Scheduling of VLBI observations to satellites with the Vienna VLBI Software (VieVS)

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Motivation for geodesy:

- Establish inter-technique ties in space
- Improved future ITRF realizations

„Co-Location in space“ (Plank L, 2014)
Framework conditions

Standard VLBI

Natural radio sources (quasars)
- At an infinite distance
- Parallel view directions \( \vec{k} \)
- Fixed points in the sky
- S/X-band

Satellite observations

Artificial signal sources
- In the Earth’s near field
- Different view directions \( (\vec{k}_1 \neq \vec{k}_2) \)
- Moving fast
- e.g. L-band for GNSS
Suitable observation plans („Schedules“) are required
• Defining the time sequence of a VLBI experiment
• Generated by dedicated VLBI scheduling software
  • SKED (Gipson J, 2012)
  • VIE_SCHED (Sun J, 2014)

➔ Problem: Available scheduling programs for geodetic VLBI did not support satellites as radio sources routinely.

➔ Idea: Development of a satellite scheduling module for the Vienna VLBI Software (VieVS; Böhm et al., 2012).
VieVS satellite scheduling module

GUI of the VieVS satellite scheduling module

Station network

Satellites

Observation parameter

Graphics & Visibility information

Time & duration

User-interface

Input data

Generation of VEX files

Catalog files

Configuration files

TLE datasets

VEX files
Satellite observation conditions

- Conditions for the temporal availability of satellites as observation targets:
  - Common visibility?
  - Sun distance?
  - Antenna slew speeds?

  - Tracking of the **cable wrap**
    - Calculation of slew times between scans
    - Check cable wrap limits
VEX Files

- VEX = Standard file format for VLBI observation plans
- Provide all required information to carry out a VLBI session
  - Observation sequence, source positions, receiver setup, etc...

- “Stepwise” satellite tracking with VEX files
  - Sequence of discrete positions (topo. Ra/Dec)
  - Feasible for standard VLBI antennas

- “VEX 2.0” (https://safe.nrao.edu/wiki/bin/view/VLBA/Vex2)
  - Inclusion of TLE orbit data
  - Improved satellite tracking in combination with satellite tracking features of the Field System
Combined schedules

- **Combination of quasar- and satellite-scans** in one schedule
- New possibilities:
  - Satellite positions in the CRF, reveal gaps in the local ties, etc…
- Observation restrictions due to limited receiver capabilities
  - e.g. S/X- versus L-band (GNSS)

Ground tracks of three GLONASS satellites & quasar positions for the epoch 2015-08-30 13:01:18 UTC
Future scheduling strategies

- Open questions:
  - How to **combine satellite and quasar observations** reasonably to improve the derived geodetic parameters?
    - Scan sequence, source distribution, etc…
  - How to handle station-dependent restrictions in the observable frequency bands?
  - etc…

➡️ Next step: **Combination of scheduling and simulation/analysis (Plank, 2014)** tools in VieVS to investigate suitable scheduling strategies for satellites.

Possible S/X- & L-band observation configuration on the baseline Onsala-Wettzell
Experiments: WTZ – ONSALA85

• Scheduled with

• Onsala, Sweden:
  • R. Haas
  • 25 m antenna, L-band feed

• Wettzell, Deutschland
  • A. Neidhardt
  • 20 m antenna, S/X-band feed

→ GLONASS satellites
  • L1 band signals
  (1602.56 - 1615.5 MHz)

Data correlation and preliminary results

→ Next talk: R. Haas et al., GLONASS-VLBI: Onsala-Wettzell test observations

• Four test sessions, one hour duration each
  • 16. January 2014: G140116a, G140116b
  • 21. January 2014: G140121a, G140121b

(Hellerschmied et al., 2014)
Summary & Outlook

• **VieVS Satellite Scheduling Module**
  - Planning of real VLBI satellite observations
  - Generation of schedule files (VEX Format)
  - Combination of quasar- and satellite scans
  - Successfully applied for test observations in January 2014
    - No automatic source selection so far

• Planned **simulation studies** with VieVS based on realistic schedules to find suitable scheduling strategies for VLBI satellite observations
Questions?

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