TECHNISCHE UNIVERSITÄT DRESDEN

The Galileo High Accuracy Service – Performance analysis of its initial service

Lambert Wanninger[1], Susanne Beer[1], Anja Heßelbarth[2]

[1]TUD Dresden University of Technology, Faculty of Environmental Sciences, Geodetic Institute, Dresden, Germany
[2]University of Applied Sciences, Faculty of Spatial Information, Dresden, Germany

1. Introduction

The Galileo High Accuracy Service (HAS) provides a free and global correction data stream to enable precise point positioning (PPP). It intends to improve the positioning accuracy associated with the broadcast navigation messages from meter level to below 20 cm horizontal and 40 cm vertical. Therefore, accurate Galileo and GPS orbit and clock corrections as well as code and phase biases are transmitted either directly through the Galileo signal in space or via internet. After a testing and experimentation phase, Galileo HAS was officially declared operational on January 24, 2023. It has now reached its initial service level on the way to full service, see Fig. 1.

We analysed the HAS corrections of the first two weeks of the operational phase with respect to the following aspects: availability and completeness of the corrections, accuracy of the corrections with respect to International GNSS Service (IGS) orbit and clock products, and accuracy of PPP solutions based on real-time corrections. All results shown are based on Wanninger et al. (2023).

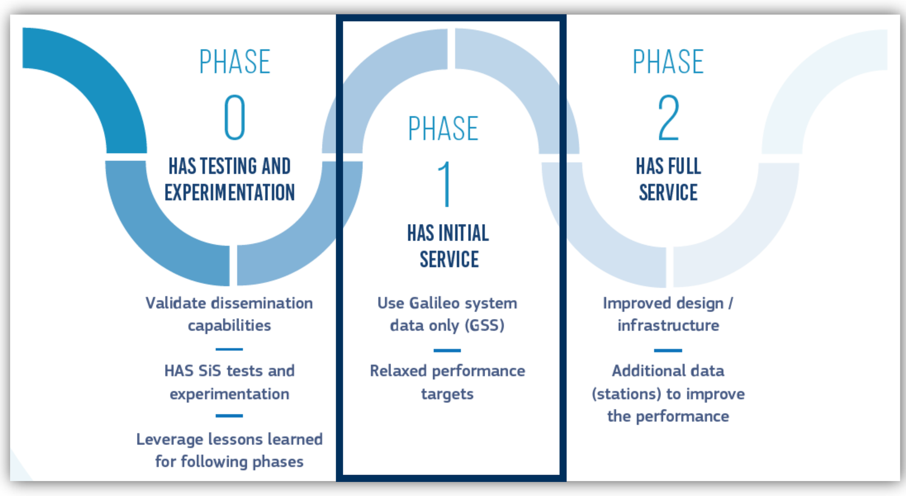

Fig. 1: *Galileo HAS roadmap (European GNSS Agency 2020) with the current phase 1*

2. Availability of HAS corrections

In the first two weeks of its initial service, the HAS data stream was continuously available. Compared to standard broadcast ephemeris, it provided corrections for 90 and 95 % of the GPS and Galileo satellites, respectively.

Fig. 2 shows the spatial availability of Galileo HAS corrections mapped to the ground tracks of the satellites. While the availability in Europe and most parts of the world is very high, it is significantly reduced in Eastern Asia and the North Pacific region. This spatial distribution corresponds to the current definition of the HAS service area, see Fig. 3. However, we found data gaps in South America and a surprisingly high availability in Australia and the South Pacific region.

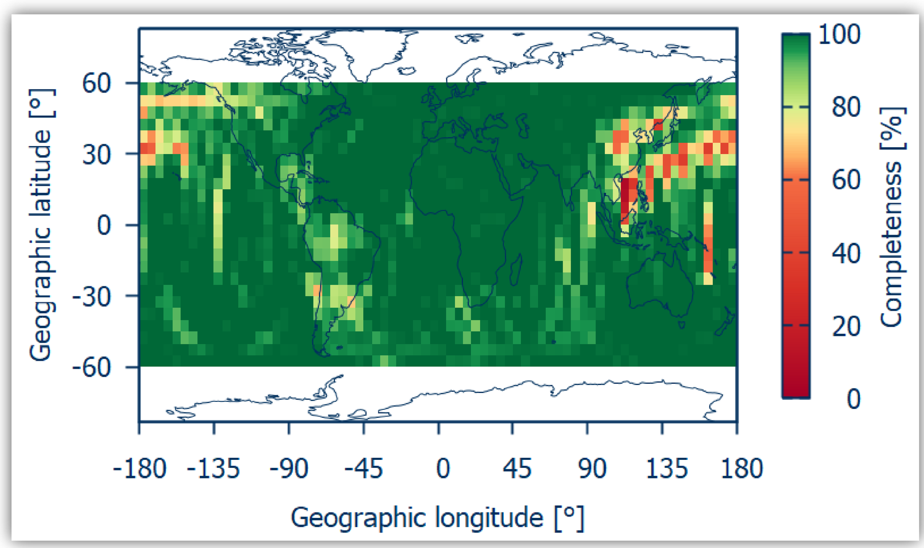

Fig. 2: *Spatial availability of Galileo HAS corrections mapped to the satellites' ground tracks*

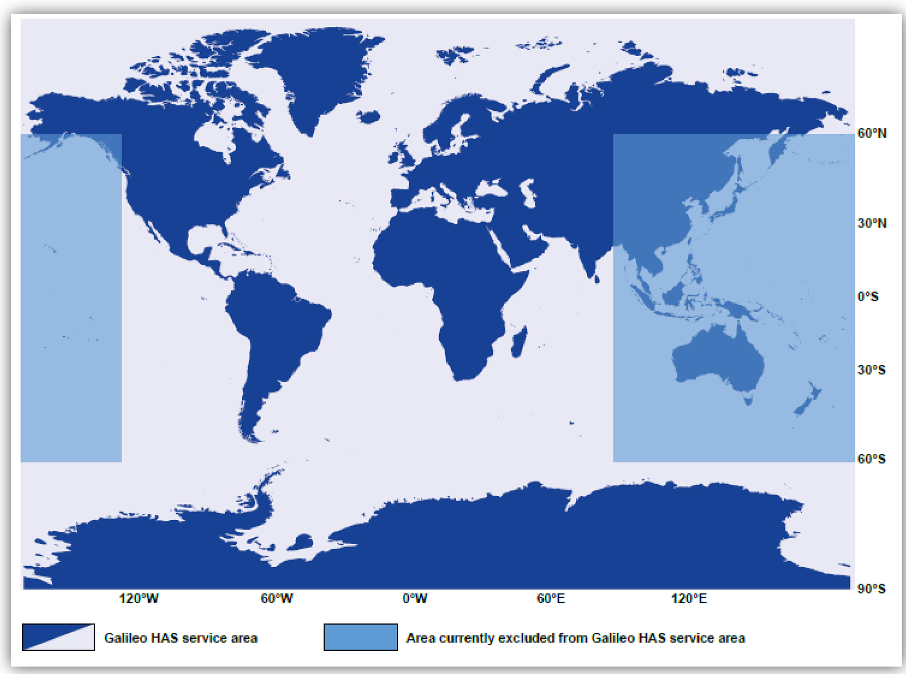

Fig. 3: *Galileo HAS service area (EUSPA 2023)*

3. Accuracy of real-time orbit and clock corrections

We used the precise orbit and clock products from the Center for Orbit Determination in Europe (CODE) as reference to evaluate the accuracy of the following real-time corrections:

- standard broadcast ephemeris of GPS (LNAV) and Galileo (F/NAV),
- HAS corrections transmitted by the Galileo satellites, and
- the CNES-RT products of the Centre national d'études spatiales (CNES) as an example for a precise real-time service.

The results are shown as 3D and 4D signal in space range errors (SISRE) in Fig. 4 and Fig. 5, respectively. While SISRE-3D accounts for orbit errors, SISRE-4D also includes clock errors.

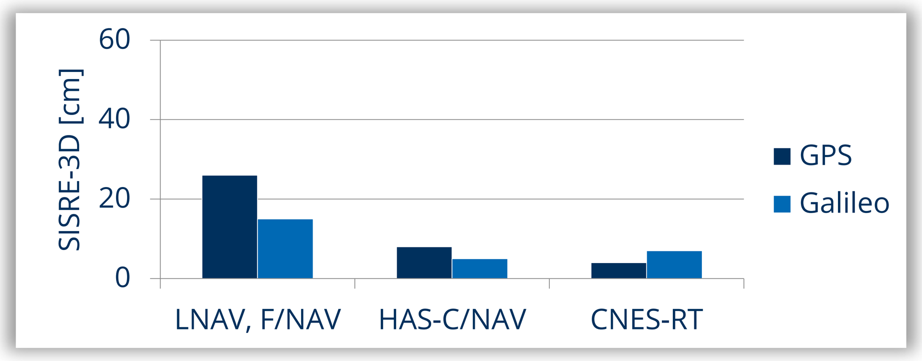

Fig. 4: *Accuracy of real-time orbit corrections as signal in space range errors 3D (SISRE-3D)*

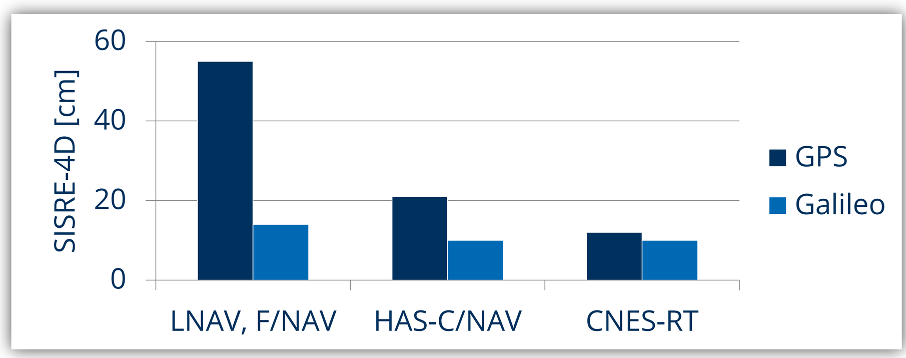

Fig. 5: *Accuracy of real-time orbit and clock corrections as signal in space range errors 4D (SISRE-4D)*

The SISRE-3D values of standard broadcast ephemeris show a significant difference between GPS and Galileo. Including the clock errors in SISRE-4D, the difference is even greater. With HAS corrections applied, a significant improvement is achieved for both GNSS. The most accurate corrections for GPS are provided by CNES-RT. However, there were 6 % outliers in the CNES-RT values. In the standard broadcast ephemeris 0.5 % outliers were found. The HAS corrections were free of any outliers.

4. Accuracy of PPP solutions with real-time corrections

We used observations of our GNSS station in Dresden, applied the different real-time corrections, see Sect. 3, and produced kinematic float-PPP solutions. Since Dresden is a permanent reference station with complete and undisturbed observations, our results represent the most optimistic accuracies (Fig. 6).

For a fair comparison with the HAS, we only used observations of GPS and Galileo and not, for example, of GLONASS. As expected, the lowest accuracy is achieved with standard broadcast ephemeris. Significantly better results are obtained with HAS, and a further increase in accuracy is observed with CNES-RT. The CODE products, which are post-processed and not available in real-time, provide the highest accuracy.

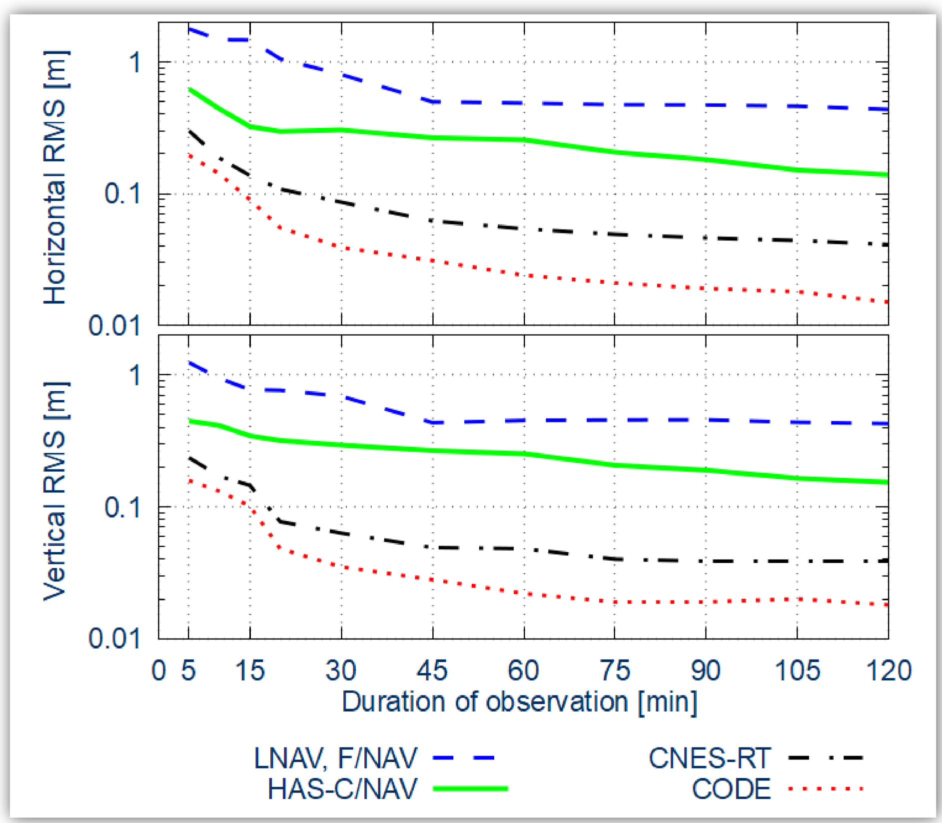

Fig. 6: *Accuracies as root mean square values (RMS) of kinematic float-PPP solutions depending on the duration of observation*

References

European GNSS Agency (2020) Galileo High Accuracy Service (HAS) Info Note

European Union Agency for the Space Programme (EUSPA) (2023) Galileo High Accuracy Service – Service Definition Document (HAS SDD), Issue 1.0, doi: 10.2878/265974

Wanninger, L., Beer, S., Heßelbarth, A. (2023) Der Galileo High Accuracy Service (HAS): Ein neues Kapitel der GNSS-Positionsbestimmung, zfv – Zeitschrift für Geodäsie, Geoinformation und Landmanagement, Heft 4/2023, 148:214-218, doi: 10.12902/zfv-0435-2023

lambert.wanninger@tu-dresden.de
susanne.beer@tu-dresden.de
anja.hesselbarth@htw-dresden.de