Towards a four technique GGOS site: VLBI - DORIS compatibility tests at Wettzell

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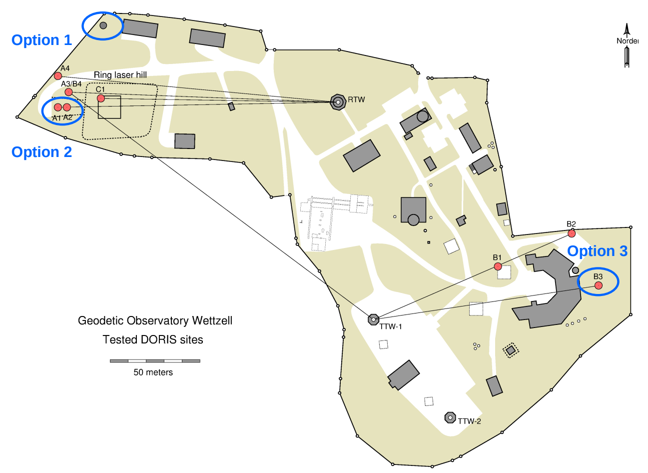
Introduction

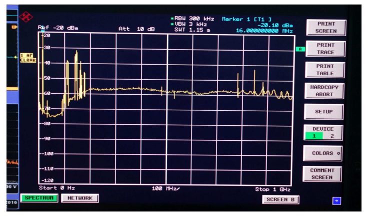
Within the framework of a Global Geodetic Observing System (GGOS), co-location sites are of special importance for the evaluation and mutual control of the individual geodetic space techniques. At the Geodetic Observatory Wettzell a DORIS (Doppler Orbitography and Radio-positioning Integrated by Satellite) beacon could complete the geodetic instrumentation consisting of three Very Long Baseline Interferometry (VLBI) telescopes, two Laser Ranging systems and a number of multi- Global Navigation Satellite System (GNSS) stations. We chose 3 options as possible sites for a DORIS beacon.



Map of the Wettzell observatory and tested DORIS sites.

The EMC problem

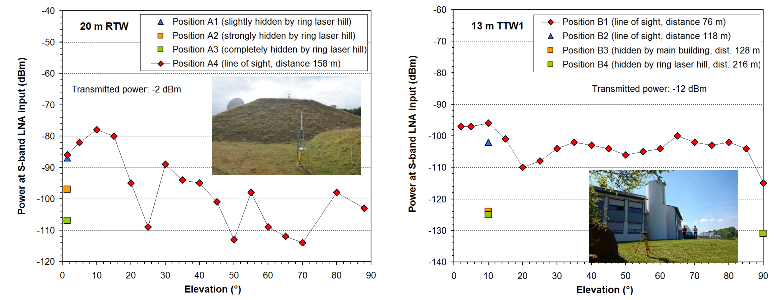
The common operation of VLBI and DORIS at one site generates problems with Electromagnetic Compatibility (EMC). While the VLBI system is designed to receive extreme weak signals down to –110 dBm, the DORIS beacon emits a 2036 MHz frequency of +40 dBm. There is a high risk of coupling DORIS signals into the VLBI S-band receiver generating spurious signal and, in the worst case, overloading the Low Noise Amplifier (LNA) and risking its damage.



DORIS signal in the intermediate frequency (IF, minus 2020 MHz) at 16 MHz beside other RFI sources (mobile phone between 90 and 180 MHz).

Test 1: Low power setup

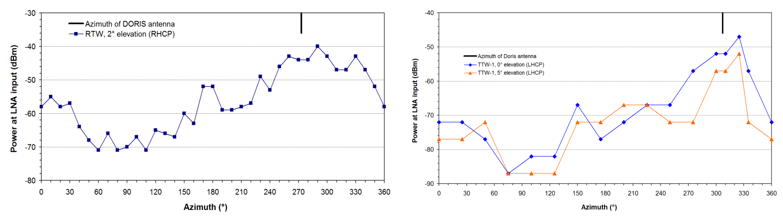
A first test at low transmitting power using a simple signal generator and a DORIS antenna was performed to get an idea how sensitive the VLBI receiving systems of the 20 m telescope (RTW) and one of the 13 m TWIN telescopes (TTW-1) respond to the 2036 MHz frequency and to evaluate different possible DORIS sites.



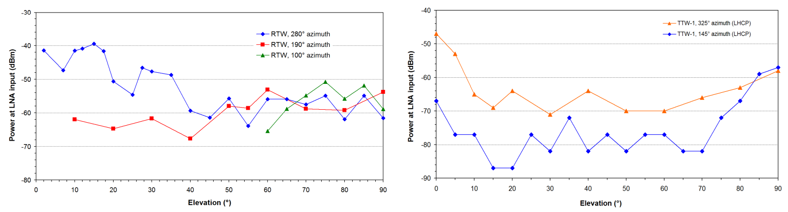
Received power at the RTW LNA input at test sites A1 – A4 (left) and at the TTW-1 LNA input at test sites B1 –B4 (right). VLBI antenna is pointing in direction of the DORIS antenna. The attenuation effect of obstacles (left: hill, right: building) is up to 20 dB.

Test 2: Real conditions

In a second test an original DORIS beacon at site A3/B4 was used under full transmitting power (10 W) to see if the power level at the LNA input is in the linear range (below –50 dBm) at all telescope positions.



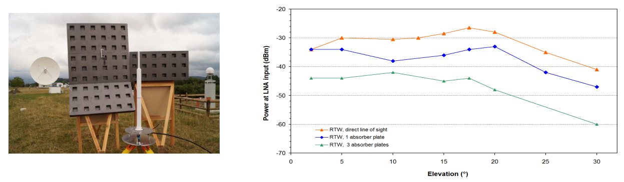
Received power at full 360° turn at low elevation of the 20-meter telescope (RTW, left) and the 13-meter telescope (TTW-1, right).



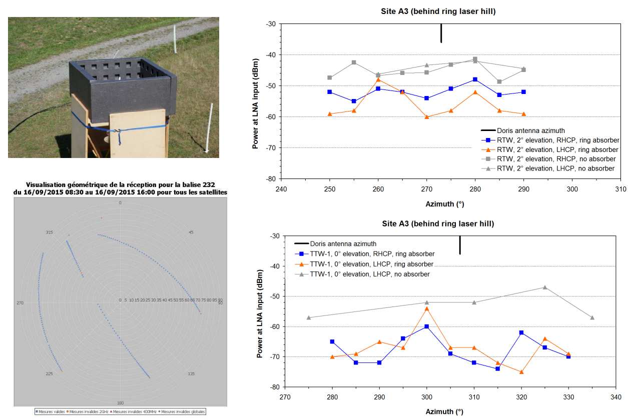
Elevation dependence of the received power at RTW (left) and TTW-1 (right).

Test 3: Effect of RF absorbers

These tests were carried out to check the effectiveness of microwave absorber plates (type COMTEST MT65, size 120 x 60 x 10 cm). In the first setup the effect of a barrier was compared to the direct line of sight at site C1. In a second setup a ring of absorber plates was mounted around the DORIS antenna at site A3/B4.

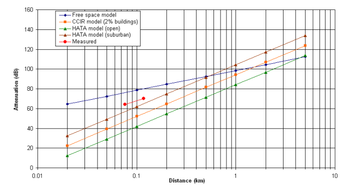


Attenuation effect of absorber plates at site C1 on RTW. 3 plates (setup left) reduce the signal by 12-20 dB.



A ring of 4 absorbers at site A3 reduces the signal additionally by 7-14 dB on average. In the skyplot (left), however, the minimum elevation of signal reception rises to 15-25°, which is not acceptable.

Attenuation vs. distance

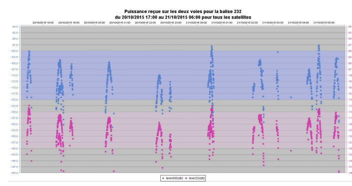


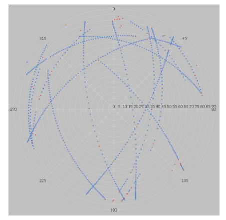
Measured power loss between sites B1 and B2 as compared to common path loss models.

Correlation results

The correlation of dedicated VLBI sessions (IN315-278, IN316-081, R1732) showed no degradation on long baselines due to the DORIS beacon operation.

DORIS signal reception





Received power levels (above) and skyplot (left) indicate good conditions at site A3. In the East the shielding effect of the ring laser hill is visible

Conclusions

- In direct line of sight, the received power at the VLBI system may exceed the LNA saturation point everywhere on the station. A LNA destruction can be excluded (DORIS antenna below 0° elevation).
- RF barriers like absorber plates or obstacles like buildings or the hills reduce the received power up to 20 dB, however, at dedicated orientations (telescope pointing in direction of the beacon, or at high elevations) the power is still at the upper limit.
- The following principles for any site layout have been drawn up:
  - Installation of the DORIS antenna on the observatory ground (good for local ties and shield erection, low installation costs, atomic clock option)
  - No direct visibility between DORIS and any VLBI antenna (using local topography or RF blockers)
  - Consider height difference between both antennas (DORIS emission is lower at low elevation)
  - Maximum distance between DORIS and VLBI (ideally more than 300-400 m)
- In practice a compromise has to be found to minimize the constraints for both systems

EGU General Assembly 2016, Vienna/Austria, April 18 – 22, 2016

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