SLOVENSKI STANDARD
oSIST prEN 16803-4:2023

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Vesolje - Uporaba sistemov globalne satelitske navigacije (GNSS) za ugotavljanje položaja pri inteligentnih transportnih sistemih (ITS) v cestnem prometu - 4. del: Opredelitve in postopki sistemskega inženiringa za načrtovanje in potrjevanje preskusnih scenarijev

Space - Use of GNSS-based positioning for road Intelligent Transport Systems (ITS) - Part 4 : Definitions and system engineering procedures for the design and validation of test scenarios

Raumfahrt - Anwendung von GNSS-basierter Ortung für Intelligente Transportsysteme (ITS) im Straßenverkehr - Teil 4: Definitionen und systemtechnische Verfahren für den Entwurf und die Validierung von Testszenarien

Espace - Utilisation du positionnement GNSS pour les systèmes de transport routier intelligents (ITS) - Partie 4: Définitions et procédures d'ingénierie système pour la conception et la validation de scénarios d'essai

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35.240.60	Uporabniške rešitve IT v prometu	IT applications in transport

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prEN 16803-4

July 2023

ICS

English version

Space - Use of GNSS-based positioning for road Intelligent Transport Systems (ITS) - Part 4 : Definitions and system engineering procedures for the design and validation of test scenarios

Espace - Utilisation de la localisation basée sur les GNSS pour les systèmes de transport routiers intelligents - Partie 4: Définitions et procédures d'ingénierie système pour la conception et la validation des scénarios de test

Raumfahrt - Anwendung von GNSS-basierter Ortung für Intelligente Transportsysteme (ITS) im Straßenverkehr - Teil 4: Definitionen und systemtechnische Verfahren für den Entwurf und die Validierung von Testszenarien

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/CLC/JTC 5.

If this draft becomes a European Standard, CEN and CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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European foreword

This document (prEN 16803-4:2023) has been prepared by Technical Committee CEN/TC 5 “Space”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

EN 16803, Space — Use of GNSS-based positioning for road Intelligent Transport Systems (ITS), consists of the following parts:

— Part 1: Definitions and system engineering procedures for the establishment and assessment of performances;

— Part 2: Assessment of basic performances of GNSS-based positioning terminals;

— Part 3: Assessment of security performances of GNSS-based positioning terminals;

— Part 4: Definitions and system engineering procedures for the design and validation of test scenarios.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

Introduction

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

As recalled in the following Figure 1, the generic functional architecture of a road ITS system based on GNSS, two main sub-systems can be considered: the positioning system [GNSS-based positioning terminal (GBPT) + external terrestrial sources of data] and the road ITS application processing the position quantities output by the terminal to deliver the final service to the user.

EN 16803 tends to give keys in order to assess the whole positioning-based road ITS system.

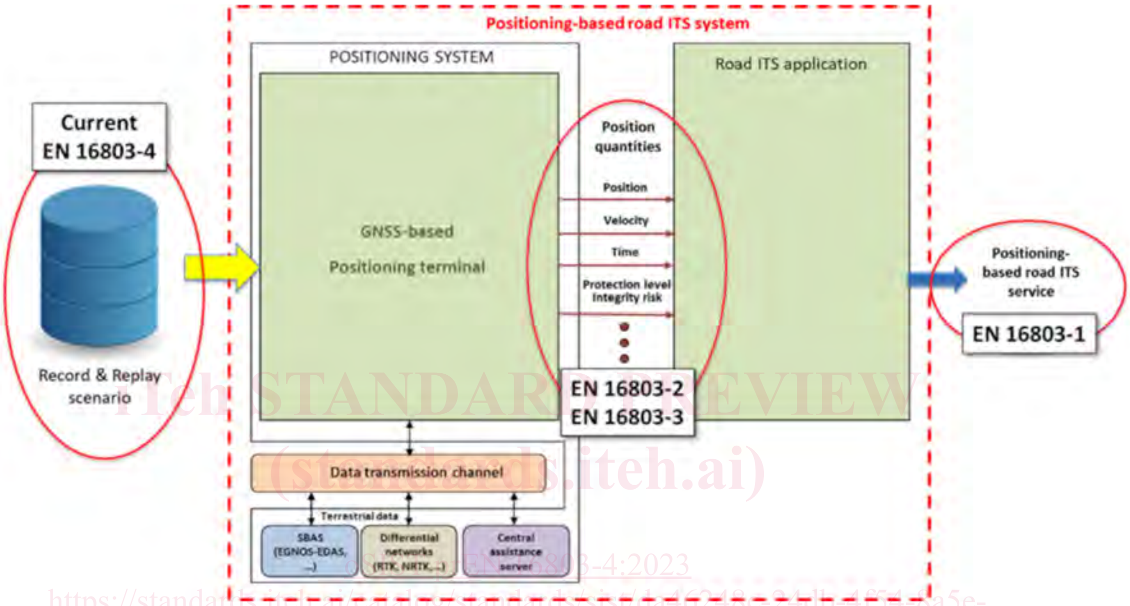

Figure 1 — Generic functional architecture of a road ITS system based on GNSS

The scope of relevance of the different parts of the EN 16803 series is reminded hereafter:

— EN 16803-1 standard proposes a method called “sensitivity analysis” to assess the adequacy of the GBPT’s performances to the end-to-end performance of the road ITS system. In addition, this first EN defines 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 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 **Record and Replay (R&R)** test methodology to assess the performance degradation when the GNSS signal-in-space (SIS) is affected by intentional or unintentional radio-frequency (RF) perturbations. Next sections below stress the importance of this assessment in the context of the security threats.

These two ENs (part 2 and part 3) are mainly targeting the generalist RF test laboratory that will be in charge of assessing the performances of GBPTs for different applications using replay techniques.

This document, EN 16803-4, describes the methodology needed for the record of the real data sets and is targeting mainly the GNSS-specialized test laboratories that will be in charge of elaborating the test scenarios.

Important note on EN ISO/IEC 17025 standard:

EN 16803 has the scope to define the methodology for the certification of performances of GBPT for road intelligent transport.

Intrinsically, this statement means that any laboratory working either for the creation of the scenario or for the evaluation of the GBPT, using the created scenario, should be accredited EN ISO/IEC 17025 norm with the suitable scopes. However, even if EN ISO/IEC 17025 can be mentioned in this document, authors remind here that EN 16803 series (especially this current part 4) can be used outside of the scope of EN ISO/IEC 17025. However, users of EN 16803 have still to keep in mind that producing certified test results will always be more meaningfulness when being accredited.

1 Scope

This document is mainly addressed to GNSS-specialized laboratories, in charge of creating reference test scenarios that will be replayed by other users such as generalist RF lab. It is a fundamental key-point to be able to deliver homogenous test scenarios. Indeed, in the context of GNSS receiver certification, the process itself has to be independent from the laboratory which design and made the scenario. In other words, the conformity level of any GNSS-based positioning terminal (GBPT) is the same whatever the specific scenario used. Using a specific urban scenario from a GNSS-specialized laboratory A has to lead to the same conclusion as using another specific urban scenario from a GNSS-specialized laboratory B. This is really the aim of this document: giving requirements and guidelines to all GNSS-specialized laboratories in order to make inter-operable test scenarios.

It will thus provide requirements and guidelines on the following topics:

— what technical documentations are required to design test scenarios (Clause 4) through:

- o technical documentation for "R&R",
- o list of documents to produce for simulation scenario;

— how to collect data in order to build test scenarios (Clause 5) through:

- o identification of the technical documentation,
- o requirements for human resources,
- o requirements for tests platform,
- o requirement for RTMeS,
- o requirement for GNSS signals digitization,
- o requirements for GNSS constellations simulator,
- o requirements for benchmark GNSS receiver,
- o requirement for GBPT embedded,
- o requirements for other sensors;

— how to validate data –after a data collection– in order to be sure of it (Clause 6) through:

- o validation of the field test,
- o validation of data for reference trajectory,
- o validation of digitized GNSS signals,
- o validation of SENSORS inertial measurements,
- o validation of corrections data (NRTK, PPP…),
- o characterization of the scenario.

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 16803-1:2020, *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 16803-2, *Space - Use of GNSS-based positioning for road Intelligent Transport Systems (ITS) - Part 2: Assessment of basic performances of GNSS-based positioning terminals*

3 Terms, definitions and acronyms

3.1 Terms and definitions

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

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

— ISO Online browsing platform: available at https://www.iso.org/obp/

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
GNSS-based positioning terminal
GBPT
component that basically outputs PVT

3.1.2
hybridized GNSS-based positioning terminal
H-GBPT
GBPT using at least another additional sensor (different from a GNSS receiver) to compute position

EXAMPLE It could be an inertial sensor for instance.

3.1.3
device under test
DUT
device that is assessed

Note 1 to entry: in the context of EN 16803-2 and EN 16803-4, DUT refers to GBPT.

3.1.4
test scenario
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 different environments as defined in EN 16803-1, there is 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 subclause 4.2.2 of EN 16803-2 for more details.

3.1.5
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 subclause 4.2.2 of EN 16803-2 for more details.

3.1.6
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 subclause 6.5 of EN 16803-2 for more details.

Note 2 to entry: considering the 6 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.

3.1.7
GNSS-specialized laboratory
laboratory in charge of producing test scenarios for generalist RF test laboratories

3.1.8
generalist RF test laboratory
laboratory in charge of assessing the performances of GBPTs thanks to test scenario

3.1.9
real time kinematic
RTK
differential GNSS technique enabling high precision positioning thanks to the use of corrections send by a close base (GNSS receiver). It requires the rover and the base receiver to be quite close (maximum 20 km) for optimal performances

3.1.10
networked real time kinematic
NRTK
same technique used in RTK but relying on a network of base stations normally having 60 km/70 km distance among them. Typically, corrections are provided by a service relying on online servers (NTRIP service), creating a virtual station close to user according to its positions

3.1.11
precise point positioning
PPP
global augmentation service providing corrections for satellites positions and clock. It enables high precision positioning for multi-frequency GNSS receiver without the need of close station providing corrections

3.2 Acronyms

Acronym	Description
CDF	Cumulative distribution function
DUT	Device under test
GBPT	GNSS-based positioning terminal
GNSS	Global navigation satellite system
HGBPT or H-GBPT	Hybridized GNSS-based positioning terminal
IMU	Inertial measurements unit
INS	Inertial navigation system
KPI	Key points of interest
ODO	Odometer unit
NRTK	Networked real time kinematic
PPK	Post-processing kinematic
PPP	Precise point positioning
PVT	Position velocity and time
R&R	Record and replay
RMS	Root Mean Square
RF	Radio frequency
RINEX	Receiver independent exchange format
RTK	Real time kinematic
RTMeS	Reference trajectory measurements system
Rx	Receiver
VSWR	Voltage standing wave ratio

4 Technical documentation for designing scenario

4.1 Technical documentation for "R&R"

4.1.1 General

To perform field tests, either for data collection or live test of a DUT, is quite a complex operation requiring high levels of skills, professional instruments and validated software and methodologies:

1. **human resources:** realization of field tests on GBPT, or data collection for scenario creations, shall be planned, supervised and analysed by people having a verified knowledge about the satellite navigation (geolocation techniques) and GNSS metrology;

2. **hardware:** evaluation of DUT performances, directly or through R&R technique, requires having a very precise reference trajectory for the comparison. Considering all possible classes of GBPT the reference trajectory shall derive from high-level instrumentation (GNSS Rx INS ODO) providing the best possible accuracy;

3. **software:** the hardware part alone, however, it is not sufficient for the derivation of the most accurate reference trajectory (example of a backward algorithm). In the same way, the used software shall be validated to be sure that all data can be processed correctly, i.e. without errors (PPK, Hybridization)

Considering the complexity and requirements associated with the field test executions, a detailed test plan shall be draft provide all information stated in the previous 3 bullets.

Besides, other information shall be provided for the scenario to meet the requirements of the EN 16803-1 and the EN 16803-2:

— description of trajectory;

— expected test environments and/or characterized obstacles;

— types of data to be collected;

— classes of GBPT to test;

— performances that is possible to test.

The overall information will, at the end of the document, enables the validation of such developed scenario.

To comply with previous requirements, at least two main documents shall be provided for the first step of validation of an operational scenario, or the validation of the live test:

1. **test plan:** a detailed description of the test to perform; the used instruments, the platform, the human resources, the foreseen route with the expected environments;

2. **field test validation:** this document shall make a critical review of the actual conditions met during the field test. Instruments, platform, people executing the test and other conditions shall be coherent with the ones foreseen in the test plan.

Two previous documents, if they are well-drafted then enable only the proper design of an operational scenario. This means that for the final validation of the operational scenario, other documents are required, such as the two following ones:

— **measurement uncertainty estimations of reference trajectory:** being the "term of comparison" for the estimation of all performances of DUTs and considering the accuracy that these last can reach under certain conditions (RTK + IMU) the reference trajectory shall be the most accurate possible. The document shall prove the way the trajectory has been estimated and to justify the derived uncertainties;

— **collected data validation:** in case of a reference scenario, the collected data shall be used for the certification of GBPTs. The validation of the collected data sets, in terms of representativeness, shall be proved through a series of analyses allowing a competent and entitled third part to validate them.

Details about these two documents will be analysed Clause 6 as part of the requirements for the validation of collected data.

Two other kinds of document should be added to the technical one. They are not considered as mandatory for the design of any operational scenario, incidentally, they can provide relevant information to any GNSS-specialized laboratory if well drafted.

The first document represents the expressions of needs. It shall be drafted by any GBPT users or integrators providing a series of information not known to GNSS-specialized laboratories, enabling better identification of al technical needs.

The second one is a technical specification of the needs expressed by GPBT users or integrators. It shall be drafted by GNSS-specialized laboratories, and it can be seen as a link between the test plan and the expression of needs.

4.1.2 Expression of needs

The present document is not considered mandatory for the designing of an operational scenario.

It shall be drafted by all stakeholders like GBPT integrators or final users to fairly specify their needs in terms of:

— **identification of the application**;

EXAMPLE GBPT used for autonomous vehicle driving.

— **typical expected environment** (as classified in EN 16803-1) and **typical expected constraints** (for example on peripheral road tunnels and/or bridges are expected to be met);

— **typical dynamics of the platform**;

— **expected performances:** according to the application selected, needs in term of accuracy (positions, velocities, angles), continuity availability and integrity (positions, velocities, angles) should be different;

— **estimated budget for the GBPT:** the estimated budget shall include the eventual prix of an antenna and/or a correction service.

This first document, if properly drafted, will enable GNSS laboratories to properly perform the most adapted operational scenarios for all needs expressed by one or more GBPT users/integrators.

4.1.3 Test specifications

This second document is the direct conversion of the expressions of needs in technical specifications. As for the first one, it is not considered as mandatory for the design of an operational scenario.

It shall be drafted by GNSS laboratories in charge of operational scenarios realization.

The document, referring to a defined expression of needs, shall identify:

— **GBPT/antenna categories:** according to the needs expressed by the final user/integrators the laboratory shall identify the most appropriate GBPT that could be tested for a defined application, or a group of them having similar environments, dynamics and GBPT classes;

— **platform:** as for the GBPT, the most suitable platform to use for the tests shall be identified;

— **test cases:** according to the expected typical environment and obstacles the most appropriates test cases shall be identified by the laboratory designing the scenario;

— **uncertainties on reference trajectory:** according to the GBPT classes that could be tested a proper identification of needs, in term of used instrument and required uncertainties, shall be done for the reference trajectory.

4.1.4 Test plan

4.1.4.1 General

Two previous documents, expression of needs and test specifications, are not considered as mandatory. They only have the aim to create a sort of link between GBPT users/integrators not having a technical background for the designing operational scenarios and GNSS laboratories having limited knowledge about the applications and the expected performances of GBPT.

The test plan is the most critical document to develop an operational scenario (cf. EN 16803-1:2020, 5.1) or a DUT live test in the frame of the EN 16803 norm. It shall provide a series of information intended to identify the following elements.

— **TEST CONTEXT**

Any test campaign shall be planned in a clear context. It can be a test campaign aiming to test a receiver during its development phase, or for its final characterization. In the same way, a test campaign can be performed in the frame of EN 16803 to collect data for the development of an operational scenario. In all cases, the test context shall be identified since from this first information shall determine the requirements related to RTMeS system (reference instrumentation), identification of the course, environments and human resources.

— **TEST METHODOLOGY**

In case of certification of a GBPT in the frame of the EN 16803 norm, the test plan shall refer to the test methodology expressed in EN 16803-2. In this document, the methodology to conduct tests in a laboratory using operational scenarios is properly described. In case of tests not fully complying with EN 16803-2, the methodology shall be explained.

— **GBPT IDENTIFICATION**

Even if not considered in the EN 16803, GBPT should be embedded in the test vehicle during the data collect test campaign. In other cases, there could be the need to perform a field test for direct evaluation of a GBPT. In this case, a complete description of the GBPT shall be provided. Are considered essential information; GBPT S/N (and other information enabling a unique identification), P/N (identification of the hardware design), firmware version, set-up (for example for GNSS mask angle and C/N0 mask, dynamic filter, used constellations and signals, use of correction service). If included as part of the GBPT antenna properties shall be listed as well.

The laboratory executing the test should use more than one GBPT (in parallel). In this case, the identification of all of them shall be done as for the single GBPT case.