SLOVENSKI STANDARD
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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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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

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European foreword

This document (EN 16803-4:2024) has been prepared by Technical Committee CEN/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of an identical text or by endorsement, at the latest by May 2025, and conflicting national standards shall be withdrawn at the latest by May 2025.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

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.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

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.

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

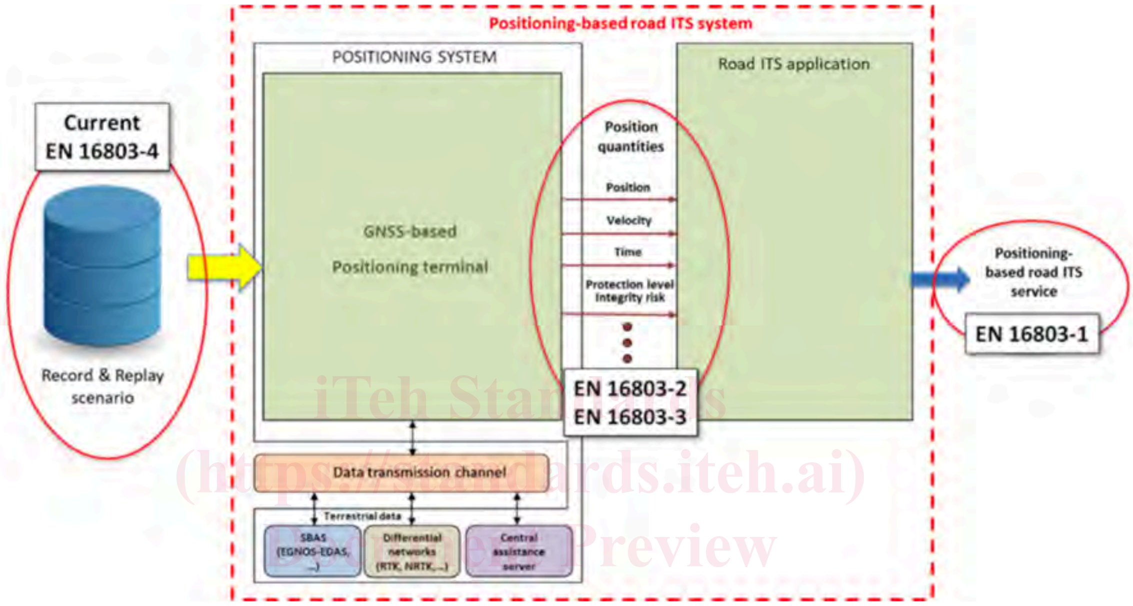

Figure 1 — Generic functional architecture of a road ITS system based on GNSS
[SOURCE: EN 16803-1:2020: *Space — Use of GNSS-based positioning for road Intelligent Transport Systems (ITS) — Part 1: Assessment of security performances of GNSS-based positioning terminals*]

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

— EN 16803-1:2020 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 16803-1:2020 can be of interest for many different stakeholders but is targeting mainly the ITS application developers;

— EN 16803-2:2020 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:

The EN 16803 series has the scope to define the methodology for the assessment of performances of GBPT for road intelligent transport. As a reminder: a complete certification process shall follow the EN ISO/IEC 17065. And the current norm doesn't address that.

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. 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, i.e. outside of the scope of accredited laboratories. Nevertheless, users of the EN 16803 series have still to keep in mind that producing accredited test results will always have higher liability and quality.

As a summary of that note:

1. EN 16803 series can be used for performing accredited tests; and this is even encouraged. EN ISO/IEC 17025 is the right standard to respect in that context;

2. EN 16803 series can also be used for performing internal or private tests, outside of any accreditation or certification schemes;

3. a complete certification process shall follow the EN ISO/IEC 17065 standard. And this is not the topic of the EN 16803 series.

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 is independent from the laboratory which designed 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 leads 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 16803-2:2020, *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

Note 1 to entry: the term “component” can be understood as “system”.

[SOURCE: EN 16803-2:2020, 3.1.1 modified – Note 1 to entry has been added]

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 H-GBPT can be a GNSS-inertial sensor-fused-system.

3.1.3
device under test
DUT
device that is assessed

Note 1 to entry: in the context of EN 16803-2:2020 and EN 16803-4, DUT refers to GBPT.

3.1.4
test scenario
non-empty combination of UTS that allows to assess a GBPT in the desired environments and complemented by a metadata description file

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 specified in EN 16803-1:2020, 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 16803-2:2020 for more details.

[SOURCE: EN 16803-2:2020, 3.1.3, modified]

3.1.5
unitary test scenario
UTS
elementary brick composed of GNSS SIS data and potential sensor data resulting from field tests

Note 1 to entry: see subclause 4.2.2 of EN 16803-2:2020 for more details.

[SOURCE: EN 16803-2:2020, 3.1.4, modified]

3.1.6
uniform environment data set
UEDS
output of the DUT collected after a replay in laboratory, sorted by environment; being 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 16803-2:2020 for more details.

Note 2 to entry: considering the 6 different environments as specified in EN 16803-1:2020, 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.

[SOURCE: EN 16803-2:2020, 3.1.5, modified]

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 using recorded test scenarios

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 station (GNSS receiver)

Note 1 to entry: close being with around 20 km around the rover.

3.1.10
networked real time kinematic
NRTK
differential GNSS technique enabling high precision positioning thanks to the use of corrections provided by a service relying on online servers (NTRIP service)

3.1.11
precise point positioning
PPP
global GNSS technique enabling high precision positioning thanks to the use of corrections of satellites positions and clock

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
IGN	National Geographical Institute [*Institut Géographique National*]
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 drafted providing all information stated in the previous 3 bullets.

Besides, other information shall be provided for the scenario to meet the requirements of the EN 16803-1:2020 and the EN 16803-2:2020:

— 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, four main documents shall be provided:

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.

3. **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;

4. **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 last 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 should 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 GBPT users or integrators. It should 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 should 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 16803-1:2020) 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 should 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 should be drafted by GNSS laboratories in charge of operational scenarios realization.

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

— **GBPT/antenna categories:** according to the needs expressed by the final user/integrators the laboratory should 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;