini, G. Maccaferri, M. Stagni, M. Nanni, C. Clivati, M. Fritelli, A. Mura, F. Levi, M. Zucco, D. Calonico, A. Bertarini, T. Artz, "The first geodetic VLBI field test of LIFT: a 550-km-long optical fiber link for remote antenna synchronization", this volume.