ESA's Genesis mission: Implications for the IGS GNSS analysis

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Outline

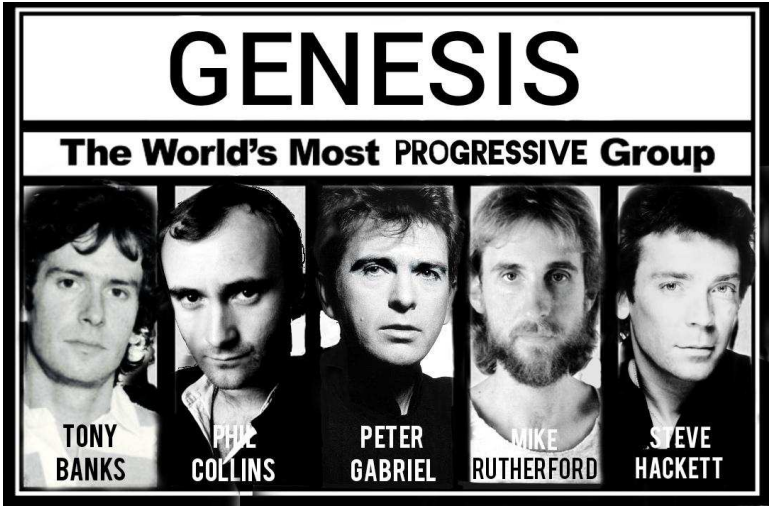
What is Genesis?

GNSS on Genesis
- Challenges when processing Genesis data
- Opportunities from the Genesis mission

Genesis and GNSS data processing within the IGS
- What to do with the GNSS satellite antenna pattern?
- Shall Genesis track GPS-L5 signal?

Summary

What is Genesis?



genesis-music.com

What is Genesis?

genesis.com

What is Genesis?

Credits: ESA

GNSS on Genesis

Credits: ESA

Mission overview from prev. presentation

GNSS instruments:

- Galileo+GPS
- 2 GNSS antennas
  - zenith
  - nadir
- one common receiver (no redundancy)

Challenges when processing Genesis data

Regarding GNSS equipment

- Two antennas (two RINEX files) for one position of the satellite.
- Stability of the hardware delay between the two antennas?

Regarding orbit modelling

- Complex spacecraft design including significant self shadowing effects

. . . only relevant for ACs that are going to process Genesis data

Opportunities from the Genesis mission

Combination of orbits across techniques

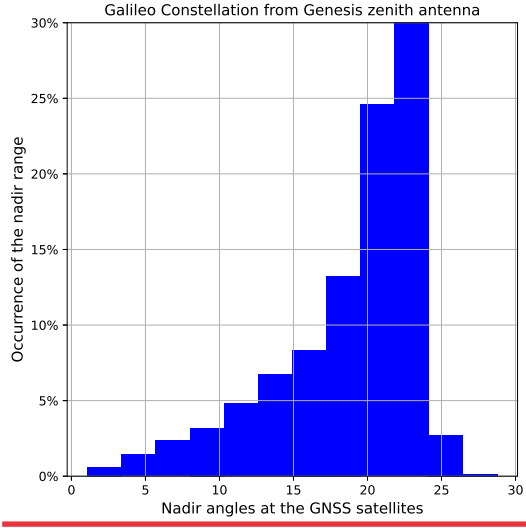
- Urs Hugentobler (TUM) has developed an algorithm to combine orbits on normal equation level between different software packages and across techniques.
  CfP for a prototype phase will follow.
- Extension of SINEX format is needed (with satellite positions including covariance information, partial derivatives and others)
- An adjustment for the SINEX format is needed for the IGS ACs
  but also for the IGS reference frame combination software
- Allows also the combination of other LEO orbits that might be included IGS AC solutions in future.

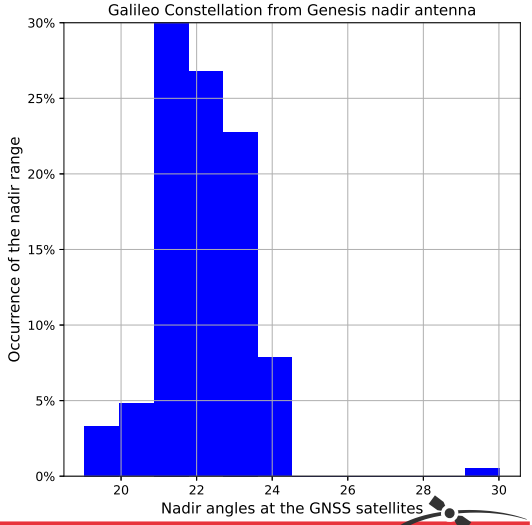
Opportunities from the Genesis mission

Combination of orbits across techniques

- The SINEX extension can be bypassed when the IERS accepts pre-combined solutions where the orbit parameters are treated within the software and are pre-eliminated.
- IERS combination centers are concerned about this:
  too many solutions (with different characteristics)
- The discussion on how to include these solutions is still ongoing on IERS-level.
- At least there is some dynamics in the discussion/acceptance of multi-technique solutions within the community.

GNSS-Satellite pattern as needed for Genesis data processing





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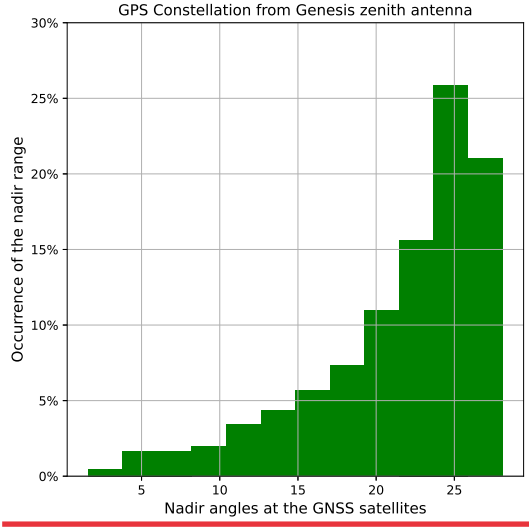
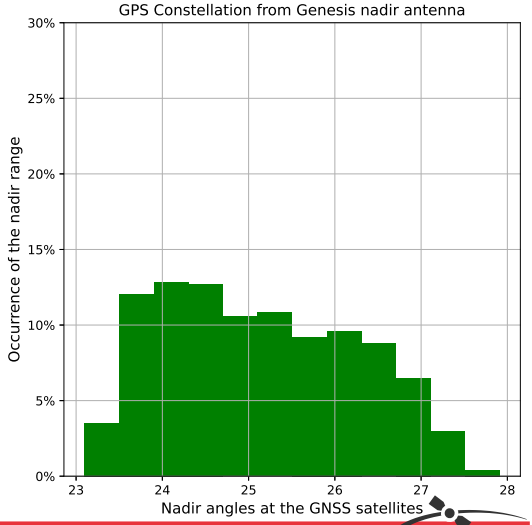
GNSS-Satellite pattern as needed for Genesis data processing





What to do with the GNSS satellite antenna pattern?

Extension for Galileo satellite antennas from 20° up to 30°:

- Request was posted to ESA (Genesis-project) – expected to be published

Extension for GPS satellite antennas from 14° up to 30°:

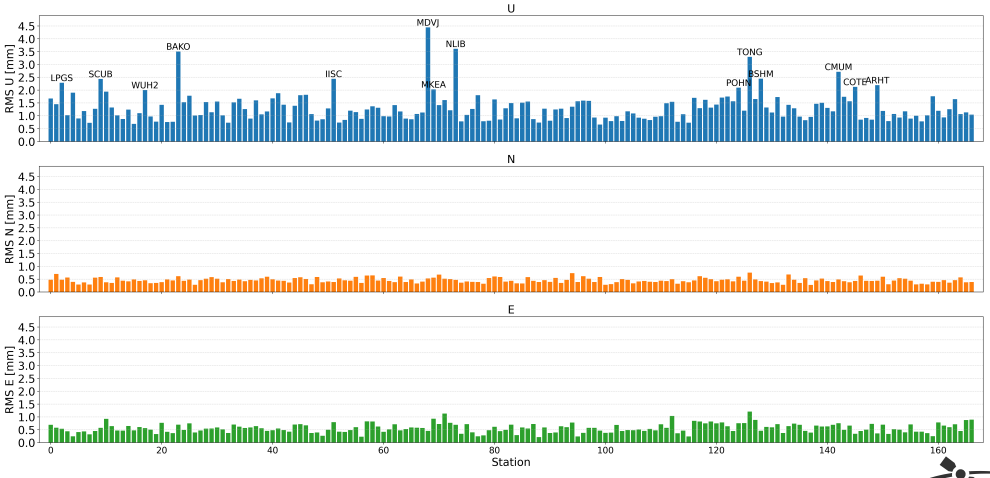
- IGS is using Block IIIA manufacturer values (without azimuth) – available
- IGS is using ground based estimates for Block IIF
  (patterns are available; offsets are adjusted in Montenbruck et al., 2023)

Should the IGS change the antenna model?

- What is the impact on the products?

Differences IGS20.ATX and LMB20.ATX

for GPS-only final solution (GFZ)



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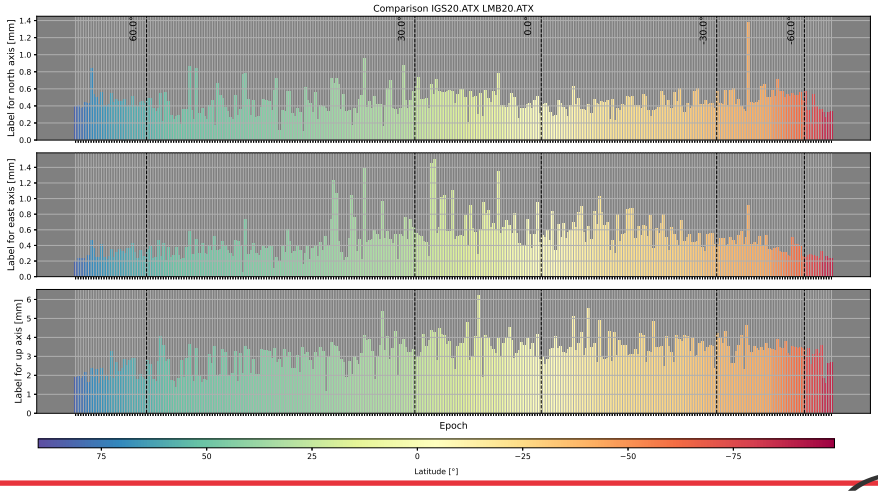

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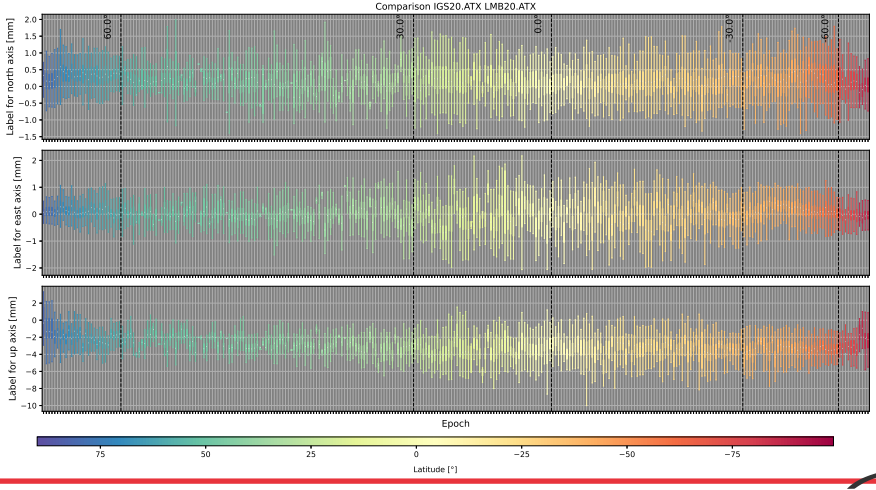

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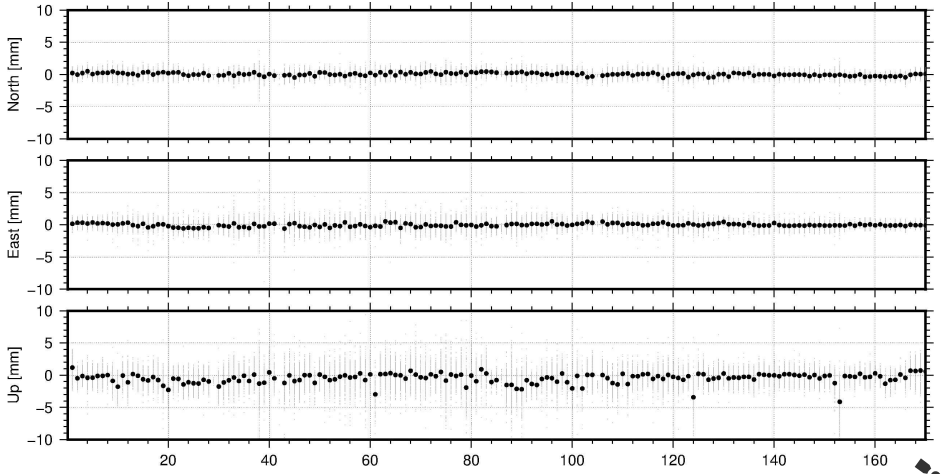
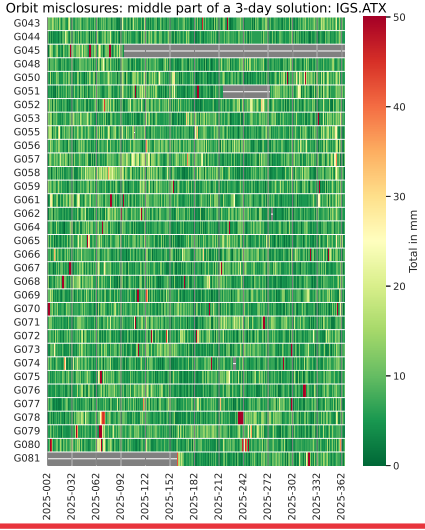
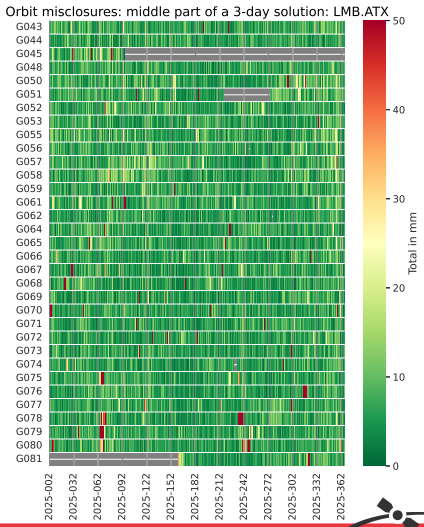


Orbit misclosures for GPS-only final solution AIUB





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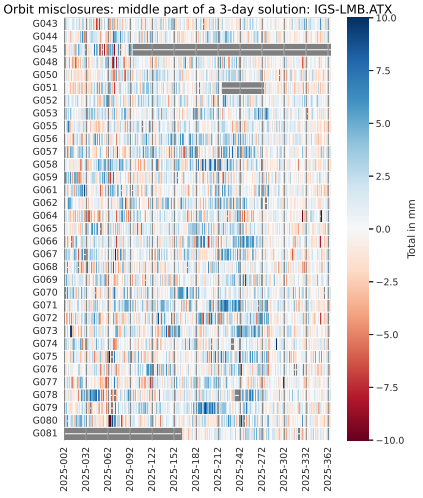


blue means smaller misclosures with LMB.ATX

Shall Genesis track GPS-L5 signal?

- GNSS receiver onboard from Genesis may support:
  - GPS L1 C/A, L2C, L5?
  - Galileo E1, E5a

- There is a limited number of channels in the receiver
  why the GPS-L5 tracking is not for free!

- What is the future policy of the IGS regading GPS-L5 signals?

Shall Genesis track GPS-L5 signal?

Codeless/Semi-Codeless GPS Access Commitments
These documents describe U.S. government commitments to support codeless/semi-codeless civilian access to the current P(Y) signals and the transition to the modernized L2C and L5 signals. This transition will not affect users of consumer GPS devices that use only the basic civil signal (L1 C/A).

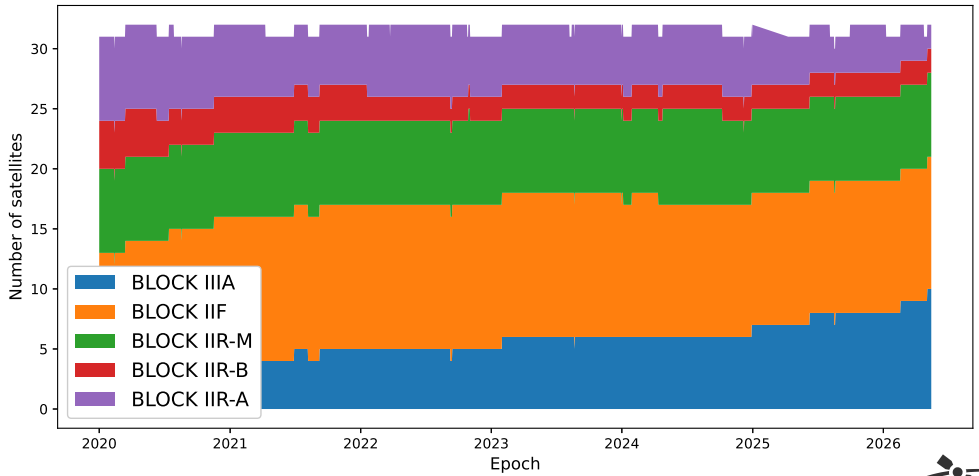
2019 Federal Radionavigation Plan
Section 3.2.8 of the 2019 Federal Radionavigation Plan states the following:

Discontinuation of Codeless and Semi-Codeless GPS Access
The USG commits to maintaining the existing GPS L1 C/A, L1 P(Y), L2C, and L2 P(Y) signal characteristics that enable codeless and semi-codeless GPS access until at least two years after there are 24 operational satellites broadcasting L5 with fully functional navigation messages. Barring a national security requirement, the USG does not intend to change these signal characteristics before then. The availability of 24 satellites broadcasting the L5 signal is estimated to occur in 2027. Maintaining the legacy signal characteristics for the stated period of time will allow for the orderly and systematic transition of users of semi-codeless and codeless receiving equipment to the use of equipment using modernized civil-coded signals. Note that it is expected that 24 operational satellites broadcasting L2C will be available by 2020, with the corresponding ground segment control capability available by 2023, enabling transition to L2C by 2023. Civilian users of GPS are encouraged to start their planning for transition now.

The above text supersedes the previously announced commitment in Federal Register Notice Vol. 73 No. 185 (see below) to maintain such signal characteristics through December 31, 2020.

Shall Genesis track GPS-L5 signal?

Number of GPS satellites supporting L5 is now at 21



Shall Genesis track GPS-L5 signal?

What does this mean for the IGS?

- The reference for our clock products are defined by the ionosphere-free linear combination of L1W/L2W (GPS).
  - Change this definition? When to change?
  - What to do with older satellites (and stations)?

- What does this mean for the reference frame?
  - IGS has a long heritage of L1/L2 station coordinates
  - Should we go for a transition to L1/L5 processing for station coordinate series?
  - Frequency plan across the systems:

	1.57 GHz	1.23 GHz	1.12 GHz
GPS:	L1	L2	(L5)
Galileo:	E1		E5a
BeiDou-3:	B1A/C		B2a
QZSS:	L1	(L2)	L5

Shall Genesis track GPS-L5 signal?

What does this mean for the IGS?

- From where do we get the L5 satellite antenna corrections for the GPS Block IIF space vehicles?
  - We can just use the L1/L2-based estimated corrections from the `IGS.ATX`.
  - Do we need a dedicated estimation campaign (for the L1/L5 corrections)?
  - Can we use the Lockheed Martin pre-launch calibrations (see Montenbruck et al., 2023)? (as we have for all GPS Block IIIA and Galileo satellites)

- **We should start to develop a plan**
  for the IGS itself but also to make specifications for Genesis.

Summary

- A reasonable number of ACs plan to contribute to the Genesis mission.
  - Challenging orbit modelling
  - Please answer the CfP for orbit combination via SINEX file

- Extension of (GPS) satellite antenna pettern up to 30° nadir angle.
  ⇒ Splinter Session on Antenna calibration

- What are the plans of the IGS regarding GPS-L5?
  During the Genesis mission the L2W-signals from GPS might switched off...
  ⇒ Splinter Session on Analysis centers, Reference frame, and Clock products

THANK YOU

for your attention

Publications of the satellite geodesy research group:

http://www.bernese.unibe.ch/publist

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