Galileo FOC Satellite Group Delay Estimation based on Raw Method and published 10V Metadata

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1. Introduction

In December 2016, the European GNSS Agency (ESA) published the Galileo In-Orbit Validation (IOV) satellite metadata [1]. These metadata include among others the three Galileo absolute satellite group delays (SGDs) for the three frequency bands E1, E5a and E5b, which indicate that the signals are not perfectly identical [2]. In the standard GNSS ionosphere-free dual-frequency processing approach, it is good practice to estimate and apply the differences between satellite group delay delays, commonly known as difference code biases (DCBs) [3]. The ionosphere-free clock offset estimates bias, which is defined by the linear combination of the ionosphere-limited group delay differences, are used to form the final clock offset parameter together with clock offset parameters, multi-signal group delay parameters, and TEC, which are jointed by making use of all available code and phase observations on multiple frequencies. Absolute calibration values, the IOV SGD can be used as a priori in the undefined phase parameters and in the refinement of multi-GNSS/multi-signal processing solutions in all environments.

2. Processing Approach

The raw method

In the raw processing method, developed by the Navigation Innovation Office (ESOC’s Space Operation Team) [4], the raw data of a 21-hour IOV campaign, period from 01/11/2016 to 14/11/2016 for the observations in (RINEK v. 3 notation): 50, 70, 80, GPS 1C, 2W, 5Q, ESOC’s multi-GNSS/multi-signal processing approach, being used together with the previously mentioned 10V dataset, all additional metadata and other satellite clock offsets in several campaign calibration.

3. Group Delay and Clock Offset Estimation

The GNSS station setup at ESOC is composed of several receivers for the IOV and ESA’s contribution to UTC together with all required equipment for signal processing. In the described IOV campaign context, allows to refer all estimated clock offsets to the local UTC realization and therefore to UTC in general. In addition, all receiver group delays have been determined in a calibration campaign with a GPS signal simulator.

Figure 2 shows the Galileo signal group delays of the receiver at ESOC (ESOC). In order to compare the daily absolute satellite group delay delays to the simulator calibration campaign and nominal receivers, the signal simulator by the manufacturer, the mean value of the absolute satellite group delays is formed from the receivers and the satellite signal from the ESOC’s multi-GNSS/multi-signal processing approach.

4. Ionospheric Delay Estimation

In addition to clock offset and group delay parameters, the ionospheric delay or its parameters are also essential for all stations and GNSS satellites to be estimated. In the IOV campaign, the real-time TECs estimated from IGS (JAVNEX) files (gests) are also given. It is expected, that the TEC estimates deviate from the IONEX file values, which are based on dual frequency ionospheric monitoring. Furthermore, the TECs are also affected by temporal and spatial resolution, however the IOV satellite group delay delays to a high degree are comparable in all receivers.

For the IOV campaign, the absolute satellite group delay delays have been estimated by the IOV campaign. The solution is determined for the absolute satellite group delay delays, similarly as the processing of the receiver code and phase observations on all wavelengths. For the IOV campaign, the absolute satellite group delay delays are available and the higher order parameters, such as the satellite clock offsets are not known.

6. Conclusions & Outlook

The attempt to estimate satellite group delay, true clock offsets and ionosphere-limited group delay delays can be directly applied in the raw method to provide the Galileo FOC satellite group delay delays in the direction of more realistic (in a physical sense) clock and ionosphere-limited group delay delays. The Galileo FOC satellite group delay delays are estimated by the Galileo-in-Orbit Validation (IOV) satellite metadata with the raw method. In the Galileo FOC satellite group delay delays, the satellite orbits, clock offsets, ionosphere-limited group delay delays, and TECs have been evaluated as a priori for multi-GNSS/multi-signal processing in the user segment.

Notes


References


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European Space Agency