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1 Introduction

EVN (European VLBI Network) is a network of radio telescopes (Europe, Asia and South Africa) that performs simultaneous observations in the cm-wavelength regime. GMVA (Global Millimeter VLBI Array) provides a complementary infrastructure that combines European and US telescopes, and ALMA to provide ultra-high resolution observations at mm-wavelengths. It is essential to maintain and improve these infrastructures in order to satisfy the requests for constantly increasing science goals and to sustain radio astronomy into the far future. The success of EVN is heavily based on standardization of equipment and procedures across the network. The Technical & Operations Group (TOG) of EVN is the platform for innovations and standardization within EVN and has been responsible for the maintenance of the technical and operational infrastructure of EVN for the last 30 years. Regular technical meetings provide a crucial work platform for the TOG. In early 2016 the GMVA Technical Group (GTG) was officially constituted to provide comparable services to the GMVA.

The TOG (Technical and Operations Group of the EVN) meeting takes place every 9 months in a different observatory of the EVN to allow a direct exchange of technical expertise and experience between the station personnel. Every 18 months the TOG meeting is held together with a meeting of the GMVA technical group (GTG). The meetings are attended by VLBI friends and technical staff of the stations and the correlators as well as by selected external experts. The general objective of the TOG and GTG meetings is to identify operational issues of the EVN and GMVA infrastructures and discuss strategies to mitigate those in the future. Permanent agenda items deal with improving the quality of calibration, maintenance of the data acquisition and recording equipment as well as of the used software components. In addition strategies for improving the future scientific capabilities of the infrastructures are being discussed and implementation plans are being established.

2 Meetings summary

Since the start of RadioNet on January 1st of 2018, three TOG meetings and two GTG meetings were held all of which received partial funding from RadioNet.

Date	Location	TOG	GTG	Links	Report
22-23.05.2017	Ventspils, Latvia	✓	✓	meeting page	report
19-20.03.2018	Shanghai, China	✓		meeting page	report
04-05.10.2018	Granada, Spain	✓	✓	meeting page	report

All meetings have been prepared and managed by the coordinator(s) of this work package together with the Local Organizing Committees (LOC) of each meeting. The coordinator(s) issued the calls for all meetings, prepared the agendas, evaluated economic requests for partial funding, chaired the meetings, generated and reviewed the minutes and published the presentations, minutes and action items.

All meetings are documented in reports, which were supplied by the coordinator(s) to the RadioNet management shortly after the event. The reports (linked in the last table column) contain detailed information on the meeting agendas, the list of participants, minutes and action items.

3 Participation

The gross attendance to the TOG and GTG meetings is summarized below:

Meeting Place (Date)	Male	Female	Total	Countries
Ventspils (May 2017)	32	2	34	12 (Europe, Africa, America)
Shanghai (March 2018)	40	2	42	12 (Europe, Africa, America, Asia)
Granada (October 2018)	34	2	36	14 (Europe, Africa, America, Asia)

There is an extremely low percentage of women versus men among the attendants. This proportion is clearly different from the more balanced ratio typically seen in the Astronomy scientific environment.

Due to the global nature of VLBI infrastructures and techniques the proportion of countries versus attendants is very high. A core group of around 30 people regularly attends the TOG and GTG meetings. Depending on the meeting location additional participants take advantage of the proximity of the meeting venue. This was especially noticeable for the Shanghai meeting that attracted many people from Japan, Korea and China which otherwise would not have participated due to the duration and cost of their travel e.g. to Europe. This clearly demonstrates the benefits of organizing meetings in all the regions the infrastructure covers.

The financial support provided by RadioNet allowed to invite experts that normally would not have attended the TOG / GTG meetings. Most noticeably the maintainers of the VLBI field system and of the Mark5 recording software were invited to give presentations on the progress of these packages, which are fundamentally important in the VLBI field.



Figure 1: Participants on the Ventspils meeting (TOG+GTG)



Figure 2: Participants of the Shanghai meeting (TOG only)



Figure 3: Participants of the Granada meeting (TOG+GTG)

4 Summary & Impact

The TOG and GTG meetings have a direct impact on the RadioNet community since they identify operational issues of the EVN and GMVA infrastructures and discuss ways to mitigate those in next sessions. Permanent agenda items deal with continuously improving the quality of calibration, maintenance of the data acquisition and recording equipment as well as of the used software components. In addition strategies for improving the scientific capabilities of the infrastructures are always an important and recurrently addressed topic.

Some of the main improvements recently achieved are highlighted in the following section

4.1 Increasing standard recording rates to 2Gbps (EVN)

During these first 18 months the TOG has worked supporting and encouraging a wide adoption of 2 Gbps recording rates at the EVN stations doubling the previous recording capacity. These rates correspond to using 256 MHz bands at both polarizations and require an increase of the storing space at the stations and the correlator. This goal has been achieved by most of the stations and surpassed by some of them. Currently the remaining issues related to the quality of the backend firmware for this recording have been identified and possible solutions are being investigated. Doubling the recording rates directly impacts the scientific results that can be obtained from these data by increasing the SNR by a factor of 1.4.

4.2 Increasing standard recording rates to 4Gbps (GMVA)

One of the main achievements of the Granada GTG meeting was to discuss and agree on a strategy of doubling the GMVA recording capability from currently 2Gbps to 4Gbps. Such an upgrade would have a major impact on the scientific capabilities and would enable new science for the GMVA users. Whereas the European GMVA stations are technically ready for the upgrade the VLBA stations (USA) will require replacement of the recording hardware. Funds for the required hardware changes have been secured by the US partners and upgrades are ongoing. Doubling the recorded bandwidth also requires doubling the data storage capabilities at the stations and the Bonn correlator. All partners have agreed to provide these capabilities. A schedule containing a number of test observations in the course of 2018 and early 2019 was worked out. In case of a positive outcome of the tests the GMVA would be able to offer the 4Gbps mode as the new standard mode starting from fall 2019.

4.3 Flexbuff data storage and e-transfer (EVN and GMVA)

One of the major activities over the previous years has been the transition from module recording to e-transfer. Traditionally VLBI data is recorded by special recording hardware (e.g. Mark5 /Mark6) and is stored on dedicated hard disk modules, which are then shipped to the correlators. Recent technological developments have opened up the possibility to transfer the recorded data from the telescopes to the correlation centers via the internet. Data is buffered locally on so-called Flexbuffs; these are custom of-the-shelf disk servers running a special software jive5ab developed by JIVE. The transition to e-transfer instead of module shipment was finished at most of the EVN stations and has considerably reduced the operational costs in terms of logistic fees and manpower both at the stations and the correlator. In addition an automatized process for efficiently handling the transfers at the EVN correlator has been established and polished during the TOG meetings.

4.4 e-VLBI (EVN)

A subset of EVN observations is realized as so-called e-VLBI observations. In this special mode data are not recorded but transmitted in real time and the backends at the stations are remotely controlled by the correlator center. The required recording rate for e-VLBI is 2 Gbps, which has now been achieved by all EVN stations except Sardinia and some sites in Russia and China. The two former ones already have the infrastructure and will possibly take part in 2 Gbps observations in the very near future.

4.5 Improved feedback between correlator and stations (EVN)

Another important aspect of the items discussed at the TOG has been the feedback mechanism between the correlator and the stations and the presentation of results from the correlator using a new web tool. This tool allows examining and evaluating the quality of the amplitude calibration at all observing frequencies and also of the performance of the different stations. This allows generating statistics of the performance of the network and trends at individual stations.

5 Publications

No publications have been released. All information: presentations, agenda and minutes are publicly available on the RadioNet wiki pages.

6 Acronyms

VLBI – Very Long Baseline Interferometry

EVN – European VLBI Network

GMVA – Global Millimeter VLBI Array

TOG – Technical and Operations Group

GTG – GMVA Technical Group

SHAO – Shanghai Astronomical Observatory, Chinese Academy of Sciences

XAO – XinJiang Astronomical Observatory, Chinese Academy of Sciences

NTSC – National Time Service Center, Chinese Academy of Sciences

IAA – Institute of Applied Astronomy, Russian Academy of Sciences

SARAO – South African Radio Astronomy Observatory

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