



VIENNA UNIVERSITY OF TECHNOLOGY
DEPARTMENT OF GEODESY
AND GEOINFORMATION



First International Workshop on VLBI Observations
of Near-field Targets,
October 5-6, 2016, Bonn, Germany

FWF Der Wissenschaftsfonds.
Project SORTS – I 2204

Scheduling of VLBI Satellite Observations with VieVS

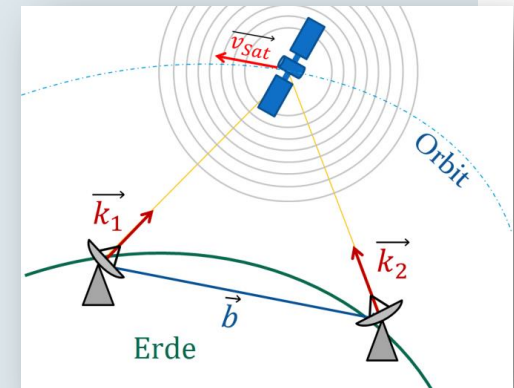
Andreas Hellerschmied¹,
L. Plank², J. McCallum², J. Böhm¹

¹ Technische Universität Wien, Austria

² University of Tasmania, Australia

Scheduling satellite observations

- Suitable observation plans („**Schedules**“) are required
 - Defining the time sequence of a VLBI experiment + setup parameters for the equipment of all stations
 - Schedule files in standardized formats (e.g. VEX)
- **Main challenges**
 - “Cross-eyed” observation geometry
 - Moving targets
 - Timing is more critical in general
 - Active tracking is required
 - Limited antenna capabilities (tracking, signal chain, etc.)

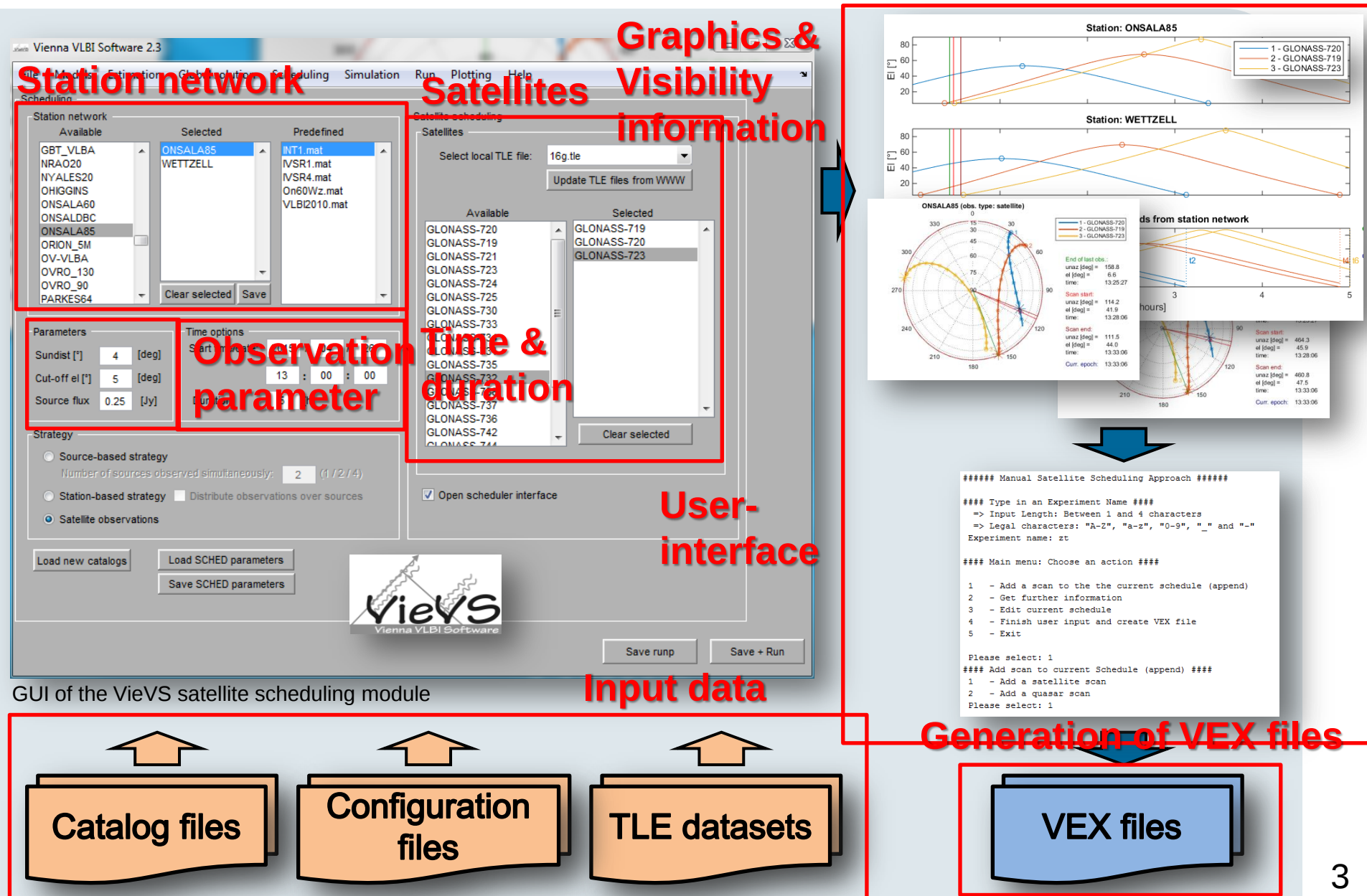


„Cross-eyed“ observation geometry.

➔ **Satellite scheduling module** for the Vienna VLBI Software (VieVS; *Böhm et al., 2012*).



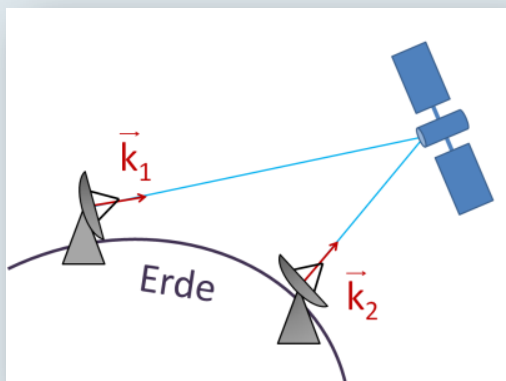
VieVS satellite scheduling module



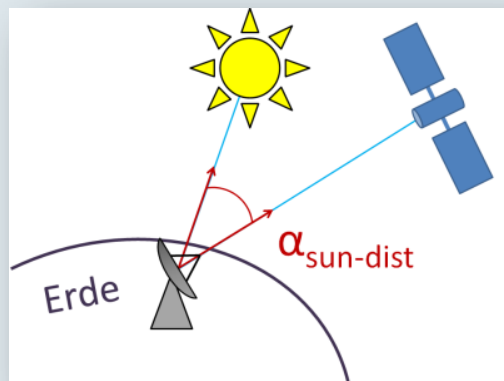
Satellite observation conditions

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

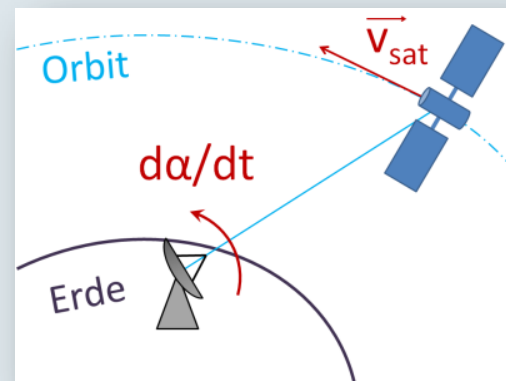
Common visibility?



Sun distance?



Antenna slew speeds?



- Tracking of the **cable wrap** (AzEl antennas)
 - ➔ Calculation of slew times between scans
 - ➔ Check cable wrap limits
- Check for violations of **axis limits** while tracking satellites

Scheduler interface

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

- 1 - Add a scan to the the current schedule (append)
- 2 - Create output
- 3 - Load/save data
- 4 - Edit current schedule
- 6 - Create schedule summary and statistics
- 7 - Automatic scheduling (satellites and quasars)
- 8 - Change settings
- 9 - Exit

```
fx Please select: |
```

Manual scheduling mode

Automatic scheduling mode

- Start with empty schedule
- Add scan in **manual or automatic scheduling mode**
- Combination of scans to quasars and satellites in one schedule

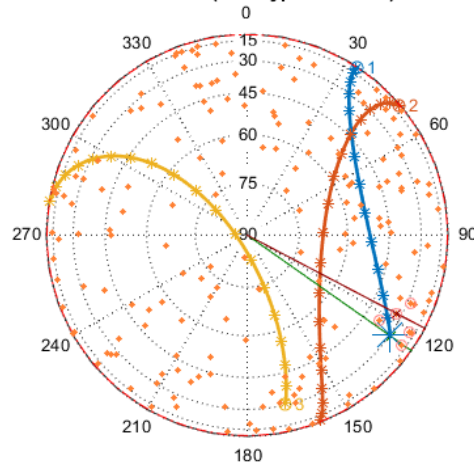
Manual scheduling mode

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

- 1 - Add a scan to the t
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fx Please select: |

ONSALA85 (obs. type: satellite)



1 - GLONASS-720
2 - GLONASS-719
3 - GLONASS-723

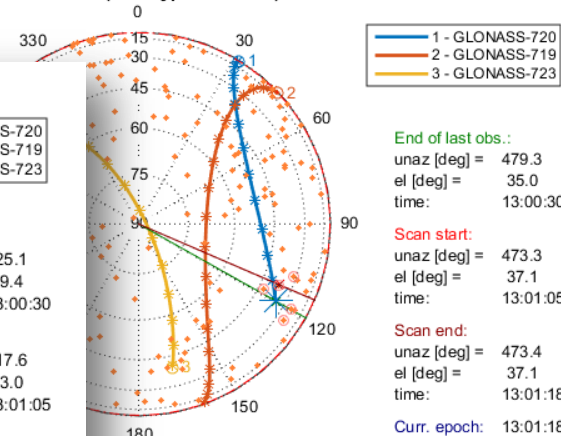
End of last obs.:
unaz [deg] = 125.1
el [deg] = 29.4
time: 13:00:30

Scan start:
unaz [deg] = 117.6
el [deg] = 33.0
time: 13:01:05

Scan end:
unaz [deg] = 117.7
el [deg] = 33.0
time: 13:01:18

Curr. epoch: 13:01:18

WETTZELL (obs. type: satellite)



1 - GLONASS-720
2 - GLONASS-719
3 - GLONASS-723

End of last obs.:
unaz [deg] = 479.3
el [deg] = 35.0
time: 13:00:30

Scan start:
unaz [deg] = 473.3
el [deg] = 37.1
time: 13:01:05

Scan end:
unaz [deg] = 473.4
el [deg] = 37.1
time: 13:01:18

Curr. epoch: 13:01:18

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

- Schedule is assembled scan by scan
- Manual source selection, e.g. interactively in sky plots
- Automatic calculation of
 - Scan start times
 - On-source times for quasars
- + Suitable for short test sessions

Automatic scheduling mode



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

- 1 - Add a scan to the the current schedule (append)
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- 3 - Load/save data
- 4 - Edit current schedule
- 6 - Create schedule summary and statistics
- 7 - Automatic scheduling (satellites and quasars)
- 8 - Change settings
- 9 - Exit

```
fx Please select: |
```

Automatic scheduling mode

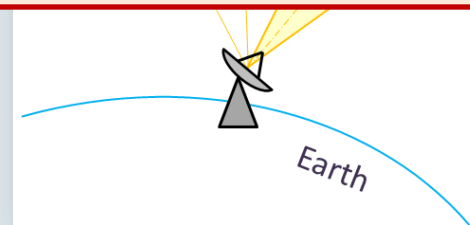
- Station-based scheduling approach (e.g. J. Sun et al., 2014)
 - Sky coverage and slew time optimisation at each site equally for quasars and satellites
- Schedule alternating blocks of scans to quasars and to satellites in a defined time ratio
- + Suitable for longer sessions and the integration of satellite scans in a geodetic schedule

VEX Files and satellite tracking

- **VEX** = Standard file format for VLBI observation plans
- Provide all required information to carry out a VLBI session
 - Observation sequence, source positions, setup parameters for the station equipment (frequ. & bandwidths, IF LOs, tracks,...), etc...

For non-standard observation modes it is difficult to define the setup parameters correctly in the VEX files!

➔ Feedback from observatories/correlators required



Principle of stepwise
satellite tracking

Scheduled sessions since 2014

Date	Duration	Code	Stations	Targets
16.01.2014	1h	G140116a	O8, Wz	GNSS
16.01.2014	1h	G140116b	O8, Wz	GNSS
21.01.2014	1h	G140121a	O8, Wz	GNSS
21.01.2014	1h	G140121b	O8, Wz	GNSS
15.06.2015	1h	615aHo	Ho	GNSS
18.06.2015	1h	169cHo	Ho	GNSS
18.06.2015	2h	169cCd	Cd	GNSS
28.06.2015	2h	179a	Ho, Cd	GNSS
19.08.2015	28 min	ex1	Wz, Wn, Wd	GNSS
20.08.2015	25 min	ex2	Wz, Wn, Wd	GNSS
24.08.2015	11 min	ex3a	Wz, Wn, Wd	GNSS
24.08.2015	4h	236a	Ho, Cd	GNSS
26.08.2015	4h	238a	Ho, Cd	GNSS
12.11.2015	30 min	ex4a	Wd, Wn	GNSS
23.11.2015	33 min	23a1	Mc, Wd	GNSS
23.11.2015	2h 15min	23b1	Mc, Wd	GNSS
23.11.2015	2h 30 min	23c1	Mc, Wd	GNSS
18.04.2016	9 min	ex5a	Wz, Wn, Wd	GNSS
05.05.2016	6h	126b	Ho, Cd	GNSS
10.05.2016	6h	131a	Ho, Cd	GNSS
11.05.2016	6h	132a	Ho, Cd	GNSS
17.05.2016	12 min	ex6b	Wn, Wz	GNSS
23.05.2016	12 min	ex7a	Wn, Wz	GNSS
23.05.2016	3h	144b	Mc, O8, Sr	GNSS
23.05.2016	40 min	144d	Mc, O8, Sr	GNSS
30.05.2016	12 min	ex8a	Wn, Wz	GNSS
06.07.2016	6 min	ap01	On	APOD
06.07.2016	9 min	ap02	On	APOD
06.07.2016	8 min	ap03	On	APOD
14.07.2016	7 min	196b	On	APOD
14.07.2016	9 min	196c	On	APOD
15.07.2016	9 min	197c	On	APOD
18.07.2016	10 min	200a	Yg, Ke	APOD
20.07.2016	9 min	202	Yg, Ke	APOD
25.07.2016	6 min	207a	On	APOD
25.07.2016	5 min	207b	On, Wn, Wz	APOD
19.09.2016	6 min	263a	On	APOD
19.09.2016	6 min	263b	On, Wn, Wz	APOD
19.09.2016	5 min	263c	On, Wn, Wz	APOD

**Hobart-Ceduna Experiments
in 2015 & 2016**

→ Next talk by Lucia

- **VieVS Satellite Scheduling Module**
 - ✓ Planning of real VLBI satellite observations
 - ✓ Generation of schedule files (VEX Format)
 - ✓ Combination of quasar- and satellite scans
 - ✓ Automatic scheduling mode implemented in 2016
 - ✓ Used to schedule about 40 VLBI satellite sessions since 2014
- **Basic version is included in the current VieVS 2.3 release**
 - See: <http://views.geo.tuwien.ac.at/>



Questions?

Contact:
andreas.hellerschmied@geo.tuwien.ac.at

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.
- Hellerschmied A et al. (2015)**, Scheduling of VLBI Observations to Satellites with VieVS, Proceedings of the IAG Symp., REFAG 2014. Luxembourg, Series: International Association of Geodesy Symposia, DOI 10.1007/1345_2015_183
- Sun J et al. (2014)**, New VLBI2010 scheduling strategies and implications on the terrestrial reference frame, J Geod, 88: 449-461