SLOVENSKI STANDARD
oSIST prEN 16803-1:2015

01-februar-2015

Vesolje - Ugotavljanje položaja z uporabo sistema globalne satelitske navigacije (GNSS) pri inteligentnih transportnih sistemih (ITS) v cestnem prometu - 1. del: Definicije in sistemskotehnični postopki za določanje in ocenjevanje zmogljivosti

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

Raumfahrt - Anwendung von GNSS-basierter Ortung für Intelligente Transportsysteme im Straßenverkehr - Teil 1: Definitionen und Systemtechnikverfahren für die Festlegung und Überprüfung von Leistungsdaten

Espace - Utilisation de la localisation basée sur les GNSS pour les systèmes de transport intelligents - Partie 1: Définitions et procédure d'ingénierie système pour l'établissement et la vérification des performances

Ta slovenski standard je istoveten z: **prEN 16803-1**

ICS:

03.220.20	Cestni transport	Road transport
33.060.30	Radiorelejni in fiksni satelitski komunikacijski sistemi	Radio relay and fixed satellite communications systems
35.240.60	Uporabniške rešitve IT v transportu in trgovini	IT applications in transport and trade

oSIST prEN 16803-1:2015 **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

DRAFT
prEN 16803-1

October 2014

ICS 03.220.20; 33.060.30; 35.240.60

English version

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

Espace - Utilisation de la localisation basée sur les GNSS pour les systèmes de transport intelligents - Partie 1: Définitions et procédure d'ingénierie système pour l'établissement et la vérification des performances

Raumfahrt - Anwendung von GNSS-basierter Ortung für Intelligente Transportsysteme im Straßenverkehr - Teil 1: Definitionen und Systemtechnikverfahren für die Festlegung und Überprüfung von Leistungsdaten

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

This draft European Standard was established by CEN and CENELEC in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN and CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN and CENELEC members are the national standards bodies and national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

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.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.

CEN-CENELEC Management Centre:
Avenue Marnix 17, B-1000 Brussels

Contents

Page

FIGURES

Foreword

This document (prEN 16803-1:2014) has been prepared by Technical Committee CEN-CENELEC/TC 5 “Space”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

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

This fist EN will be followed by two other ENs dedicated to the performance assessment of the *GNSS-based positioning terminal* itself, still in the context of the Road Intelligent Transport Systems (ITS).

1 Scope

The civil applications of geopositioning are undergoing exponential development. The latest market analysis for the GNSS systems shows 2 major fields of application which, all together, practically share the whole of the market.

- Intelligent Transport Systems (ITS), mainly in the Road ITS domain.
- Location Based Services (LBS), accessible on smartphones and tablets.

When a *Road ITS system* needs GNSS positioning, which is the case for most of them, there is the question of the choice of the type or receiver and of its minimum performances which are necessary to satisfy the system's final requirements at user level. To meet these requirements, the system includes a processing *Application module* which uses the outputs (*PVT* = Position-Velocity-Time) of a *GNSS-based terminal*[1] to provide the service with a given *End-to-end performance*. Consequently, this latter depends on the quality of the positioning outputs, which are highly variable with respect to the operational conditions of the system, but also on the performance of the application module itself.

The main ITS systems concerned by this issue are:

- GNSS-based tolling systems (road, parking zone, urban…)
- Localized emergency calls (eCall)
- Electronic tachograph
- Taximeter
- Regulated freight transport systems (hazardous substances, livestock, etc.)
- "Pay-as-you-drive" insurance
- Road management systems, traffic information systems,
- Advanced Driver Assistance Systems (ADAS)
- etc.

Some *Road ITS systems* are considered as “safety critical”, because their failure may cause human death or injury and others are “liability critical”, because they include financial or regulatory aspects. In some cases, their development is subject to an official certification/homologation process. Particularly for those systems, there exists a strong need to be able to prove they do meet their *End-to-end performance* requirements.

Presently there is no norm or standard that supports such certification process, while in parallel, the assessment of GNSS positioning performances is by nature difficult to handle.

The objective of this EN is to fill this gap, by providing an approach for handling performances aspects of *Positioning-based road ITS systems*, that differentiates clearly the role played by the *Positioning terminal* and by the *Application module* respectively.

It provides with standard definitions of performance metrics for the outputs of the *GNSS-based positioning terminal,* relevant for road ITS, definitions of the various items to be considered when specifying an *Operational scenario* together with a method to characterize an environment, and finally procedures to reconcile tests results on the different system components to assess the system *End-to-end performances*.

[1] We will use the term *GNSS-based positioning terminal* because the terminal providing the position can be an hybridized terminal using other sensors than a sole GNSS receiver. In this document, the terminal will always be composed of at least a GNSS receiver.

The document can be used by different stakeholders, for different purposes:

- It can be used by a test laboratory, to assess the performances of the whole *Road ITS system* comprising a given *Positioning terminal* and supposed to be operated following such a scenario,
- It can be used by a *Road ITS system* developer wishing to choose the right positioning technology compliant with its application performances of wishing to tune its application algorithm with respect to the terminal performances,
- It can be used by a *Positioning terminal* manufacturer wishing to develop a specialised range of terminals dedicated to such applications or to propose one of his products to a *Road ITS system* developer.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NMEA 0183 V 4.10 Interface standard

3 Terms and definitions

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

3.1 Acronyms

3.1.1
EGNOS
European Geostationary Navigation Overlay Service. European SBAS

3.1.2
GNSS
Global Navigation Satellite Systems: general acronym designating satellite positioning systems

3.1.3
GPS
Global Positioning System: acronym for the GPS-Navstar American satellite positioning system

3.1.4
ITS
Intelligent Transport Systems: systems applying information, communication and positioning technologies to the transport domain

3.1.5
SBAS
Satellite Based Augmentation System: term designating the regional augmentation systems of complete systems such as GPS or GLONASS. In Europe, EGNOS is the regional SBAS system

3.2 General terms

3.2.1
Digital map
Digital description of the road network and of a certain number of attributes assigned to the elements of this network. At the data processing level it takes the form of a geo-referenced database.

3.2.2
Localization
Action of determining the position of a mobile object or a person. Will be used as a synonym for Positioning in this document.

3.2.3
Navigation
Action of leading a vehicle or pedestrian to a given destination, by calculating the optimal trajectory and giving guidance with reference to this trajectory and its real time position.

3.2.4
Navigation message
Data transmitted by the GNSS signals in space necessary for the position computation

3.2.5
Performance
Global characterisation of the quality of the service provided by a system. The performance is generally composed of several given performance features of given outputs of the system and measured by using given metrics.

3.2.6
Performance class
For a given performance metric, designates a domain delimited by 2 boundaries.

3.2.7
Performance feature
A given characteristic used to qualify and quantify the service provided by a system, for example horizontal accuracy for a *Positioning system*.

3.2.8
Performance metric
Precise definition of the means of measuring a given performance feature of a given output of a system. An example of accuracy metric can be the median value of an error sample acquired during a given test following a given protocol.

3.2.9
Phase measurement
Measurement, by the GNSS receiver, of the phase variation of the carrier wave received by the receiver, proportional to the distance between the satellite antenna and the receiver antenna. This measurement includes an integer number of carrier cycles (ambiguities) than needs to be fixed by the position computation. Belongs to the category of Raw measurements

3.2.10
Positioning
Considered as synonym for Localization in this document.

3.2.11
Pseudo-range
Measurement, by the GNSS receiver, of the distance between a satellite antenna and the receiver antenna, biased by the error due to the difference between the satellite clock and the receiver clock. Belongs to the category of Raw measurements.

3.2.12
Raw measurements
Or *Raw data*. Describes all the measurements of a GNSS receiver signal processing stage and designates the Pseudo-range, Doppler and Phase quantities, which are relative to each satellite

processed by the receiver and from which the *PVT* will be calculated. Sometimes, the signal-to-noise ratio CN0 is also considered as being a *Raw measurement*.

3.2.13
Trajectory
Series of time-stamped positions (and possibly speeds) of a mobile object.

3.3 Specific terms

3.3.1
Application module
In this document, synonym of *Road ITS application*. Processing part downstream of the *Positioning terminal*(s) which computes the *Application quantities* and provides the *Road ITS service*.

3.3.2
Application quantity
A quantity produced by the *Road ITS application*, from which an *End-to-end performance* can be calculated. This quantity is normally deducted from a set of positions (and/or speeds) produced by the *Positioning system*. For example, the time of presence of a vehicle inside a given zone is an application quantity for a *Geofencing* application.

3.3.3
Assisted GNSS
Technique consisting in assisting the positioning calculation performed by the GNSS terminal by providing it, via a telecommunication system, with partial or full navigation data as borne by the GNSS Signal in Space. This reduces the Time To First Fix, and lowers the acquisition sensitivity threshold.

3.3.4
End-to-end performance (E2E performance)
Performance of the service provided by a *Road ITS system*. E2E performance is measured by applying a performance metric to an *Application quantity*. Synonym in this document of *Key Performance Indicator* (KPI).

3.3.5
False detection rate
Upon the whole number of detected *Toll events*, the ratio of false *Toll events* corresponding to vehicles detected while driving on non-taxable roads. Example of *End-to-end performance* of a road tolling system based on *Toll events*.

3.3.6
Geofencing
Function consisting in determining the presence of certain persons or of certain moving objects within a certain geographical zone, this zone can be defined in several ways.

3.3.7
Geo-object
Geographic entity in the form of a virtual polygon framing a point of interest or delimiting a zone of interest.

3.3.8
Integrity
General performance feature referring to the trust a user can have in the delivered value of a given *Position* or *Velocity* component. In this document, this feature is expressed by 2 quantities: the *Protection level* and the associated *Integrity risk* [2].

3.3.9
Integrity risk
For *Positioning terminals* providing a *Protection level* as integrity indicator, refers to the probability that the actual error on a given *Position* or *Velocity* component exceeds the associated *Protection level* provided with this quantity

3.3.10
Map-matching
Processing operation consisting in determining the position of the mobile on a map representing the road network. Requires a digital map.

3.3.11
Operational scenario
Description of the conditions in which the *GNSS-based road ITS system* is operating and particularly affecting the *GNSS-based terminal*.

3.3.12
Positioning system
Set of hardware and software components, which can be in different locations, but interconnected, which contribute to estimating the position, speed and associated timestamp of a mobile.

3.3.13
Positioning terminal
Equipment (unit) carried by a vehicle or a person delivering a position solution to a Road ITS application. The *Positioning terminal* is the "terminal" component of the *Positioning system*, directly interfaced with the position data user (in this document the *Road ITS application*). In most cases, and this is the case in this document, this terminal uses a GNSS receiver which may also be hybridized or assisted.

3.3.14
Positioning-based road ITS system
System consisting of one or more *Positioning terminals* and of a *Road ITS application* providing a *Positioning-based Road ITS service*.

3.3.15
Positioning-based road ITS service
Main function(s) of a *Positioning-based Road ITS system*, making use of the *Application quantities* (for instance: computation and secure storage of tax events for a road tolling system).

3.3.16
Pricing point
Legally defined point on a segment of road which, when crossed by a vehicle, triggers the billing of a charge proportional to the length of the segment. Synonyms: *Toll point*, *Virtual gantry*.

[2] **In this document, dedicated to road ITS, the definition of integrity is inspired by, but significantly simpler than the definition of the same concept for the civil aviation community**

3.3.17
Protection level
Estimation of an upper bound for the error made on a *Position* or *Velocity* component (e.g. the plane position) associated with a given probability called Integrity risk. Like the actual error, this feature can be characterized by its distribution function.

3.3.18
PVT error model
Parametric mathematical models representing the errors affecting a *PVT* component, composed with noise and biases observed on this component, output by a Positioning terminal operating in a certain environment". The *PVT error model* will be used to draw pseudo-random trajectories representative of real trajectories.

3.3.19
PVT
Summarized way of naming the data related with the position, the velocity and the time which is available at the output of a GNSS receiver or of a *Positioning terminal* in general.

3.3.20
Reference GNSS receiver
In this document, refers to a widely used and off-the-shelf high sensitivity GNSS receiver offering a good availability and a high sensitivity to the multipath and NLOS phenomena) whose production can be guaranteed for a long period.

3.3.21
Reference trajectory
Series of time-stamped positions (and possibly speeds) of a reference point on a mobile object (test vehicle), produced by a *Reference trajectory measurement system*.

3.3.22
Reference trajectory measurement system (RTMeS)
Term used in this document for a measurement means capable of accuracy performances better than at least one order of magnitude than those of the *Positioning terminal* being tested.

3.3.23
Road ITS application
See *Application Module*.

3.3.24
Sensitivity Analysis
Method to assess the performance of an *Application module* consisting in injecting a high number of simulated degraded *PVT* data obtained by adding to a reference trajectory *PVT error models* representing the real errors observed during dedicated field tests .

3.3.25
Toll detection rate
Upon the total number of actual *Toll events*, the ratio of detected *Toll events*. Example of *End-to-end performance* of a road tolling system based on *Toll events*.

4 Description of the generic architecture of a road its system based on gnss

4.1 Generic architecture

A *Positioning-based road ITS system* based on GNSS, thus providing a *Positioning-based road ITS service*, consists of a *Positioning system* and of an *Application module*, using localisation data to provide a *Service* for the user (navigation aid, tracking, events or presence detection, etc.). Figure 1 illustrates the architecture of such a system.

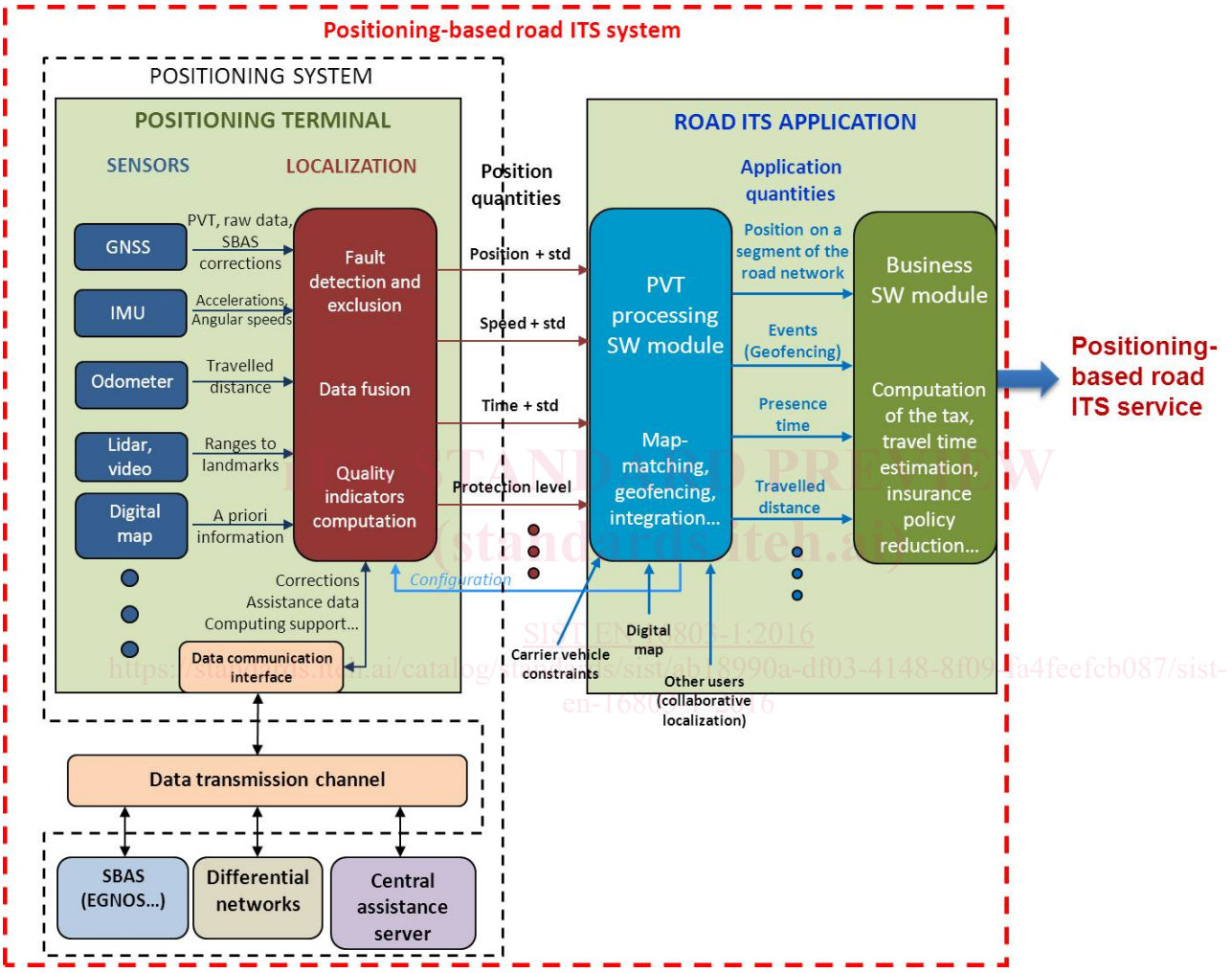

Figure 1 — Generic architecture of a Road ITS system including a GNSS-based positioning terminal

4.2 Components

4.2.1 Positioning components and outputs

We call *Positioning terminal* the on-board part of the *Positioning system*, i.e. the part attached to the mobile object (vehicle), whose position is expected from the application. In this respect, the terminal is the "terminal" component of the *Positioning system*, directly interfaced with the *Position quantities* user (in our case the *Road ITS application*). More precisely, since this EN is addressing the uses cases where a GNSS receiver is used, the terminal is called *GNSS-based positioning terminal*, or *GBPT*.

The terminal itself consists of a series of on-board sensors and a localisation algorithmic layer (localisation module) supplying the application module with *Position quantities*. When the *Localisation module* inside the terminal, or the GNSS sensor itself, uses external GNSS provided through a data transmission channel, for instance: assistance data (*Assisted GNSS*), differential GNSS data or data coming from SBAS satellite augmentation systems, the *Positioning system* includes a part which is external to the on-board part. In some cases, the localisation computation can be partially or totally performed by a module external to the mobile object. In this case also, the *Positioning system* is only partially on-board of the vehicle, but the terminal on intended in the frame of this document as the component providing the final position output to the application.

In all the cases considered in this document, this terminal shall use at least a *GNSS receiver* which may also be hybridized or assisted.

In the frame of this EN, the *Position quantities* output in real time by the *Positioning terminal* shall comprise at least one of the two following quantities:

- the position of the phase centre of the GNSS receiver antenna or of any other reference point of the vehicle[3], expressed in a standard geodetic reference system,

- the velocity of this point,

each of them being associated with a timestamp indicating the time to which the output corresponds.

Depending on the application, the position can be either the 3 components of the 3D position (i.e. a vector), or a subset of them, for example the 2D horizontal position (projection of the 3D position on the horizontal plane or on a plane tangent to the ellipsoid used by the geodetic reference frame) or the vertical position.

The same way, the velocity can be limited to the horizontal 2D velocity or even to the module of it, i.e. the horizontal speed, or to any single component of the 3D velocity.

All along this document, the set of position, velocity and time quantities are called ***PVT***.

In the case when the *Positioning terminal* is delivering *Integrity* information on any position or velocity component of the *PVT*, this information shall comprise at least:

- a *Protection level* on the concerned *PVT* component, according to the definition given in this document, that is to say a value that statistically bounds the error of the position or velocity component provided by the positioning terminal with a very high probability,

[3] The position of this reference point should be deduced from the position of the antenna by a simple translation in space

- computed for a given *Integrity risk* , wh*ich* is the complementary probability of the latter, that is to say the probability that the actual error on the component actually exceeds its associated *Protection level*.

4.2.2 Application module and outputs

The *Application module* is a software module which is broken down for the purpose of this document into 2 sub-modules:

1. The PVT processing module is a pure processing module which transforms the *Position quantities* into *Application quantities* derived directly from the PVT and other data depending on the application and which are the key quantities necessary to deliver the final service to the user (for instance: position on a road segment (map-matched position), virtual toll barrier detection, zone entry/exit detection, speed, distance covered…);

2. The Business sub-module is another piece of software, dedicated to the provision of the final service and highly dependent on the business model chosen by the operator of the system. For instance, this module can be computing the bill to be sent to the user for a road pricing system or the insurance policy reduction for a “pay-as-you-drive” insurance company.

Since the processing depending on the business case of the operator of the system can be extremely variable and is totally out of the scope of this technical standard, it will be considered in this document only the cases when the *End-to-end performances* of the system providing the service are established on the *Application quantities,* by the application of application-dependent metrics.

The *E2E performances* are also called *Key Performance Indicators*, or *KPIs*.

In Annex A (informative) is presented a survey and a classification of some *Road ITS systems* using GNSS-based positioning. It can be noticed from this survey that most of the systems needs the horizontal position to elaborate the *Applications quantities*, but some are using or may use the speed or velocity components. For each of the system listed, *Application quantities* are indicated, together with some examples of *End-to-end performances* as well as the *PVT* data processing necessary to transform the *Position quantities* into *Application quantities*.

5 Overall system engineering approach

5.1 Introduction

The performances management approach proposed in this document is based on a classical System Engineering approach and is a support for engineers facing the problem of handling the performances of a *Positioning-based road ITS system* all along the system lifecycle.

The general engineering approach followed by the engineers facing this issue is the following:

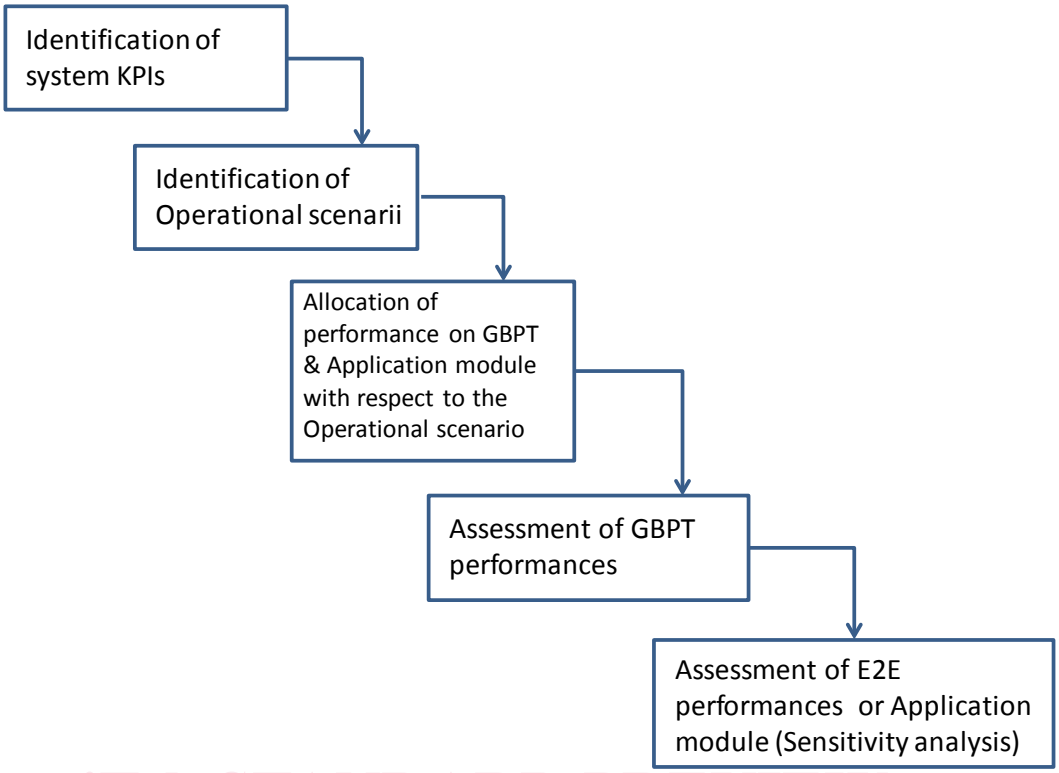

Figure 2 — Logic of the overall performance engineering approach

The starting point of any performances management of a *Positioning-based road ITS system* **shall** be the definition and clear statement of the *End-to-End performances* which are targeted by the system to design and/or test, as expressed by the customer.

In the context of this document, the reference system architecture and the system breakdown into components **is** the one described in section 4 where two main components are identified:

- The *GNSS-based positioning terminal* (*GBPT*)
- The *Application module*

The interface between these two components is assumed to be the *PVT* information, together with some auxiliary information, for instance *Integrity* information for GBPTs which are designed to provide this kind of information.

Performance requirements are generally stated as requirements on the outputs of a given system component, assuming that the other components feeding it with input information do respect their own performance requirements.

Hence, the performance allocation from the E2E KPIs onto the system components **should** follow the general scheme below.