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

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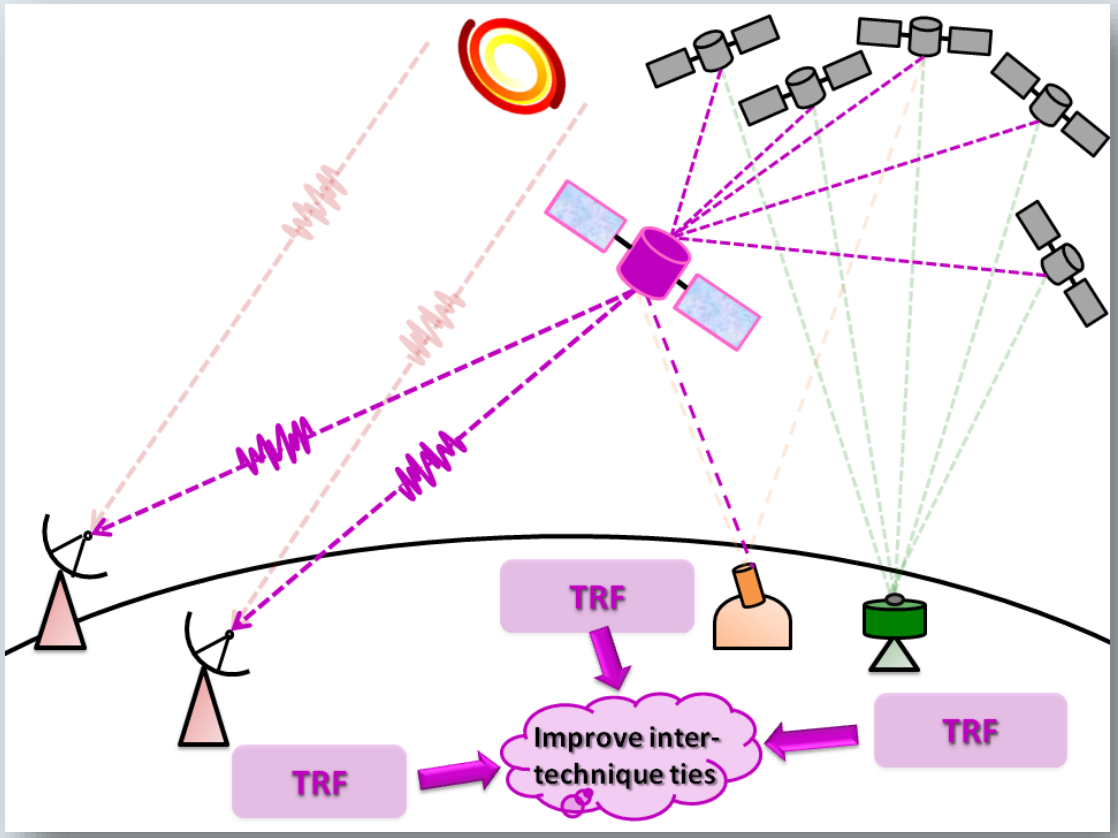
VLBI satellite observations (1)

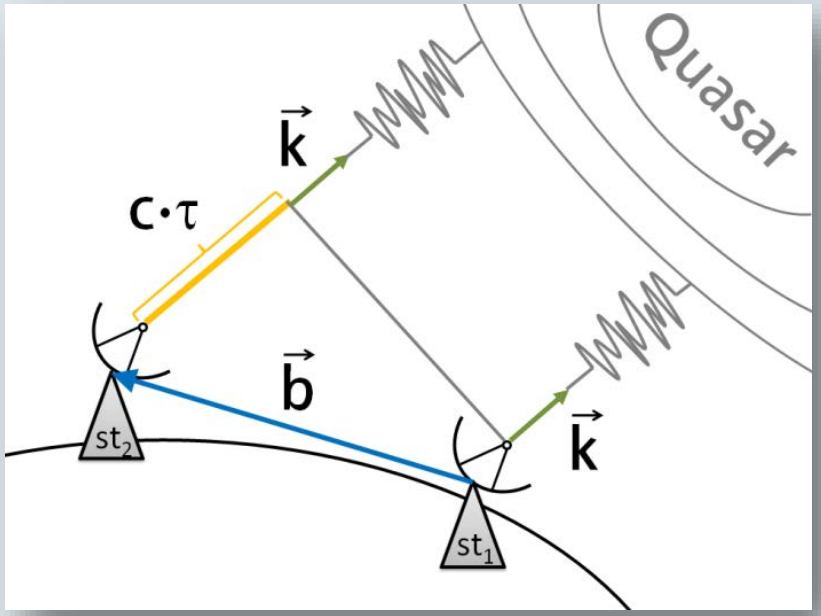
- Motivation for geodesy:
  - Establish inter-technique ties in space
  - Improved future ITRF realizations



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

Framework conditions

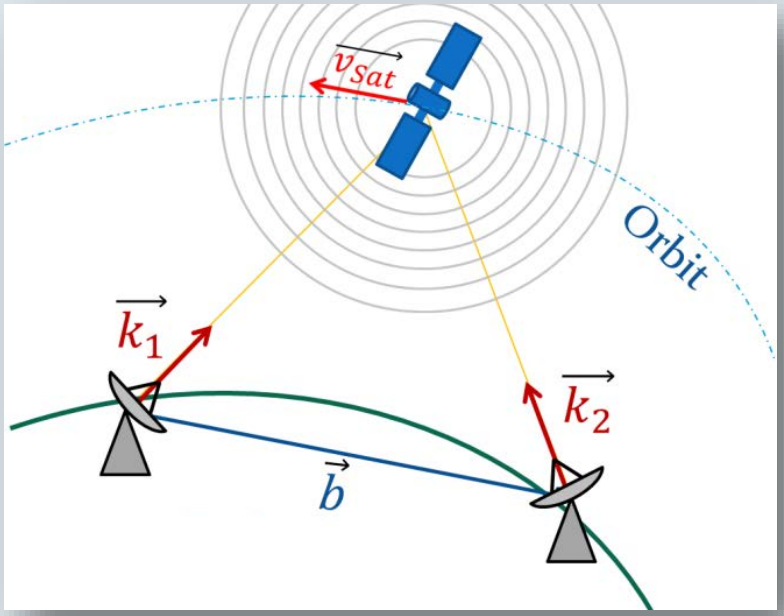
Standard VLBI



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

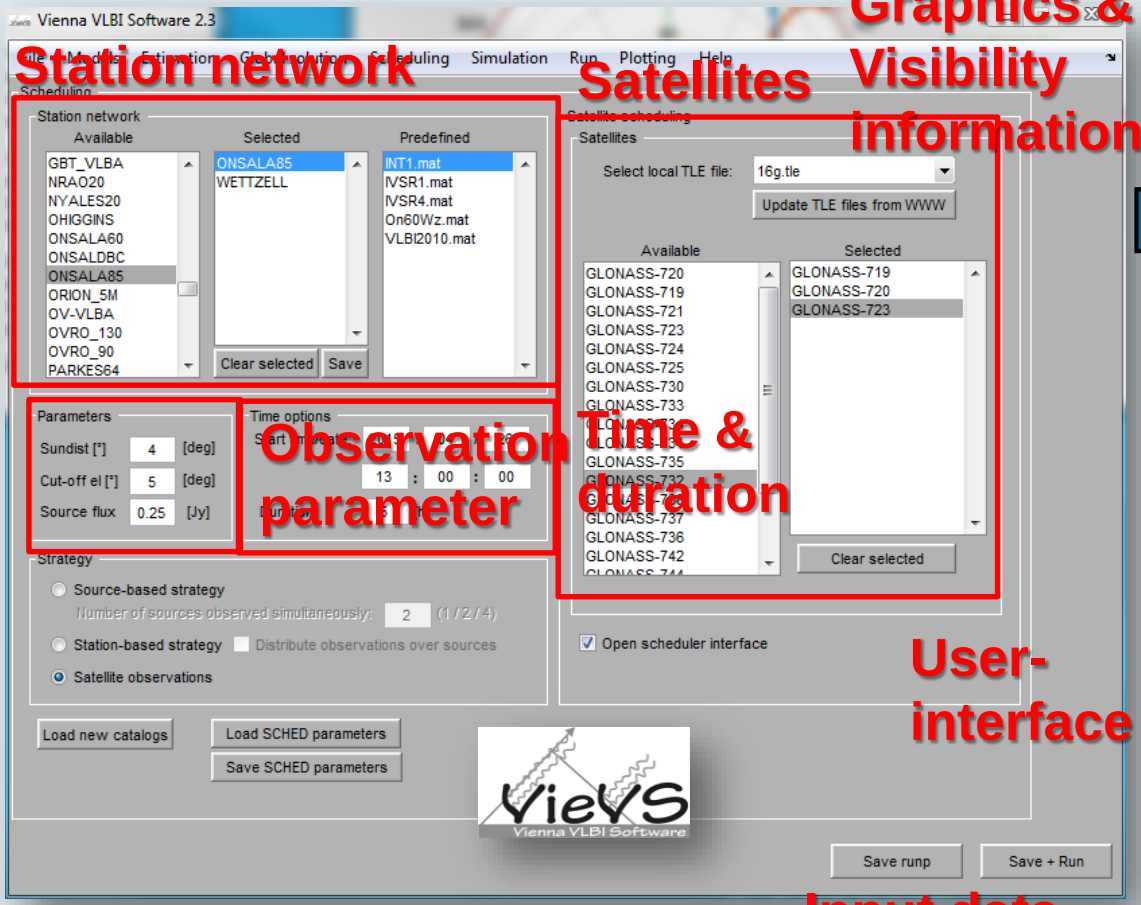
VLBI satellite observations (2)

- 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*)

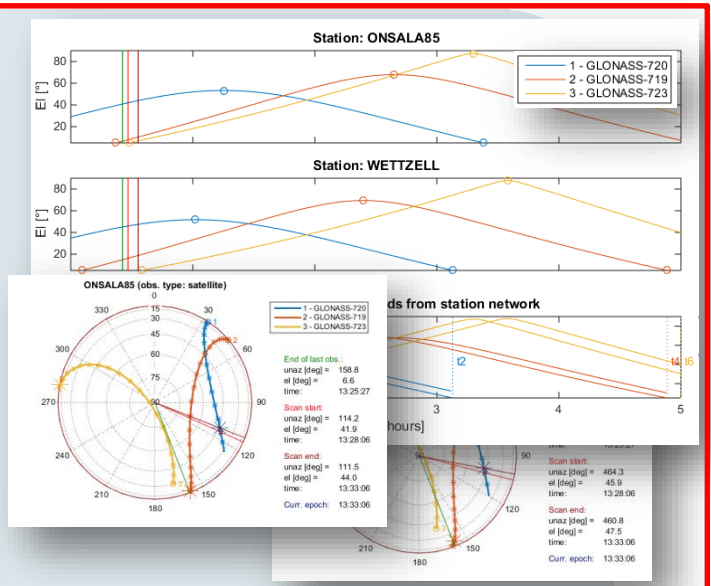
➔ **Problem:** Available scheduling programs for geodetic VLBI did not support satellites as radio sources routinely.

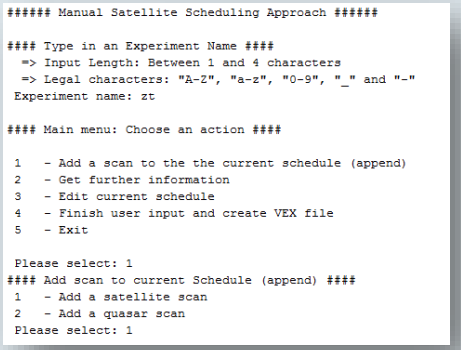
➔ **Idea:** Development of a **satellite scheduling module** for the Vienna VLBI Software (VieVS; *Böhm et al., 2012*).

VieVS satellite scheduling module



GUI of the VieVS satellite scheduling module





```
###### Manual Satellite Scheduling Approach ######

#### Type in an Experiment Name ####
  => Input Length: Between 1 and 4 characters
  => Legal characters: "A-Z", "a-z", "0-9", "_" and "-"
 Experiment name: zt

#### Main menu: Choose an action ####

 1   - Add a scan to the the current schedule (append)
 2   - Get further information
 3   - Edit current schedule
 4   - Finish user input and create VEX file
 5   - Exit

 Please select: 1
#### Add scan to current Schedule (append) ####
 1   - Add a satellite scan
 2   - Add a quasar scan
 Please select: 1
```

Generation of VEX files

Catalog files

Configuration files

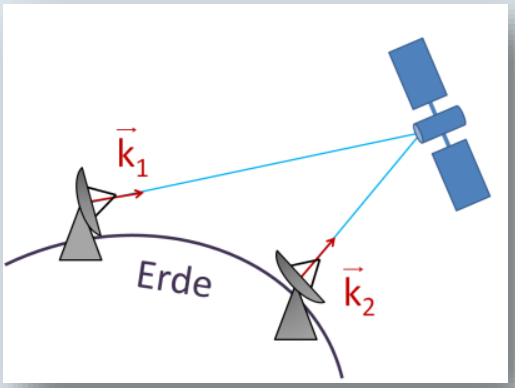
TLE datasets

VEX files

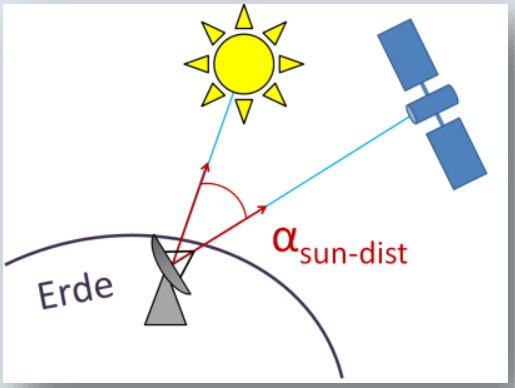
Satellite observation conditions

- Conditions for the temporal availability of satellites as observation targets:

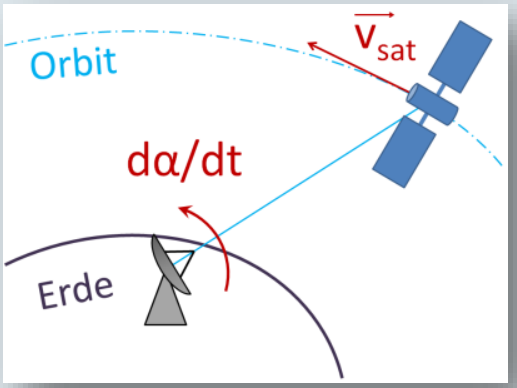
Common visibility?



Sun distance?



Antenna slew speeds?

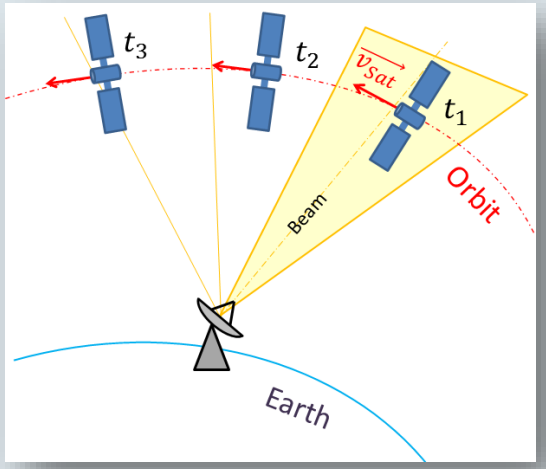


- Tracking of the **cable wrap**
  - ➔ Calculation of slew times between scans
  - ➔ Check cable wrap limits

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

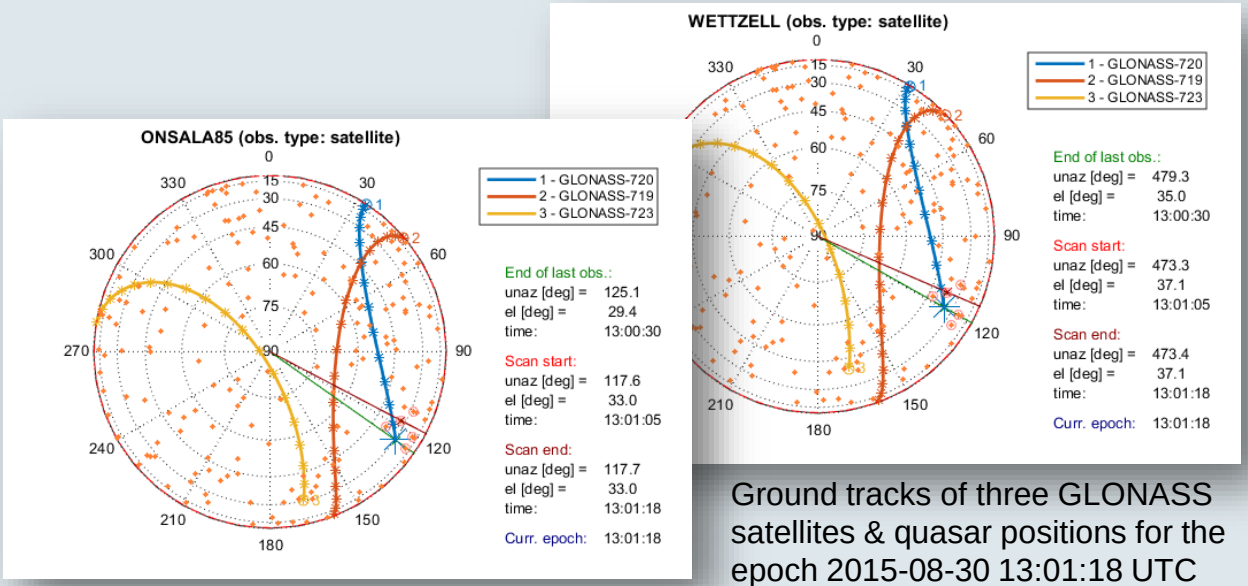


Principle of stepwise satellite tracking

- "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

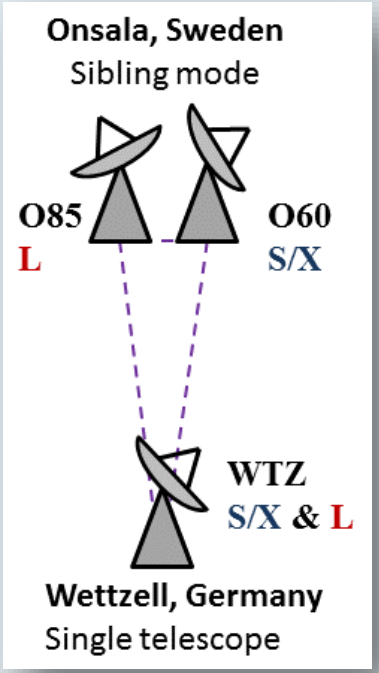
- **Combination of quasar- and satellite-scans** in one schedule
- New possibilities:
  - Satellite positions in the CRF, reveal gaps in the local ties, etc…
- Observation restrictions due to limited receiver capabilities
  - e.g. S/X- versus L-band (GNSS)



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-depended **restrictions in the observable frequency bands**?*
  - *etc…*



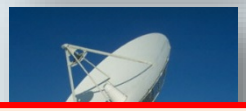
Possible S/X- & L-band observation configuration on the baseline Onsala-Wettzell

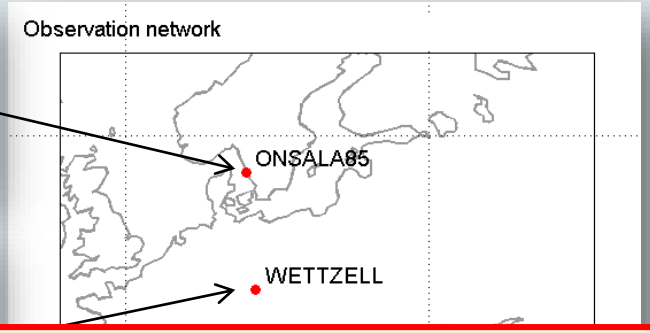
➔ Next step: **Combination of scheduling and simulation/analysis** *(Plank, 2014)* tools in VieVS to investigate suitable scheduling strategies for satellites.

Experiments: WTZ – ONSALA85

- Scheduled with VieVS Vienna VLBI Software
- Onsala, Sweden:
  - R. Haas
  - 25 m antenna, L-band feed
- Wettzell, Deutschland
  - A. Neidhardt

➔ 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

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Questions?

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References:

Böhm J et al. (2012), The New Vienna VLBI Software, Proceedings of the 2009 IAG Symposium, Buenos Aires, Argentina, 31 August 2009 - 4 September 2009, Series: International Association of Geodesy Symposia, Vol. 136, Kenyon S, Pacino MC, and Marti U (eds.), ISBN 978-3-642-20337-4, pp. 1007-1012.

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