Geodetic Observatory Wettzell - 20-m Radio Telescope and Twin Telescopes

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Abstract In 2013 the 20-m radio telescope at the Geodetic Observatory Wettzell, Germany contributed again very successfully to the IVS observing program. 2013 was the anniversary year of the antenna as it started its operations in the year 1983. Technical changes, developments, improvements, and upgrades have been made to increase the reliability of the entire VLBI observing system. Therefore, a complete shutdown was necessary in the months from July to September to replace the complete servo and gear system. In parallel the new Twin radio Telescope Wettzell (TTW) was officially inaugurated during a ceremony with international guests. Additionally, first light and correlation tests were successfully performed in August.

1 General Information

The 20-m Radio Telescope in Wettzell (RTW) is an essential component of the Geodetic Observatory Wettzell (GOW) and is jointly operated by Bundesamt für Kartographie und Geodäsie (BKG) and Forschungseinrichtung Satellitengeodäsie (FESG) of the Technische Universität München (Technical University Munich). In addition to the RTW an ILRS laser ranging system, several IGS GPS permanent stations, a large laser gyroscope G (ringlaser) and the corresponding local techniques, e.g. time and frequency, meteorology and super conducting gravity meters, etc., are also being operated. Currently also the first antenna of the fully VLBI2010-compliant Twin radio Telescope is in an operational test phase. It should extend the observation possibilities according to the technical suggestions of the IVS Working Group 3 (WG3) and the VLBI Global Observing System (VGOS) observations.

Within the responsibility of the GOW are the TIGO system in Concepción, Chile, operated mainly together with the Universidad de Concepción (see separate report about TIGO), and the German Antarctic Receiving Station (GARS) O'Higgins on the Antarctic peninsula, operated together with the German Space Center (DLR) and the Institute for Antarctic Research Chile (INACH) (see separate report about O'Higgins).

2 Staff

The staff of the GOW consists in total of 34 members (excluding students) for operations, maintenance, and repair issues and for improvement and development of the systems. The staff operating RTW is summarized in Table 1. In 2013, two chief engineers were appointed to be responsible for the technical issues at the two radio telescope systems of the GOW. Christian Plötz took over the duty for the 20-m RTW and Gerhard Kronschnabl for the TTW.

Until March 2013, one additional engineer was on a research position which was funded by the "Novel EXploration Pushing Robust e-VLBI Services" (NEXPReS) project in cooperation with the Max-Planck-Institute for Radioastronomy (MPIfR), Bonn. Another research position, which is partly involved in VLBI

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Table 1 Staff - members of RTW.

Name	Affiliation	Function	Mainly working for
Torben Schüler	BKG	head of the GOW (since January 2013)	GOW
Alexander Neidhardt	FESG	head of the VLBI group and VLBI station chief	RTW, TTW
Erhard Bauernfeind	FESG	mechanical engineer	RTW
Ewald Bielmeier	FESG	technician	RTW
Gerhard Kronschnabl	BKG	electronic engineer (chief engineer TTW)	TTW, RTW, TIGO
Christian Plötz	BKG	electronic engineer (chief engineer RTW)	O'Higgins, RTW, TTW
Raimund Schatz	FESG	software engineer	RTW
Walter Schwarz	BKG	electronic engineer	RTW, WVR)
Reinhard Zeitlhöfler	FESG	electronic engineer	RTW
Martin Ettl	FESG/ MPIfR	Computer scientist (until March 2013)	NEXPReS (EU FP7)
Jan Kodet	FESG	appl. phys. engineer	DFG FOR1503
Gordon Klingl	FESG/ BKG	student	Operator RTW/SLR
Yvonne Klingl	FESG/ BKG	student	Operator RTW/SLR

developments, is founded by the DFG research group FOR1503 about reference systems, local ties, and co-location on ground and space.

3 Observations in 2013

The 20-m RTW has been supporting the geodetic VLBI activities of the IVS and partly other partners, such as the EVN, for almost 30 years. All successfully observed sessions in the year 2013 are summarized in Table 2. After the repair of the bearings in 2010, it was also necessary to replace the gears, the motors, the servo system, and the control system with a new, state-of-the-art technique. This was realized in the months from July to September 2013. Nevertheless, the telescope is in a very good and stable state. The main priority in operations was participation in all daily one-hour INTENSIVE-sessions (INT) in order to determine UT1-UTC. According to the implementation of a Field System extension for remote control, weekend INTENSIVEs were partly done in the new observation modes by remote attendance, remote control from students at the laser ranging system (WLRS), or completely unattended. Meanwhile, all data are transferred with e-VLBI techniques. RTW now routinely uses the Internet connection capacities of 1 Gbit/sec for the e-transfers with the Tsunami protocol to the correlators in Bonn, Tsukuba, Haystack, and Washington.

Table 2 RTW observations in 2013.

program	number of 24h-sessions
IVS R1	40
IVS R4	41
IVS T2	6
IVS R&D	7
RDV/VLBA	3
EUROPE	5
total (in hours)	**103 2472**

special program	number of 1h-sessions
1h-INT1	179
1h-INT2/K	56
1h-INT3/K	25
VEX/MEX/RadioAstron	31
VLBA102	24
Satellite tracking	1
total (in hours)	**316**

In addition to the standard sessions, RTW was active for other special observations such as the tracking of the ESA Venus Express (VEX) spacecraft, the Mars Express (MEX) spacecraft (Phobos fly-by) and the RadioAstron satellite for the EVN. More progress was possible for the tracking of Glonass and GPS satellites. Additional developments of an L-band receiver and the activation of a permanent satellite tracking mechanism, using the new antenna control unit after the modification of the RTW, enabled frequent observations. A cooperation with the technical university in Vienna also allowed to extend the scheduling module of the Vienna VLBI Software (VieVS) to produce VEX files for satellite observations.

4 Technical Improvements and Maintenance

Regularly, tasks and maintenance days (obtaining replacements for the hardware, 8-pack repair, gear maintenance, exchange of motors after reaching their lifetime, NASA Field System updates, cryo-system maintenance, servo replacements, and improvements for e-VLBI issues) were scheduled for the usual maintenance work. As the components of the servo system were overaged, it was possible to commission a replacement of the whole system and to upgrade it to a similar, modern technique such as the one installed in the Twin telescopes. The upgrade was performed by the company Vertex Antennentechnik GmbH, Duisburg, Germany from July to September. During this upgrade the gears for the azimuth and elevation axes were replaced. The new gears have new AC-servos and a

completely digital control system. Therefore the complete servo and control racks were replaced and the cable wrap was reconfigured. As a new Twin-like antenna control unit controls the whole system, the station computer software was re-written. The new software supports the classic tracking modes and additional satellite tracking possibilities and modes, which reduce power consumption for the slewing between sources with optimal acceleration behavior. In addition to the upgrade of the servo system, the complete surface of the reflector and sub-reflector was polished and varnished again. To improve the de-icing of the reflector, the heating system in dedicated reflector panels was replaced.

Fig. 1 Some replacement work at the RTW: new setup of the cable wrap (left), replacement of the gears and motors (upper right), and new varnishing of the reflector surface (lower right).

Upgrades and repairs were also necessary for the Mark IV data acquisition rack. The revision of the replacement dewar systems for Wettzell and O'Higgins were completed by the labs at the astronomical observatory in Yebes, Spain.

The usage of the EVN-PC for e-transfer was continuously extended. In addition the usage of e-transfer for the 24-hour sessions to the correlators in Bonn, Haystack, Washington, and Tsukuba was routinely used with up to 600 Mbit per second. A combination of the Mark 5 software "fuseMk5" and the communication protocol "Tsunami" is used on a regular Mark 5B system.

The usage of the new Digital Baseband Converters (DBBC) was forced. Several test data were correlated at the Bonn correlator to check functionality and quality (especially in combination with the Twin operation tests). Additionally new CoMo boards were installed to upgrade to a standard version of the equipment. The development is still under progress.

The remote control software "e-RemoteCtrl" was also extended, mainly by the TUM. In close cooperation with the developers of the NASA Field System and with other test sites at Australia (e.g. Hobart, Katherine, and Yarragadee) new features were established. The AuScope network and the Wettzell site already use the software routinely. The software development was funded in task 3 of work package 5 of the NEXPReS project and is performed in cooperation with the MPIfR.

Another new field is the preparation for tracking of global navigation satellites. Therefore new amplifier and receiver boards were improved. These can be used after the waveguides for S-band to receive the L-band of the satellite. Additionally the software is now able to track satellites permanently, using orbits in the Two-line Elements format.

5 The TWIN Radio Telescope Wettzell (TTW)

The Twin Telescope Wettzell project is Wettzell's realization of a complete VLBI2010 conformity. The mechanical system is now completely functional, and the installation work of the receiving and the data acquisition systems was continued. The new tri-band horn was put into operation. Quality checks together with the company Vertex Antennentechnik GmbH demonstrated the very good performance of the feed horn in combination with the antenna for S- and X-band. The new control room was completely set up to control both the Twin telescopes and the old 20-m antenna. Additionally connections to the TIGO telescope and to the AuScope telescopes in Australia was established.

The Twin telescopes started their operational test phase with an official inauguration with international guests on April 26th. After the ceremonial act, the Undersecretary of State of the German Ministry of the Interior Cornelia Rogall-Grothe, the Vice-President of the Technical University Munich (TUM) Prof. Hans Pongratz, and the President of the Federal Agency for Cartography and Geodesy (BKG) Prof. Hansjörg Kutterer symbolically started the operations under a clear and sunny sky by pushing a red start button.

Fig. 2 The Twin radio Telescope Wettzell (TTW) as Wettzell's realization of a complete VLBI2010 conformity.

Fig. 3 A "symbolic" start of the new telescopes.

The first operational test sessions were then performed in August. The north tower of the Twin telescope joined the regular INT3 session together with the 20-m antenna. To test different digital baseband converters, one session used the Japanese ADS3000 system, while another used the DBBC. The scans were correlated in Bonn and resulted in good results, which gave also some hints for improvements of the data quality. Revised versions of the S-/X-receiver in combination with Ka and dual-polarization are under development. New software components for the new receiver and data acquisition system are designed and under implementation. A new transfer technique with the Mark 5 software "Jive5ab" from the Joint Institute for VLBI in Europe (JIVE) allows the sending of recording data from one Mark 5 to another in real-time, which should be used to record all streams in the new Data Center in the Twin operations building.

Fig. 4 The new control room and Data Center in the Twin operations building.

The broadband feed horn (Eleven feed) for the second telescope (south tower), which is built by Omnisys in Sweden, is almost finished and is currently in quality control. Chalmers University recently measured the radiation patterns and the data of the coherence and cross-polarization. The feed is expected for 2014.

Within a pilot study, a student of the Applied University Dresden ran a permanent survey of the reference point of the south tower, using two total stations and 20 to 30 reflectors in the back structure. The analysis showed very good stability over time.

6 Future Plans

Dedicated plans for 2014 are:

- Update of the de-icing control system,
- Upgrade of the RTW for complete remote control from the Twin control room,
- Completion of the Twin implementations of the north tower and continuation of the operational tests, and
- Development of new receiver and system monitoring software.