

Opportunities with VLBI transmitters on satellites

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Der Wissenschaftsfonds.

Introduction

- VLBI observations to satellites are not routine task
 - Challenges in scheduling, observation, correlation and fringe-fitting, modelling, and analysis
 - Test experiments observed with few decimeters accuracy, e.g., to
 - GNSS satellites (Haas et al. 2017, Plank et al. 2017)
 - APOD-A (Hellerschmied et al. 2018)
 - \Rightarrow Dedicated VLBI transmitters with sufficient bandwidth and at least two frequencies are required

Introduction

- Why do we need VLBI observations to satellites?
 - "It is a missing link in space geodesy" are there more reasons?
- We focus on Galileo satellites and Genesis from a VLBI perspective



- It is desirable to have correct orbits in the inertial frame \Rightarrow
 - Use UT1 from VLBI
 - Use VLBI observations for estimation of orbital parameters and UT1
- GNSS do not need highly accurate UT1 values for positioning
 - Errors in UT1 are compensated by right ascension of ascending node (Dach 2022)

- Estimation of right ascension of ascending node Ω
- Example: Jan 1, 2021 0-24 UT
 - 9 station VGOS network
 - GSAT0101 (E11)
 - EOP estimated
 - Monte Carlo simulation



45°N

45°S

180°

120°W 60°W

0°

60°E

120°E

180°

0°

- Estimation of right ascension of ascending node Ω
- Example: Jan 1, 2021 0-24 UT
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50 μ as < 1cm at altitude of orbit

Ratio satellite observations %	Rep Ω [µas]	Rep UT1-UTC [μs]
3.4%	48.9	1.5
6.9%	41.4	1.4
9.0%	39.7	1.4
11.5%	39.2	1.3
11.8%	42.2	1.4
13.9%	43.0	1.4
20.7%	44.9	1.4

• Deriving local ties and assessing frame ties



- Estimation of VLBI station coordinates from VT observations (Wolf and Böhm 2023)
- Example: August 27, 2022 0-24 UT
 - 3 VT on Galileo satellites in plane A
 - 12 VGOS stations
 - Orbits and EOP fixed
 - Monte Carlo simulation



- Estimation of VLBI station coordinates from VT observations
 - Different ratio of satellite/quasar observations



VLBI transmitter on Genesis

- ESA missions
 - To be launched in 2027/28
 - Polar orbit in 6000 km altitude
 - GNSS, SLR, DORIS, and VLBI



VLBI transmitter on Genesis

- Orbit determination with VLBI
 - Better geometry for Genesis than for Galileo
 - Best DOP values for 9 station network:

DOP	Galileo	Genesis
Radial	15.6	2.6
Along	1.0	0.4
Cross	1.3	0.4



VLBI transmitter on Genesis

- Space tie transfer to ground
 - More difficult because of worse visibility
 - Longer observation history needed to determine station coordinates with mm accuracy (Anderson et al. 2018)



Conclusions

- VLBI observations to VLBI transmitter on Galileo useful tool for
 - Orbit determination
 - Ω better than 1 cm from 24 h session
 - Assessment of local ties/frames ties
 - > 2 VT needed @ 30% satellite observations
- For Genesis, more investigations are needed
 - From technical point of view
 - With simulations





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