ETSI TR 103 183 V1.1.1 (2012-10)

Satellite Earth Stations and Systems (SES);
Global Navigation Satellite Systems (GNSS)
based applications and standardisation needs

Reference
DTR/SES-00330

Keywords
GNSS, location, MSS, navigation, performance, receiver, satellite, system, terminal

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Contents

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://ipr.etsi.org).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

1 Scope

The present document addresses location based applications and associated standards.

The purpose of the present document is to identify the potential areas for further standardisation related to GNSS based applications that require navigation, communication or a combination of both technologies.

In order to achieve these objectives, the present document first introduces types of applications which rely on location information in order to provide services. Then, the existing standards across various relevant standardization bodies are inventoried. Finally, the potential areas for further standardisation are listed.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ITU-R Recommendation M.1903: "Characteristics and protection criteria for receiving earth stations in the radionavigation-satellite service (space-to-Earth) and receivers in the aeronautical radionavigation service operating in the band 1 559-1 610 MHz".

[i.2] RTCA DO-229D (2006-12): "Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment".

[i.3] IEC 61108-1 (2003-07): "Maritime navigation and radiocommunication equipment and systems - Global navigation satellite systems (GNSS) - Part 1: Global positioning system (GPS) - Receiver equipment - Performance standards, methods of testing and required test results".

[i.4] IEC 61108-2 (1998-06): "Maritime navigation and radiocommunication equipment and systems - Global navigation satellite systems (GNSS) - Part 2: Global navigation satellite system (GLONASS) - Receiver equipment - Performance standards, methods of testing and required test results".

[i.5] IEC 61108-3 (2010-05): "Maritime navigation and radiocommunication equipment and systems - Global navigation satellite systems (GNSS) - Part 3: Galileo receiver equipment - Performance requirements, methods of testing and required test results".

[i.6] IEC 61108-4 (2004-07): "Maritime navigation and radiocommunication equipment and systems - Global navigation satellite systems (GNSS) - Part 4: Shipborne DGPS and DGLONASS maritime radio beacon receiver equipment - Performance requirements, methods of testing and required test results".

[i.7] RTCM 10403.1 (2011-07): "Differential GNSS (Global Navigation Satellite Systems) Services - Version 3 + Amendments 1, 2, 3, 4, and 5".

[i.8] RTCM 10410.0 (2011-06): "Standard for Networked Transport of RTCM via Internet Protocol (Ntrip) - Version 2.0 with Amendment 1".

[i.9] RTCM 10401.2: "Standard for Differential Navstar GPS Reference Stations and Integrity Monitors (RSIM)".

[i.10] ETSI TS 136 171 (V10.0.0): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for Support of Assisted Global Navigation Satellite System (A-GNSS) (3GPP TS 36.171 Release 10)".

[i.11] ETSI TS 122 071 (V9.0.0): "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Location Services (LCS); Service description; Stage 1 (3GPP TS 22.071 Release 9)".

[i.12] ETSI TR 101 593: "Satellite Earth Stations and Systems (SES); Global Navigation Satellite (GNSS) based location systems; Minimum Performance and Features".

[i.13] RTCA DO-229C (2001-11): "Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment".

[i.14] RTCA DO-253C (2008-12): "Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment".

[i.15] ETSI TS 145 005: "Digital cellular telecommunications system (Phase 2+); Radio transmission and reception (3GPP TS 45.005 Release 10)".

[i.16] ITU-T Recommendation P.681-6: "Propagation data required for the design of Earth-space land mobile telecommunication systems".

[i.17] ETSI TS 123 271: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Functional stage 2 description of Location Services (LCS) (3GPP TS 23.271 Release 10)".

[i.18] ETSI TS 136 355: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP) (3GPP TS 36.355 Release 10)".

[i.19] IS-GPS-200E: "Global Positioning System Wing (GPSW) Systems Engineering & Integration, Interface Specification".

NOTE: Available at: http://www.losangeles.af.mil/shared/media/document/AFD-100813-045.pdf.

[i.20] Galileo OS SIS ICD: "European GNSS (Galileo) Open Service Signal In Space Interface Control Document".

NOTE: Available at: http://ec.europa.eu/enterprise/policies/satnav/galileo/files/galileo-os-sis-icd-issue1-revision1_en.pdf.

[i.21] U.S. FCC Report and Order 99 - 245.

[i.22] ETSI EN 302 645: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices; Global Navigation Satellite Systems (GNSS) Repeaters; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".

[i.23] ETSI TS 137 571-1 (V10.0.0): "Universal Mobile Telecommunications System (UMTS); LTE; Universal Terrestrial Radio Access (UTRA) and Evolved UTRA (E-UTRA) and Evolved Packet Core (EPC); User Equipment (UE) conformance specification for UE positioning; Part 1: Conformance test specification (3GPP TS 37.571-1 Release 10)".

[i.24] OMA-RD-SUPL-V2-0: "Secure User Plane Location Requirements".

[i.25] OMA-RD-LPPe-V1-0: "LPP Extensions Requirements".

[i.26] OMA-AD-SUPL-V2-0: "Secure User Plane Location Architecture".

[i.27] OMA-TS-ULP-V2-0: "UserPlane Location Protocol".

[i.28] OMA-TS-LPPe-V1-0: "LPP Extensions Specification".

[i.29] ECC Report 168: "Regulatory framework for indoor GNSS pseudolites".

[i.30] ECC/REC/11(08): "Framework for authorisation regime of indoor global navigation satellite system (GNSS) pseudolites in the band 1559-1610 MHz".

[i.31] ECC Report 129: "Technical and operational provisions required for the use of GNSS repeaters".

[i.32] ECC Report 145: Regulatory framework for Global Navigation Satellite System (GNSS) repeaters".

[i.33] ECC/REC/10(02): "A framework for authorisation regime of Global Navigation Satellite System (GNSS) repeaters".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

GNSS logical assistance data channel: communication channel established between a server and GNSS receiver, which dispatches information usable by the GNSS receiver, and allowing to improve its functions and performance

location based application: application which is able to deliver a service to one or several users, built on the processing of the location information related to one or several mobile targets

location system: infra-structure for reporting to a location based application the location information of one or several positioning terminals, periodically or upon request

pseudolite: l ground based transceiver that is used to create local, GNSS functionalities

SOS: distress signal

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3GPP	3rd Generation Partnership Project
ABAS	Aircraft-Based Augmentation System
ADAS	Advanced Driver Assistance Systems
ADS-B	Automatic Dependent Surveillance-Broadcast
AEO	Authorised Economic Operator
ARNS	Aeronautical Radio Navigation Service
ATP	Automatic Train Protection
AWGN	Additive White Gaussian Noise
CAT	CATegory
CEPT	European Conference of Postal and Telecommunications Administrations
DGNSS	Differential Global Navigation Satellite System
DGPS	Differential Global Positioning System
DM	Digital Map
EAS	Emergency Alert Services
EC	European Commission
EDGE	Enhanced Data for GSM Evolution
ERTMS	European Railway Traffic Management System
ESA	European Space Agency
ETCS	European Train Control System
EU	European Union

EVC	European Vital Computer
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FDE	Frequency Domain Equalization
GBAS	Ground-Based Augmentation System
GEO	Geostationary Earth Orbit
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile communications
HF	High Frequency
HTTP	Hypertext Transfer Protocol
ICAO	International Civil Aviation Organization
ICD	Interface Control Document
IEC	International Electrotechnical Commission
IMO	International Maritime Organization
INS	Inertial Navigation System
IP	Internet Protocol
ITS	Intelligent Transport Systems
ITU	International Telecommunications Union
ITU-R	International Telecommunication Union - Radiocommunication sector
LAAS	Local Area Augmentation System
LBS	Location Based Services
LCS	LoCation Services
LOS	Line Of Sight
LPP	LTE Positioning Protocol
LTE	Long Term Evolution
LU	Local Unit
MOPS	Minimum Operational Performance Specification
MSC	Maritime Safety Committee
OMA LOC	Open Mobile Alliance Location working group
OS	Open Service
PAYD	Pay As You Drive
PC	Personal Computer
PDA	Personal Digital Assistant
PL	pseudolite
PLMN	Public Land Mobile Network
PSAP	Public Safety Answering Point
PVT	Position, Velocity and Time
RAIM	Receiver Autonomous Integrity Monitoring
RBC	Radio Block Centre
RF	Radio Frequency
RIS	River Information Services
RNSS	RadioNavigation Satellite Service
RTCA	Radio Technical Commission for Aeronautics
RTCM	Radio Technical Commission for Maritime Services
RTK	Real-Time Kinematic
SBAS	Satellite Based Augmentation System
SC	Special Committee
SCN	Satellite Communications and Navigation
SISA	Signal In Space Accuracy
SOL	Safety Of Life
STD	STanDard
TBD	To Be Defined
TC	Technical Committee
TSO	Technical Standard Order
UE	User Equipment
UHF	Ultra-High Frequency
UMTS	Universal Mobile Telecommunications System

UNECE	United Nations Economic Commission for Europe
V2V	Vehicle to Vehicle
WAAS	Wide Area Augmentation System
WG	Working Group

4 Overview of location based applications needs

This clause provides an inventory of the possible location based applications in different domains in order to identify the necessary functions needed to be supported by the location systems. However this list is not exhaustive and additional applications can be added in subsequent versions of the present document.

4.1 Location based applications per domain

The applications that are considered in the present document are related to these different domains:

- transport domain (road, rail) (guidance, fleet management, road charging);
- multimodal domain (applicable to various means of transport);
- agricultural domain (in particular for precision farming);
- finance domain (synchronisation of financial operation across the globe).

Table 1 lists the applications inventory, together with a description of the purpose of each application. A synthesis of this inventory is proposed in clause 4.2, with the objective to build classes of applications, and streamline the key functions required to location systems.

Table 1: Classification of transport applications by domain (road, rail, multimodal, etc.)

Domain	Application name	Application description
ROAD	**Electronic fee collection**	The concept behind electronic fee collection consists of an automatic service that will take charge of paying the vehicle toll for using some road network (whether the roads are urban or metropolitan roads or motorways, etc.) using GNSS systems data as source for position, speed, time, etc.
	On-street parking pricing	Current policies aiming to reduce the traffic volume in main cities have led to the implementation of street parking strategies in most countries. The implantation of a system where the information about a car's position is transmitted and managed at a monitoring centre which is in charge of issuing the invoice, would avoid problems with the drivers that decide not to pay.
	Taxi services pricing car/ride sharing applications **Car rental pricing**	The idea of carpooling and later car/ride sharing has been present for a long time. It is based in work colleagues or people from the same neighbourhood that instead of using their own cars, share the travel with more people, organizing the time in which each one is going to be the one driving and using the car, i.e. on a weekly basis, on a monthly basis, etc. Related applications: 1) Non-Dynamic Car/Ride Sharing (long terms trips, next day car sharing, etc.). 2) Car Rental pricing and sharing. 3) Taxi service pricing. 4) Street Parking Pricing.
	Pay Per Use Insurance (Pay-as-you-drive (PAYD) related applications)	It allows insurance companies to use an automatic tool that surveys the general driving behaviour of the user, measuring parameters such as distance travelled, speed, manoeuvres, luminosity, weather, road conditions, road quality etc. All this information will be used as the base of the insurance fee paid for vehicle users. Instead of a fixed quoted to be paid each year, after analysing the last year results, the inclusion of pay per use allows for a continuous and flexible update of its fee.
	Freight tolling/Tax collection	Vehicle motor taxes are one of the main sources of income for the European Union. This application is aimed to support governmental taxes for trucks based, for example, on distance driven, number of axles, the emission category of the truck, weight, etc. GNSS would be used to implement a fairer tax collection system.

Domain	Application name	Application description
	Accident reconstruction	Accident reconstruction is at this stage a common tool for insurance companies and judgement as already mentioned, reconstruction often provides the real vision about the occurrence of an accident, considering the data provided for the vehicles involved in the accident, drivers and occupants affected and witnesses.
	Recovery after theft	Recovery after theft applications deals with providing a reliable and accurate Intelligent Transport Systems (ITS) system that while installed on board a vehicle can provide the needed means in order to track and locate a missing vehicle after it has, due to a theft, disappeared.
	Legal speed enforcement	There is an effort from the side of the law enforcement authorities to increase the control on the speed of road users. The law enforcement bodies would benefit from the use of GNSS as the investment in infrastructure would be significantly reduced. From the side of road users, they would benefit from a reliable service which would make the roads safer, as speed is one of the main causes of road accidents.
	E-call/Emergency services	The in-vehicle eCall is an emergency call generated either manually by vehicle occupants or automatically via activation of in-vehicle sensors. When activated, the in-vehicle eCall system will establish a voice connection directly with the relevant PSAP (Public Safety Answering Point), this being either a public or a private eCall centre operating under the regulation and/or authorisation of a public body. At the same time, a minimum set of incident data will be sent to the eCall operator receiving the voice call. The application is mentioned in the 3GPP LCS Service Description (see TS 122 071 [i.11]).
	ADAS applications **(Advanced Driver Assistance Systems)**	Advanced Driver Assistance Systems applications can be viewed at two levels: • Vehicle Control Systems: The main ADAS applications offering vehicle control are: Adaptive and Predictive Cruise Control, Stop and Go, Lane Keeping/ Warning, Platooning, Intelligent Speed Adaptation. • Collision Warning Systems: These systems detect and warn of an obstacle/critical situation in the vehicle's trajectory. If the driver does not adequately respond to the warnings, Vehicle Control Systems can be introduced to take control of the steering, brakes or throttle to manoeuvre the vehicle in order to avoid collision. Collision warning systems include functions such as: Forward, Rear Impact and Parking Collision Warning, Lane Departure Warning Systems, Lane Change/Intersection Warning Systems, Vision Enhancement Vehicle Control.
	Information for vulnerable and/or disabled road users	According to the data provided by the UNECE (United Nations Economic Commission for Europe), 41,2 % of the persons killed in 2004 in road traffic accidents in the EU - 27 countries were vulnerable road users (motorbike users, cyclists and pedestrians are vulnerable road users). Information and guidance specifically designed for this type of users (taking into account their safety vulnerabilities) could help to improve their safety conditions, as well as improve comfort in their daily transport activities. Special necessity of handicapped or disabled people should also be considered. The use of accessibility maps would allow the implementation of route guidance systems which could avoid accessibility barriers. Blind citizens are one of the potential users of GNSS applications.
	Traffic travel information	The first concept is that related to traffic information, this service is intended to provide the user with comprehensive local and urban, and urban areas, regional and cross-border travel information with a co-modal perspective allowing for well-informed travel decisions, both pre-trip and on-trip, to be taken while using its vehicle. The objective of this activity is to provide the European traveller with relevant information in a harmonized manner which is easy to understand. The application is mentioned in the 3GPP LCS Service Description (see TS 122 071 [i.11]).
	Management and tracking of vehicles (special vehicles, livestock transport)	The most common strategy for goods transportation is the use of road infrastructure. This application concerns position, speed, heading and time information for fleets of vehicles, reporting to a control centre to improve operations. The use of GNSS would allow a better management of the vehicles, and could be of great importance for the transportation of dangerous goods (for instance, GNSS could ensure that the vehicle has not left the authorized route).

Domain	Application name	Application description
	Fleet management	The basic idea for fleet management applications is to control and monitor the status of the different vehicles belonging to one company. This, thanks to the use of Location Based Services (LBS) devices installed in the vehicles (cars, vans, trucks, etc.), allows the tracking and tracing of the vehicles while they circulate on the roads. With all this information, central systems at the disposal of the company buying the service take care of processing the real-time information processing and storage. Using real-time decision algorithms and Geographic Information System (GIS) tools, the system allows the fleet controllers to provide real-time decision making and thus increase the efficiency of commercial vehicles normal operations. The application is mentioned in the 3GPP LCS Service Description (see TS 122 071 [i.11]).
	City logistics	City centres suffer from negative impacts of transport such as high rates of congestion and CO_2 emissions. Part of this is produced by badly-controlled or uncontrolled urban freight transport.
	Regulated fleets in urban areas	City authorities need to impose regulations on certain types of vehicles (tourist coaches, taxis, public transport busses operated by third parties) as to which parts of the city they are allowed to go to, which streets they are allowed to drive in and which parking place they should use or how often they should provide transport from A to B. In accordance with the different routes and destinations covered there are fees to pay and infringement or negligence will result in additional amounts payable (or even in a fine). In effect GNSS will be used for a form of access control and law enforcement, if data is used by authorities to impose sanctions on drivers.
	Transport on demand	Transport on demand aims to solve situations characterized by the lack of interurban transport due to low demand which does not justify the implementation of regular services. The transport on demand service offers the possibility of optimize the route of a vehicle in the real time, depending on the demand of service, thus only the needed stops or no stops and no travel will be produced if there is no demand from users.
	Eco-driving and carbon emissions foot print	The use of GNSS systems, and in particular the future GALILEO system, is a key enabler for this application and the information of Position, Velocity and Time (PVT) should be used in the calculations related to the eco-driving module in order to implement the following measures that will have an impact in the fuel and CO_2 production in the road domain: a) Increasing fuel efficiency by making traffic flow more smoothly. b) Help drivers find the most eco-friendly route and mode choice. c) Giving travellers information about different journey alternatives. d) Collecting real-time information about traffic and environment conditions, incidents. e) Support drivers to acquire and adopt eco-driving techniques by measuring the driver's behaviour.
	Vehicle to Vehicle (V2V) technologies	Vehicular communication systems are an emerging type of networks in which vehicles and roadside units are the communicating nodes; providing each other with information, such as safety warnings, traffic information, payment information, etc. As a cooperative approach, vehicular communication systems can be more effective in avoiding accidents and traffic congestions than if each vehicle tries to solve these problems individually. The application is mentioned in the 3GPP LCS Service Description (see TS 122 071 [i.11]).
RAIL	**Level crossing protection**	The level-crossing supervision can be based on the GNSS systems. The level crossing protection applications is able to send a speed restriction to the train. The value of the speed restriction depends upon the status of the level-crossing, closed detected, closed not detected, and on the line and direction of the movement. The GNSS subsystem should manage a digital map with geographical information: level crossing location, track description in the level crossing surroundings, location activation/deactivation point.
	Cold movement detector	This application provides an input information (from outside the Automatic Train Protection (ATP) system) to the ATP on-board system to confirm the validity of the stored train position when the system is powered off. After being switched off, the ATP on-board equipment should be capable to detect and record whether the engine has been moved or not. When powered on again, the ATP on-board equipment should use, if available, the memorised information about cold movement in order to update the status of information stored by on-board equipment.

Domain	Application name	Application description
	Train awakening	Train awakening in a Radio Block Centre (RBC) area describes the procedure when the train equipment is powered up and a cab is activated. If the train and/or the RBC can determine a safe envelope for the train location, then the train should be able to start its mission in full supervision after awakening. GNSS technologies can be used in the process of qualifying stored data, identifying the RBC, and also can deal with operational scenarios where a train is starting a mission with stored position data qualified as invalid or unknown. Taking advantage of the GNSS capabilities and in particular absolute positioning and absolute movement detection, invalid or unknown initial positions can be qualified as valid. This can allow trains to start a mission in Full Supervision mode in situations where, under nominal procedures, the system would not have enough information to start in a supervised mode.
	Enhanced odometry	Enhanced odometry is an ATP application and therefore it is safety critical. Trains should be equipped with odometric systems, which determine the location of the train in relation to a reference point and its speed. The enhanced odometry function is based on GNSS in order to increase the availability, both at low and high speeds, regardless of the operational conditions, and to reduce the maintenance costs. The GNSS system could provide all the odometry information to the European Vital Computer (EVC) or be one of the sources of that kind of data.
	Absolute positioning	It is an ATP application which provides a way to have a direct access on the positioning without integration of the speed. As a consequence, one of the main advantages of absolute positioning is the possibility to have a confidence interval on the travelled distance, which is independent of the travelled distance and dependent only of the GNSS measurement accuracy, satellites geometry, integrity technique and transformation from GNSS absolute 3D position to 1D along track distance. Nevertheless, European Train Control System (ETCS) is intrinsically based on a train location referenced to balises (electronic beacons) in the track. Consequently, translation process is mandatory in order to integrate this concept into ETCS. A common coordinate system for trackside and train borne is therefore necessary and one solution to achieve that is the use of a digital map containing balises identifier and position in the GNSS referential. To be noted is that when the train approaches a danger point very high accuracy is required (1 m to 5 m). This can be obtained by keeping/installing "relocation" balises before the stopping point or equipping the on-board Local Unit (LU) with high accuracy devices.
	Track Identification	A track identification system would make use of GNSS and other track based infrastructure information to determine the current track on which the train is running. With the distance between the different tracks (including parallel tracks) being in the order of 4 m, very high accuracy is required in the cross-track direction.
	Train integrity and Train length monitoring	Train integrity is an application in the frame of the European Railway Traffic Management System (ERTMS) level 3, both for high speed and conventional lines but not defined yet. It is also applicable to freight rail transport and out of the scope of ERTMS. Train integrity is the level of belief in the train being complete and not having left coaches or wagons behind. A train integrity system should ensure that the train is complete before transmitting its location. This application is able to provide the signalling system with a train length confirmation or a real time status of the train completeness, in order to alert when a train is broken in several parts following the breading of one or several couplers between wagons or cars of this train. GNSS provides a solution to Train Integrity by placing a GNSS antenna and receiver at the rear of the train ("End of Train" device) in communication with a GNSS subsystem at the front end of the train ("Head of Train" device).

Domain	Application name	Application description
	Trackside personnel protection	The maintenance and upgrade of the infrastructure is a major activity involving movements of personnel, equipment and materials. Personnel working on or close to the track should be protected from trains using the network. Speed restrictions may apply or the train may be prevented from entering the work zone completely. Besides, personnel working should be warned when a train is approaching the working area and if the workers are required to move to the trackside, a minimum time for the warning is required. GNSS applied to trackside personnel protection will improve current manual or semiautomatic procedures. This application can monitor the location of the working team, the assets (rail construction machinery, etc.) and the trains. The system, knowing the position of the elements, could issue warnings to the trains for slowing speed or event stop, and orders to the working equipment and teams to abandon working areas when trains are approaching.
	Management of emergencies	The management of emergencies can be greatly improved if an accurate, continuous location of the train is available, allowing the emergency teams to optimise their operations, thus GNSS is suitable for this kind of application. In the event of an accident, it is important to know the location of the train in the line, so that rescue teams can reach the place of the accident. For this kind of application the geographical position of the train should be provided and it should be expressed in co-ordinates understandable to railway personnel and the emergency services, which normally use different coordinate systems. Location of the rescue team could be also convenient, to optimise the route to be followed by the rescue team to the place of the accident taking into account entry points to the track. This application cannot be considered strictly a safety application, although accuracy and dependability of the information can have an influence in the final number of casualties in an accident.
	Train warning systems	Some railways require a special warning to passengers on a platform when a train is approaching and is expected to pass the platform at a speed greater than a defined level. This application is concerned with safety and has therefore been included as part of the list of protection management systems, as opposed to passenger information. This application requires details of train location, speed and other infrastructure data, and may result in an automatic station announcement via a public service broadcast. These applications are considered liability critical as the system failure has associated liabilities either in terms of economic, administrative or legal consequences, in such a way that "large non-reported errors" may affect their operational results or even the application's feasibility.
	Infrastructure charging	In some European Member States, train operators are charged in proportion to use of the infrastructure. Penalties are also imposed according to delays. The use of an independent location/speed/time service from GNSS could be used within the charging process to determine accurate infrastructure usage according to location and duration and hence generate accurate billing information. Besides, the application allows for transparent process for allocating blame and charges and provision of evidence.
	Hazardous cargo monitoring	Some of the goods carried by rail freight operators can damage the environment if they are spilt in transit and/or pose a threat to society if they are stolen. These include: crude petroleum and petroleum products; compressed, liquefied and refrigerated gases; flammable/corrosive/toxic chemicals and chemical/nuclear hazardous wastes. GNSS can be used to provide an alarm and alert system when used in conjunction with satellite or terrestrial communications and geofencing technologies. This solution allows managers to remotely monitor, track and communicate with their cargoes in real-time. Furthermore, this application provides updates on location, speed, mapping directions, security, etc. It also helps in archiving of vital condition data and an ability to track stolen cargoes.

Domain	Application name	Application description
	On-board train monitoring and recording unit	The on train monitoring recorder provides a complete record of each state change of all monitored signals. Data recording takes place in a crash survivable memory module, with journeys in excess of 24 hours duration easily accommodated. The data is protected from damage during vehicle accident, providing a secure record for incident investigations. The recorded information can be used for safety monitoring procedures and the analysis of operational performance. If a GNSS receiver is added to the on-board recording unit, then accurate positional data can be determined and logged by it, as well as accurate time stamp. Logging of the positional data can be performed after a specific time interval has elapsed, after a set distance has been travelled or when some events trigger the logging. The stored data can be analysed to provide a data base of longitude/latitude references against signal numbers, platform, etc.
	Traffic management systems (Dispatching)	The objective of this application is to improve the regulation of traffic based of the accurate, real-time information of the positions of the trains in the controlled area. Railway traffic managers control the movement of trains by making judgements of the position and speed of the trains, and anticipation of their future performance. Comparison of predicted and actual performance can be used to pre-empt future difficulties. Adequate management of traffic (accurate positioning and real time communications) can improve train headway and thus increase the capacity of the line. This application is mission critical because failure of interruption in service can provoke the interruption in operation of trains. This kind of system will be also very useful in determining and allocating responsibilities when a failure of a train on the network occurs, thus affecting the rest of the services, which implies strong requirements in terms of accuracy and integrity of the information received.
	Fleet management	The tracking of assets (rolling stock, wagons) is crucial to achieve an optimised use of an operator fleet. The accurate determination of position and distances covered by a resource can ease the maintenance of a vehicle. The vehicles can be monitored everywhere at every time of their life-cycle. Long-term management and planning of the use of rolling-stock, the composition of train and the preparations for maintenance are facilitated if a more automated tracking of these resources can be made. Because of the de-centralised nature of the rolling-stock owners' and lessors' industry, some autonomy in the derivation of this data is required.
	Cargo condition monitoring	The importance of accurate information for freight customers, particularly accurate estimation of the arrival of trains at depots, is inestimable. Unplanned late arrival can result in delays to unloading that seriously disrupt the running of subsequent services. This is a mission critical application if there are not complementary systems acting as back up. Complete train, individual containers or even goods can be tracked by radio-navigation systems potentially through multiple modes of transport, thereby requiring the integration of management information from multiple service providers and requiring the interoperability of different systems.
	Multi-modal terminal management	The management of fleet and goods within a major transport terminal raises specific requirements in addition to those relating to general fleet management. Within a major multi-modal terminal, such as an airport, harbour or major terminus, it is possible that multiple modes of transport will be integrated together through a large number of freight or passenger movements and a single operating authority will be responsible for the smooth operational running of that terminal. Tracking of freight containers by radio-navigation systems is applicable also for intermodal transport. When the transportation of freight is truly multi-modal across a wide national area, the requirement of a single solution across all modes could be easily met by GNSS.
	Energy charging	To monitor the energy consumption of trains and hence users, vehicles can be fitted with GNSS and energy meters. Meter readings will then be available either when borders are crossed or as required. The border crossing event is registered by GNSS and the reading from the energy consumption meter is forwarded to a recording point for billing. The application creates the opportunity for new revenues through the allocation of energy consumption without requiring high positional accuracy.

Domain	Application name	Application description
	Infrastructure data collection	Railway is a dangerous environment with the growing demand for faster trains and greater capacity, this puts severe time and financial constraints for access to working on or near the line. To allow data to be collected on the railway infrastructure, while accommodating the constraints of obtaining access, mobile survey systems combining radio navigation systems with digital images, video and laser measurements are very useful. Some operations that benefit from this technology include: signal sighting, asset data collection, site surveys, design verification, route familiarization, rapid response of emergency services, virtual inspection, etc.
	Digital Map (DM) creation	The concept of a single DM is attractive from both an operational and safety perspectives. From an operational side, a common harmonised source of track layout can provide a framework for the development of operation, management and passenger information services. From a safety perspective, if the data within the digital map meets the required safety integrity level, then the data can provide an essential sensor within future train control and signalling operations. The production of a DM is also an application area for GNSS. Precise reference of the route using high precision GNSS can provide an accurate reference map database with the necessary levels of integrity, capable for use in safety critical operations.
	Structural monitoring	The industrial driver for the use of GNSS technology in structural monitoring is the increasing need for reliable, accurate and cost-effective condition monitoring systems for bridges and other major structures within the railways. Monitoring is an important tool in planning the systematic maintenance of the bridge stock in order to preserve adequate levels of structural integrity and maximise operational benefits. In addition to bridges, slope stability is also required to be monitored to ensure that the embankments are stable and the risk of landslide is minimised. GNSS solutions are supporting both application areas. GNSS is used to provide real-time position sensing of critical locations which can be used to inform infrastructure operators and train operators of any "out of tolerance" behaviour.
	Energy efficiency	Backed up by information on the train's scheduled position and actual location at any given moment as well as on anticipated running events, indications are to be given to the driver that enable the journey to be continued in as fuel-efficient a manner as possible. Armed with this information the train driver is able to drive economically. Notification of, for instance, ascending or descending gradients or trains in advance or signals at danger enables the driver to deploy and release power in an optimal manner.
	Shunting operations	Application supporting the composition of different trains on different tracks.
	Infrastructure charging on rails	GNSS-based toll systems supporting the charging of railway infrastructure fees.
MULTIMODAL	**Goods tracking and tracing**	Application allowing tracking and tracing the ITU positioning along the supply chain, including also identification of goods and, if necessary, continuous status monitoring of transported freight (including tampering control) (see note).
	Dangerous & hazardous cargoes tracking and tracing survey	To provide real-time track and trace solutions to foster the security for the movement of dangerous and hazardous through the global supply chain (explosives, ammunition, gases, poisons, chemicals, radioactive, corrosives or inflammable material).
	Special (high value, sensitive, dual) goods traffic tracking	Sensitive goods:goods easily attracting criminal activity (arms, tobacco, cultural assets, money, etc.). The use of GNSS is seen in its capability of helping locate the freight during transport, and consequently to prevent the misuse of such goods. A "dual-use good": product or service "that can be used for both civil and military purposes".
	Perishable goods/food tracking and tracing	Traceability. Application allowing tracking and tracing the ITU positioning along the supply chain, including also identification of perishable goods and, if necessary, continuous status monitoring of transported freight (including tampering control).
	Livestock transport tracking & tracing survey	Location of the livestock transport vehicles in any given moment. Traceability of livestock and animal products are all aspects inherently linked together to prevent sanitary fraud and ensure food safety. Conversely, rising public preoccupation over the impact of long distance transportation on the welfare of live animals has led to new legislation covering the conditions of transport.

Domain	Application name	Application description
	Medical supplies tracking and monitoring survey	Transport of unconventional cargo: blood, chemicals, organs.
	Emergency call (pedestrian and in-vehicle users)	In case of an emergency situation the user would make a distress call easily using a portable device, which would automatically send the user location (information provided by GNSS) to an emergency centre. The application is mentioned in the 3GPP LCS Service Description (see TS 122 071 [i.11]).
	Emergency Alert Services (EAS)	EAS may be enabled to notify wireless subscribers within a specific geographic location of emergency alerts. This may include such alerts as tornado warnings, pending volcano eruptions, etc. No requirements currently exist for EAS, and they may be considered for further study. The application is mentioned in the 3GPP LCS Service Description (see TS 122 071 [i.11]).
	Resource management	Application within the emergency services user group. The location of the deployed emergency vehicles should be known at a central command unit so that task allocation and resource management activities can be done more efficiently.
	Pedestrian resource management	Equivalent application to "Resource Management" but for pedestrian users. It is considered a different application due to the more stringent user needs that have been identified.
	Route guidance	Application within the emergency services user group. The guidance of emergency vehicles to an emergency area would be done with a reliable system, as the time of arrival to the destination could be critical to save lives.
	Asset and resource management	Application managing assets and resources within the terminal. It makes possible to always have an updated picture of the terminal itself and thus know where ITU, wagons, locos are positioned together with relative information on status and content.
	Intermodal cargo operations	Positioning of goods while transferring between different means of transport.
	Haulage delivery and freight collection	Application supporting the series of safety and commercial controls during this phase of the transport. This phase starts when the transport means arrives/departs to/from the terminal gate.
	AEO (Authorised Economic Operator/E-Customs)	Containers movements control.
	Truck dispatch	Application connected to the mining sector. Computerized truck dispatch systems incorporate real-time information sent to a control centre to monitor and efficiently dispatch haul tracks to shovel and loaders.
	Waterway charges and barge harbour dues	Applications supporting the River Information Services (RIS) directive by assisting in levying charges for the use of the waterways. The travel data (together with the type and size of vessel, type and volume of cargo, frequency of travel, time of day, etc) can be used to automatically calculate the charge and initiate invoicing, thus facilitating the process for waterway users and authorities.
	Inland navigation and guidance support	The RIS concept, which represents the most substantial change in this sector in several decades, aims at the implementation of information services in order to support the planning and management of traffic and transport operations.
	Home-Zone billing	Location based charging allows a subscriber to be charged different rates depending on the subscriber's location or geographic zone, or changes in location or zone. The application is mentioned in the 3GPP LCS Service Description (see TS 122 071 [i.11]).
Agricultural	**Field geolocating**	Geolocating a field enables the farmer to overlay information gathered from analysis of soils and residual nitrogen, and information on previous crops and soil resistivity. The field is delineated using an in-vehicle terminal as the farmer drives a tractor around the field.
	Agricultural assets remote guidance	Precise positioning of the assets used in the agricultural domain enables to develop solutions for the use of unmanned vehicles, which offer opportunities to achieve more efficient exploitation of the fields (nightly operations, parallel harvesting).
Finance	**Precise time synchronization**	GNSS systems also offer the opportunity to achieve precise time synchronization across the coverage area (i.e. entire globe). This ability can be exploited for any type of application requiring distribution of a single time reference over wide area, such as financial operations.
NOTE: This application can rely on integration with information coming from applications managing the transport means (e.g. road fleet management, train monitoring and positioning, vessel monitoring and positioning, etc.).		

4.2 Application classes definition

The inventory in table 1 provides a good overview of typical needs encountered when developing location based applications in the various considered domains. It is proposed to synthesize these needs, and organize applications facing similar needs in a reduced number of classes.

a) Location Based Charging:

- The objective is to charge a user based on its reported position. The main requirements are:

  - **Reliability of check point crossing detection:** risk that user reported position triggers a charging event whereas it is actually in a position free of charge.
    This risk is generally very low.

  - **The service availability:** percentage of cases when user actual position is able to trigger charging event, but system is not properly informed. The service unavailability can be due either to an erroneous reported position, or the unavailability of the location information itself.
    This service unavailability is generally low.

NOTE 1: This type of location-related requirement is needed for road user charging (road), on-street parking fee pricing (road), waterways and harbours charging (maritime/multimodal), home zone billing, regulated fleets in urban area, etc.

b) Pay as you drive (PAYD) charging:

- The objective is to charge a user based on the travelled distance (mainly applicable for pay per use insurance). The challenge is quite similar to the previous group, except that useful information is rather the travelled distance than the position itself.

- The mains drivers are:

  - the **representativity of the computed distance**; or

  - the **representativity of the followed trajectory.**

  in order to globally optimise the fee collection.

NOTE 2: This type of location-related requirement is needed for pay per use insurance (road), car rental pricing (road), taxi service pricing (road), freight tolling (road), car pooling (road), pay as you pollute (road) and energy charging (train).

c) Cooperative basic geo-localization (including fleet and asset management):

- The objective is to recover the position of one or several assets or vehicle, remotely or not. The main drivers are generally:

  - **The reported position accuracy:** as far as fleet management or personal navigation is concerned, the main target is explicitly to obtain an accurate position estimate.
    The required accuracy highly depends on the application: tens of meters for personal road navigation and vehicle fleet management, meters for pedestrian personal navigation and city sightseeing.

  - **The service availability:** position availability might not be as driving as for other application (see a) above, location based charging applications), but it is a clear challenge in the considered applications: car positioning in urban areas (including high masking or shadowing, tunnel, important multipath) clearly suffers from degraded availability.

NOTE 3: This type of location-related requirement is needed for fleet/asset/resource management, personal navigation (pedestrian, road, multi-modal), traffic travel info, city sightseeing, etc.

d) Non-cooperative geo-localization (possibly applied to fleets):

- Asset positioning might be required when asset is non-cooperative. In other words, compared to the regular "cooperative basic geo-localization", a new driver is reported: the **service reliability**.
- In other words, this new requirement is important any time the terminal is placed in an "hostile" environment, and that the confidence in the reported position should be maximized.

NOTE 4: This type of location-related requirement is needed for some kind of fleet management (car rental), car recovery after theft (road), city logistics (road).

e) Reliable geo-localization (including dangerous, precious and/or sensitive cargoes):

- The objective is to obtain a reliable position estimate for any application where position is a key driver for security or safety (of cargo, travellers).
- The main driver here is the **confidence level associated to the applicative figure of merit**. This figure of merit can be:
  - the reported position;
  - application event: billing event, trajectory.
- In other words, for such applications it becomes paramount to be informed of the probability that reported information is inaccurate.
- Of course, **reported position accuracy** and **service availability** are important drivers, which might however depend on the specific applications.
- The border between "non-cooperative" and "reliable" geo-localization is thin. To that point, they are however considered separately:
  - Non-cooperative geo-localization only targets position uncertainty caused by position spoofing (i.e. wanted). In other words, any position uncertainty due to unwanted origins (GNSS signal, interference, other) are not covered: they are deemed naturally bounded, and the application required accuracy is compatible with this bound.
  - Reliable geo-localization however covers all sources of position uncertainty, in order to bring confidence not only in the position authenticity, but position accuracy.

NOTE 5: This type of location-related requirement is needed for livestock transport tracking and tracing survey, dangerous and hazardous cargoes tracking and tracing survey, special (high value, sensitive, dual) goods traffic tracking, perishable goods/food tracking and tracing.

f) (Reliable) Vehicle movement sensing:

- Some applications aim at collecting, in addition to the terminal position, additional information related to its movement: speed, acceleration, heading, gyration, etc.:
  - The main driver is of course the **movement caption accuracy**. The objective might be to measure vehicle speed for law enforcement of eco-driving advice.
  - As previously mentioned, a **confidence level** associated to the reported parameter might also be needed.

NOTE 6: This type of location-related requirement is needed for:

- Liability critical applications: legal speed enforcement (road), accident reconstruction (road), vehicle control assistance (ADAS) + collision warning (road), cold movement detector (train), traffic management systems (train).
- Non-liability critical applications: eco-driving and carbon emissions foot printing (road), traffic congestion reporting (road).

5 Overview of existing standards relevant to GNSS

The objective of the present document is to highlight the relevancy of the proposed standardisation work. In the previous clause, extensive technical background has been provided and the concept of location system has been introduced. The objective of the present clause is to now review any existing standard which can provide an even partial coverage of the targeted standardization work.

This will allow:

- first to identify the lacks of the existing standards for the established objective, and thus stress for the need for the proposed standardization work; and
- then to build the standard on already existing basis considered relevant, and therefore ensure that the created standard will be consistent and compatible with the existing ones.

In order to build a relevant and acknowledge Harmonized standard, it is considered of paramount importance to have consistency between the standard under construction and all existing standards in the various application domain (non-safety critical applications).

Special care is therefore taken in order to ensure this consistency. The existing standards identified in clause 6 have been listed as relevant information sources. This list might evolve further with later versions of the present document.

5.1 ITU Recommendations

The ITU Recommendation ITU-R Recommendation M.1903 [i.1] has been issued in order to analyze the radio-frequency interference impact on Radio Navigation Satellite Service (RNSS) (space-to-Earth) and on Aeronautical Radio Navigation Service (ARNS) receivers operating in the band 1 559 MHz to 1 610 MHz from radio sources other than in the RNSS.

5.1.1 GPS receiver characteristics

Several GPS receiver types are described in this clause. There are three aeronautical receivers for which the requirements are relatively well developed. (SBAS and GBAS air navigation receiver and SBAS ground network receiver characteristics can be found in [i.2]. Each has its counterpart for land and/or marine applications, and it is intended that the characteristics stated in this clause would apply to GPS receivers that are used in such applications. At this time it is not known whether the non-aviation applications are more susceptible to interference or less, nor is it known how susceptible future applications will be, considering both the current GPS with its augmentations and evolutions of GPS.

The first aeronautical receiver is a civil navigation receiver designed to provide category I precision approach guidance. It should meet the requirements of a satellite-based augmentation system (SBAS) specification. It should track both GPS satellites and SBAS satellites, which have GPS-like codes and transmit at the same centre frequency of 1 575,42 MHz. The SBAS signal is modulated with data using a symbol rate of 500 bit/s, which is then decoded with a convolutional decoding scheme to output information at a rate of 250 bit/s.

The second aeronautical receiver is an air navigation receiver designed to provide Category II/III precision approach guidance. It should meet the requirements of a Ground-Based Augmentation System (GBAS). It should track GPS satellites and pseudolites. Pseudolites are ground-based transmitters which emit a signal having the characteristics of GPS, but utilizing different spreading codes. There are wideband and narrow-band pseudolites currently under consideration. Wideband pseudolites emit a code similar to the Y code (see note), thus the signal has the spectral characteristics of the Y code. The pseudolites are pulsed with a duty cycle of less than 4 %. The narrow-band pseudolites emit a signal having C/A code characteristics, offset from the L1 (L1 band is at 1 559 MHz to 1 610 MHz) centre frequency by 10,23 MHz. They are pulsed, with a duty cycle of about 9 %.

NOTE: Y code is a modified P code, having the same chipping rate and spectral characteristics as that of the P code.

The third receiver is a ground-based receiver which is used in SBAS operations to determine ionospheric delays. It is also used in non-SBAS ground applications. This receiver uses a semi-codeless technique that exploits a unique feature of the GPS architecture whereby the L1 and L2 (L2 band is at 1 215 MHz to 1 260 MHz) Y code signals are cross-correlated to provide a measurement of signal delay at L2, thus making it possible to determine the signal delay due to the ionosphere. The cross-correlation scheme is made possible by the fact that the GPS L1 and L2 signals have identical codes. This receiver should acquire and track both GPS and SBAS satellites at L1. Semi-codeless receivers are more sensitive to interference because they operate without benefit of knowing the Y code.

In the following descriptions power levels at the antenna input refer to the power that would be received by an isotropic, circularly polarized antenna of the proper polarity, while power levels at the antenna output refer to the power levels that account for the antenna gain in the direction of the specific signal or interference source.

- **Land vehicle and marine navigation receiver:**
  - Land vehicle and marine navigation receivers are designed to provide metre-level guidance, using differential corrections obtained from any of a number of GPS augmentation systems, including SBASs, radio beacon networks, or other local area broadcasts that use one of several frequencies from HF to UHF. Their characteristics are similar to those of the first aeronautical receiver described above.
- **Semi-codeless receivers:**
  - Semi-codeless GPS receivers use a technique unique to GPS whereby the L1 and L2 Y code signals are cross-correlated to provide an estimate of the ionospheric delay or an independent set of carrier phase measurements that support rapid removal of wavelength ambiguities, even when the receiver is in motion. This process provides improved position accuracy. The cross-correlation scheme is made possible by the fact that L1 and L2 have identical, synchronized Y codes. This receiver will have characteristics similar to the third aeronautical receiver described above, but may differ in its susceptibility to interference.
- **Commercial ground network receiver:**
  - Some commercial ground network receivers operate at a single frequency, in which case their characteristics will be similar to the first aeronautical receiver described. Two frequency receivers may also be used in commercial networks. If so, their characteristics are similar to the third aeronautical receiver, except that instead of performing relative carrier phase computations, the cross-correlated L1 and L2 signals are processed to determine the ionospheric delay in the signals. This information is used by the network to improve accuracy over a large region.

5.2 Aeronautical standards

5.2.1 RTCA (Radio Technical Commission for Aeronautics)

DO-229C - Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment [i.13]

DO-229C contains Minimum Operational Performance Standards (MOPS) for airborne navigation equipment (2D and 3D) using the Global Positioning System (GPS) augmented by the Wide Area Augmentation System (WAAS).

DO-229C [i.13] supersedes DO-229B and includes:

1) Message Type 28 information;
2) modification of the satellite tracking constraints;
3) changes to the equipment classifications and the accommodating document realignment;
4) interference environment revisions in Appendix C; and
5) new GPS/Inertial requirements in Appendix R.

The regulatory application of these standards is the responsibility of appropriate government agencies. In the United States, the Federal Aviation Administration (FAA) plans to publish Technical Standard Order (TSO) C-145 and C-146 for GPS/WAAS equipment. TSO C-146 will reference the requirements and bench tests procedures in Section 2.

FAA Technical Standard Order (TSO) - C145 references this document.

DO-229D -Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment [i.2]

DO-229D contains Minimum Operational Performance Standards (MOPS) for airborne navigation equipment (2D and 3D) using the Global Positioning System (GPS) augmented by the Wide Area Augmentation System (WAAS). The primary areas of change from DO-229C [i.13] to DO-229D [i.2] are:

- Clarifications.
- Numerous changes have been incorporated to more clearly describe the meaning and intent of the requirements. To accomplish this there have been changes in the requirements text, explanatory notes added to clarify intent, or both:
  - There are three new appendices in DO-229D [i.2], Appendix S, Appendix T and Appendix U. Appendix S contains process flow diagrams that are examples of the computation and logic flow to meet MOPS requirements for the possible operational modes. Appendix T is a description of the tool used to determine GEO bias error in receiver correlator designs. Appendix U contains guidance information for interfacing WAAS with ADS-B equipment. Appendices F and I from DO-229C [i.13] have been deleted and replaced with entirely new material. Appendix F now addresses SBAS capability considerations for ADS-B. Appendix I now contains mode switching process flow diagrams to aid in understanding the mode transition requirements.
- Corrections:
  - There are numerous changes in DO-229D [i.2] to correct errors in equations and to update references to other documents. For example, equations in several places had incorrect signs, symbols, and/or nomenclature. Some of these errors were noted in the errata sheet and TSO-C145a/C146a. The errors documented by those sources have been incorporated; and, many additional errors were found during the review. Further, the update to DO-229D [i.2] includes changes related to the changing environment for GPS and service provider experience gained thru operating SBAS systems. For example, the narrow-band geostationary satellites in the WAAS system are in the process of being replaced with wide-band satellites. A result is that major requirement changes have been incorporated in DO-229D [i.2] related to noise, minimum/maximum satellite power levels, and antenna gains.
- New Requirements:
  - There is a new requirement for Fault Detection Prediction so that SBAS equipment provides at least the same capability as TSO-C129a equipment when operating outside of SBAS coverage. There are new requirements either embedded within previously existing requirements from DO-229C [i.13], or, captured as entirely new sections that never previously existed. Some examples are:
    - There is a new GEO bias error requirement to account for the net group delay through the receiver correlator that results from the signal bandwidth of SBAS satellites compared to GPS satellites.
    - There is a requirement to only use weighted solutions for FDE algorithms.
- Section 2.3 for Delta-class receivers has been extensively re-written and expanded.

DO-253C- Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment [i.14]

DO-253C provides the Minimum Operational Performance Standards (MOPS) for Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Local Area Augmentation System (LAAS).

The standards in the document define minimum performance requirements, functions, and features for LAAS airborne equipment to support CAT I, II and III precision approach operations. Compliance with these standards by manufacturers, installers, and users is recommended as a means of assuring that the equipment will satisfactorily perform its intended functions under conditions encountered in routine aeronautical operations.

DO-253A superseded DO-253 and included:

1) recommendations harmonized with the ICAO GNSS Panel Standards and Recommended Practices (SARPs);

2) the use of LAAS differential position to support area navigation; and

3) the easing of the LAAS Ground Subsystem Siting constraints (Ephemeris Error Protection).

DO-253B harmonized the LAAS MOPS with the revised WAAS MOPS - DO-229D [i.2]. DO-253C [i.14] includes the earlier revisions and provides the requirements/standards for LAAS to support Cat. II and III precision approaches. In addition, the revision incorporates changes to existing Cat. I and positioning service standards, and includes velocity requirements to further support ADS-B.

SBAS-based sensors that provide information to multi-sensor system or separate navigation system. This is covered by MOPS DO-229D [i.2].

The Minimum Operational Performance Standards for Galileo receiver is a EUROCAE standard defining the minimum performance, functions and features for:

- Galileo airborne receivers using Galileo Open Service (MOPS under construction).

5.2.2 EUROCAE(European Organisation for Civil Aviation Equipment)

EUROCAE is a non profit organisation formed to provide a European forum for resolving technical problems with electronic equipment for air transport. EUROCAE deals exclusively with Aviation standardisation (Airborne and ground systems and equipments) and related documents as required for use in the regulation of aviation equipment and systems.

1) Development of Galileo Stand-alone receiver standards:

The development of the Galileo receiver standards started with the establishment in 2002 of a dedicated EUROCAE working group 62 (WG-62) having as objective to prepare MOPS for future Galileo receivers.

The development of EUROCAE documents is organised by working groups where members provide experts working on voluntary basis. The WG-62 is in charge of the development of Galileo airborne receiver equipment and aeronautical antenna performance standards as well as supporting the development of combined Galileo/GPS/SBAS Standard.

Draft the Galileo Stand-alone MOPS including:

- Enhancing and improving the overall document in order to achieve sufficient maturity before proposing an official document to EUROCAE and RTCA.

This task should aim in general at global improvement of the document as well as at some specific points identified in the draft such as:

Review and complement the minimum requirements and the definition of the environmental conditions:

- Expand and mature the test procedures chapter in line with performed studies and EUROCAE WG-62 recommendations.

- Update of the Galileo signal, link budgets values as well as an accurate assessment and update of the GNSS system noise values.

- Update the Non-Precision Approach RAIM/FDE algorithms based on inputs for the Galileo RAIM Assumptions provided by EC and ESA such as SISA definition and functionality, information on Galileo satellite failure model and constellation availability.

Review and consolidation of the Antenna part of the document and align with Antenna MOPS data.

Consolidate with GPS L1/L5 MOPS in terms of structure and content:

- Align the current structure of the document with the GPS L1/L5 structure in order to facilitate the merge of the two documents into a combined GPS/Galileo MOPS. This task should be done in cooperation with the development of Combined Galileo/GPS/SBAS receiver standards.

- Update the document in order to clearly identify E5 frequency topics by separating the E5a frequency as baseline for the combined Galileo/GPS MOPS and E5b frequency as an optional solution.

Conduct the necessary tests, simulations and studies to support the document drafting.

Organise a review process, submit the consolidated document to a peer review involving key actors in the domain (receiver manufacturers, antenna manufacturers, airframe manufacturers, EUROCAE WG-62 members, RTCA SC-159 members), collect and analyze all feedback received. A second and final version of the MOPS will be prepared to reflect the outcome of the review process.

Participate to the EUROCAE WG 62 (All meetings in Europe- 3 per year).

2) Galileo/GPS/SBAS Receiver Standards:

In parallel to the development of Galileo Stand-alone receiver MOPS, EUROCAE WG- 62 is also pursuing the objective to define jointly with RTCA SC-159 a combined GPS/Galileo receiver MOPS which will include SBAS and ABAS. The purpose of the related work is to draft an initial version of a dual constellation, dual frequency combined document based on the existing Galileo-only and GPS L1/L5 MOPS (to be developed by RTCA) by establishing the optimal multi-constellation/multi-frequencies combinations to meet future needs for aviation stakeholders.

The work on this objective is organised in two phases. The first step aimed at producing a Concept of operations document in order to present the operational concepts for the use of combined GALILEO and GPS multiple frequency constellations and associated services. It includes also the qualitative and quantitative elements, based on preliminary work performed by WG-62, showing the operational benefits when using combined GPS/Galileo receivers including SBAS or ABAS. The objective of this document is to assess the different combinations of GPS, Galileo and augmentation systems in order to define a reasonable subset of them to be standardised. It presents the different combinations and integrity schemes, assesses their benefits using predefined criteria and identifies the optimal multi-constellation/multi-frequencies ones to meet future needs for aviation stakeholders.

Based on the Galileo/GPS Concept of Operations and assuming available inputs, two families of combinations have been identified including one set of three configurations of Galileo/GPS using RAIM with single or dual frequency and one set of combinations desirable to be developed but not necessarily all, that include all frequencies (L1, L5, E1, E5a and E5b) and all possible integrity schemes (RAIM, INS, SBAS, SOL).

In a second phase, an initial draft of Galileo/GPS/SBAS MOPS has been developed reusing the RTCA DO-229D [i.2] document and the draft Galileo OS MOPS addressing one set of three combinations of Galileo/GPS using RAIM, with single or dual frequency.

At the current stage, the combined GPS/Galileo MOPS is in a very initial stage derived from a previously adopted skeleton and the Galileo only MOPS document and contains a limited set of requirements. In addition the operational goals for integrity combinations and switching logic are developed and receiver functional and operational classes are defined. The testing requirements and the test procedures are still to be developed as well as the environmental test conditions. This document should be further developed in close cooperation between EUROCAE WG-62 and RTCA SC 159.

In addition, the current considerations to extend the SBAS services to cover dual frequency users, both for GPS (L1/L5) as for Galileo (L1/E5) SBAS provides an opportunity to envisage another possible combination. The extension of GPS SBAS for L1/L5 is under study by EUROCAE and RTCA, and is in a relatively advanced stage of development. The development of an SBAS L5 ICD addressing the data format topics for GPS and Galileo SBAS L1/L5 is also ongoing. Therefore, it will be required to consider the introduction of SBAS as potential possibility to provide a single integrity equation for a combined Galileo /GPS receiver and proceed to the complement of the receiver standards in order to encompass the SBAS dual constellation options.

The objective of this task is to support the work carried out in cooperation between EUROCAE WG-62 and RTCA SC 159 towards the development of a MOPS for combined receivers. This should include updates of the Concept of Operations, assessment of performance of different receiver architectures through simulations, derivation of operational benefits and drafting of combined receiver standards.

The main activities to perform within EUROCAE are:

- Review and update the Concept of Operations in line with the latest available inputs and the EUROCAE WG-62 group feedback:
  - Update and align the document with the official publications on the Galileo and GPS roadmaps.
  - Propose and agree with EUROCAE WG-62 an update scheme of the document taking into account the need to reflect the GPS, Galileo, SBAS and RAIM roadmaps updates as well as the MOPS completion and incorporation of its material.
- Drafting the Galileo/GPS MOPS including:
  - Enhancing and improving the overall document in order to achieve acceptable maturity.
  - Review and complement the minimum performance requirements and draft the test procedures and the environmental conditions in coordination with RTCA SC 159.
- Consolidate the definition of GPS/Galileo based RAIM algorithm targeting worldwide Non-Precision Approaches.
- Conduct the necessary tests, simulations and studies in order to support the drafting of the combined MOPS document.
- Conduct technical work on the definition of civil aviation receiver functional and performance requirements for the new SBAS signals. This work should result in technical contributions to a new SBAS MOPS in coordination with EUROCAE and RTCA. The work should:
  - Provide proposal for functional and performance requirements of the new SBAS receiver standard.
  - Provide RF robustness requirements for new SBAS receiver standard.
  - Describe, the data processing mechanism (e.g. protocol for the use of new parameters broadcast by the SBAS signals).
- Secure adequate interfacing (mainly functional) requirements to facilitate combination with Galileo part of the receiver standard developed by EUROCAE WG-62.
- Support the coordination between EUROCAE WG-62 and RTCA SC-159 WG#2 to develop the combined Galileo/GPS receiver MOPS. This activity should include promotion and support of a join EUROCAE WG-62/RTCA SC-159 group.
- Organise a review process, submit the consolidated documents to a peer review involving key actors in the domain (receiver manufacturers, airframe manufacturers, EUROCAE WG-62 members, RTCA SC-159 members), collect and analyze all feedback received.

5.3 Maritime standards

The following International Electrotechnical Commission (IEC) publication have been identified as relevant sources.

Table 2: Overview of existing maritime standards

IEC publication	Our reference	IMO resolution	Title	Issue date
IEC 61108-1 [i.3] Edition 2.0	[i.3]	MSC.112 (1973)	Maritime navigation and radio communication equipment and systems Global navigation satellite systems (GNSS) - Part 1: Global positioning system (GPS) - Receiver equipment Performance standards, methods of testing and required test results	2003-07-01
IEC 61108-2 [i.4] Edition1.0	[i.4]	MSC 113 (1973)	Maritime Navigation and Radio communication Equipment and Systems - Global Navigation Satellite Systems (GNSS) - Part 2: Global Navigation Satellite System (GLONASS) - Receiver Equipment - Performance Standards, Methods of Testing and Required Test Results	1998-06-01
IEC 61108-3 [i.5] Edition 1.0	[i.5]	MSC 223 (1982)	Maritime Navigation and Radio communication Equipment and Systems - Global Navigation Satellite Systems (GNSS) - Part 3: Galileo receiver equipment - Performance requirements, methods of testing and required test results	2010-06-08
IEC 61108-4 [i.6] Edition1.0	[i.6]	MSC.114 (1973)	Maritime navigation and radio communication equipment and systems Global navigation satellite systems (GNSS) - Part 4: Ship borne DGPS and DGLONASS maritime radio beacon receiver equipment Performance requirements, methods of testing and required test results	2004-07-01

As reflected in the title in table 2, these standards need to be considered since they provide valuable inputs on:

- Description of the maritime receivers characteristics.
- Definition of the minimum performance requirement.
- Definition of the performance test, together with the test conditions (including interference).

In addition to the IEC standards, the following RTCM standards are also considered worth exploiting:

- **RTCM 10403.1 [i.7]:** This standard is used around the world for differential satellite navigation systems, both maritime and terrestrial.
  - This standard had been developed by RTCM Special Committee (SC) 104 as a more efficient alternative to the documents entitled "RTCM Recommended Standards for Differential Navstar GPS Service, Version 2.x. Service providing and vendors represented on the SC 104 Committee requested the development of a new standard that would be more efficient, easy to use and more easily adaptable to new situations.
  - Unlike Version 2.x, the Version standards do not include tentative messages. The messages in Version 3 have undergone testing for validity and interoperability, and are considered to be permanent. Future modifications of the standard may change the meaning of reserved bits or provide additional clarify test, but no changes will be made in the data fields.
  - The initial release of the new standard, i.e. Version 3.0 (RTCM paper 30-2004/SC104-STD), consisted primarily of messages designed to support real-time kinematic (RTK) operations. Version 3.0 provided messages that supported GPS and GLONASS RTK operations, including code and carrier phase observables, antenna parameters, and ancillary system parameters.
  - RTCM SC-104 believes that the new Standard 10403.1 for DGNSS services will prove useful in supporting highly accurate differential and kinematic positioning as well as a wide range of navigation applications worldwide throughout the next decade.

- Standard 10403.1(Version 3.1) describes messages and techniques for supporting GPS and GLONASS operation with one reference station or a network. However, the format is specially designed to make it straightforward to accommodate new systems that are under development, Galileo on particular as well as modifications to existing system. It can also accommodate augmentation systems that utilize geostationary satellite with transponders operating in the same frequency bands. Generically these are called satellite-based augmentation system (SBAS), and they have been designed to be interoperable. The first to be implemented is the WAAS (Wide Area Augmentation System) which has been developed by the U.S. Federal Aviation Administration to supplement the GPS. The second is the European Geostationary Navigation Overlay System (EGNOS), designed to augment both GPS and GLONASS.

- **RTCM 10410.0 [i.8]:** An application-level protocol that supports streaming Global Navigation Satellite System (GNSS) data over the Internet.

  - Networked Transport of RTCM via Internet Protocol (Ntrip) is an application-level protocol that supports streaming Global Navigation Satellite System (GNSS) data over the Internet. Ntrip is a generic, stateless protocol based on the Hypertext Transfer Protocol (HTTP) 1.1. The HTTP objects are extended to GNSS data streams.

  - Ntrip is designed to disseminate differential correction data or other kinds of GNSS streaming data to stationary or mobile users over the Internet, allowing simultaneous PC, Laptop, PDA, or receiver connections to a broadcasting host. Ntrip supports wireless Internet access through Mobile IP Networks like GSM, GPRS, EDGE, or UMTS.

  - Ntrip consists of three system software components: NtripClients, NtripServers and NtripCasters. The NtripCaster is the actual HTTP server program, while NtripClient and NtripServer act as HTTP clients.

  - Ntrip is meant to be an open non-proprietary protocol. Major characteristics of Ntrip's dissemination technique are the following:

    - It is based on the popular HTTP streaming standard; it is comparatively easy to implement when limited client and server platform resources are available.

    - Its application is not limited to one particular plain or coded stream content; it has the ability to distribute any kind of GNSS data.

    - It has the potential to support mass usage; it can disseminate hundreds of streams simultaneously for up to a thousand users when applying modified Internet Radio broadcasting software.

    - Regarding security needs, stream providers and users are not necessarily in direct contact, and streams are usually not blocked by firewalls or proxy servers protecting Local Area Networks.

    - It enables streaming over any mobile IP network because it uses TCP/IP.

- **RTCM 10401.2 [i.9]:** A companion to RTCM 10403.1, this standard addresses the performance requirements for the equipment which broadcasts DGNSS corrections.

5.4 LBS standards

In the LBS domain, standardization activity is covered at 3GPP level and OMA Currently the OMA does not cover the performance standardization.

GNSS receivers' performance standardization has been covered in GSM, UMTS and LTE cases. All three cases are aligned. It is therefore proposed to exploit the following source:

- TS 136 171 [i.10].

GNSS minimum performance requirements (User Equipment (UE) supports A-GPS L1 C/A only):

- The minimum performance requirements specified in clause 5 of TS 136 171 [i.10] apply for UEs that support A-GPS L1 C/A only. The requirements for UEs that support other or additional A-GNSSs are specified in clause 6 of TS 136 171 [i.10].

- The A-GNSS minimum performance requirements are defined by assuming that all relevant and valid assistance data is received by the UE in order to perform GPS L1 C/A measurements and/or position calculation. This clause 5 of TS 136 171 [i.10] does not include nor consider delays occurring in the various signalling interfaces of the network.

- In the following clauses the minimum performance requirements are based on availability of the assistance data information and messages defined in annexes D and E of TS 136 171 [i.10].

GNSS minimum performance requirements (UE supports other or additional GNSSs):

- The minimum performance requirements specified in clause 6 of TS 136 171 [i.10] apply for UEs that support other A-GNSSs than GPS L1 C/A, or multiple A-GNSSs which may or may not include GPS L1 C/A. The requirements for UEs that support A-GPS L1 C/A only are specified in clause 5 of TS 136 171 [i.10].

- The A-GNSS minimum performance requirements are defined by assuming that all relevant and valid assistance data is received by the UE in order to perform GNSS measurements and/or position calculation. This clause 6 of TS 136 171 [i.10] does not include nor consider delays occurring in the various signalling interfaces of the network.

- In the following clauses the minimum performance requirements are based on availability of the assistance data information and messages defined in annexes D and E of TS 136 171 [i.10].

Table 3: A-GNSS performance requirements

Subclass	Description	Requirement
Sensitivity	A sensitivity requirement is essential for verifying the performance of A-GNSS receiver in weak satellite signal conditions. In order to test the most stringent signal levels for the satellites the sensitivity test case is performed in AWGN channel. This test case verifies the performance of the first position estimate, when the UE is provided with only coarse time assistance and when it is additionally supplied with fine time assistance.	-Coarse time assistance -Fine time assistance
Nominal accuracy	Nominal accuracy requirement verifies the accuracy of A-GNSS position estimate in ideal conditions. The primarily aim of the test is to ensure good accuracy for a position estimate when satellite signal conditions allow it. This test case verifies the performance of the first position estimate.	Minimum requirements (nominal accuracy)
Dynamic range	The aim of a dynamic range requirement is to ensure that a GNSS receiver performs well when visible satellites have rather different signal levels. Strong satellites are likely to degrade the acquisition of weaker satellites due to their cross-correlation products. Hence, it is important in this test case to keep use AWGN in order to avoid loosening the requirements due to additional margin because of fading channels. This test case verifies the performance of the first position estimate.	Minimum requirements (dynamic range)
Multi-path scenario	The purpose of the test case is to verify the receiver's tolerance to multipath while keeping the test setup simple. This test case verifies the performance of the first position estimate. In this requirement 5 satellites are generated for the terminal. Two of the satellites have one tap channel representing Line-Of-Sight (LOS) signal. The three other satellites have two-tap channel, where the first tap represents LOS signal and the second reflected and attenuated signal.	Minimum requirements (multi-path scenario)

In addition to this TS 136 171 [i.10], 3GPP working groups have also issued a high level description of the Location Services (LCS):

- TS 122 071 [i.11].

Horizontal Accuracy:

- The accuracy that can be provided with various positioning technologies depends on a number of factors, many of which are dynamic in nature. As such the accuracy that will be realistically achievable in an operational system will vary due to such factors as the dynamically varying radio environments (considering signal attenuation and multipath propagation), network topography in terms of base station density and geography, and positioning equipment available.

- The accuracy for location services can be expressed in terms of a range of values that reflect the general accuracy level needed for the application. Different services require different levels of positioning accuracy. The range may vary from tens of meters (navigation services) to perhaps kilometres (fleet management).

- The majority of attractive value added location services are enabled when location accuracies of between 25 m and 200 m can be provided.

- Based on decreasing accuracy requirement some examples of location services are provided in table 4. The LCS service should provide techniques that allow operators to deploy networks that can provide at least the level of accuracy required by the regional regulatory bodies.

Table 4: Example of location services with decreasing accuracy requirement

Location-independent	Most existing cellular services, stock prices, sports reports
PLMN or country	Services that are restricted to one country or one PLMN
Regional (up to 200 km)	Weather reports, localized weather warnings, traffic information (pre-trip)
District (up to 20 km)	Local news, traffic reports
Up to 1 km	Vehicle asset management, targeted congestion avoidance advice
500 m to 1 km	Rural and suburban emergency services, manpower planning, information services (where are?)
100 m (67 %)	U.S. FCC Report and Order 99 - 245 [i.21] for wireless emergency calls using network based positioning methods
300 m (95 %)	-
75 m - 125 m	Urban SOS, localized advertising, home zone pricing, network maintenance, network demand monitoring, asset tracking, information services (where is the nearest?)
50 m (67 %)	U.S. FCC Report and Order 99 - 245 [i.21] for wireless emergency calls using handset based positioning methods
150 m (95 %)	-
10 m - 50 m	Asset Location, route guidance, navigation

- Accuracy may be independently considered with respect to horizontal and vertical positioning estimates. Some location services may not require both, others may require both, but with different degrees of accuracy.

- Given that the location estimate is the best possible within the bounds of required response time, the location estimates of a fixed position UE (assuming several estimates are made) will reveal a 'spread' of estimates around the actual UE position. The distribution of locations can be described by normal statistical parameters and suggests that a small proportion of location estimates may lie outside of the acceptable Quality of Service (QoS) parameters for specific services (as determined by the network operator).

Vertical Accuracy:

- For Value Added Services, and PLMN Operator Services, the following is applicable:

  - The LCS Server may provide the vertical location of an UE in terms of either absolute height/depth or relative height/depth to local ground level. The LCS Server should allow a LCS Client to specify or negotiate the required vertical accuracy. The LCS Server should normally attempt to satisfy or approach as closely as possible the requested or negotiated accuracy when other quality of service parameters are not in conflict.

  - The vertical accuracy may range from about ten metres (e.g. to resolve within 1 floor of a building) to hundreds of metres.

  - For Emergency Services (where required by local regulatory requirements) there is no requirement for the support of vertical positioning.

Response Time:

- Different location based services, or different LCS Clients, may have different requirements (depending on the urgency of the positioning request) for obtaining a response. The location server may need to make trade-offs between requirements for positioning accuracy and response time.

- For Value Added Services, and PLMN Operator Services, the following is applicable:

  - Response Time is one of the negotiable QoS parameters. Support of response time by a Public Land Mobile Network (PLMN) is optional. The LCS Server may allow a LCS Client to specify or negotiate the required response time (in the context of immediate location request, see table 1) either at provisioning or when the request is made. The LCS Server may optionally ignore any response time specified by the LCS Client that was not negotiated. If response time is not ignored, the LCS Server should attempt to satisfy or approach it as closely as possible when other quality of service parameters are not in conflict.

- For immediate location request response time options are as follows:

  - "no delay": the server should immediately return any location estimate that it currently has. The LCS Server should return either the Initial or Last Known Location of the Target UE. If no estimate is available, the LCS Server should return the failure indication and may optionally initiate procedures to obtain a location estimate (e.g. to be available for a later request).

  - "low delay": fulfilment of the response time requirement takes precedence over fulfilment of the accuracy requirement. The LCS Server should return the Current Location with minimum delay. The LCS should attempt to fulfil any accuracy requirement, but in doing so should not add any additional delay (i.e. a quick response with lower accuracy is more desirable than waiting for a more accurate response).

  - "delay tolerant": fulfilment of the accuracy requirement takes precedence over fulfilment of the response time requirement. If necessary, the server should delay providing a response until the accuracy requirement of the requesting application is met. The LCS Server should obtain a Current Location with regard to fulfilling the accuracy requirement.

- For Emergency Services (where required by local regulatory requirements) there may be no requirement to support negotiation of response time. The network should then provide a response as quickly as possible with minimum delay. Response time supervision is implementation dependent.

TS 122 071 [i.11] provides a list of identified LBS receiver use cases (list of possible Location Based Services), for which the overall 3GPP LCS specifications (A-GNSS in particular) have been tailored. For the sake of overall consistency, such inventory is considered when executing this study.

6 Potential areas of standardization

This clause lists all the areas of standardization potentially falling within the terms of reference of the ETSI Satellite Communications and Navigation (SCN) Working Group.

6.1 Location system architecture, features and performance

This first field of standardization is intended to address several aspects of the location systems. First aspect is the definition for the key functional requirements applicable to location systems in order to fulfil their objectives. Second aspect is the definition of a reference system architecture (which imbeds both terminals and servers), and within this architecture, the identification of the components interfaces needed to achieve the location function. Finally, the last aspect is the specification of a set of minimum performances applicable to these location systems.

The objective is now to assess the relevance of each existing standard for the sake of TC SES/SCN targeted standardisation work. To do so, the following method is followed:

- a list of the key contributions needed in order to achieve TC SES/SCN goal is built;
- for each of these contributions, the existing standards are examined to identify if they contain relevant information (even partially relevant); and
- finally, a conclusion is proposed, assessing the lack of existing standards exhibited through this analysis.

Table 5 lists the results of the first 2 steps.

Table 5: Synthesis on relevancy of existing standards

	ITU	RTCA	RTCM	3GPP	OMA
Application inventory	TBD	One application domain Safety of Life application however not addressed in the standard	One application domain	TS 122 071 [i.11] Partial Inventory of mass market application Missing rail and road related ones	OMA-RD-SUPL-V2_0 [i.24] OMA-RD-LPPe-V1_0 [i.25]
Operational environment	> ITU-T Rec. P.681-6 [i.16] Propagation models relevant for space-earth communication > ITU-R Rec. M.1903 [i.1] Impact on RF interference on RNSS in L1 band	MOPS DO-229D [i.2] Very specific, limited in particular in terms of local error components Used dynamic not adapted to mass market applications	Very specific, limited in particular in terms of local error components Used dynamic not adapted to mass market applications	TS 145 005 [i.15] Small diversity of defined operational environment. No focus on use dynamics	OMA-RD-SUPL-V2_0 [i.24] OMA-RD-LPPe-V1_0 [i.25]
Location architecture definition	> ITU-R Rec. M.1903 [i.1] At terminal level, preliminary list of GNSS receiver technical characteristics for receiver classification	None	IEC 61108, parts 1 [i.3] to 4 [i.6] Input on maritime receiver characteristics	TS 123 271 [i.17] (Stage 2 architecture) Single type of terminal (GSM/UMTS/LTE handset) considered Terminal techno limited to A-GNSS, full variety of targeted hybridization not achievable	OMA-AD-SUPL-V2_0 [i.26] Single type of terminal (GSM/UMTS/LTE handset) considered Terminal techno limited to A-GNSS, full variety of targeted hybridization not achievable
Interface definition	None	None	None	TS 123 271 [i.17] (Stage 2 architecture)	
Protocol definition	None	None	None	TS 136 355 (LPP) [i.18] Good basis, for the Location server/ Location terminal exchange protocol	OMA-TS-ULP-V2_0 [i.27] OMA-TS-LPPe-V1_0 [i.28] Good basis, for the Location server/Location terminal exchange protocol
Minimum performance	> ITU-R Rec. M.1903 [i.1] Assessment of performance degradation due to RF interference		> IEC 61108, parts 1 [i.3] to 4 [i.6] Input on required minimum performance	TS 136 171 [i.10]	Clearly out of the activities of OMA LOC.
Test procedure			> IEC 61108, parts 1 [i.3] to 4 [i.6] Input on test conditions	TS 137 571-1 [i.23]	

The conclusion of this analysis stresses the importance of the standardization work promoted in the present document.

Indeed, it becomes clear that the various existing standards suffer from a number of limitation when addressing the standardization of architecture, interface and minimum performance for Location Systems over a wide scope of applications:

- Civil aviation standards address a very specific field of application , with safety of life issues. Considered environments are very specific (see clause 5.4 of TR 101 593 [i.12]), regarding local error components and used dynamics.
  On the other hand, these standards propose a classification of GNSS receivers which can be exploited, in particular concerning the list of parameters considered.
  - new standard is needed to export these technical elements to the range of applications considered here.
- ITU Recommendations propose valuable information regarding propagation condition, and RF interference impact on L1 GNSS signals, which can be exploited in the frame of the standard under construction. However, concerning definition of system architecture, interface and minimum performance, little information is available.
  - new standard is needed to fulfil this need.
- As far as maritime domain is considered, a very relevant standard is available, since it proposes specification on "Receiver Equipment - Performance Standards, Methods of Testing and Required Test Results". However, in this domain, the need concerns both the diversity of considered applications (restricted to maritime use) and receiver technology considered (maritime receiver).
  - new standard is needed to adapt the work performed in the maritime domain to a wider scope of applications, in accordance with the on-going standardisation work.
- Finally, terrestrial mobile telecommunications standards (through 3GPP and OMA) propose may be the most relevant source of information. Thus, it provides definition of the system architecture, interface, protocol, in a form which seems compatible with the on-going standardization work. However, it suffers from a lack in terms of technological enablers' inventory at terminal level, since it only considers GNSS receiver and communications modem as source location capability.
  - new standard is needed to extend the system architecture, interface, protocol and performance definition to new enablers such as INS, smart antenna, or any new sensor supporting the location function. Note also that the scope of application should be widened.ECC Report 129: "

6.2 Pseudolites

Pseudolites (Pseudo satellites, PL) are ground based radio transmitters , that transmit an "RNSS"-like navigation signal that can be received and processed by standard radio navigation receivers compatible to the signals published in the Signal-in-Space Interface Control Documents (SIS-ICD) of the Galileo [i.20] and GPS [i.19] systems. They are intended to complement systems in the Radio navigation Satellite Service (RNSS) by transmitting on the same frequencies in the bands 1 164 MHz to 1 215 MHz, 1 215 MHz to 1 300 MHz, and 1 559 MHz to 1 610 MHz. PL may also apply to the GLONASS system as well.

Since other radio services could also be affected by uncontrolled use of PLs, CEPT conducted radio regulatory sharing studies between indoor PLs and other radio services. ECC Report 168 [i.29] as well as ECC Recommendation (11)08 [i.30] for indoor pseudolites is available containing a framework for an authorisation regime of indoor GNSS pseudolites.

CEPT also conducted studies on other devices in the GNSS bands, GNSS repeaters, these are described in CEPT Reports 129 [i.31] and 145 [i.32] and developed ECC Recommendation (10)02 [i.33] for providing guidance to administrations for implementing an authorisation scheme for GNSS Repeaters. ETSI has also created a Harmonized European Standard for GNSS Repeaters, EN 302 645 [i.22].

Studies regarding outdoor pseudolite usage are ongoing in the CEPT.

6.3 GNSS logical assistance channel

This is for further study.

History

Document history		
V1.1.1	October 2012	Publication