Input paper: [[1]](#footnote-1) ENG18-3.2.2.2

Input paper for the following Committee(s): check as appropriate Purpose of paper:

**□** ARM X ENG **□** PAP **□** Input

**□** DTEC **□** VTS **□** Information

Agenda item [[2]](#footnote-2) n.n

Technical Domain / Task Number 2 …………………………………

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Development of Galileo Timing receiver Standard in line with Future Galileo Timing Service

# Summary

This paper presents the development of the Galileo Timing receiver Standard, which will support the future Galileo Timing Service. GNSS timing technology is essential for applications requiring synchronization, particularly for critical infrastructures, and also appealing for IALA members, especially for VDES R-mode technology. The Galileo program has initiated the development of the first international standard for timing receivers, enhancing the performance, robustness, and integrity of these devices. The Standard ensures the functional and performance requirements of timing receivers on which end to end Service commitments can be provided.

The European Commission has been defining and implementing a Galileo Timing Service, considering user needs such as robustness, reliability, and accuracy. Amongst the features of the future Galileo Timing Service within Galileo Second Generation (G2G), the Service will include a monitoring function with the capability to disseminate Timing Flags, adding an extra layer of integrity to the timing receivers.

The standard for Galileo timing receivers includes functional and performance requirements and contains tests to verify compliance. It addresses interference issues, making receivers more robust against threats like jamming and spoofing. Standardized timing receivers are required to include OSNMA functionality, making them also more robust against cyber-attacks. It also includes requirements for the accuracy and availability contributions of the receiver. And it includes additional integrity barriers, such as T-RAIM.

The standardization process is well advanced under CEN/CENELEC, and the standard is in a validation phase prior to publication, expected in 2024. This paper provides a comprehensive overview Receiver Standard and its implications for various sectors.

The installation of the User Equipment, including the antenna location in the best visibility conditions, precise position computation and calibration are important aspects to are covered in the standard as well.

If you are interested in this topic, please contact Hector Llorca (hector.llorca@gmv.com) for more information.

## Purpose of the document

The main purpose of this input paper is to inform the ENG committee members about Galileo's initiative to development of the Galileo Timing receiver Standard in line with the future Galileo timing service.

## Related documents

There are two main documents related to this input paper:

* Fidalgo, Javier, Píriz, Ricardo, Cezón, Ana, Fernández, Alejandro, Callewaert, Karel, Bolchi, Marco, Defraigne, Pascale, Bauch, Andreas, Danesi, Antonio, Jeannot, Marc, Boyero, Juan Pablo, "Proposal for the Definition of a Galileo Timing Service," *Proceedings of the 32nd International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2019)*, Miami, Florida, September 2019, pp. 827-839.
* Cueto Felgueroso, Gema, Martinez, Jorge, Blesa, Sergio, Moreno, Gines, López Martínez, Manuel: Galileo Timing for R-Mode Testing Campaign. 35th International Technical Meeting of the Satellite Division of The Institute of Navigation, ION GNSS+2022. Denver, Colorado (USA).
* Fidalgo, Javier, Píriz, Ricardo, Ortas, Guillermo, Bárcena, Javier, Arribas, F.L., Callewaert, Karel, Catalano, Valeria, Pauwels, Gert-Jan, Sgammini, Matteo, Fortuny, Joaquim, Motella, Beatrice, Aguilera, Miguel, Boyero, Juan Pablo, "Standardisation of Galileo Timing Receivers," *Proceedings of the 36th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2023),* Denver, Colorado, September 2023, pp. 1572-1586.
* ENG16-3.1.3.3, Galileo Timing and Galileo Authentication Service, Ana Senado, Emilio Gonzalez, Maria Mota, Manuel Lopez.

# Background

The GNSS timing technology is relevant to all types of applications that require synchronization. That is, any application where it is necessary to mark an event with respect to a known time reference, usually Coordinated Universal Time (UTC). Strategic sectors and critical infrastructures, including telecommunications, financial services, transportation, and power distribution, utilize GNSS timing.

In the maritime domain, R-mode technology (i.e. VDES, MF) is a prominent example highlighting the benefit of using GNSS timing. In the IALA Guideline G1158 VDES R-Mode, it is explained that this system works based on measuring, among others, the timing parameter to obtain the user’s position. As mentioned in the guide: “each ranging signal generator, the VDES base station for VDES R-Mode, has to be synchronised to the RMST in this region”.

Among the synchronization methods identified in the VDES R-mode guide, it is mentioned GNSS receiver time solutions. In this topic, the Galileo program has carried out the initiative to create the first international standard for timing receivers, under CEN/CENELEC. In this way, users with Galileo timing receivers will be able to take advantage of the end to end commitments.

# Galileo timing receiver standard

Galileo's timing receivers provide the following output signals:

* A One-Pulse-Per-Second (1PPS) that comes normally out of a dedicated connector on the receiver.
* A data message or “label” containing the Time Of Day (TOD). Receivers normally report both UTC TOD and GNSST TOD.
* Optionally, a frequency signal (for example at 10MHz) aligned (“disciplined”) to the 1PPS.

The standard for Galileo timing receivers has the following considerations:

* The Nominal mode for the Galileo Timing Receiver is Galileo-only. including GPS constellation is not prohibited, but GPS processing is not covered in the Standard.
* It considers Galileo Iono-free dual-frequency (E1-E5a or E1-E5b) combination.
* The nominal mode of Galileo Timing Receiver assumes static users with precise antenna position configured. Moving users are not covered by the Standard.

The standard describes a series of functional and performance requirements that the receivers shall meet. In addition, it contains a suite of tests to verify compliance with these requirements.

One of the most interesting features of the standard is that it is the first to include integrity capability in timing receivers. This capability is based on two fundamental pillars, the processing of Timing Flags to be disseminated in the future Galileo Navigation Message, and T-RAIM (Timing Receiver Advance Integrity Monitoring) processing.

On the other hand, it also addresses the issue of interference, setting requirements and defining jamming tests. In this way, receivers certified under this standard will be more robust against this type of threat. In a nominal Radio-Frequency (RF) environment, the receiver is requested to remain under specification to the set Service Level and so maintain timing outputs without any warning of failure. Also, The Galileo Timing Receiver should fulfil the nominal performances when operating under the out-of-band interference conditions/environment. In a degraded RF environment, the receiver should either notify the user with a warning, switch to holdover mode, and continue providing a solution based on Galileo while keeping the user informed, or stop the 1PPS.

In addition, standardized timing receivers are required to include OSNMA functionality. This makes them more robust against cyber-attacks, one of the current threats to GNSS systems.

In terms of performance, the following table summarizes the main requirements included in the standard:

1. Summary of Galileo Timing Service and Receiver Performance Requirements

|  |  |  |
| --- | --- | --- |
| **GNSS Metric** | **Key Performance Indicator** | **Requirement** |
| **Accuracy** | GST Accuracy |  |
| **Accuracy** | UTC Accuracy |  |
| **Availability** | Receiver contribution to Availability | < 10-4 |
| **Integrity** | Probability of Failure | < 10-5 failures / hour |
| **Integrity** | Functional requirements to ensure the correct processing of timing flags for each service level |  |
| **Integrity** | T-RAIM Probability of missed detection | < 10-5 |

For Availability, assuming the Galileo Timing Service is performing in Nominal conditions as per the Galileo Service Definition Document, the probability that a Galileo Timing Receiver operating under the nominal conditions defined in the Galileo Timing Receiver Standard does not provide valid outputs should be lower than 10-4.

The UTC accuracy in the order of 10ns could be achieved by the Galileo Timing Service with receivers fulfilling the Standard . These performances fit with the timing requirements of R-mode, since, as explained in [1], “R-Mode is sensitive to mutual time errors of about 10 ns”, establishing a requirement of MTIE < 10 ns at all times that would be satisfied with a Galileo Timing Receiver that follows the standard.

Recommendations for the antenna, cabling and installation of the equipment are provided in an Annex of the Galileo Timing Receiver Standard. In order to fix the position of the Receiver to fully exploit the timing capabilities of the products, it is suggested that the user computes the precise antenna position using techniques such as Precise Point Positioning (PPP). Also, recommendations for the calibration of time delays are provided as an Annex of the Galileo Timing Receiver Standard. Depending on the Service Level targeted by the Receiver, different methodologies and accuracies for the calibration are proposed.

Currently, the standardization process is well advanced, and the standard is in a validation phase prior to publication. The standard is expected to be finally published in 2024.

# References

1. IALA Guideline G1158 VDES R-Mode. Edition 1.1 urn:mrn:iala:pub:g1158:ed1.1
2. Fidalgo, Javier, Píriz, Ricardo, Ortas, Guillermo, Bárcena, Javier, Arribas, F.L., Callewaert, Karel, Catalano, Valeria, Pauwels, Gert-Jan, Sgammini, Matteo, Fortuny, Joaquim, Motella, Beatrice, Aguilera, Miguel, Boyero, Juan Pablo, "Standardisation of Galileo Timing Receivers," Proceedings of the 36th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2023), Denver, Colorado, September 2023, pp. 1572-1586.

# Action requested of the Committee

The Committee is requested to:

1. Be aware of the future Galileo Timing Receiver Standard and to take it into consideration when there are activities that involve timing.
2. Contact the authors if there is interested in this topic.

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-1)
2. Leave open if uncertain [↑](#footnote-ref-2)