Joint Design of GNSS Signal and Message Structure for Galileo 2nd Generation

The design of a new GNSS signal is always a trade-off between several figures of merit such as the position accuracy, the sensitivity or the Time To First Fix (TTFF). However, if the goal of the new signal design is to improve the acquisition process, the sensitivity and the TTFF have a higher relevance as figures of merit. Considering that, the main goal of this work is to present the joint design of a GNSS signal and the message structure to propose a new Galileo 2nd Generation (G2G) signal, which provides a higher sensitivity in the receiver and reduces the TTFF, in order to improve the acquisition process. Besides that, since this work has focused on the Galileo E1 Open Service (E1-OS), the signal must be compatible with those signals already presented in the same radio frequency spectrum. However, many of the concepts and methodologies can be easily extended to any GNSS signal.

In order to present the join design of a GNSS signal and the message structure, several aspects such as the spreading modulation, the pseudorandom noise (PRN) codes, the channel coding or the signal multiplexing must be addressed.

Firstly, the spreading modulation definition must consider the radio frequency compatibility in order to cause acceptable level of interference inside the band. Once considering the spectrum-compatibility, the correlation properties, the resistance against distortion and the ranging performance can be evaluated in order to provide a signal capable of reducing the TTFF and having high sensitivity. In this work, in order to propose a new G2G signal designed for helping the acquisition process, several figures of merit such as the autocorrelation function, the Spectral Separation Coefficients (SSC), the Gabor bandwidth, the MultiPath Error Envelope (MPEE) or the anti-jamming coefficients were evaluated for candidates in the state of the art (Binary Offset Carrier (BOC)and Binary Phase Shift Keying (BPSK) modulations), and a family of Binary Code Symbols (BCS) modulation. Finally, we show that the BCS family provides better performance than all current proposals.

Secondly, the choice of the new PRN code is also crucial in order to obtain both, good spectral and correlation properties. A simple model criterion based on a weighted cost function is used to evaluate the PRN codes performance. This weighted cost function takes into account different figures of merit such as the autocorrelation, the cross-correlation and the power spectral density. In this work, a Gold code family, a large Kasami code family and an optimized random code family, based on the current E1-B PRN codes generation technique, are compared to be proposed for the new G2G signal.

Thirdly, the design of the channel coding scheme is always connected with the structure of the message. A joint design between the message structure and the channel coding scheme can provide both, reducing the TTFF by reducing the time to retrieve the Clock and Ephemerides Data (CED), and an enhanced resilience in the data decoding, as it was provided in recent works [2]. These recent works propose an evolved structure of the current Galileo E1-B jointly co-designed with an extra channel coding scheme (Maximum Distance Separable MDS code) to enhance the resilience of the CED and to reduce the TTFF. In this work, a new method to co-design the message structure and the channel coding scheme for the new G2G signal is proposed [3]. This method provides the guideline to design a message structure whose the channel coding scheme is characterized by both, the full diversity and the MDS properties. Thanks to those properties, we achieve an optimal decoding performance, which provides a higher robustness in the system compared with previous proposals, in parallel with an outstanding reduction of the TTFF.

Finally, to transmit a new signal in the same carrier frequency and using the same High Power Amplifier (HPA) generates constraints in the multiplexing design, since a constant envelope is needed in order to decrease the non-linear distortions. Moreover, a high efficiency is also needed in order to not waste the satellite power. As a future line and in order to multiplex the new acquisition-aiding signal, new multiplexing techniques will be proposed.

References:

[1]Lorenzo Ortega Espluga, Charly Poulliat, Marie-Laure Boucheret, Marion Aubault, Hanaa Al Bitar. *New Solutions on the Design of a Galileo Acquisition-Aiding Signal to Improve the TTFF and the Sensitivity (regular paper). ION International Technical Meeting of The Institute of Navigation (ITM 2018), USA, 29/01/2018-01/02/2018*, Institute of Navigation (ION).

[2]Lorenzo Ortega Espluga, Charly Poulliat, Marie-Laure Boucheret, Marion Aubault, Hanaa Al Bitar. *New Solutions to Reduce the Time-To-CED and to Improve the CED Robustness of the Galileo I/NAV Message (regular paper). ION POSITION LOCATION AND NAVIGATION SYMPOSIUM (PLANS 2018), Monterey, California, USA, 23/04/2018-26/04/2018*, Institute of Navigation (ION), .

[3]Lorenzo Ortega Espluga, Charly Poulliat, Marie-Laure Boucheret, Marion Aubault, Hanaa Al Bitar. *Co-design of message Structure and Channel Coding Scheme to Reduce the Time to CED and to Improve the Resilience for a Galileo 2nd Generation New Signal (regular paper). ION GNSS+, Miami, Florida, USA, 24/09/2018-28/09/2018*, Institute of Navigation (ION), .