SLOVENSKI STANDARD
SIST EN 16803-2:2020

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Vesolje - Uporaba sistemov globalne satelitske navigacije (GNSS) za ugotavljanje položaja pri inteligentnih transportnih sistemih (ITS) v cestnem prometu - 2. del: Ocenjevanje osnovnih tehničnih lastnosti terminalske opreme za določanje položaja, ki uporablja GNSS

Space - Use of GNSS-based positioning for road Intelligent Transport Systems (ITS) - Part 2: Assessment of basic performances of GNSS-based positioning terminals

Raumfahrt - Anwendung von GNSS-basierter Ortung für Intelligente Transportsysteme (ITS) im Straßenverkehr - Teil 2: Bestimmung der grundlegenden Leistungen von GNSS-basierten Ortungsendgeräten

Espace - Utilisation du positionnement GNSS pour les systèmes de transport routier intelligents (ITS) - Partie 2 : Evaluation des performances de base des terminaux de positionnement GNSS

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ICS:

03.220.20	Cestni transport	Road transport
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35.240.60	Uporabniške rešitve IT v prometu	IT applications in transport

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EUROPEAN STANDARD

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English version

Space - Use of GNSS-based positioning for road Intelligent Transport Systems (ITS) - Part 2: Assessment of basic performances of GNSS-based positioning terminals

Espace - Utilisation du positionnement GNSS pour les systèmes de transport routier intelligents (ITS) - Partie 2 : Évaluation des performances de base des terminaux de positionnement GNSS

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European foreword

This document (EN 16803-2:2020) has been prepared by Technical Committee CEN-CENELEC/TC 5 “Space”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2021, and conflicting national standards shall be withdrawn at the latest by March 2021.

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Introduction

The EN 16803 series of CEN-CENELEC standards deals with the use of GNSS technology in the intelligent transport domain and address more particularly the issue of performance assessment.

As recalled in the generic functional architecture of a road ITS based on GNSS, two main sub-systems can be considered: the positioning system (GNSS-based positioning terminal (GBPT) + external sources of data) and the road ITS application processing the position quantities output by the terminal to deliver the final service to the user.

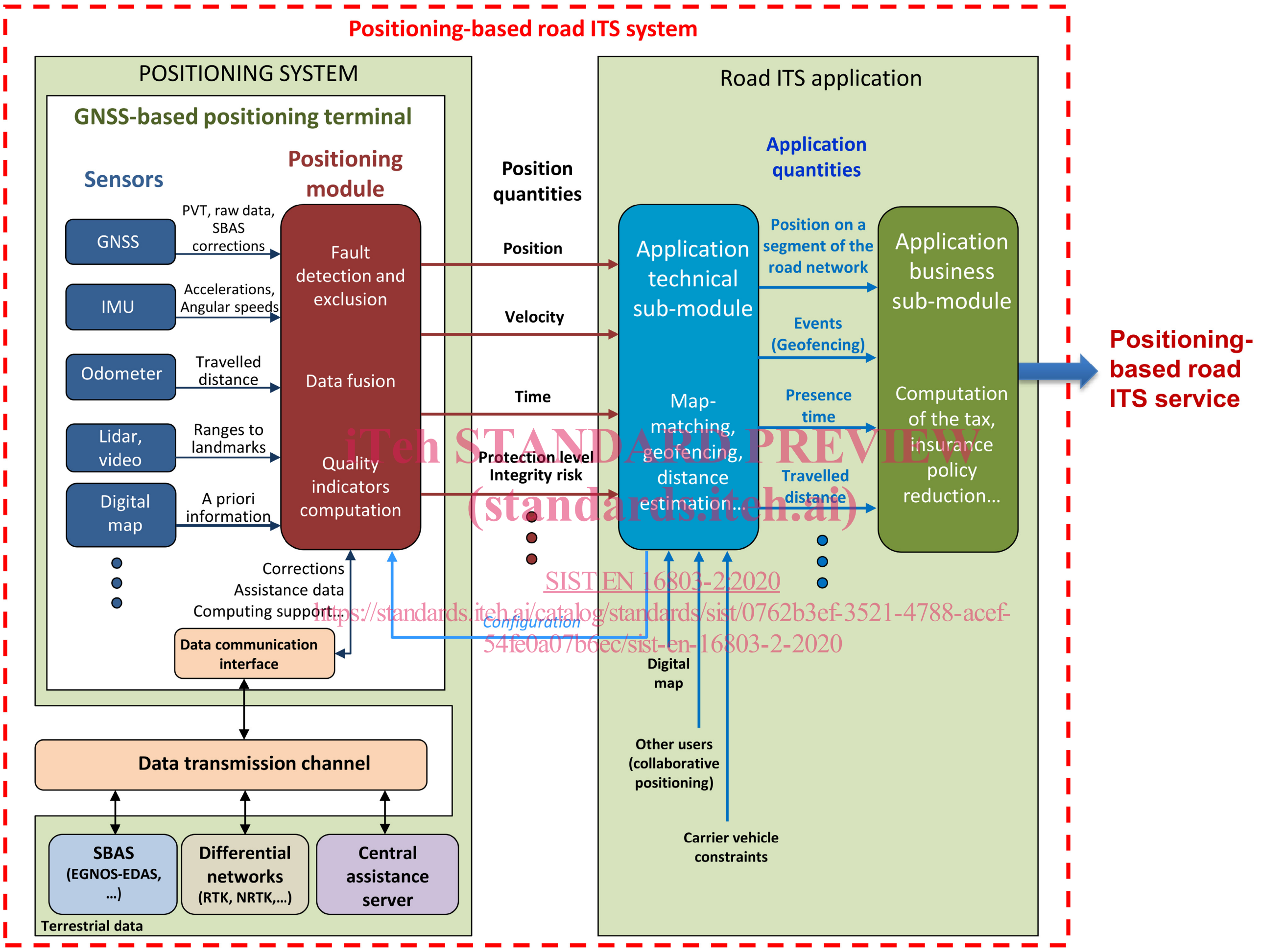

Figure 1 — Generic functional architecture of a Positioning-based road ITS system

This document is the second one of the EN 16803 series.

The performance assessment issue can also be considered at these two levels.

According to Figure 3 in the Introduction of EN 16803-1, the performances of the application cannot be assessed independently from the GBPT and the adequacy of the GBPT's performances to the end-to-end performance of the system cannot be assessed independently from the application. For these two kinds of assessment, the EN 16803-1 standard proposed a method called "Sensitivity analysis". In addition, this first document defined the generic architecture, the generic terms and the basic performance metrics for the Positioning quantities.

EN 16803-1 can be of interest for many different stakeholders but is targeting mainly the ITS application developers.

EN 16803-2, EN 16803-3 and EN 16803-4 address specifically the performances of the GBPT itself, as they can be measured by the metrics defined in EN 16803-1:

— EN 16803-2 proposes a test methodology based on the replay in the lab of real data sets recorded during field tests, assuming no security attack during the test.

— EN 16803-3 proposes a complement to this test methodology to assess the performance degradation when the GNSS signal-in-space (SIS) is affected by intentional radio-frequency (RF) perturbations such as jamming, spoofing or meaconing, also applicable to unintentional RF perturbations.

These 2 (two) ENs are targeting mainly the generalist RF test laboratory that will be in charge of assessing the performances of GBPTs for different applications.

EN 16803-4 (in preparation) will propose the methodology for the recording of the real data sets and is targeting mainly the GNSS-specialized test laboratories that will be in charge of elaborating the test scenarios that will be replayed by the previous category of test laboratories.

1 Scope

Like the other documents of the whole series, this document deals with the use of GNSS-based positioning terminals (GBPT) in road Intelligent Transport Systems (ITS). GNSS-based positioning means that the system providing position data, more precisely Position, Velocity and Time (PVT) data, comprises at least a GNSS receiver and, potentially, for performance improvement, other additional sensor data or sources of information that can be hybridized with GNSS data.

This new document proposes testing procedures, based on the replay of data recorded during field tests, to assess the basic performances of any GBPT for a given use case described by an operational scenario. These tests address the basic performance features **Availability**, **Continuity**, **Accuracy** and **Integrity** of the PVT information, but also the **Time-To-First-Fix** (TTFF) performance feature, as they are described in EN 16803-1, considering that there is no particular security attack affecting the SIS during the operation. This document does not cover the assessment tests of the timing performances other than TTFF, which do not need field data and can preferably be executed in the lab with current instruments.

“Record and Replay” (R&R) tests consist in replaying in a laboratory environment GNSS SIS data, and potentially additional sensor data, recorded in specific operational conditions thanks to a specific test vehicle. The data set comprising GNSS SIS data and potential sensor data resulting from these field tests, together with the corresponding metadata description file, is called a “**test scenario**”. A data set is composed of several data files.

This EN 16803-2 addresses the “**Replay**” part of the test scenario data set. It does not address the “Record” part, although it describes as informative information the whole R&R process. This “Record” part will be covered by EN 16803-4 under preparation.

Although the EN 16803 series concerns the GNSS-based positioning terminals and not only the GNSS receivers, the present release of this document addresses only the replay process of **GNSS only terminals**. The reason is that the process of replaying in the lab additional sensor data, especially when these sensors are capturing the vehicle’s motion, is generally very complex and not mature enough to be standardized today. It would need open standardized interfaces in the GBPT as well as standardized sensor error models and is not ready to be standardized. But, the procedure described in the present EN has been designed to be extended to GBPT hybridizing GNSS and vehicle sensors in the future.

This EN 16803-2 does not address R&R tests when specific radio frequency signals simulating security attacks are added to the SIS. This case is specifically the topic of EN 16803-3.

Once standardized assessment tests procedures have been established, it is possible to set minimum performance requirements for various intelligent transport applications but it makes sense to separate the assessment tests issue from minimum performance requirements, because the same test procedure may be applicable to many applications, but the minimum performance requirements typically vary from one application to another. **So, this document does not set minimum performance requirements for any application**.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 16803-1:2016, *Space - Use of GNSS-based positioning for road Intelligent Transport Systems (ITS) - Part 1: Definitions and system engineering procedures for the establishment and assessment of performances*

EN 16803-3, *Space — Use of GNSS-based positioning for road Intelligent Transport Systems (ITS) — Part 3: Assessment field tests for security performances of GNSS-based positioning terminals*

3 Terms and definitions

For the purposes of this document, the following terms and definitions.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at http://www.iso.org/obp
- IEC Electropedia: available at http://www.electropedia.org/

3.1 Definitions

3.1.1
GBPT
GNSS-Based Positioning Terminal
term used to define the component that basically outputs PVT

3.1.2
DUT
Device under Test
term used to define a device that is assessed

Note 1 to entry: In the context of EN 16803-2, DUT refers to GPBT.

3.1.3
test scenario
composed of GNSS SIS data and potential sensor data resulting from field tests, complemented by a metadata description file; a test scenario is a non-empty combination of UTS that allows to assess a GBPT in the desired environments

Note 1 to entry: Data inside a Test Scenario are raw data, either RF signals from GNSS satellites, or raw data from other embedded sensors.

Note 2 to entry: A Test Scenario is the whole package that a GNSS-specialized test laboratory delivers to a Generalist RF test laboratory in charge of performance assessment tests according to the EN 16803 series.

Note 3 to entry: Considering the 6 (six) different environments as defined in EN 16803-1, there's a combination of 2^6 - 1 = 63 possible test scenarios; from let's say "Rural only" test scenario up to "All environment" test scenario that covers the 6 different environments. See 4.2.2 for more details.

3.1.4
Unitary Test Scenario (UTS)
elementary brick of a Test Scenario, resulting from a specific field test; in other words, a Test Scenario is composed of a concatenation of several Unitary Test Scenarios

Note 1 to entry: See 4.2.2 for more details.

3.1.5
Uniform Environment Data Set (UEDS)
output of the DUT collected after a replay in laboratory sorted by environment; it is a concatenation of the output of the DUT for all UTS restricted to a unique environment

Note 1 to entry: See 6.4 for more details.

Note 2 to entry: Considering the 6 (six) different environments as defined in EN 16803-1, there is the same number of UEDS; i.e. 6.

Note 3 to entry: Data composing a Uniform Environment Data Set are PVT data, as they are output by a GBPT.

Note 4 to entry: Uniform Environment Data Sets are the data sets to which the metrics shall be applied to assess the performances of the device under test.

3.1.6
GNSS-specialized test laboratory
laboratory in charge of producing Test Scenarios for generalist RF test laboratories

3.1.7
Generalist RF test laboratory
laboratory in charge of assessing the performances of GBPTs thanks to Test Scenario

3.1.8
Benchmark Unitary Test Scenario (B-UTS)
dedicated UTS used specifically for the validation procedure as defined in Clause 7

3.1.9
Benchmark Uniform Environment Data Set (B-UEDS)
each of the UEDS obtained with the benchmark receiver at the GNSS specialised lab (used by the generalist lab to validate their test platform and procedures)

3.2 Acronyms

Acronym	Description
ACAI	Availability, Continuity, Accuracy, Integrity
BPM	Benchmark Performance Metrics
B-UEDS	Benchmark Uniform Environment Data Set
B-UTS	Benchmark Unitary Test Scenario
CDF	Cumulative Distribution Function
DUT	Device Under Test
GBPT	GNSS Based Positioning Terminal
GNSS	Global Navigation Satellite Systems
I/Q	In-phase and Quadrature – I/Q format is an efficient way to store RF signals so that it is possible to reproduce RF signals in laboratory after modulation. I/Q format is the format used to store GNSS signals in UTS
ITS	Intelligent Transport Systems
KML	Keyhole Markup Language

Lab-A	GNSS-specialized test laboratory
Lab-B	Generalist RF test laboratory
PVT	Position Velocity and Time
RAMS	Reliability, Availability, Maintainability, and Safety
RF	Radio frequency
R&R	Record and Replay
SIS	Signal In Space: RF signals coming from the GNSS satellites
UTS	Unitary Test Scenario
UEDS	Uniform Environment Data Set
TTFF	Time To First Fix

4 Overview of the whole assessment process

4.1 Definition of the general strategy: what kind of tests

4.1.1 Rationale

Performances and behaviours of GNSS-based positioning terminals not only depend on their design but also, and strongly, on a lot of external situations and parameters, uncontrolled by the stakeholders. Among those parameters, we can quote the status of international worldwide space systems (GNSS), the physical atmospheric conditions, and other environmental conditions in the proximity of the vehicle (buildings in vicinity, traffic, tree foliage, etc.).

As an example, this situation implies that any realization of one field test procedure of a given product at a given date and hour, will give a different result than the same test procedure of the same product in the same location, but at a different date and hour (not stationary stochastic process).

The obvious consequence is that, if a pure field test strategy is targeted as a preferred solution for the performance assessment aiming certification of devices, the analysis of the tests results would require specialists, and may frequently result in intangible and unreliable interpretations, the opposite of metrology.

A solution to avoid this issue is to have a total trust in simulations where all the tests conditions are controlled, and which could be perfectly repeatable. ETSI addressed a similar issue during its standardization process targeting the GNSS based Location Based Services. As a conclusion of its work, ETSI, selected a solution exclusively based on simulations (see [1]).

Considering that the real-life environment remains complex to be simulated, the pure simulation technique will lead to scenarios with a very great number of parameters to be set-up, inducing risk of human manipulation errors, and anyway a remaining lack of true representation of the reality.

A standardized performance assessment process, designed for certification, needs to be unquestionable (undisputable?), repeatable, realistic with respect to the real conditions the GBPT will operate in and cost-effective. Since the reality of all the physical phenomena impacting the behaviour of GNSS receivers is quite impossible to be simulated with mathematical models, but still has a significant impact, the principle of field tests is preferred in this standard to the principle of simulating the GNSS SIS with constellation simulators.

But, in pure field tests where the device under test (DUT) is on-board the test vehicle, this latter is stimulated with various environmental features that remain unpredictable and uncontrolled, rarely reproducible from one run to another and leading to large difficulties to interpret the results.

Consequently, the present EN made the choice of "**Record and Replay**" (R&R) technique that combines realism, repeatability and cost effectiveness. R&R technique covers all constellation and all frequencies by allowing recording lower L-Bands and upper L-Bands of GNSS SIS.

4.1.2 Record and Replay choice

The "**Record and Replay**" technique **starts on the field, by recording** of the test data collection according to an agreed scenario. This step shall guarantee a **high-fidelity digitalization of numerous parameters, in particular the capture of radio signals** issued from the worldwide infrastructure (GNSS) in a realistic local environment of propagation. It **ends in the lab to replay as many times as required the same scenario**, using exactly the same radio signal inputs and thus the same environmental conditions of reception.

With respect to pure simulation, the R&R technique offers a better representation of reality since it comes from real situations, but less flexibility of tested situations (rare events are unlikely). The chance to integrate a satellite failure in one recorded test scenario is near to zero. However, as with simulations, a lot of devices can be tested in exactly the same conditions.

With respect to field tests, the R&R technique offers better metrological features since the repeatability can be reached.

It also saves money, since the setup of the test bench for recording is similar to one field test, but the setup of the test bench for replaying is largely less expensive and enables to test a multitude of receivers with less additional cost.

Finally, a very interesting feature of the R&R approach, is that **the interface between the record phase and the replay phase is a repository of files**, offering capabilities like copies and licensing, cut and paste (in smaller files if a customization by application would become necessary as an example…), browse, etc. Today, the amount of data are important for storage techniques (2TB/min of recording) but remains feasible for some hours of recording. It is expected that in few years, improved solution could be available (currently no data compression is used).

Since the record phase needs recognized skills and experience in GNSS metrology, this work shall be performed by **GNSS-specialized laboratories**, ISO/IEC 17025 homologated, and accredited for that job by a certification authority. They shall follow standardized procedures for recording the data sets that shall become themselves **standardized scenarios** that can be replayed by a larger panel of homologated, but not GNSS-specialized, radio frequency (RF) test laboratories.

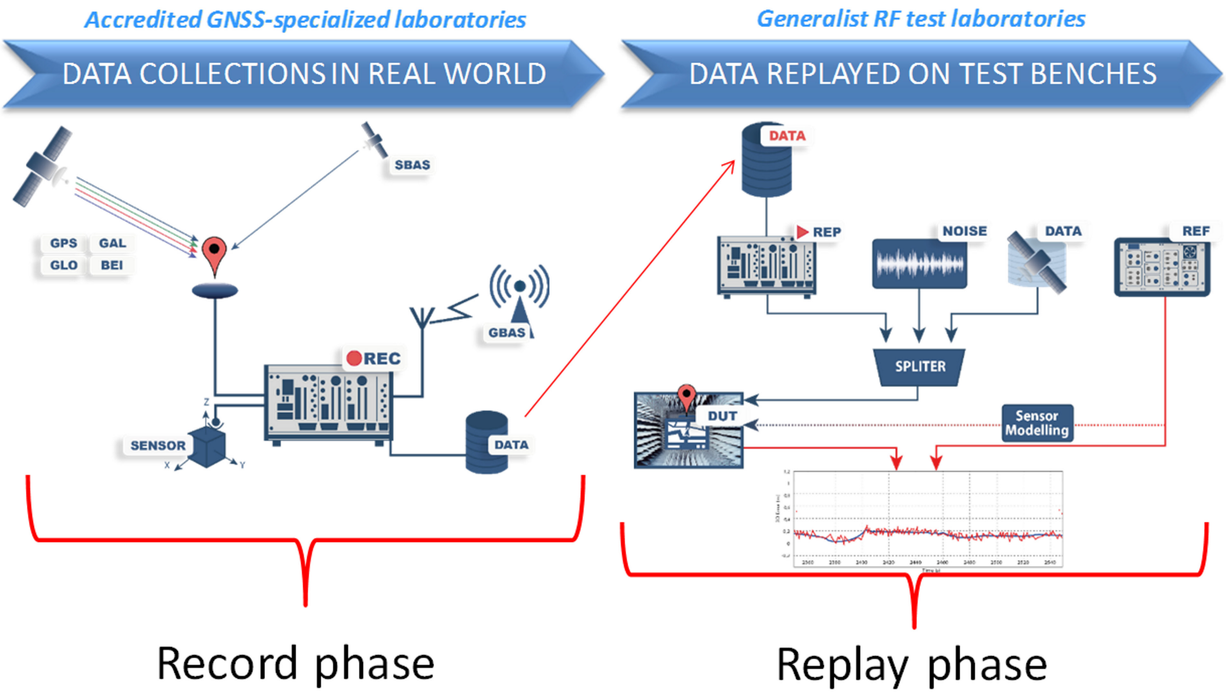

Figure 2 — The "Record and Replay" principle

This feature has a true interest in the worldwide economy. First it enables to make in Tokyo a field test recorded in Paris, or inversely to replay anywhere in Europe and with few expenses a record performed in Shanghai. Moreover, it is interesting, as an additive business model for GNSS, offering a European capability to export standardized data sets towards other regional economies, enabling worldwide competitors to accept and apply the European standards, and even promoting the European methodologies to be extended to world.

4.2 Construction of the operational scenarios: how to configure the tests

4.2.1 General

<u>Foreword</u>: most of this section is informative in the sense that in provides informative material on how to proceed to record a scenario that is compatible with the quality required for high-level standards. This information is necessary to understand the complete R&R process, but this is not the aim of this EN to standardize the record procedure. The record procedure and its quality framework will be totally and precisely described in EN 16803-4 (under preparation).

4.2.2 Basic principles

4.2.2.1 Unique data collection for all the metrics

Availability, continuity, accuracy and integrity shall be evaluated from a Uniform Environment Data Set (UEDS).

The metrics for measuring the GBPT performances with respect to these different performance features are introduced in EN 16803-1 and precisely described in the present document In Clause 5.

These performances are totally linked in the applicative needs, since a position or velocity output can make sense for any application only if it is simultaneously available (declared as valid), accurate (at a certain level), and that we can have trust on it (at a certain level of risk). Therefore, the metrics of the 4 (four) types (except the integrity risk, see 4.2.2.2 below) shall be established on the same data collection campaign.