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Technical Report

3rd Generation Partnership Project;

Technical Specification Group Services and System Aspects;

Study on positioning use cases;

Stage 1

(Release 16)

** 

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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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x the first digit:

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

# 1 Scope

This technical report relates to a study on positioning use cases for both outdoor and indoor environments. It analyses positioning use cases and complements existing work on 5G use cases involving positioning needs in order to identify potential requirements for 5G positioning services.

This document also identifies new use cases, their scope and environment of use along with the related KPIs. For use cases already addressed (fully or partially) in other 3GPP studies, it consolidates and validates the KPI and assumptions.

The document further develops the identified use cases by providing some considerations on the suitability of positioning technologies to these use cases. These considerations support the identification of potential requirements that can be achieved with 3GPP positioning technologies or with a combination of 3GPP and non-3GPP positioning technologies. The use cases and performance targets are independent of specific solutions even though, in order to support these considerations, the report provides some illustrative allocation between existing positioning technologies and 3GPP new positioning technologies (e.g. NR-based).

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 38.805: “NG Radio Access Network (NG-RAN); Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN”

[3] ISO-CD 19363.2 20180120:Electrically propelled vehicles

[4] IEC TS 61980-3 ED1:Electric vehicle wireless power transfer (WPT) systems – Part 3 Specific requirements for the magnetic field wireless power transfer systems

[5] NGMN Alliance: “5G White Paper”

[6] ETSI TS 103 246-1 V2.0.13 (2016-10): “Satellite Earth Stations and Systems (SES); GNSS based location systems. Part 1: Functional Requirements”

[7] FCC CSRIC WORKING GROUP 3 “E911 Location Accuracy - Indoor Location Test Bed Report”

# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

## 3.2 Symbols

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

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

2D: 2-dimensions

3D: 3-dimemsions

CDF: Cumulative Distribution Function

HA-GNSS: High Accuracy GNSS

FTM: Fine-Time Measurement (as defined in 802.11-2016)

IMU: Inertial Measurement Unit

KPI: Key Performance Indicator

RTK: Real Time Kinematic

UAV: Unmanned Aerial Vehicle

UAS: Unmanned Aerial System

# 4 Overview

Clause 5 describes the positioning use cases, categorized by verticals, as follows:

- Regulatory (e.g. emergency call, LI)

- Mission Critical

- Location-Based Services (e.g. LCS, gaming, social networking, position-enabled advertisement)

- Industry and eHealth (e.g. automation, asset management and tracking, device telemetry – metering, patient monitoring)

- Road (e.g. vehicle environment, road-user charging)

- Railway

- Maritime

- Aerials (e.g. UAV/UAS)

- Others

A synthesis of all the use cases requirements is provided in Clause 6 summarising targets for positioning services along with a grouping of some use cases, when this grouping is possible and relevant.

Clause 7 develops some considerations on the suitability of positioning technologies for the identified use cases, considering both 3GPP and non-3GPP positioning technologies. The related mapping builds on a background material to reveal the use cases that can be covered by existing technologies (standalone or combined) and the use cases for which 3GPP new positioning technologies (e.g. NR-enabled) are needed to cope with the shortcomings of existing technologies.

Clause 8 identifies initial potential requirements for 5G positioning services based on the considerations developed in Clause 7.

# 5 Use cases

## 5.1 Foreword

### 5.1.1 Key Performance Indicators and Key attributes for positioning use cases

The following KPI apply to the definition of the use-cases positioning requirements:

- **Position accuracy**: describes the closeness of the measured position of the UE to its true position value. The accuracy can describe the accuracy either of an absolute position or of a relative position. It can be further derived into a horizontal position accuracy – referring to the position error in a 2D reference or horizontal plane, and into a vertical position accuracy – referring to the position error on the vertical axis or altitude.

- **Speed accuracy**: describes the closeness of the measured magnitude of the UE’s velocity to the true magnitude of the UE’s velocity.

- **Bearing accuracy**: describes the closeness of the measured bearing of the UE to its true bearing. Both the measured and the true bearing are defined in a common base coordinate system, using yaw-pitch-roll as for aircraft principal axes. For a moving UE, the bearing is a measure of the velocity’s direction and this KPI can be combined with speed accuracy into the velocity’s accuracy.

- **Timestamp accuracy**: the position-related data (e.g. position, velocity) are usually associated to a timestamp, marking the time when the position-related data has been determined. The timestamp accuracy describes the closeness of the timestamp value to the true instant when the related data was computed.

- **Availability**: percentage of time when a positioning system is able to provide the required position-related data within the performance targets or requirements.

- **Latency**: time elapsed between the event that triggers the determination of the position-related data and the availability of the position-related data at the positioning system interface. At initialisation of the positioning system, the latency is also defined as the Time to First Fix.

- **Time to First Fix (TTFF)**: time elapsed between the event triggering for the first time the determination of the position-related data and the availability of the position-related data at the positioning system interface. TTTF is greater or equal to Latency.

- **Update rate**: rate at which the position-related data is generated by the positioning system. It is the inverse of the time elapsed between two successive position-related data.

**- Power consumption**: electrical power (usually in mW) used by the positioning system to produce the position-related data.

**- Energy per Fix**: electrical energy (usually in mJ per fix) used by the positioning system to produce the position-related data. It represents the integrated power consumption of the positioning system over the required processing interval. It considers both the processing energy and the energy used during the idle state between two successive productions of position-related data. This KPI can advantageously replace the power consumption when the positioning system is not active continuously (e.g. device tracking).

**- System scalability**: amount of devices for which the positioning system can determine the position-related data in a given time unit, and/or for a specific update rate.

The aforementioned Key Performance Indicators can be dependent of the UE’s dynamic and/or dependent of its location in the cell. The KPI defines a target either for each dependence, or for the worst-case.

Furthermore, some applications can have specific needs in terms of insurance of the quality of service, usually addressed in dedicated certification process and standards outside 3GPP. Most of the time, these applications are safety-critical or liability-critical applications.

For the purpose of this document, the following additional KPIs can be considered on a case-by-case basis.

**- Continuity**: likelihood that the positioning system functionality will be available during the complete duration of the intended operation if the positioning system is operational at the beginning of the operation.

**- Reliability**: measure of the ability of a positioning system to provide the position-related data under stated conditions for a specified period.

**- Integrity**: measure of the trust in the accuracy of the position-related data provided by the positioning system and the ability to provide timely and valid warnings to the UE and/or the user when the positioning system does not fulfil the condition for intended operation.

**- Time to alert**: time elapsed between a change of the integrity (as defined above) and the information to the UE and/or the user.

**- Authentication**: provision of assurance that the position-related data associated with the UE has been derived from trusted and authorised sources (e.g. real signals and not falsified signals). This KPI is different from security, which defines the measures to ensure that the position-related data is safeguarded against unapproved disclosure or usage inside or outside the positioning-system. Because it cannot be summarised and quantified as a scalar target, this KPI is managed as a binary field in the present report: yes or no provision of positioning authentication is needed.

**- Security / Privacy**: measures to ensure that the position-related data is safeguarded against unapproved disclosure or usage inside or outside the positioning system and/or to ensure that a non-authorized party cannot access information relating to the privacy of the user. Because it cannot be summarised and quantified as a scalar target, this KPI is managed as a binary field in the present report: yes or no security and/or privacy is needed.

In addition to the aforementioned KPIs, the use cases’ description can consider the following key attributes, because they affect significantly the positioning performances and operating conditions of the related technologies:

**- Environment of use**: the physical environment in which the UE operates. It describes the service area or volume (e.g. building, cell or network coverage, regional, global coverage) as well as the high-level properties affecting radiofrequency propagation and positioning such as the nature of the service area (open i.e. no obstruction, aerial, sub-urban, canyons urban or natural, indoor including tunnels). In case of multiple environments, the attribute shall also define whether the use case is expected to operate seamlessly in all these environments.

- **5G positioning service area** - a service area where positioning services would solely rely on infrastructures and positioning technologies that can be assumed to be present anywhere where 5G is present (e.g. a country-wide operator-supplied 5G network, GNSS, position/motion sensors). It corresponds to the so-called “identical communication and positioning coverage area” in 5.55 from 3GPP TR 22.891-e20 (Feasibility study on New Services and Markets Technology Enablers). This includes both indoor and outdoor environment, and for the latter, any outdoor environment (rural with low density of node but little obstruction, urban with high density of node and obstruction by building, etc.). The 5G positioning service area can be considered for use cases that must work in any 5G environment, for example in any building – commercial, public or residential alike – e.g. to localize a patient getting a heart attack in an apartment building

- **Bounded service area** or **Dedicated service area** - a subset of the 5G positioning service area where specific positioning services can be provided (e.g. enhanced performances when compared to the performances achieved in the whole 5G positioning service area).

- **Enhanced positioning area** - a subset of the 5G positioning service area that is assumed to be provided with additional infrastructure or deploy a particular set of positioning technologies to enhance positioning services. It corresponds to the term “Enhanced positioning coverage area” in 5.55 from 3GPP TR 22.891-e20 (Feasibility study on New Services and Markets Technology Enablers). For example, a hospital (campus) could be equipped to enable tracking of patients, personnel and assets throughout the hospital with improved accuracy and availability (e.g. using a higher density of small cells, nodes or WLAN access points). This additional infrastructure could use a combination of 3GPP technologies and non-3GPP technologies, and cover both indoor and outdoor environments.

**- UE dynamic**: the UE can be either static or moving. In the latter, the attribute shall also provide some elements about its motion, e.g. maximum speed, trajectory.

**- UE density**: defined as the number of UEs per km².

**- Consideration on positioning sources (or reference nodes) density with impact on positioning KPI** - for example, some use case may consider a specific density or deployment to improve KPI target in a well-defined service area (e.g. hospitals, factory floor, etc.).

## 5.2 LBS-related use cases

### 5.2.1 Accurate positioning for shared bikes

#### 5.2.1.1 Description

The shared bike service allows a rider to rent a bike via a mobile app and drop it off anywhere for the next user. The accurate locations of shared bikes are available in the mobile app for the riders to find the nearest bike.

This service offers the citizens a cheap and convenient way for city trip. However, the ruthless management of bike parking will cause the problems such as blocking sidewalks. Electronic fence is used as a tool for regulating the parked bikes, and it requires high accuracy positioning of shared bikes.

#### 5.2.1.2 Pre-conditions

Tom downloads an app on his smart phone, which allows him to locate and unlock a nearby shared bike.

The shared bikes are equipped with 5G communication modules, smart lock as well as a 5G positioning module. This positioning module can use a combination of 3GPP technologies and non-3GPP technologies. This includes, but not limited to, GNSS (e.g. BeiDou, Galileo, GLONASS, and GPS), Terrestrial Beacon Systems (TBS), Bluetooth, WLAN, RFID, and sensors.

The parking areas are categorized as strictly parking-controlled areas and non-strictly parking-controlled areas.

For strictly parking-controlled areas which are mainly near bus hubs, subway stations and shopping centres, riders who park bikes outside the allowed areas (i.e., electronic areas) cannot lock them and will continue to be charged.

For non-strictly parking-controlled areas, instead of being forced, riders are just encouraged to park at any public bike rack or public location that does not interfere with pedestrians or traffic.

#### 5.2.1.3 Service Flows

1. Tom locates a nearby shared bike and unlocks it to start the trip. 5G provides positioning service with 2m horizontal position accuracy, 90% availability, less than 1s latency.

2. Tom rides the bike to the destination at the speed of 15-20km/hour, and during the trip the bike will report its location to the server frequently. 5G provides positioning service with 2m horizontal position accuracy, 90% availability, less than 1s latency.

3. Tom has completed his trip.

a) If the parking area is non-strictly parking-controlled area, Tom could park the bike freely at any public location and then lock the bike. The bike reports its location to server. 5G provides positioning service with 2m horizontal position accuracy, 90% availability, less than 1s latency.

b) If the parking area is strictly parking-controlled area, the mobile app will indicate him to park the bike in a designated electronic fence nearby. Otherwise, Tom cannot lock the bike and will continue to be charged. The app needs to check if the bike is precisely parked into the dedicated area. 5G provides a positioning service with 0.2m horizontal position accuracy, 99% availability, less than 1s latency.

#### 5.2.1.4 Post-conditions

[Editor's Note: text to be provided or "None" to be stated]

#### 5.2.1.5 Potential Impacts or Interactions with Existing Services/Features

[Editor's Note: text to be provided or "None" to be stated]

#### 5.2.1.6 Potential Requirements

The 5G system shall be able to provide a positioning service with 2m horizontal position accuracy, 90% availability, and less than 1s latency for the moving UE at the speed of 15-20km/hour outdoor.

The 5G system shall be able to provide a positioning service with 0.2m horizontal position accuracy,99% availability, and less than 1s latency for the static UE in a enhanced positioning area outdoor.

The 5G System shall be able to provide a positioning service with a TTFF less than [10] s

### 5.2.2 Accurate positioning to support Augmented Reality (AR)

#### 5.2.2.1 Description

Augmented reality (AR) goggles and Head-up displays (HUD) superpose contextual information relating to the user’s position and motion on the user’s field of view. AR goggles allow, for instance, the user to navigate, record video, identify targets and gather information about the surrounding environment for improved performance. They also allow the user to communicate with other users by sharing location and sending messages or communicate with those at home privately or on social media by sharing live video.

AR is enabled by the knowledge of the user’s position, motion and eventually, direction of view, and by access, with low latency, to databases of contextual information and geo-localized information systems (GIS). All users willing to interact with each other in an AR application should be equipped and communicate among each other with low latency.

In the field of LBS, AR supports multiple applications, including outdoor sports and leisure activities (skiing, motorcycling, sailing, surfing, rally, aviation and gaming) as well as social networking. Information about the weather conditions such as strength of wind or depth of snow layer may improve performance and help prevent dangerous situations such as avalanches. AR may also support “Blue forces”, like firefighters, that need to know real-time information about the fire such as temperature and severity of smoke, identify targets, safe location, etc. This area is not covered is the current use case.

At least for gaming and sports applications, the position-related data need to be secured and protected against tampering to dissuade from any attempt to fraud or cheat.

#### 5.2.2.2 Pre-conditions

The UE comprises at least a self-powered AR goggles, associated to a 5G communication module and a 5G positioning module. The 5G modules can be integrated in the goggles or held by the user and connected to the goggles.

The users have access to the AR Application Server through a 5G Network. The AR Application Server has access to all relevant contextual information, including maps of the user’s surrounding. Mapping and establishment of contextual information database are done beforehand.

#### 5.2.2.3 Service Flows

The user turns on the UE, and allows the system to initialise and eventually calibrate (e.g. heading, field of view).

The 5G positioning module enables the 3GPP system to determine position, velocity and goggles heading at a high rate. The frequency of the determination may vary according to the application requirements. This information is reported to the AR Application Server to provide the AR goggles with contextual information.

While moving, the user visualises messages and contextual information on the screen of the goggle. He can use the navigation feature to find a specific location or a target, follow a friend or pursue a track (for instance, a ski track, a route, etc.). He can use the communication feature to find out where friends or colleagues are and what they want to do next. He can also share live video to social media, or to a hospital in the case of an emergency.

The user can use the additional information available on the screen of the goggle to find out where it is best to go next for a safer and more enjoyable journey. This information can be a weather report, heart rate, steepness of slopes, altitude, temperature of the surroundings, etc.

#### 5.2.2.4 Post-conditions

[Editor's Note: text to be provided or "None" to be stated]

#### 5.2.2.5 Potential Impacts or Interactions with Existing Services/Features

[Editor's Note: text to be provided or "None" to be stated]

#### 5.2.2.6 Potential Requirements

The 5G system shall be able to provide positioning service to support AR applications with [1-3] m horizontal position accuracy, 80% availability, for static or UE moving at speed below 50km/h outdoor.

The 5G system shall be able to provide positioning service to support AR applications with better than [10] m horizontal position accuracy, 80% availability, for UE moving at speed up to 130 km/h outdoor.

The 5G system shall be able to provide positioning service to support AR applications with [0.1-3] m vertical position accuracy, 80% availability.

The 5G system shall be able to provide positioning service to support AR applications with better than [2] m/s horizontal velocity accuracy and [10]º bearing accuracy, 80% availability, for UE moving at speed up to 130 km/h outdoor.

The 5G System shall be able to provide positioning service to support AR applications with a TTFF less than [10] s.

The 5G system shall be able to fulfil the requirements of the positioning service using less than [5] % of the UE’s power consumption on average and less than [10] % of the UE’s power consumption in the worst case.

The 5G System shall support mechanisms to protect positioning-related data against tampering and spoofing.

The 5G System shall support mechanisms to detect tampering and spoofing attempts on the position-related data.

The 5G System shall be able to ensure the positioning related data are secured, and shall allow the protection of the user’s privacy.

### 5.2.3 Power saving mechanism of wearable devices

#### 5.2.3.1 Description

Wearable device applications are becoming more and more grateful. Some of the top wearable device manufacturers are constantly providing new features, such as smart watches. For some areas, smart watches can replace mobile terminals to provide basic services, such a tracking, activity monitoring and emergency messages, especially for minors or the elderly people. Smart terminals focus on providing location services and provide better positioning and monitoring functions for these populations. But these wearable devices require higher power durability.

#### 5.2.3.2 Pre-conditions

Ryder is a minor, and his parents want to monitor his location by a smart watch. His range of motion is regular but calls for different working point of the monitoring function:

- When Ryder is in school, his environment’s security is relatively high and there is less need for continuous monitoring of his location.

- When Ryder is outside school, in various environment less secured than the school, it is desirable for his parents to monitor continuously his location.

Ryder wears a smart watch. As a 5G UE, it is equipped with 5G communication and 5G positioning modules.

- Wearable devices, such as smart watches, can be accessed into a macro network or any 5G enabled access network.

- Intelligent control terminals, such as mobile phones and pad, access to the same network, and to monitor the location of the selected wearable devices. They run a monitoring function making them a monitoring terminal.

- A security range set, Ryder’s parents using the monitoring terminal may access the 5G network and set the security area on the positioning modules.

#### 5.2.3.3 Service Flows

1. The monitoring terminal (that is an intelligent control terminal) sets one or several security ranges through the network. The security ranges are stored in the positioning modules of network.

2. Ryder enters his school, identified as one of the security range in the positioning modules of the network. His current location is determined and available to the network. The smart watch is informed to switch into the power-saving mode.

3. The position update rate of the smart watch is reduced, lengthening the update interval to save power.

4. Ryder arrives at the school boundary or crosses the boundary. The smart watch returns to its normal position update rate, according to the network instruction.

#### 5.2.3.4 Post-conditions

Power normal mode, is that the smart watch provides the nominal positioning update rate in areas where continuous monitoring is needed, with an update interval of the position between 1s and 10s. And if the UE is in the normal mode, the positioning service update is 2m horizontal position accuracy, 99% availability, and less than 1s latency.

Power saving mode, is that the smart watch switch to power saving mode with lower update rate when the user is in secured or trusted ranges, with an update interval of the position between 30s and 300s. By adapting its positioning update rate to the effective monitoring needs, the smart watch lengthens its battery lifetime. And if the UE is in the power saving mode, the positioning service update is 2m horizontal position accuracy, 90% availability, and less than 1s latency.

The use case could be expanded to other verticals and categories, for instance e-health for patient tracking, industry for mobile security monitoring, etc.

#### 5.2.3.5 Potential Impacts or Interactions with Existing Services/Features

None identified.

#### 5.2.3.6 [Potential] Requirements

The 5G system shall be able to provide positioning service with 2m horizontal position accuracy, indoor [1-3] m vertical position accuracy, 90% availability, and less than 1s latency for the UE in the location power saving mode.

The 5G system shall be able to provide positioning service with 2m horizontal position accuracy, indoor [1-3] m vertical position accuracy, 99% availability, and less than 1s latency for the UE in normal mode.

The 5G System shall be able to request the UE to provide its location periodically with an update rate ranging from one location every [1s-10s] in location normal mode to one location every [30s-300s] in location power saving mode.

The 5G network shall be able to request the UE to provide its location wherever it is indoor or outdoor.

The 5G System shall be able to provide positioning service with TTFF less than [10] s.

### 5.2.4 Location-based advertising push

#### 5.2.4.1 Description

Data mining has been widely used in OTT (over the top). However, operators do not have a flexible mechanism to apply location data. People’s activity is regular and causal. According to the records of the UE’s location in a period of time, comfort active areas can be formed. People don't want to be bothered by unnecessary advertisements, except things that are closely related to themselves in the comfort active areas. Therefore, data analysis based on human activity location needs to be introduced into location-based advertising push.

#### 5.2.4.2 Pre-conditions

Users of the 5G network are equipped with 5G communication module, as well as a 5G positioning module. This positioning module can use a combination of 3GPP technologies and non-3GPP technologies. This includes, but not limited to, GNSS (e.g. BeiDou, Galileo, GLONASS, and GPS), Terrestrial Beacon Systems (TBS), sensors, WLAN, and Bluetooth-based positioning.

In the network, there will be user location analysis equipment. Users of the 5G network periodic send location to the network. Their daily location habits will be recorded into the analysis equipment. The analysis of equipment will form a comfortable area of activity.

Operators have business location and advertising information in the comfort active area.

#### 5.2.4.3 Service Flows

1. Ryder uses 5G terminals, and often goes to the local supermarket near home.

2. He also plays football every week.

3. And stick to the training centre to learn Spanish.

4. His locations form the triangle region at the top of these three places.

5. The network analysis the comfort active area according to his locations and residence time.

6. The operator extracts the location and advertising information of shops in his comfort area based on the analysis of his locations and residence time.

7. For example, Ryder often stays on the football field. Therefore, the network extracts the advertising information of some football related stores.

8. The network pushes him discount information on nearby local supermarkets and drink price tips for use during the football match in bars in the neighbourhood.

#### 5.2.4.4 Post-conditions

None identified.

#### 5.2.4.5 Potential Impacts or Interactions with Existing Services/Features

None identified.

#### 5.2.4.6 [Potential] Requirements

Subject to regulatory requirements and user consent, the 5G System shall be able to provide the UE’s location information, with less than 3m horizontal position accuracy, [3 m] vertical position accuracy, over 90% availability, and less than 1min latency.

### 5.2.5 Flow management in large transportation hubs

#### 5.2.5.1 Description

Airports are getting bigger and busier which calls for efficient flow management to maximise punctuality to the benefit of passengers and airline companies. By using a location-based mobile application, the passengers can easily find their way around, even in unknown airports and in a hurry, reducing time of transit in the airport and lowering risk of delays and missed connections. In the eventuality of work or maintenance performed in the passengers’ halls, the application will propose alternative routes to passengers.

Airline companies can be informed, by the airport and the application server, of their passengers’ situation in near real-time: they can use the information to optimise their embarking operations and reduce risk for last minutes call to gate, flight delays because of one passenger, etc.

Using passengers’ location information, the airport will be able to elaborate statistics on passengers flow to optimise their organisation and signalling to passenger.

By extension, the use case may encompasses applications for any transportation hub (metro or rail station, etc.) facing large passenger flows, connection and transit time issues.

#### 5.2.5.2 Pre-conditions

The passenger has a UE equipped with 5G communication modules, and 5G positioning module.

The passenger downloads a mobile application to his UE allowing him to find the quickest way to the gate, define a transit route accounting for his personal needs and matters (shopping, lunch, etc.) as well as for the need to proceed with security controls.

The application server has access to all relevant contextual information, including a map of the airport, flight information, and estimates transit time between different locations in the airport, including waiting time of security lines.

Mapping and establishment of contextual information database are done beforehand and updated in near-real time with the information reported by the users.

#### 5.2.5.3 Service Flows

1. The passenger turns on the application as he reaches the airport.

2. The application will suggest an itinerary to the gate of departure depending on preferences of the passenger (as quickly as possible, as little walking as possible, wheelchair friendly, shopping friendly, etc.).

3. The passenger will be notified of the estimated time to reach the gate, if there is a change of gate, time of departure or congestion or queues in some areas. The application will suggest a new route if relevant. The information in the application is provided in the language of preference of the passenger.

4. The passenger can use the app to find specific locations in the airport such as information desks, bathrooms, elevators, restaurants, shops, taxis, etc.

5. Based on the location of the passenger, the app can mark an alert if he is short of time and needs to proceed to the gate immediately.

6. In real time, airport and airlines operations are notified if passengers are delayed within their transit into the airport, or if they face risk of being delayed (security control, shopping, etc.). They have access to estimations of the expected time the passenger will need to reach gate (considering its effective position and real time flow estimation). They can use the information to organise individual call to gate (last minute calls, etc.) and make the overall flow more fluent.

#### 5.2.5.4 Post-conditions

Passengers can get to their gates more quickly, which reduces time of transit and time of travel in general. This will reduce delays, improve customer experience and optimise airport operations.

Airport authority and airline companies optimise their operations thanks to low management and improve their punctuality and efficiency.

#### 5.2.5.5 Potential Impacts or Interactions with Existing Services/Features

#### 5.2.5.6 Potential Requirements

The 5G system shall be able to provide positioning service with better than [10] m horizontal positioning accuracy, [80] % availability and update rate of [0.1] Hz in a enhanced positioning area, primarily indoor.

The 5G system shall be able to provide positioning service with better than [3] m vertical positioning accuracy, [80] % availability and update rate of [0.1] Hz in a enhanced positioning area, primarily indoor.

The 5G System shall be able to provide positioning service with TTFF less than [10] s.

The 5G System shall be able to ensure the protection and the privacy of the user’s position-related data.

The 5G System shall be able to provide indication of the user’s motion (velocity, bearing).

## 5.3 Industry and eHealth related use cases

### 5.3.1 Person and medical equipment location in hospitals

#### 5.3.1.1 Description

In some hospitals like psychiatry or geriatrics, it is necessary to locate the patients in real time on the site of the hospitals (indoor and outdoor) and to notify the medical staff if the patients reach a non-authorised area in order to avoid runaway patients.

Additionally, it is necessary to locate caregivers and medical equipment (e.g. crash cart), especially in emergency situations.

It is necessary to take into account the environment of hospitals: some are made up of several buildings on several hectares with large green areas and others are buildings of several floors and basements.

#### 5.3.1.2 Pre-conditions

The patient wears a device, e.g. a wrist-band which supports some mechanisms to obtain its location, as part of a 5G positioning module. The caregiver carries a mobile phone or tablet. The medical equipment has a built-in 5G positioning module. It is assumed that the 5G positioning module is linked to a communication module together forming a UE. The positioning module can use a combination of 3GPP technologies and non-3GPP technologies. The positioning module and related communication module have to be able to operate with very low energy consumption, given that the device in which it is used (e.g. patient worn wrist band) may have very limited battery and form factor.

NOTE: the hospital can be considered an enhanced positioning area.

#### 5.3.1.3 Service Flows

The UE enables the 3GPP system to determine its current location in a periodic or an event-triggered manner. The frequency of the location reporting may change according to the application requirements.

The UE reports location information that may include its applicable Equipment Identity. At any time, upon request, the UE shall be able to report its location information.

External systems can provide additional information to the Hospital System in order to improve location accuracy of a UE.

In case of periodic location reporting, the Hospital System supervises the continuous supply of the location information.

The received location information is stored by Hospital System.

#### 5.3.1.4 Post-conditions

The location information of the person or medical equipment is available in the Hospital System.

#### 5.3.1.5 Potential Requirements

The UE shall be able to provide its location to the Hospital System.

The 5G System shall be able to request the UE to provide its location.

The 5G System shall be able to request the UE to provide its location periodically.

The 5G System shall be able to request the UE to stop providing its location periodically.

The 5G System shall be able to handle additional location information from other external sources.

The 5G System shall be able to provide positioning service with a horizontal accuracy less than [3 m], a vertical accuracy less than [2 m] (i.e. floor accurate), an availability over [99%] and a latency lower than [1 minute]. The environment of use for the provision of the service shall be both indoor (including underground) and outdoor within the boundaries of the Hospital.

The 5G System shall support positioning of UEs using very little energy consumption on the UE.

NOTE1: the solution should consider UEs with limited form factor, limited CPU power, limited peak power, and limited radio access technology support (e.g. eMTC type communication only).

NOTE2: The aforementioned potential requirements do not preclude whether the position is computed in the UE or elsewhere in the 5G System (e.g. core network). Indeed, the determination of the UE’s position or location requires the UE to transmit some information (e.g. position, OTDOA measurements made on PRS, some signal allowing the UE’s identification and UTDOA measurements in the nodes, etc.) which refers to position-related data.

### 5.3.2 Patient location outside hospitals

#### 5.3.2.1 Description

In some hospitals like psychiatry or geriatrics, it is necessary to locate the patients in real time to notify the medical staff if the patient reaches a non-authorised area in order to avoid runaway patients.

When a patient manages to leave the hospital without authorisation, it is necessary to locate him (in a city and in rural area) in order to bring him back to the hospital.

Additionally, ambulatory patients with a potentially critical condition (e.g. cardiac, diabetes, high-risk pregnancy), as well as frail elderly, need to be localized in case their condition gets critical (e.g. elderly falling).

#### 5.3.2.2 Pre-conditions

The patient wears a device containing a 5G communication module, and a 5G positioning module. This positioning module can use a combination of 3GPP technologies and non-3GPP technologies. The patient’s wearable device should have a battery life of at least several days.

#### 5.3.2.3 Service Flows

The 5G positioning module enables the 3GPP system to determine its current location in a periodic or an event-triggered manner. The frequency of the location reporting may change according to the application requirements.

The 5G positioning module reports location information that may include its applicable Equipment Identity. At any time, upon request, the 5G positioning module shall be able to report its location information.

External systems can provide additional information to the Hospital System in order to improve location accuracy of a 5G positioning module.

In case of periodic location reporting, the Hospital System supervises the continuous supply of the location information.

Hospital System stores the received location information.

#### 5.3.2.4 Post-conditions

The medical staff localizes the patient.

#### 5.3.2.5 [Potential] Requirements

The 5G System shall be able to provide positioning service with a horizontal accuracy less than [10] m both indoors and outdoors. Furthermore, for indoors, the 5G System shall be able to provide positioning service with a vertical accuracy sufficiently accurate to determine the floor, so typically less than [3] m. This localization accuracy needs to be achieved throughout the 5G positioning service area.

### 5.3.3 Trolley location in factories

#### 5.3.3.1 Description

Factories use mobile trolleys and it is necessary to monitor their location and track the movement of these trolleys.

It is necessary to take into account the environment of factories: buildings have several floors and may have deep basement, some factories are made up of several buildings distributed over several hectares (e.g. campus with large green areas, trees, etc.). In addition, factories may be spread over several sites in vicinity.

In addition, exchanges of trolleys between factories are possible, and this includes exchanges between international locations: it shall therefore be ensured that the monitoring may be enabled in multiple locations, including in different countries.

#### 5.3.3.2 Pre-conditions

The trolleys are equipped with 5G communication modules, smart lock as well as a 5G positioning module. This positioning module can use a combination of 3GPP technologies and non-3GPP technologies.

#### 5.3.3.3 Service Flows

The 5G system shall be able to determine the current location of the UE in a periodic or an event-triggered manner. The frequency of the location reporting may change according to the application requirements. The 5G communication module reports location information that may include its applicable Equipment Identity. At any time, upon request, the 5G communication modules shall be able to report its location information.

External systems can provide additional information to the Factory System in order to improve location accuracy of 5G modules.

In case of periodic location reporting, the Factory System supervises the continuous supply of the location information.

The Factory System stores the received location information.

#### 5.3.3.4 Post-conditions

The location information for the connected trolley is always accessible in the Factory System.

#### 5.3.3.5 [Potential] Requirements

The 5G system shall be able to provide positioning service with [50] cm horizontal position accuracy, [1-3] m vertical position accuracy, and less than [20] ms latency for the moving UE at the speed of [50] km/hour indoor, taking into account at least a service area from [1 000 to 100 000] m².

The 5G system shall be able to provide positioning service in case of roaming.

### 5.3.4 Waste Management & Collection

#### 5.3.4.1 Description

Cities and urban population are expending and growing generating more and more waste to be managed and collected. Traditionally, waste collection was organized on fixed schedules through a given route, whether containers were full, partially full or even empty.

In order to reduce costs as well as to reduce drastically the impacts on the environment, municipalities are required to have smarter waste collection and management which is more efficient and optimize in particular the collection route.

Residential bins are including sensors that can signal when they need to be emptied. The routes taken by waste collection vehicles can then be optimised accordingly.

The connected bins can be configured to only send a message when they are full or to send updates once a day or even on a more regular basis (typically every 2 hours which could be configurable to 3h, 6h...). This allows for the reduction in number of vehicles needed for waste collection and thereby curbs greenhouse gas emissions. The sensors can also detect fires in the bins and send an alarm accordingly.

Trucks and vehicles in charge of the waste collection are equipped with positioning technology and can be send based on dedicated route to collect only the bins that have to be collected. In particular cases, some of these vehicles equipped to handle particular waste can be easily diverted to address urgent needs.

Furthermore, there are more and more waste containers not only for residential use but as well for use for retail stores, restaurants, hotels, etc. and other uses such as construction or building sites. For this particular case, very often these containers are not on a regular position and are moved to new site as soon as they are not needed anymore in their previous site. Companies that are managing many waste containers need then to know where are their containers to be able to re-allocate them when their use for a particular need is done.

#### 5.3.4.2 Pre-conditions

The waste bins and containers are equipped with a UE including a 5G communication module, as well as a 5G positioning module. This location equipment supports some mechanisms to allow the 5G System to determine the bin’s (or container’s) position either on demand or on a regular basis.

The waste collection vehicles are equipped with on-board unit including a 5G communication module, as well as a 5G positioning module.

The two aforementioned positioning modules can use a combination of 3GPP technologies and non-3GPP technologies such as GNSS (e.g. BeiDou, Galileo, GLONASS, and GPS), Terrestrial Beacon Systems (TBS), sensors, WLAN, and Bluetooth-based positioning.

The 5G system is interfaced to an application server (e.g. Waste Management and Collection System).

#### 5.3.4.3 Service Flows

The waste collection teams prepare their work plan. For that, they download information from the Waste Management and Collection System, these includes information relating to the waste bins and containers under their responsibility and supposed to be located in their area of work: filling percentage, most recent use (e.g. bin opening and evolution of filling following opening), position (or most recent positions log)

The Waste Management and Collection System determines whether the bins needs to be collected (it is full, it is expected to be full within the week, it is not full, but is rarely filled, therefore content may degrade and generate inconvenience to the neighbourhood: bad smell, animals trying to get bins content, etc.).

It also identifies a few container with waste requiring some specific handling as per regulation. The Waste Management and Collection System checks the identification and location of the container to verify if these are in line with regulation, and to check if owner is indeed complying with regulation.

If a bin or container is identified in the wrong place, the Waste Management and Collection System reports the incident, and notifies its owner to dissuade him from using the bin beyond its purpose. The Waste Management and Collection System may consider charging more the owner.

Knowing the bins and container to be collected, as well as the estimation of waste, the Waste Management and Collection System can determine the optimal work plan for the collect: number of vehicles involved, their trajectory, as well as their size and type tailored to the quantity and type of waste to be collected.

With the plan established, the team start the collect. They follow the scheduled work plan and route, guided in this thanks to the trucks position which is also determined by the 5G System

During the collect, a container equipped to report its status with low latency reports to the System it needs to be emptied. As its location is nearby the route of one of the collect vehicles, the Waste Management and Collection System updates the work plan, informs the vehicle and team (through the on-board unit) of the update. The team reroutes itself in due time to consider the new container to be collected.

#### 5.3.4.4 Post-conditions

The bin or waste containers are collected only when relevant. The collection vehicles collect only the relevant bins or containers, and are guided towards these by the Waste Management and Collection System with an optimised route.

The waste collection process is more efficient and this benefits to all stakeholders.

#### 5.3.4.5 Potential Impacts or Interactions with Existing Services/Features

[Editor's Note: text to be provided or "None" to be stated]

#### 5.3.4.6 [Potential] Requirements

The 5G System shall be able to determine the position of the UEs (bin, waste container) as well as the on-board units (waste collection vehicles) and report these positions to an application server (e.g. Waste Management and Collection system).

The 5G System shall be able to request the UE (bin/waste container) to provide its location.

The 5G System shall be able to request the UE (bin/waste container) to provide its location periodically with an update rate ranging from one location every [2 hours] to one location every [several days].

The 5G System shall be able to provide positioning service with a horizontal accuracy less than 3m, a vertical accuracy less than 2m, an availability over [99%] and a latency lower than 1 minute. The environment of use for the provision of the service shall be both outdoor (main use) and indoor (including underground parking…).

The 5G system shall be able to fulfil the requirement of the positioning service without affecting the UE’s battery overall lifetime by more than [5] % (e.g. 9 months out of a total of 15 years’ lifetime).

### 5.3.5 Support to accurate and reliable handling of containers

#### 5.3.5.1 Description

Products are transported mainly in containers and autonomous container management is becoming more and more frequent. Containers are stored in varied places as ships, docks or factories. In order to take up as little space as possible, they are stacked on several level and/or floors.

In addition to the possibility of locating them, it is very useful to have information the location on the container of the reference point used for their location, to determine the attitude or bearing of bearing of the container as well as to acces information on their size (width, height, depth among the possible standards). This then helps their autonomous handling and also allows a better spatial representation of the 3D arrangement of containers on a storage site. The containers doors must be well oriented in any case and this orientation must be known by the handling system.

In addition, containers are often handled in challenging environments for positioning technologies (For example, the high density of containers in harbour or on board ships, the way they are stacked, etc. create many obstructions for radio waves used by most positioning technologies). It is therefore relevant to consider the use of multiple sensors, sometime of different positioning technologies, to allow the system to enhance positioning performances like accuracy, availability even in complex situation.

A minimum of two sensors is needed in order to identify the direction of the container. Two or more sensors enable measurement diversity which can in turn improve availability and reliability of the measurements when the containers are located in harsh conditions for wireless systems (e.g. when they are stacked).

#### 5.3.5.2 Pre-conditions

The containers are equipped with 5G communication modules, smart lock as well as a 5G positioning module. This positioning module can use a combination of 3GPP technologies and non-3GPP technologies, involving multiple sensors. For different reason, including accommodation of physical constraints, protection against shock, and others, these sensors are distributed in different places on the containers. A minimum of two sensors is needed to determine the position and the heading of the container.

The 5G System knows the position of the different sensors placed on a container involved in the determination of both the position and the heading.

The Factory System knows the relative position of the sensors involved in the determination of both the position and the heading.

The Factory System knows the dimension of the container.

#### 5.3.5.3 Service Flows

Container C reaches an intermodal node by rail and needs to be stored for a while before being transborded on a cargo ship. This handling involves some automatic operation managed by the Factory System, using among other inputs, the position and the heading of the container.

Multiple positioning sensors distributed on container C are activated and enable the 5G System to collect the associated position-related data. The 5G system combines these information to determine the position and the orientation of the container C. The 5G system can also combine data from different sensors and technologies in order to enhance the overall performances of the positioning service (accuracy, availability in harsh environments, reliability, etc.).

The 5G system provides all information concerning the container C (positioning sensors and their reference) to the Factory System.

The Factory System, according information stored in its database (size, relative position of the different sensors on the container) can determine the exact 3D position to manage the container C’s handling operations.

#### 5.3.5.4 Post-conditions

Thanks to the high-quality position and heading data provided by the 5G System, the Factory System was able to handle the container from the wagon to its storing location, on top of three other containers, with minimal shocks and risk of hazards.

The information provided by the 5G System relating to the different sensors placed on the container allows the Factory System to mane them and to determine the exact 3D position of the container.

#### 5.3.5.5 Potential Impacts or Interactions with Existing Services/Features

[Editor's Note: text to be provided or "None" to be stated]

#### 5.3.5.6 [Potential] Requirements

The 5G Sytem shall be able to determine relative positioning of one UE versus another UE, in order to determine the heading of an object carrying the UEs.

The 5G system can combine data from different technologies in order to enhance the overall performances of the positioning service (accuracy, availability in complex environments, reliability, etc.).

The 5G System shall be able to provide the relative positioning of UEs to an application server.

The 5G system shall be able to provide this complementary information in case of roaming.

## 5.4 Emergency and Mission Critical related use cases

### 5.4.1 Accurate positioning for emergency services

#### 5.4.1.1 Description

An emergency service enables a user to contact a Public Safety Answering Point (PSAP) and requires the emergency services user/UE to have accurate positioning such that they may be located and offered aid by first responders. The level of positioning accuracy (and other KPIs) required is dependent upon local and regional regulatory requirements.

This service offers the citizens within a jurisdiction to be located in the time of need and requires high accuracy UE positioning in all service areas, including those that could potentially be challenging for some positioning technologies (e.g. urban canyons, indoors).

#### 5.4.1.2 Pre-conditions

Tom experiences or witnesses an emergency situation (e.g. fire, accident, medical emergency).

Tom has a UE equipped with 5G communication module, as well as a 5G positioning module. This positioning module can use a combination of 3GPP technologies and non-3GPP technologies. This includes, but not limited to, GNSS (e.g. BeiDou, Galileo, GLONASS, and GPS), Terrestrial Beacon Systems (TBS), sensors, WLAN, and Bluetooth-based positioning.

The 5G communication system includes an interface to a PSAP to dispatch first responder(s).

#### 5.4.1.3 Service Flows

1. Tom detects an emergency situation and dials/contacts the emergency number for his region. This may initiate a call, video or messaging service to a local PSAP.

2. The 5G system initiates a positioning function, without user intervention, with 3-dimentional position accuracy according to local regulatory requirements (including minimal e.g. latency and other KPIs).

3. Tom communicates his emergency situation with the PSAP.

4. The PSAP dispatches first responders to Tom’s location, where the first responders are given a 3-Dimensional position and confidence for his location.

5. Tom completes his emergency communication with the PSAP.

#### 5.4.1.4 Post-conditions

The location information of the UE is available in the PSAP and the first responder.

#### 5.4.1.5 Potential Impacts or Interactions with Existing Services/Features

N/A

#### 5.4.1.6 Potential Requirements

The 5G System shall be able to provide positioning service with three-dimensional position accuracy and associated KPI targets, determined by regulatory agencies (e.g. FCC), as follows:

- Accuracy [< 50m] horizontal ([80%]), [< 3 m] vertical ([80%])

- Latency and TTFF [< 30 seconds]

- Availability [> 95%]

- Environment of use: indoor and outdoor

NOTE 1: The aforementioned requirements are based on FCC benchmarks to be met around by 2020/2021. These may change in the future, as the ultimate goal of the regulatory agencies is to get to sufficient accuracy to determine ‘which door to knock on’ in an office or apartment building.

NOTE 2: The aforementioned requirements are meant throughout the 5G positioning service area.

NOTE 3: The vertical positioning requirement should be sufficiently accurate to determine the floor.

The 5G System shall support the UE to provide the positioning methods used in calculating the position and the associated uncertainty/confidence of the position.

The 5G System shall be able to request the UE to provide location information (e.g. measurements, position) with some periodicity as necessary.

The 5G system shall be able to determine the reliability of the positioning information.

### 5.4.2 Accurate Positioning for First Responders

#### 5.4.2.1 Description

Accurately locating a first responder who is injured or incapacitated during mission critical operations has long been a goal of public safety. A mission critical service such as MCPTT enables a first responder to stay in contact with other first responders as well as dispatch and command/control. Mission Critical Organizations require mission critical services to have accurate positioning such that first responders may be located at all times during normal and critical operations. The level of positioning accuracy (and other KPIs) required is much more stringent than that required by local and regional regulatory requirements for commercial users.

This location service offers first responders to be located in emergency situations and requires high accuracy UE positioning in all service areas, including those that could potentially be challenging for some positioning technologies (e.g. indoors).

#### 5.4.2.2 Pre-conditions

The ESA One Fire Department is dispatched to a report of a building fire in an apartment complex. Three engines arrive to find thick smoke has risen into the building from a fire on a lower floor, requiring all floors of the apartment complex to be evacuated. Several residents are suffering from smoke inhalation and are in need of medical treatment

The ESA One battalion chief establishes an Incident Command System and assigns incoming firefighters to separate operational groups, including “fire attack”, “evacuation” and “medical operations”. Each operational team uses a separate MCPTT group to coordinate their actions. There are also additional MCPTT groups to support communications between the group leaders and the incident commander.

Each fire-fighter has a UE equipped with a 5G communication module, as well as a 5G positioning module. In addition, the UEs of the ESA One Fire Department are configured to initiate an Emergency Alert when a connected man-down accessory detects an abnormal condition.

#### 5.4.2.3 Service Flows

1. Members of the fire attack and evacuation groups enter the building to fight the fire and coordinate the evacuation.

2. The Incident Command System displays the location of each fire-fighter within the building.

3. While searching for trapped residents, fire-fighter McJanky is overcome by heat and smoke, and collapses.

4. McJanky's man-down accessory attached to his MCPTT UE detects the abnormal condition (i.e. lack of movement, a horizontal tilt, or both) and notifies the MCPTT UE.

5. The MCPTT UE, in conjunction with the 5G system initiates a positioning function, without user intervention, with 3-dimensional position accuracy and other KPIs (e.g. minimal latency).

6. The MCPTT UE sends an Emergency Alert with man-down indication to the Incident Command System. The Emergency Alert contains his precise location within the building.

7. The Emergency Alert with precise location is also distributed to other members of his group.

8. The ESA One battalion chief sees the Alert and coordinates the rescue. Other fire-fighters are able to locate McJanky quickly and they take him out of the building to the emergency medical team. McJanky is revived and lives to tell the story.

#### 5.4.2.4 Post-conditions

The precise location information of each fire-fighter UE continues to be available in the Incident Command System.

#### 5.4.2.5 Potential Impacts or Interactions with Existing Services/Features

Mission Critical Services such as MCPTT, MCVideo, and MCData and MCX UEs require access to the 5G positioning function.

#### 5.4.2.6 Potential Requirements

For outdoor location the 5G System shall provide a positioning service with three-dimensional position accuracy and associated KPI targets required by mission critical organizations as follows:

- Accuracy < [1m] horizontal [95%], < [0.3] meters vertical [95%]

- Latency < [5] seconds

- TTFF < [10] seconds

- Availability > [98%]

For indoor location the 5G System shall provide a positioning service with three-dimensional position accuracy and associated KPI targets required by mission critical organizations as follows:

- Accuracy < [1m] horizontal [95%], < [2] meters vertical [95%]

- Latency < [1] seconds

- TTFF < [10] seconds

- Availability > [95%]

NOTE: Both absolute position and relative position can be used to meet the accuracy requirements based on operational needs.

The 5G System shall enable an MCX UE to use the positioning service to calculate its position with the associated uncertainty/confidence of the position.

The 5G System shall provide a mechanism to request an MCX UE to provide location information (e.g. measurements, position) with remotely adjustable periodicity.

The 5G System shall provide a mechanism to request that an MCX UE provides an immediate location report.

The 5G System shall provide a mechanism to request an MCX UE to provide an event-triggered location report. The 5G system shall be able to determine the reliability of the positioning information

### 5.4.3 Alerting nearby emergency responders

#### 5.4.3.1 Description

In case of a medical emergency, all qualified individuals within close vicinity of the victim get alerted via their phones with a request to provide urgent care. The qualified individuals will often be layman volunteers (i.e. not medical professionals) with a training in first aid, such as applying CPR (Cardiopulmonary Resuscitation) and using an AED (Automatic External Defibrillator) on a patient with SCA (Sudden Cardiac Arrest). For example, in the Netherlands, a layman responder network of 170,000 volunteers (~1% of the general population) has been equipped with an App to provide emergency care to provide timely response to SCA. In this case, every second counts and help should be provided within 6 minutes.

NOTE: The scenario intended to cover in this use case does not exclude UEs supporting V2X applications. For example, in suburb or rural areas, a UE carrying a passenger or driver under emergency situation can get connected to nearby UE(s) supporting V2X applications so that the nearby qualified individual in that vehicle can immediately take necessary actions as an emergency responder using the related location information.

The purpose of this use case is to improve the localization of the emergency responders closest to the victim, in order to safeguard the quickest availability of care. The main requirements are to have a robust solution that works both indoors and outdoors, that is scalable to large numbers of responders and that maximizes privacy of the (layman) responders (i.e. no continuous tracking).

#### 5.4.3.2 Pre-conditions

Paul and Sonia are layman responders trained in CPR/AED. They are registered to the layman responder network and have installed the layman responder App on their respective phones. Their phones are equipped with a 5G positioning module. This positioning module can use a combination of 3GPP technologies and non-3GPP technologies such as GNSS (e.g. Beidou, Galileo, GLONASS and GPS), terrestrial beacons (e.g. Bluetooth, RFID, TBS), dead-reckoning sensors, etc.

#### 5.4.3.3 Service Flows

1. Joe, a 68 years old retired teacher is in reasonable health. One particular day, Joe visits the mall. While walking through the mall, he suddenly experiences chest pain and drops on the floor.

2. Mary, sees Joe dropping, kneels by him and notices he’s unconscious. She immediately calls 911 and explains an elderly man grabbed his chest in pain, suddenly dropped on the floor and remains unconscious.

3. Andy, the 911 call center agent taking Mary’s call, suspects SCA and initiates the layman responder network.

4. Mary’s location – as determined by her phone (see use case 5.4.1 “Accurate positioning for emergency services”) – is automatically forwarded to the layman responder network, which notices two qualified layman first responders in Mary’s (Joe’s) immediate vicinity, Paul and Sonia. Also, an ambulance from the nearby hospital is directed to the scene.

5. Paul, who’s just one floor away from Joe gets an instant notification on his phone from the layman responder App, indicating that a possible cardiac arrest victim is in need of his help. He confirms his willingness to help, by clicking “Accept Call” in the App and is guided towards Joe by his phone.

6. Sonia, who’s on the other side of the mall, but in close vicinity of an AED, also gets and instant notification on her phone and also she confirms. After this she is directed towards the nearest AED (see use case 5.4.3 “Emergency equipment location outside hospitals”). She then picks up the AED and heads for Joe.

7. Paul arrives first on the scene, notices that Joe has no pulse and starts administering CPR.

8. Sonia arrives a little bit later with the AED and together they apply the AED.

9. Joe’s heart starts beating again and ten minutes later the ambulance arrives to take Joe to the hospital.

#### 5.4.3.4 Post-conditions

Joe lives, because the nearest by layman responders get notified instantly.

#### 5.4.3.5 Potential Impacts or Interactions with Existing Services/Features

What’s called for is a location-aware group messaging service, that is scalable to very large groups of responders nationwide and that avoids continuous tracking of individuals. This will require an interplay of various network features and elements, specifically also because the service needs to work across different operator networks. Also the division of functionality between the network and the application remains to be determined.

#### 5.4.3.6 [Potential] Requirements

The 5G system (in conjunction with the layman responder network) shall be enabled to alert the group of [~ 10] potential responders with shortest travel time to the victim, scanned from a radius of [5 km] from the victim. This requires localization of each responder with a horizontal resolution of less than [50 m] and, indoors, a vertical resolution sufficiently accurate to determine the floor, so typically less than [3 m]. This localization accuracy needs to be achieved throughout the 5G positioning service area.

The 5G system shall not perform continuous tracking of each layman responder to respect his/her privacy.

The 5G system shall be scalable to address the positioning of at least [5%] of all subscribers being registered to the layman responder service.

The 5G system shall work across boundaries of individual operator networks in the region.

### 5.4.4 Emergency equipment location outside hospitals

#### 5.4.4.1 Description

Life-saving medical equipment, such as AED’s, deployed throughout public and private spaces can be localized instantly in case of need, to be able to take the equipment within the minimum possible amount of time to an emergency scene. This use case is about knowing for sure where the equipment actually is, rather than where it is supposed to be, and making sure it does not get lost, i.e. it is about maintaining an up-to-date location database of all equipment deployed throughout a region or a nation.

This use case is related to use case 5.4.2 “Alerting nearby emergency responders”.

#### 5.4.4.2 Pre-conditions

The equipment (AED) is connected to the 5G network for maintenance purposes (e.g. checking battery-level) and also provided with a 5G positioning module. This positioning module can use a combination of 3GPP technologies and non-3GPP technologies such as GNSS (e.g. Beidou, Galileo, GLONASS and GPS) and terrestrial beacons (e.g. Bluetooth, RFID, TBS).

The equipment uses the 5G positioning module to provide regular updates of its actual location to the AED positioning system (e.g. at least each time motion is detected an update should be provided). The AED positioning system maintains a location database of all AED’s deployed throughout a region or a nation. The layman responder app/system (as mentioned in Section 5.4.2) has access to the AED positioning system.

The equipment can be located either indoor or outdoor.

#### 5.4.4.3 Service Flows

1. Sonia, a lady who is subscribed to the layman responder network, has received and accepted a call for help to resuscitate Joe, an elderly man experiencing Sudden Cardiac Arrest.

2. The layman responder network app (or system) interrogates the AED positioning system which maintains an up-to-date location database of AED’s, and determines the closest AED on the way between Sonia’s current location (as determined by her 5G phone) and the location of the victim in need for help and informs the layman responder App on Sonia’s 5G phone of this location.

3. Sonia’s 5G phone computes the quickest way to the AED.

4. Sonia follows the instructions on her 5G phone and picks up the AED.

5. After picking up the AED, the AED wakes up from its sleep mode, connect to the network. The AED positioning module is activated and position updates are provided the AED positioning system.

6. Sonia heads for Joe following instructions on here phone and applies the AED on Joe.

7. After usage, the AED positioning system receives several updates to the AED’s position before it is put back on its original place.

8. Once put back, the AED enters sleep mode for an extended period of time, and wakes up only once per week/month to connect to the network.

#### 5.4.4.4 Post-conditions

Joe lives, because an accurate record can be maintained with the location of critical equipment (AED).

#### 5.4.4.5 [Potential] Requirements

The 5G System shall be able to provide positioning service with a horizontal accuracy less than [10 m] and, indoors, with a vertical accuracy sufficiently accurate to determine the floor, so typically less than [3 m]. This localization accuracy needs to be achieved throughout the 5G positioning service area.

The 5G System shall allow UEs to sleep for extended periods of time (e.g. one week), without requiring the UE to update its position data.

The 5G system shall allow UEs to trigger a different update rate of the position data based on whether the UE is moving or not.

## 5.5 Road-related use cases

### 5.5.1 Accurate positioning to support Traffic Monitoring, Management and Control

#### 5.5.1.1 Description

This use case describes the traffic monitoring, management and control services supervised by a regional/local authority that has the objective to optimise traffic flow when needed and provide feedback to road users to make traffic more fluent.

NOTE: This use case is not intended to utilize the 3GPP sidelink interface. Possible ways of collecting location fixes of vehicles of interest and notifying lane-management information/instruction are based on Uu-interface.

Decision relating to traffic monitoring and control, congestion and access to some areas for some vehicle (parking, access to city centre) are becoming more complex due to more intensive use of lane management techniques in the future by highway operators. Currently the traffic monitoring relies primarily on video surveillance, Priorities and rules applications to roads and lanes are mostly static, or may be, in some cases, updated in real time with information panels on gantries.

As traffic increase, lane choices and priorities become more complex (more diversity in vehicles types and regulations, vehicle automation levels increase, time-varying priorities for different type of vehicles, incentive to use low energy vehicles or car-sharing), some level of decision support assistance will be required. This use cases address a more dynamic implementation, complementing video surveillance monitoring with positioning-related data determined involving the 5G system.

The Traffic Management Server (TMS) will monitor the traffic in real time, processing information reported messages transmitted by vehicles and video surveillance installed at key points along roads. Depending on the traffic situation, planned public work, need for emergency route, etc. the Traffic Management Server (TMS) will send message to vehicles via the 5G network to give them guidance and updates. For instance, some of the vehicles might be requested to maintain the lane they are on others might be asked to change to other lane due to various reasons (crowded lane, vehicle class not allowed on the current lane etc.). Traffic management will monitor vehicles at the level of lane, this and therefore need to reference any positioning information to the map of the infrastructure (roads, lanes) and manage the vehicles’ positioning information over multiple road segments and long distance. It is also necessary to be able to distinguish superposed road segments and lanes (typically bridges, large highway crossings, etc.). This use case therefore needs both horizontal and vertical absolute positioning. 3GPP TS 22.186 v15.2.0 defines relative positioning requirements, primarily for platooning. In the case where relative positioning information is transposed into absolute 3D positioning information using LTE positioning technologies, the resulting accuracy would not be sufficient for the proposed use case.

To satisfy the use cases, the vehicle position needs to be determined with an accuracy able to identify the lane the vehicle is using.

The TMS collects data received (user location, crash alert, driving speed, etc.) from the road traffic participants in the areas it is covering, provides traffic guidance to road users and modifies rules and priorities applicable to the different lanes. The TMS uses the position-related data to check that the drivers are indeed applying the new rules and priorities. The positioning-related data provided to the TMS by the UE and/or the System (e.g. vehicle location, speed, heading, etc.) need to be trustworthy and/or allow the TMS to investigate and check their trustworthiness. For instance, Users (and third parties) should not be able to fraud the TMS’ control by tampering the positioning-related data, for example, to drive on a newly unauthorised lane.

#### 5.5.1.2 Pre-conditions

The vehicle is equipped with a 5G communication module and a 5G positioning module. These modules can be integrated in the smartphone of the vehicle’s user. The positioning module provides vehicle position, velocity and time information. This positioning module can use a combination of 3GPP technologies and non-3GPP technologies. This includes, but not limited to, GNSS (e.g. BeiDou, Galileo, GLONASS and GPS), Terrestrial Beacon Systems (TBS), Bluetooth, WLAN, RFID, and sensors, eventually complemented with data to enhance these technologies.

A regional TMS exists and is connected to a 5G Network. The TMS is used by relevant local authorities and overlooks only regional/local geographic areas and has the role of ensuring proper lane management according to the changing traffic conditions.

Environments: outdoors and indoors (tunnels), within 5G positioning service area.

#### 5.5.1.3 Service Flows

The 5G positioning module enables the 3GPP system to determine its current location at a high rate. The frequency of the location reporting may change according to the application requirements.

The 5G positioning module reports location information, velocity and heading to other vehicles and infrastructure (Road Side Unit). At any time, the 5G positioning module shall be able to report its location information. The TMS has access to velocity information with a certain accuracy e.g. less than [1] m/s.

The Server advises for changing lanes, checks if user is allowed to be in a lane, recommends staying in the lane, etc.

#### 5.5.1.4 Post-conditions

The vehicle’s users benefit from optimized flow management, up to date information on the traffic, and will always drive on the correct lane.

TMS collects and aggregates traffic info at lane level and allows road operator to optimise road management (lane) to avoid congestions and improve the traffic flow. However, at no point the TMS would know from which vehicle (or user) this information came from and will not disclose to 3rd parties any position – related data provided by road users.

#### 5.5.1.5 Potential Impacts or Interactions with Existing Services/Features

#### 5.5.1.6 Potential Requirements

The 5G System shall be able to provide positioning service with a horizontal accuracy of [1] m across-track and [3] m along-track for UE speed up to the maximum speed authorized on highways (e.g. [130-160] km/h).

NOTE: The use case is intended to support applications that performs tasks of monitoring and reporting the effective traffic’s density at lane level, but it does not involve Safety-of-Life or critical operations (such as those in autonomous vehicles). To identify the lane a vehicle (of variable width: car, truck or motorbike) is using, the positioning service should have an accuracy better than half the lane’s width, accounting for some margin and the uncertainty on the width of the vehicle and the place where the position sensor is on the vehicle. The lane width is typically in the range of 3 – 4 m and the margin does not need to be tight (because it is not a critical application), therefore, a target accuracy of 1m seems reasonable to detect lane.

The 5G System shall be able to provide positioning service with a vertical accuracy of [2.5] m for speed up to the maximum speed authorized on highways (e.g. [130-160] km/h).

NOTE: Vertical separation of superposed roads may be as low as 5 meters. The position sensors may be distributed in various places of the vehicles, including on the upper part of the vehicle or on the roof, hence more than one meter above the road level. This may vary significantly from one type of vehicle to the other. To allow the system to distinguish between two vehicles moving on superposed road, each with position sensors in different places, a vertical accuracy in the range 2.5m seems a reasonable target.

The 5G System shall be able to provide positioning service with an availability of [95] %.

The 5G System shall be able to provide positioning service with a TTFF less than [10] s.

The 5G System shall be able to provide positioning service with an update rate of [10] Hz.

The 5G System shall be able to provide positioning service with a latency of less than [30] ms.

The 5G System shall be able to ensure the positioning-related data are secured.

The 5G System shall support mechanisms to protect positioning-related data against tampering and spoofing.

The 5G System shall support mechanisms to detect tampering attempts on the position-related data and spoofing.

The 5G System shall be able to support the protection of the UE’s privacy.

### 5.5.2 Road-User Charging (RUC)

#### 5.5.2.1 Description

Road-User Charging (RUC) defines generic services monitoring a vehicles position (and/or motion) with the aim of levying a charge or a tax on the vehicle’s user, based on the way the road infrastructure is used by the user. It may apply to any kind of road (local and national network, motorways and can be expanded to access control to urban areas or parking) and may target all kinds of vehicle, primarily:

- Personal vehicles, for applications such as Pay-as-you-drive (PyD) such as insurance and car as a service, management of traffic congestion and incentive for certain vehicle energy or car-sharing (dissuade use of low occupancy vehicles on high occupancy lanes, etc.)

- Professional vehicles, for applications such as road tolling (based on distance, time, type of vehicle and freight, period of day or week, availability of alternative multimodal transports schemes, etc.)

Originally, RUC services relied on static, rigid implementations, either access control to road (tolling booth) or annual fees (insurances) and taxes per vehicles. The development of LBS technologies allows the implementation of dynamic and highly flexible RUC services: an On-board Unit (OBU) enables the determination of the vehicle’s position and motion (e.g. velocity or velocity profile) and reports this information to the RUC system (for instance, a regional or national processing facility). The latter applies RUC algorithms to establish the fee to be charged. The RUC algorithms may be adapted to evolving needs and applications, expand the coverage in terms of the charged road and conditions without the need to deploy new infrastructure like tollbooth, gantries, etc. The RUC algorithms may also apply different charging strategies according to traffic condition (congestion, period of day), lane occupancy or priorities (priority vehicle, incentive for car sharing, management of specific freight or hazardous materials, etc.), velocity profile. Consequently, the position-related data should be accurate enough to determine the position of the vehicle at lane level and to determine the vehicle’s velocity with good accuracy.

The positioning-related data provided to the RUC Application Server need to be fully trustworthy: reliability, integrity, high confidence level and protection against tampering are key aspects for any RUC service. Users (and third parties) should not be able to fraud the RUC Application Server by tampering the positioning-related data in order to avoid application of the charges.

#### 5.5.2.2 Pre-conditions

The user or the user’s vehicle is equipped with a RUC OBU, comprising a 5G communication module and a 5G positioning module. This positioning module can use a combination of 3GPP technologies and non-3GPP technologies. This includes, but not limited to, GNSS (e.g. BeiDou, Galileo, GLONASS and GPS), Terrestrial Beacon Systems (TBS), Bluetooth, WLAN, RFID, and sensors, to allow the RUC system to determine vehicle position-related data.

The RUC Application Server is connected to a 5G Network, and it includes algorithms to compute the charges, monitors the traffic and manage fraud detection algorithms.

The environment of use is primarily outdoor, including urban areas and rural areas (wide coverage area), but includes also road tunnels and parking areas, which may obstruct positioning signals.

#### 5.5.2.3 Service Flows

The 5G positioning module enables the 3GPP system to determine position, velocity (or velocity profile). The frequency of the determination may vary according to the RUC application requirements. Indeed, depending on the application, determination of the position-related data needs to be achieved in close-to-real-time or not. Insurance and PyD applications may handle charging on a regular, for instance on a monthly or yearly basis.

This information is reported to the RUC Application Server in addition with information relating to the user (including type of vehicle and transported passenger or freight).

For what regards road user charging, one can distinguish two main types of applications. The first one deals with levying a fixed tax depending on the road that is taken by the vehicle. In this case, the position information shall be available each time with a periodicity of 1s but the information can be reported to the central application server by packets in non-real time. The second type of application deals with a dynamic fees level in order to control dynamically the traffic. In this case, real time reporting shall be insured.

For PyD insurance applications, the position data information shall be available each second in order to compute distances. Report shall be sent periodically to the central server.

In all cases, Integrity of the information shall be insured all along the information chain

#### 5.5.2.4 Post-conditions

The user is charged according to its use of the road infrastructure or according to the use of the vehicle and driving behaviour.

The operator of the road infrastructure has access to additional information to plan his operations (evolution and capacity increase, maintenance, etc.).

The processing (determinist or statistical analysis) of the reported information brings additional benefits to the road user community, enabling by-products for the operators of road infrastructure, like for instance:

- Traffic flow statistics and management (including real time traffic management, establishment of priority lanes according to period of day, etc.)

- Feedback of road usage, to plan for road evolution (increase of capacity, bypass route) or maintenance (for instance, in case of more heavy traffic on some roads or lane)

- More secure traffic for all road users.

#### 5.5.2.5 Potential Impacts or Interactions with Existing Services/Features

[Editor's Note: text to be provided or "None" to be stated]

#### 5.5.2.6 Potential Requirements

The 5G System shall be able to provide positioning service with a horizontal accuracy in the range [1 – 3] m, an update rate of [1] Hz and an availability of [99] % for speed up to [130 km/h].

The 5G System shall be able to provide velocity information with an accuracy of [2] m/s, an update rate of [1] Hz and an availability of [99] % for speed up to [130 km/h].

The 5G System shall be able to provide positioning service with a TTFF less than [10] s.

The 5G System shall be able to provide positioning service with a user density up to at least [1000 per km²].

The 5G System shall support mechanisms to protect positioning-related data against tampering and spoofing.

The 5G System shall support mechanisms to detect tampering and spoofing attempts on the position-related data.

## 5.6 Rail and Maritime related use cases

### 5.6.1 Asset and freight tracking (wagon, container)

#### 5.6.1.1 Description

Asset tracking is becoming a key capability for worldwide logistics like in the railway or maritime freight sector (containers, tanks and wagons):

- For providers and customers: it provides means to optimise the overall transportation efficiency, and improves end-to-end traceability. Freight tracking enables more accurate scheduling of all involved operations (departure and arrival time, delays, organisation of transhipment, etc.).

- For freight operators, it eases lean asset management (maintenance and retrofit of assets, reduced risks relating to lost or stolen cargos, containers and wagons)

- Freight tracking helps securing the transportation of hazardous materials and goods, and supports efficient operations in relation with regulation, for instance at customs (procedures may adapt to freight, transit route, countries through which the container / wagon travelled, etc.).

The asset tracker should fulfil very long lifetime (up to 15 years), with very low maintenance and power autonomy enabled by batteries sustaining the whole lifetime or with energy harvesting (solar panel, mechanical energy harvesting during transportation) or with both.

The position-related data need to be secured and protected against tampering to dissuade from any unauthorized use, fraud or theft of the transported goods.

The use case can be expanded to other verticals, as it is the case in clause 5.43 of 3GPP TR 22.891 v14.2.0 (Feasibility Study on New Services and Markets Technology Enablers).

#### 5.6.1.2 Pre-conditions

The UE (asset tracker installed on a container, tank, and wagon) is equipped with a 5G communication module and a 5G positioning module. It is self-powered using energy harvesting or long-lifetime battery, and connects to sensors reporting relevant information about the asset (temperature, pressure, shock and motion detection, etc.). When installed on the asset, the UE is properly initialised, with secure parameters and trusted initial conditions.

The service areas are categorized as follow:

- Transportation areas: outdoor, covering very wide areas (regional and continental level) including mountainous areas, canopy and tunnels. The transportation areas can include areas with no terrestrial coverage (e.g. a container on a ship at sea).

- Storage areas: enhanced positioning areas (up to 10 km²), with storage both indoor and outdoor (warehouse, railway stations, harbours, etc.) and a very high density of users (above 100 000 per km²).

The Asset Management System (AMS), connected to a 5G Network, collects and processes the information reported by all device trackers relating to a given customer.

#### 5.6.1.3 Service Flows

Container C, equipped with an asset tracker (UE), is planned to deliver a cargo from storage area A to C, using a train that will transit via B. If A, B and C have different applicable regulations for the transported freight, specific control will apply upon arrival in C. Before departure from A, the UE is initialised securely (initial position, planned route, etc.)

From A to C (transportation service area), the UE enables the 3GPP system to determine its current position (and velocity), and reports relevant parameters related to the asset or freight container (collected parameters like freight temperature, pressure, detection of shock). The determination of position (and velocity) is performed on a regular basis, but not continuously, and does not need to be reported in real-time to the AMS. Position-related data should allow to coarsely identify where the freight is, whether it is moving and in which direction.

Meanwhile, Container C’s position-related data and parameters are collected and used by the AMS at least to:

- monitor the transfer and delivery by Container C, and update stakeholders on schedule and delivery time, and eventually, raise alert in case of delivery delays, rerouting (different route than the one initially planned), etc.

- support End-to-End traceability, efficient procedure at customs (transit via B) and facilitate the control of the compliancy to regulation.

Upon arrival in the storage area C, and until customer takes delivery of the container’s content, the UE’s position is determined in 3D and used to identify container C. High accuracy is needed to distinguish containers on stacks. During handling, position-related data are determined continuously, also with very high accuracy. After handling, during storage, the UE switches to idle mode, monitors motion to detect unauthorised handling or move, and wakes up regularly (e.g. daily basis) to enable position check.

The position of the asset tracker must be determined all along its travel into the transportation area to ensure continuity of the traceability information. This includes areas with no terrestrial coverage. Therefore, when the UE is outside coverage of 3GPP RAT-dependent positioning technologies:

- The UE enables non-3GPP positioning technologies to determine its position (e.g. using a GNSS receiver). In the case that the UE determines its position (e.g. using a GNSS receiver), it shall log the position-related data into its memory.

- The 5G system is able to access to the log of the position determined outside the coverage of 3GPP RAT-dependent positioning technologies.

#### 5.6.1.4 Post-conditions

Container C was delivered in due time, with minimal latency and time overheads. It followed a safe route, duly reported and traced in the AMS. The customer had continuously access to the full traceability of the delivery and is in turn able to provide evidence of traceability to subsequent customer.

Thanks to the logged information, the freight operator may demonstrate the compliancy to regulation with minimum effort, and use the information collected by the AMS to improve the efficiency of his deliveries.

#### 5.6.1.5 Potential Impacts or Interactions with Existing Services/Features

[Editor's Note: text to be provided or "None" to be stated]

#### 5.6.1.6 Potential Requirements

The 5G system shall be able to provide positioning service for the static UE in an enhanced positioning area, indoor or outdoor with the following potential requirements:

- Absolute position accuracy: [1] m (horizontal and vertical), [99] % availability, an update rate up to [1] Hz and a latency less than [1] s.

- TTFF less than [10] s.

The 5G system shall be able to provide positioning service for UE moving at speed up to 180 km/h outdoor, over very wide coverage with the following potential requirements:

- Absolute position accuracy: [10-30] m horizontal position accuracy, [99] % availability

- Velocity accuracy: [5] m/s horizontal velocity accuracy, [99] % availability

- Position and velocity update rate: the time interval between 2 successive position fix can vary between [300 s] and [24 hours].

The UE shall support mechanisms to determine its position using non-3GPP positioning technologies when outside the coverage of 3GPP RAT-dependent positioning technologies.

The 5G system shall support mechanisms to access the UE’s position-related data determined when the UE is outside the coverage of 3GPP RAT-dependent positioning technologies.

The 5G System shall be able to provide a positioning service involving an average of less than [20 mJ] of the UE’s energy per position fix.

NOTE: the value of the energy per fix is an averaged figure, determined over a time interval larger than the position update period (for example, 1 hour, 24 hours, 1 week, etc.). This requirement does not presume the positioning method, which can be in the UE or in the core Network.

The 5G System shall support mechanisms to protect positioning-related data against tampering and spoofing.

The 5G System shall support mechanisms to detect tampering and spoofing attempts on the position-related data.

## 5.7 Aerial-related use cases

### 5.7.1 Accurate positioning to support Unmanned Aerial Vehicle (UAV) missions and operations

#### 5.7.1.1 Description

Unmanned Aerial Vehicle (UAV) or drones for professional or leisure applications are used for several missions. During their mission, they might be connected to a remote user or a Mission Application Server to report regularly or by burst mission information that are processed to generated added value products. The Mission information that is reported is often images of the environment that is flown over. The images can be optical or another type of sensor, such as an infrared sensor. The images are in general tagged with Meta Data describing the mission.

In such a context, the images often need to be geo-localised with a high accuracy in order to allow recombining the images as a sequence of image representing a given scene compared or superimposed onto a ground digital map. This allows generating benefit information from the recombined images mapped on a given existing reference.

In other situations, several flights are performed over the same area, and the mission of the drone’s sensor is to provide information to evaluate particular environmental evolutions at various dates. For automatic processing of the flow of images, the images and therefore the UAV shall be accurately geo-localised with absolute positions information.

In addition, during the landing phase, the UAV operations need also precise 3D geo-localisation information in order to allow automatic landing

#### 5.7.1.2 Pre-conditions

The user’s drone is equipped with a Navigation Unit, comprising a UE with a 5G communication module and a 5G positioning module. This positioning module can use a combination of 3GPP technologies and non-3GPP technologies. This includes, but not limited to, GNSS (e.g. BeiDou, Galileo, GLONASS and GPS), Terrestrial Beacon Systems, Bluetooth, WLAN, RFID, and sensors, to allow the Navigation Unit system to determine UAV position-related data.

The UAV Mission Application Centre is connected to a 5G Network. The Centre includes algorithms to process the images and generate added value information from a series of images in sequences or at various dates.

The environment of use is primarily outdoor, including urban areas and rural areas (wide coverage area).

#### 5.7.1.3 Service Flows

The 5G positioning module enables the 3GPP system to determine position, velocity (or velocity profile) and date. The frequency of the determination shall be regular typically every second.

The need for reporting the information can vary depending on the applications. In some implementations, the UAV system may use the information directly, and thereof, this information is not reported as such to the Mission Application Centre.

In some cases, the information shall be reported in quasi real time in order to allow a remote control of the mission.

In case where the position-related data is used in the processing and analysis of the images collected by the UAV, the Mission Application Centre processes the images reported by the UAV, either in real time or in post processing when the UAV has landed and uploaded its images bank to the server. Very low latency is not mandatory.

In the case where the Navigation Unit information is used for landing operations, the position information are reported to the on-board flight computer to control the flight in order to ensure a smooth landing. Latency need to be commensurate to the velocity of the UAV in the landing phase to maintain the relevancy of the accuracy requirements.

#### 5.7.1.4 Post-conditions

The images are georeferenced using the position-related data provided by the UAV Navigation Unit, as part of Meta Data describing each image. Based on this Meta Data, the Mission Application Centre can recombine precisely a sequence of images to generate a scene precisely located in space. The Centre can also compare the environment situations by processing various images taken at various dates, with a common position reference, or by comparing the images with any other sources of geo-localised information.

#### 5.7.1.5 Potential Impacts or Interactions with Existing Services/Features

#### 5.7.1.6 Potential Requirements

The 5G system shall be able to provide positioning service to support drones applications with [10] cm horizontal and vertical position accuracy, 99% availability, for UE moving at [150] km/h outdoor.

The 5G system shall be able to provide positioning service to support applications with under [50] cm/s horizontal and vertical velocity accuracy and [2]º bearing accuracy, over 99% availability, for UE moving at speed up to [150] km/h outdoor.

The 5G System shall be able to provide positioning service to support applications with a TTFF less than [10] s.

The 5G system shall be able to provide positioning service such that the UE's power consumption will be less than [200] mW in the worst case.

The 5G System shall support mechanisms to protect positioning-related data against tampering.

The 5G System shall support mechanisms to detect tampering attempts on the position-related data.

The 5G System shall be able to ensure the positioning related data are secured, and shall allow the protection of the user’s privacy.

### 5.7.2 Transport and inspection by drones for medical purposes

#### 5.7.2.1 Description

Medication and cures need to be transported between two different buildings (for instance, pharmacy to a dedicated unit) inside a hospital made up of several buildings on several hectares with large green areas or between two different hospitals (in the same city). Drones can be used for these transportations.

Some hospitals may organise and pool their stock of medication and production of cures.

Some hospitals, part of a same group or not, may exchange medication, for instance, in case one face empty stock, or is not equipped to store some cures (e.g. chemotherapy).

In all these cases and situations, medication and cures need to be transported between two distinct locations, in a trusted, secure and time-controlled process. The locations may be distant from several tens of kilometres. Drones can be used to ensure such transportation.

In addition to transport between buildings, drones can be used to transport life-saving equipment (e.g. AED) from a predetermined location to an arbitrary outdoor (or even indoor) location in close vicinity of a patient (e.g. suffering of Sudden Cardiac Arrest). Also a drone (could be the same drone delivering the life-saving equipment) needs to hover over the scene and provide a live video feed to an emergency call centre, enabling better life saving support.

The drone flies at low altitude. The drone needs to maintain a continuous connection with the mobile network, which requires the network supports continuous wireless coverage in low altitude flight scenarios.

During the whole delivery process, the position and the status of the drone needs to monitored and logged in order to ensure the full traceability of the delivery, as well as the security of the delivery.

A drone and remote control are connected to the mobile network. A continuous connection with the mobile network is needed, especially in the case of transport between two hospitals requiring a way in the public domain.

The drone is piloted with remote mode, the data being transmitted via the network

Position accuracy is defined to minimise risk of damage to property or life in densely populated areas.

Extreme Real-Time Communications are addressed in the NGMN 5G white paper [5].

#### 5.7.2.2 Pre-conditions

The drone and its payload container are equipped with 5G communication modules, smart lock as well as a 5G positioning module. This positioning module can use a combination of 3GPP technologies and non-3GPP technologies.

A drone and remote control are connected to the mobile network.

The drone is piloted with remote mode, the data being transmitted via the network.

#### 5.7.2.3 Service Flows

Tom needs to receive a cure in emergency in Hospital A, the one close to the place he lives. The cure must be delivered within the next 24 hours, but is not available in Hospital A. The doctors consider Tom’s health does not allow transporting him to another Hospital. Fortunately, Hospital A is organised with other Hospitals in the region to manage such circumstances: it was agreed in the past that the stock of this cure would be centralised in Hospital B and the cure distributed when needed using drones.

Hospital A’s Pharmacist requests the delivery of the cure using the Hospital specific drone system. The trajectory and details of the delivery (including a unique identifier linking the delivery operation, ID of the patient, ID of Hospital A and B, ID of the cure, etc.) are defined in the delivery management application and loaded in the drone and its payload container. The container can only be opened upon arrival in duly identified and authorized locations (Hospital A and Hospital B), and if handled by authorized personnel.

The drone leaves Hospital A and reaches Hospital B less than one hour later. Meanwhile, Hospital B’s Pharmacy prepared the cure, put it in an adequate and secured container ready for transportation.

Upon arrival of the drone, after reporting its arrival, Hospital B’s Pharmacist unlocks the drone and its container using his ID, introduces the cure into the drone’s payload container and locks it again with his ID.

The drone flies back to Hospital A, where upon arrival, the Pharmacist of Hospital A proceeds with similar actions as above to retrieve the cure from the container.

The cure has reached the Pharmacy of Hospital A, and can now be handled as if it came out of the stock of Hospital A.

During the whole operation, all relevant information about the drone’s trajectory, the status and content of the container are logged. In addition, the drone’s positioning module enabled the determination of its position in a secure way, resilient to spoofing and tampering attempt, this to prevent errors in the delivery, misuse and attempt to smuggle the cure.

#### 5.7.2.4 Post-conditions

Tom receives the cure in due time. The handling of the delivery is more efficient than the former system used by Hospital A and B, which relied on ambulances or taxi delivery, particularly expensive in case of emergency and in night shifts.

All information about the operation are authenticated, exchanged and logged with adequate security for traceability

#### 5.7.2.5 [Potential] Requirements

The 5G system shall support:

- Round trip latency less than [150 ms], including all network components.

- Due to the consequences of failure being loss of property or life, reliability goal is [near 100%.]

- Reliability to be at the same level for current aviation Air Traffic Control (ATC). Link supports command and control of vehicles in controlled airspace. The integrity of the position needs to be ensured in compliance with the regulations.

- Priority, Precedence, Preemption (PPP) mechanisms shall be used to ensure sufficient reliability metrics are reached.

- Position is to be authenticated, and logged in the system for security and traceability.

For en-route phases and hovering over an emergency scene, the 5G system shall be able to provide positioning service with [50 cm] horizontal position accuracy and a [30 cm] vertical accuracy, 99% availability, for the moving UE at the speed of up to [50km/hour]. The accuracy needs to be met throughout the 5G positioning service area. The environment of use for en-route phase is outdoor, mainly unobstructed.

During docking phases (take-off and landing), the 5G system shall be able to provide positioning service with [50 cm] horizontal position accuracy and a [10 cm] vertical accuracy, 99.9% availability for quasi stationery UE in enhanced positioning area of [10m2]. The environment of use for the docking-phase is outdoor, but may suffer obstruction from buildings in the vicinity of the drone’s docking stations.

The 5G System shall support mechanisms to protect positioning-related data against tampering.

The 5G System shall support mechanisms to detect tampering attempts on the position-related data.

## 5.8 Other use cases

### 5.8.1 Support of multiple different location services

#### 5.8.1.1 Description

Generally, the MNO provides basic positioning service for all users. For specific applications, the MNO provides customized positioning service which has different positioning performance for different users.

#### 5.8.1.2 Pre-conditions

Bob and Arthur are subscribers of operator A. Operator A provides basic positioning service for all subscribers

Airport H is an enterprise customer of operator A According to contract, operator A provides advanced positioning service for people stayed in the area of airport. Passengers who register the airport service will get guest level positioning service with higher accuracy and the airport security stuff will get security level positioning service with highest priority and best positioning performance.

#### 5.8.1.3 Service Flows

Arthur is the police of Airport H. During his working time in Airport H, he can be provided with the security level location service.

Bob goes to Airport H with the help of location service provided by operator A to pick up his mother Mary.

After Bob enters Airport H, he registers Airport H’s service platform and agrees the usage terms. Then he gets guest level location service. His electric car is routed to the specific parking set, parked, and being charged which need higher accuracy positioning assistance and can be provided by the Airport H’s service platform.

Bob goes upstairs and wants to find the nearest flower store. Under the Airport H’s location service direction, Bob finds it and selects flower for his mother. Bob waits for his mother in the café bar.

For security, Arthur can retrieve Bob’s higher accuracy location under the regulation agreement.

When Mary’s aircraft lands down, she powers on her smart phone and Airport H’s service is pushed to her smart phone. Mary accepts the service provided by Airport H. Bob is notified that Mary’s aircraft has been landed.

Bob shares his location to Mary. Mary then is routed to the exit B which is closest to Bob’s location under the direction of Airport H’s location service.

Bob is notified that his mother will be arrived in exit B after 1 minute. He goes to the exit B and meets his mother.

They are routed to Bob’s car served by Airport H’s and drive to Bob’s home with the help of location service provided by operator A.

#### 5.8.1.4 Post-conditions

In Airport H, different level location service are provided to different kind of user classes.

In Airport H, Bob can be provided location service with higher accuracy positioning data through Airport H’s platform besides basic location service provided by operator A. When out of Airport H, they only can be provided the basic location service provided by operator A.

#### 5.8.1.5 Potential Impacts or Interactions with Existing Services/Features

None identified.

#### 5.8.1.6 [Potential] Requirements

The 5G System shall be able to position the UE when it is indoor or outdoor.

The 5G system shall be able to provide different positioning services with different KPI performance for the UE whenever it is indoor or outdoor according to operator’s policy or 3rd party’s request.

The 5G System shall be able to provide positioning service with TTFF less than [10] s.

The 5G system shall be able to provide positioning service with 2m horizontal position accuracy, 90% availability, and less than 1s latency for the UE outdoor.

The 5G system shall be able to provide positioning service with 0.1m horizontal position accuracy, 99% availability, and less than 1s latency for the UE indoor.

NOTE: this 0.1m position accuracy target is source from [3] and [4].

The 5G system shall supply a method for 3rd party to configure and manage different positioning services for different users according to agreement between operator’s policy and 3rd party.

The 5G system shall supply a method for operator to configure and manage different positioning services for different users according to agreement between operator’s policy and 3rd party

### 5.8.2 Support location method negotiation

#### 5.8.2.1 Description

One location module in a UE may support multiple methods to supply its position information, for example, 3GPP technologies and non-3GPP technologies. This includes, but not limited to, GNSS (e.g. BeiDou, Galileo, GLONASS, and GPS), Terrestrial Beacon Systems (TBS), Bluetooth, WLAN, RFID, and sensors. Different location methods support different level position performance and capabilities. So, it is suggested to support negotiation of location capabilities considering user, application, or network operator’s demands.

#### 5.8.2.2 Pre-conditions

Bob is user of operator A. Bob’s UE supports multiple mode location methods, for example, 3GPP technologies and non-3GPP technologies. This includes, but not limited to, GNSS (e.g. BeiDou, Galileo, GLONASS and GPS), Terrestrial Beacon Systems (TBS), Bluetooth, WLAN, RFID, and sensors.

The 3GPP system of Operator A supports multiple location methods, for example, 3GPP technologies and non-3GPP technologies. This includes, but not limited to, GNSS (e.g. BeiDou, Galileo, GLONASS and GPS), Terrestrial Beacon Systems (TBS), Bluetooth, WLAN, RFID,, and sensors. Bob has registered the location service from operator A.

#### 5.8.2.3 Service Flows

Bob is going to drive to his office. When he leaves his home, he switches on the GNSS e.g. BeiDou location enable button in his UE and open the Map application.

Bob’s UE notifies the 3GPP system that it can support LTEand BeiDou location methods now, and requests that which ones the system use to supply location service.

The 3GPP system identifies that Bob’s UE is in outdoor and the navigation application is active, so responses that the LTE, 5G and BeiDou location methods can be used.

Bob’s UE receives the response and begins to supply position data to the 3GPP system periodically. During Bob is driving to his office, the 3GPP system provides navigation location service to him.

Bob arrives his office basement and plans to park his electric car to the wireless charging port which requires higher accuracy positioning capability. The parking application sends positioning requirement to 3GPP system to request higher accuracy positioning requirement.

Then, the 3GPP system analyses that this higher accuracy positioning requirement can be supported by 5G and asks Bob’s UE that whether the 5G location method can be used now. Bob’s UE responses that WLAN, LTE, 5G location methods can be used.

The 3GPP system decides to use 5G which can support higher accuracy location performance to support parking application positioning requirement.

The 3GPP system notifies Bob’s UE of the selected location method and parking application that its positioning request can be supported.

The 3GPP system and Bob’s UE switch location method to 5G location methods. The location service continues and helps to park Bob’s car.

#### 5.8.2.4 Post-conditions

Bob is provided with different location services in different scenarios.

#### 5.8.2.5 Potential Impacts or Interactions with Existing Services/Features

None identified.

#### 5.8.2.6 [Potential] Requirements

The 5G system shall be able to support multiple single and hybrid location methods to supply location service according to operator’s policy or application’s requirements or user’s preference.

The 5G System shall be able to negotiate location methods according to operator’s policy or application’s requirements or user’s preference.

The 5G system shall be able to support the 5G network or UE to trigger to negotiate location methods.

The 5G system shall be able to supply a method to support the 3rd party to request 5G system to trigger location methods negotiation.

# 6 Synthesis of the use cases performances targets

## 6.1 Foreword

Adaptability and flexibility are among the key features of the 5G system to satisfy a diversity of services to many different verticals, representing different classes of performances and environment of use. This applies also to 5G positioning services, which can be supported by either 3GPP positioning technologies or a combination of 3GPP and non-3GPP positioning technologies to optimise the performances provided to the different users.

The following table summarises the potential performances requirements of the positioning use cases organised per vertical in Clause 5. Doing so, it also features a comprehensive illustration of the diversity of positioning services the 5G system aims to support.

Table 6.1-1 – Use cases synthesis

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Use cases** | | **Potential requirements per use cases** | | | | | | | |
| **Environment of Use** | **Position Accuracy** | **Velocity** | **Avail.** | **Update rate or interval** | **TTFF** | **Latency** | **Other KPI** |
| 5.2.1 | Bike sharing | 5G positioning service area - Outdoor | 2m Horizontal |  | 90 % |  | 10s | 1s |  |
| Enhanced positioning area - Outdoor | 0.2m Horizontal |  | 99 % |  | 10s | 1s |  |
| 5.2.2 | Augmented Reality | Outdoor - 5G positioning service area | 1-3m Horizontal  0.1-3m Vertical | 2 m/s  10deg. | 80 % | 1 - 10 Hz | 10s | 1s | Low Energy |
| 5.2.3 | Wearables | 5G positioning service area - -Outdoor/Indoor | 2m Horizontal  1-3m Vertical |  | 90 % | 30s - 300s | 10s |  | Power saving mode |
| 5G positioning service area - -Outdoor/Indoor | 2m Horizontal  1-3m Vertical |  | 99 % | 1s - 30s | 10s | 1s | Normal mode |
| 5.2.4 | Advertisement push | 5G positioning service area - -Outdoor/Indoor | 3m Horizontal  3m Vertical |  | 90 % |  |  | 60s |  |
| 5.2.5 | Flow management | Enhanced positioning- Outdoor/Indoor | 10m Horizontal |  | 80 % | 10s | 10s |  |  |
| 5.3.1 | Person and medical equipment location in Hospital | Enhanced positioning- Outdoor/Indoor | 3m Horizontal  2m Vertical |  | 99 % |  |  | 60s |  |
| 5.3.2 | Patient location (outside Hospital) | 5G positioning service area  Outdoor/Indoor | 10m Horizontal  3m Vertical (floor) |  | 99 % |  |  |  |  |
| 5.3.3 | Trolley | Enhanced positioning- Outdoor/Indoor | 0.5m Horizontal  1-3m Vertical |  | 99 % |  |  | 20ms |  |
| 5.3.4 | Waste management | 5G positioning service area - Outdoor | 3m Horizontal |  | 99 % | 2h - 1 day |  | 60s | Very low energy (15 years) |
| 5.4.1 | Emergency call | 5G positioning service area  Outdoor/Indoor | 50m Horizontal 3m Vertical |  | 95 % |  | 30s | 60s | Reliability/ Confidence |
| 5.4.2 | Accurate Positioning for First Responders | Outdoor | 1m Horizontal,  0.3 m Vertical |  | 98 % |  | 10s | 5s | MCX Confidence  Event-triggered report |
| Indoor | 1m Horizontal,  2 m Vertical |  | 95 % |  | 10s | 1s |
| 5.4.3 | Alerting nearby emergency responders | 5G positioning service area Outdoor/Indoor | 50m Horizontal  3m Vertical (floor) |  | 99% |  | 10s |  | Privacy, scalability, cross operator |
| 5.4.4 | Emergency equipment loc. outside hospitals | 5G positioning service area Outdoor/Indoor | 10m Horizontal  3m Vertical (floor) |  | 95% |  | 10s |  | Extended sleep periods |
| 5.5.1 | Traffic Monitoring & Control | 5G positioning service area - Outdoor | 1-3m Horizontal 2.5m Vertical |  | 95 % | 10 Hz | 10s | 30ms | Antispoofing Antitampering |
| 5.5.2 | Road User Charging | 5G positioning service area - Outdoor Enhanced positioning-Tunnels | <1m (across track) 3m (along track) | 2 m/s | 99 % | 1 Hz | 10s |  | Antispoofing Antitampering |
| 5.6.1 | Asset tracking and management | 5G positioning service area - Outdoor | 10-30m Horizontal | 5 m/s | 99 % | 300s-1day |  |  | 20 mJ/fix (average), Antispoofing, Antitampering, support for "out of coverage" positioning |
| Enhanced positioning - Outdoor | 1m Horizontal |  | 99 % | 1s | 1s in enhanced positioning area |  |
| 5.7.1 | UAV  (Data analysis) | 5G positioning service area - Outdoor | 0.1m Horizontal 0.1m Vertical | 0.5 m/s 2 deg. | 99 % |  | 10s |  | Low Energy, Antispoofing, Antitampering |
| 5.7.2 | UAV (Remote control) | 5G positioning service area - Outdoor | 0.5m Horizontal 0.3m Vertical |  | 99 % |  |  | 150ms | Antispoofing Antitampering |
| Enhanced positioning area - Outdoor | 0.5m Horizontal 0.1m Vertical |  | 99.9 % |  |  | 150ms | Antispoofing Antitampering |
| 5.8.1 | Support multiple different location service | 5G positioning service area - Outdoor | 2m Horizontal |  | 90 % |  | 10s | 1s | Management of different KPI and positioning services |
| Enhanced positioning area - Indoor | 0.1m Horizontal |  | 99 % |  | 10s | 1s |
| 5.8.2 | Support location method negotiation | 5G positioning service area Outdoor/Indoor |  |  |  |  |  |  | Support + negotiation of positioning methods (incl. hybrid) |
| Note: most use cases also feature potential requirements on modes of operation, intended for the UE, the Network or for the 5G system. | | | | | | | | | |

Nonetheless, in spite of their diversity, those potential requirements cannot be considered as fully independent from one use case to the other. The considerations developed in the present clause complement the use cases descriptions with transversal analysis. In perspective of the requirements consolidation, they highlight potential similarities among use cases, beyond the verticals boundaries, and lead to further grouping of the uses cases.

## 6.2 Considerations on the commonalities of performances targets among use cases

### 6.2.1 Time to first fix (TTFF)

Many of the reported use cases target a TTFF less than 10 seconds. The “Emergency call” use case requires a TTFF better than 30 seconds, bounded by regulatory requirements. Finally, some use cases do not consider TTFF as a primary requirement.

Even though a lower TTFF increases the user’s experience, a higher TTFF may allow for improvements in the system’s capabilities in terms of accuracy, coverage (indoor) or availability for a given complexity.

Consequently, a TTFF target of 10 seconds can be considered reasonable, if it does not affect the system’s ability to efficiently comply with other requirements, in particular regulatory requirements. Alternatively, the system might support mechanisms to adapt the TTFF between 10s and 30s in order to satisfy other requirements (e.g. regulatory).

### 6.2.2 Latency

In most of the reported use cases, the proposed latency shares a same order of magnitude with the TTFF and the inverse of the update rate, typically 1s or higher.

A latency lower than 500 ms is needed primarily to support:

- Remote control (for instance for UAV), with latency target in the order of 100 – 200 ms.

- Collision avoidance, for which latency is required to be better than 20 – 30 ms (the values represent more or less the time needed to travel the position uncertainty at the maximum speed).

Very low latency requirements might affect the complexity of the involved positioning technologies. Moreover, the remote control capabilities and collision avoidance functions can be supported by multiple technological options, among other:

- Very low latency standalone positioning technologies associated to low latency communications,

- Combination of accurate but high latency positioning technologies with low latency relative positioning technologies in the UE (e.g. IMU, positioning with D2D short range links, etc.),

- Collision avoidance function independent of the positioning service, using local awareness sensors like camera, ultrasound, radar, etc.

Hence, an alternative to latency requirements lower than 500 ms might be to consider a system able to support mechanism for both remote control and collision avoidance, for example, using a combination of positioning technologies.

### 6.2.3 3D-position and velocity measurements

Some use cases need positioning in 3D, adding vertical accuracy targets to the horizontal ones and featuring two classes of vertical accuracy targets:

- Between 2 m and 3 m. This is needed both indoor and outdoor, typically to distinguish multiple 2D service areas overlaying each other in a man-made environment (e.g. floors inside a building or roads crossing each other with bridges)

- Between 0.1 m and 0.3 m. This derives from the need to control objects moving in 3D, in particular in vicinity of obstacles (e.g. UAV in landing phase) whereby the positioning accuracy may be relative to other objects (not absolute). In those cases, primarily outdoor environment of use is considered, and these are either environment with mild signal obstruction or enhanced positioning areas (e.g. a few tens of meters around the docking station). Additionally, indoor use cases with a small service area may be considered.

Accurate velocity is only required for use cases outdoor, and accuracy better than 1 m/s is then needed only for use cases operating in environment with mild signal obstruction.

For both the aforementioned KPIs, the combination of positioning technologies should leverage the system’s ability to support the associated use cases.

### 6.2.4 Accuracy and availability

Horizontal accuracy and availability of the position-related data are the primary KPIs reported by the use cases descriptions. For what concerns positioning technologies, these two KPIs behave monotonously with system’s complexity and in opposition of each other (antagonism):

- Higher availability, or improved accuracy of positioning-related data, may increase the system’s complexity

- Higher availability may come at the cost of lower accuracy (and vice-versa) for a given complexity. When measurement samples are time-independent, their CDF provides a convenient illustration of such behaviour.

The following figure represents two sets of data:

- Scattered points scaled with the left axis: the availability requirements plotted versus the horizontal accuracy requirements

- Colour bands scaled on the right axis: the theoretical CDFs of three normal distributions with zero-mean and standard deviation of respectively: [3cm – 15cm], [0.5m – 1.5m] and [5m – 25m].

NOTE: the representation of the CDF is here illustrative and does not presume that the 5G position measurements are time-independent or follow a normal distribution with zero mean.

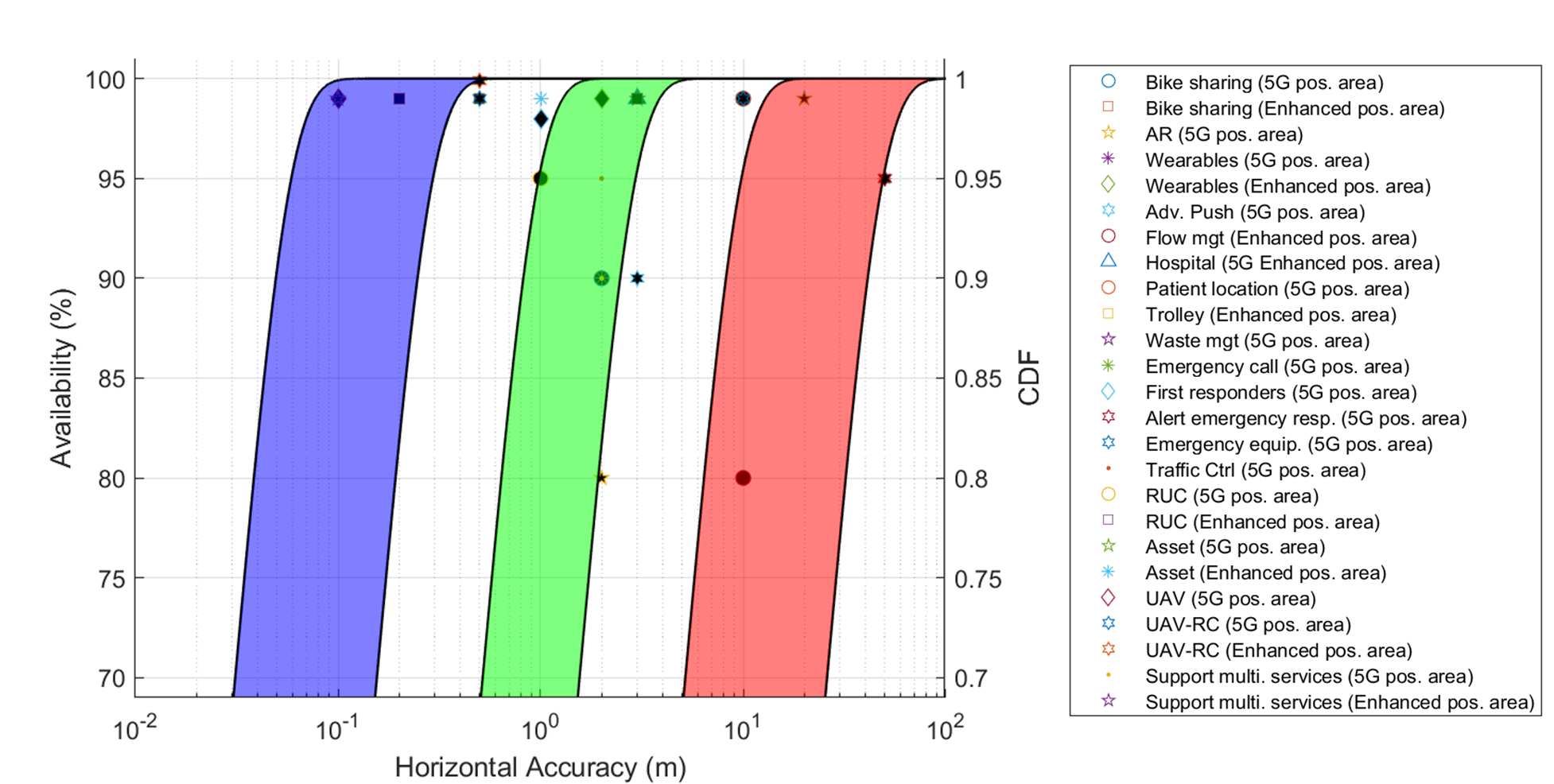


Figure 6.2.4-1 – Accuracy and Availability potential requirements for the use cases

This graphical representation supports multiple interpretations, one of them yields three groups of use cases and working points for the horizontal accuracy:

- Very high accuracy use cases in favourable environment of use, either enhanced positioning areas or relatively mild outdoor environments (limited signal obstruction). For instance, UAV, trolley and bike sharing in dedicated areas.

- High accuracy use cases, with less demanding availability (e.g. 90%) or facing either outdoor or enhanced positioning areas. For instance, most LBS use cases.

- Use cases for which accuracy targets can be relaxed to fulfil more demanding requirements, such as a higher availability throughout the 5G positioning service area or low energy consumption. For instance, emergency calls, patient location outside the hospital, and asset management require high availability and accuracies less stringent (above the sub-meter range).

### 6.2.5 Consideration on relative positioning

Several use cases need positioning accuracy below 0.2 m. Their descriptions make clear this need refers to relative positioning and a small service area: a user need to find and pick-up the bike he rented through a 5G-enabled application, or a UAV need to land on a docking station. In Guidance-Navigation-Control vocabulary, such situation is identified as a rendezvous phase, usually preceded by a homing phase.

The need to access very high accuracy, down to the decimetre level, in 2D or in 3D, during the rendezvous phase is fully justified in the aforementioned use cases. However, until the involved UEs are in “short range” of the rendezvous (e.g. from each other), defined as the rendezvous service area, the positioning service primarily guides them towards this rendezvous area. Therefore, during this homing phase, the service can sustain less accurate positioning than during the rendezvous.

These considerations allow deriving what “short range” is, thus defining the size of the rendezvous service area in which relative positioning accuracy below 0.2 m is to be achieved.

- Prior to entering the rendezvous service area, the UEs are guided using absolute positioning service in a enhanced positioning area. The service must switch to rendezvous phase accuracy before the position uncertainty of the UEs involved in the rendezvous overlap or affects the rendezvous operations (including margin to ensure the service achieves a high level of confidence).

- According to the use cases description, the homing phase would be provisioned in a enhanced positioning area, primarily outdoor, where a positioning accuracy of 0.5m (95% or more) can be expected (potential requirement of many use cases for this kind of service areas).

- Therefore, the rendezvous service area does not need to be significantly larger than 2m around the rendezvous position (e.g. around the rented bike or the docking station).

In conclusion, the use cases requiring less than 0.2m accuracy can be supported by the following capabilities:

- An absolute positioning service with an accuracy less than 0.5 m in enhanced positioning areas (homing phase)

- A relative positioning service with an accuracy less than 0.1m (3D) when the involved UEs are within 5 m from each other (rendezvous phase).

### 6.2.6 Respect of the user’s privacy

Some use cases report the necessity to respect the user’s privacy when providing a positioning service in 5G. From the use cases description and potential requirements, one understands that privacy is considered in those use cases in a rather large sense, as the concepts covers, depending on the use cases:

- The protection of the privacy of the user or owner of the UE (e.g. eHealth related use cases, described in clauses 5.3.1 and 5.3.2)

- The protection of the UE’s trajectory, as this trajectory can represent a signature of the owner’s identity, even if the owner’s identity is well protected or made anonymous in the system (use cases on flow management described in clause 5.2.5, on road-user charging described in clause 5.5.1, on support to UAV mission described in clause 5.7.1)

- The respect of the user’s consent to some positioning services (use case on Location-based advertising push described in clause 5.2.4).

In conclusion, the following capabilities should be able to support the use cases requiring the aforementioned privacy protection:

- The 5G positioning services shall be able to protect, by some mechanism, the UE’s privacy and the privacy of the UE’s user or owner, including the respect of its consent to the positioning services.

NOTE 1: This includes the ability for the System to provide the positioning services on demand without having to track continuously the position of the involved UE.

NOTE 2: The respect of the user’s consent to some positioning services could abide by different rules in case of emergency (for example, rules that would also receive consent from the user, but well before the emergency occurs).

### 6.2.7 Flexibility, versatility and configurability of the positioning services

Some use cases report the need to adapt the capabilities and performances in different situation, such as adaptation to the needs of users, operator or 3rd parties, adaptation to the environment of use, to the operation mode of the use case, etc. Although the needs are expressed in different ways throughout the potential requirements of the different use cases, they address primarily the following capabilities:

- Adaptation of update rate to user needs, environment, energy consumption constraints (e.g. use case on power saving mechanism described in clause 5.2.3, waste management in described in 5.3.4)

- Configuration by the system (also involving the user or a 3rd party) of different working points and performances to fulfil or optimise the service (depending on need of the user, the operator or a 3rd party), as for instance described in clause 5.7.2 for UAV landing phase, and in a more general way in in clauses 5.8.1 and 5.8.2.

The potential requirements sometime also make clear the aforementioned capabilities need to be managed in a dynamic way, although latency of any update or change to the working point is not translated in a requirement. This is for instance the case for power saving mechanism (described in clause 5.2.3), asset tracking (described in clause 5.6.1), and also to support the negotiation of different location methods (described in clause 5.8.2).

In conclusion, the following capabilities should be able to support the use cases requiring this aforementioned adaptability and configurability of the positioning services:

- The 5G System shall provide different 5G positioning services with configurable performances working points (e.g. accuracy, availability, energy consumption, update rate, TTFF) according to the needs of users, operators and 3rd parties.

- The 5G system shall support mechanism to configure dynamically the update rate of the position-related data to fulfil different performances (e.g. power consumption, latency) or different location modes.

## 6.3 Considerations on the grouping of use cases

In clause 5, the positioning use cases have been organised by categories more or less mapping different verticals. They are supported by different classes of UE, eventually transverse to some verticals, which in turn represent another convenient way to group them:

- Handheld and wearables UEs, primarily supporting LBS and eHealth use cases

- Machine-type UEs, primarily used in machine control (trolleys, UAV) and/or transportation sector (tracking of road vehicles for traffic management purpose)

- Very low energy UEs, able to sustain a lifetime of 15 years with simple batteries (e.g. AA, AAA or button-cell batteries)

As discussed in the clause 6.2, positioning accuracy supports another reading of the use cases and another way to group them. The following table translates the two aforementioned grouping into a common illustration, where the cells colours are indexed on the accuracy range.

Table 6.3-1 – Overview of grouped use cases (UE type, Accuracy & Environment of use)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Type of UE** | **Related  Use cases** | **KPI** | **Service area – environment of use** | | | |
| **Enhanced positioning area** | **5G positioning service area** | | |
| Outdoor / Indoor | Outdoor  (rural, suburban) | Outdoor (deep urban) | Indoor |
| Very Low Energy  (up to 15 years lifetime) | Waste Management  Asset tracking and management" | Horizontal Accuracy | 1m | 3m - 30 m | 3m - 30 m |  |
| Vertical  Accuracy |  |  |  |
| Velocity (bearing) |  | 5m/s | 5m/s |
| Availability | 99% | 99% | 99% |
| TTFF | 10s |  |  |
| Handheld / wearables | Bike Sharing  Augmented Reality  Wearables  Advertisement push  Flow management  Patient Location (2)  Emergency Call | Horizontal Accuracy | 0.2m - 1m | 1m - 3m | 1m - 3m | 10m - 50m |
| Vertical  Accuracy | Outdoor:1-3 m  Indoor: 0.1-1 m | 3m | 3m | 0.1 – 3 m |
| Velocity (bearing) |  | 2m/s (10deg.) | 2m/s (10deg.) |  |
| Availability | 80 % - 99% | 80% - 99% | 80% - 99% | 0.95 |
| TTFF | 10s - 30s | 10s - 30s | 10s - 30s | 10s - 30s |
| Machine Control / Transportation | Trolley  Traffic M&C  Road User Charging  UAV (Data Analysis)  UAV (Remote Control)  Support multiple different location services | Horizontal Accuracy | 0.1m - 0.5m | 0.1m - 3m | 1m - 3m |  |
| Vertical  Accuracy | 0.1m | 0.1m - 0.3m | 2.5m |
| Velocity (bearing) |  | 0.5m/s (2 deg) - 2m/s | 0.5m/s (2 deg) - 2m/s |
| Availability | 99% - 99.9% | 95% - 99.9% | 95% - 99.9% |
| TTFF | 1s - 10s | 1s - 10s | 1s - 10s |
| **Colour legend** | | | | | | |
|  | Very high accuracy use cases in favourable environment of use: either enhanced positioning areas or outdoor environments with limited signal obstruction. This group features accuracy levels below 0.2 m, expected for relative positioning services, during rendezvous phase between two UE standing in close range of each other (< 10 m). | | | | | |
|  | High accuracy use cases, with less demanding availability (e.g. 90%) or facing outdoor or enhanced positioning areas. | | | | | |
|  | Use cases for which accuracy targets are relaxed to fulfil reasonable positioning service over a wide area, usually throughout the 5G positioning service area (both indoor and outdoor) or with very low energy consumption (e.g. to sustain a 15-years of battery lifetime) | | | | | |

Eventually, depending on the desired level of achievement in terms of use cases coverage (e.g. conservative, intermediate or ambitious), different consolidated potential requirement for horizontal accuracy can be derived from the above categories, such as those presented in table 6.3-2.

Table 6.3-2 Sets of horizontal accuracy requirements for each range of accuracy level

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Achievement level** | **Wide coverage** | **High accuracy** | **Very High accuracy** | **Accuracy target derived from accuracy range of use cases category** |
| Conservative | 50 m | 3 m | 0.5 m | Upper bound |
| Intermediate | 10 m | 1 m | 0.3 m | Intermediate |
| Ambitious | 3 m | 1 m | 0.1 m | Lower bound |

# 7 Considerations on the suitability of positioning technologies for use cases

## 7.1 Introduction and proposed approach

In addition to the considerations developed in clause 6 on the use cases performance targets, an initial identification of how existing positioning technologies meet such targets is presented, with the objective to identify targets that can be met already and in particular others that would require new technologies to be possibly considered in 5G NR. A qualitative assessment based on a colour – coded scale is used as in table below.

Table 7-1: Classification scale

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Performance targets fully met (at least 95%) | Performance targets largely met (at least 68%) | Performance targets met under certain conditions | Performance targets rarely met | Performance targets never met (or met under exceptional conditions) |

In the next clause, this approach is presented in more detailed tables for the different Key Performance Indicators.

The positioning technologies captured in TS 38.305 are the baseline used for the apportionment exercise. They can be classified into the following categories:

- 3GPP technologies included/to be included in TS 38.305: downlink positioning (OTDOA), enhanced cell ID (E-CellID)

- Non-3GPP technologies included/to be included in TS 38.305: A-GNSS, HA-GNSS (e.g. RTK), TBS, WLAN (also with FTM, Fine-Time Measurement, as defined in 802.11-2016), Bluetooth method

- Positioning sensors included/to be included in TS 38.305: barometric pressure sensor method, IMU

NOTE: TS 38.305 is expected to be updated based on the positioning enhancements standardised for LTE Release 15 i.e. hence, the addition of HA-GNSS to this list.

The suitability of technologies is performed for key performance indicators and associated targets, as identified in the use cases and in clause 6, typically:

- Horizontal accuracy classes: 50 m, 3 m, 0.1-0.5 m (see clause 6.3)

- Vertical accuracy: typically 2-3 m

- Relative positioning accuracy: 0.1-0.2 m

- Velocity accuracy: 1-5 m/s

And for different environment of use (which refers to the nature of the environment, and not to the geographical coverage, for instance, of a cellular network):

- Outdoor rural (includes any outdoor with almost no obstruction)

- Outdoor sub-urban (includes any outdoor with limited obstruction) and urban

- Outdoor deep urban (or any environment with very significant obstruction)

- Indoor

- Enhanced positioning coverage area

The GNSS accuracy displayed below reflects performances from ETSI TS 103 246-3 [6] while HA-GNSS performance corresponds to state of the art RTK results reported in literature or in technical specifications released by GNSS receiver manufacturers. The values associated to terrestrial positioning technologies are derived from 3GPP standards such as TR 37.857 (Study on indoor positioning enhancements for UTRA and LTE ) and FCC E911 Location Accuracy - Indoor Location Test Bed Report [7] for 3GPP LTE and TBS, and from state of the art results for WLAN and Bluetooth.

The potential impacts related to the infrastructure configurations and density are reported qualitatively in the tables comments (for example, coverage of GNSS is global, for HA-GNSS and LTE it depends on the network deployment) or use of technologies at user level or hybridisation of various technologies).

## 7.2 Suitability of existing positioning technologies for different KPIs

### 7.2.1 Horizontal accuracy KPI

Clause 7.2.1 maps in color-coded scale the capability of each positioning technology to meet 3 classes of absolute horizontal accuracy corresponding to the categorisation presented in clause 6.3: 50 m, 3 m and 0.3 m.

Table 7.2.1-1: Technologies capabilities for KPI horizontal accuracy when target performance is better than 50 m

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Positioning technology** | **5G positioning service area** | | | | **Enhanced positioning coverage area** |
| **Outdoor rural** | **Outdoor Suburban / Urban** | **Outdoor Deep Urban** | **Indoor** |
| **3GPP (LTE)** | Depends on network configuration and density | Depends on network configuration and density | | |  |
| **TBS** | Depends on network configuration and density | | | |  |
| **WLAN** |  |  | Depends on network configuration and density | Depends on network configuration and density |  |
| **Bluetooth** |  |  | Depends on configuration and density | Depends on configuration and density |  |
| **GNSS** |  |  |  | Light indoor for high sensitivity receivers |  |
| **HA-GNSS** |  |  |  |  |  |
| **Barometer** | NA | | | | |
| **IMU** | Improves availability and reliability | | | | |

Table 7.2.1-2: Technologies capabilities for KPI horizontal accuracy when target performance is better than 3 m

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Positioning technology** | **5G positioning service area** | | | | **Enhanced positioning coverage area** |
| **Outdoor rural** | **Outdoor Suburban / Urban** | **Outdoor Deep Urban** | **Indoor** |
| **3GPP (LTE)** |  |  |  |  |  |
| **TBS** | Depends on network configuration and density | | | | Depends on network configuration and density |
| **WLAN** |  |  |  | Depends on technology used, network configuration and density | With FTM, depends on network configuration and density |
| **Bluetooth** |  |  |  |  | Depends on configuration and density |
| **GNSS** |  |  |  |  |  |
| **HA-GNSS** |  |  |  |  |  |
| **Barometer** | NA | | | | |
| **IMU** | Improves availability and reliability | | | | |

Table 7.2.1-3: Technologies capabilities for KPI horizontal accuracy when target performance is better than 0.3 m

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Positioning technology** | **5G positioning service area** | | | | **Enhanced positioning coverage area** |
| **Outdoor rural** | **Outdoor Suburban / Urban** | **Outdoor Deep Urban** | **Indoor** |
| **3GPP (LTE)** |  |  |  |  |  |
| **TBS** |  |  |  |  |  |
| **WLAN** |  |  |  |  |  |
| **Bluetooth** |  |  |  |  |  |
| **GNSS** |  |  |  |  |  |
| **HA-GNSS** |  |  |  |  |  |
| **Barometer** | NA | | | | |
| **IMU** | Improves availability and reliability | | | | |

### 7.2.2 Technologies capabilities for vertical accuracy KPI

Clause 7.2.2 maps in color-coded scale the capability of each positioning technology to meet a 3 m vertical accuracy.

Table 7.2.2-1: Technologies capabilities for KPI vertical accuracy when target performance is better than 3 m

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Positioning technology** | **5G positioning service area** | | | | **Enhanced positioning coverage area** |
| **Outdoor rural** | **Outdoor Suburban / Urban** | **Outdoor Deep Urban** | **Indoor** |
| **3GPP (LTE)** |  |  |  | Depends on network configuration and density | If dense indoor small cells |
| **TBS** |  | Yes, for devices equipped with a pressure sensor | Yes, for devices equipped with a pressure sensor |  |  |
| **WLAN** |  |  |  |  | With FTM, depends on network configuration and density |
| **Bluetooth** |  |  |  |  | Depends on network configuration and density |
| **GNSS** |  |  |  |  |  |
| **HA-GNSS** |  |  |  |  |  |
| **Barometer** | Good calibration is not always possible | Yes, when calibrated in the working environment. Experiences problems when a user moves from outdoor to indoor and the opposite. | | | |
| **IMU** | Improves availability and reliability | | | | |

### 7.2.3 Technologies capabilities for relative positioning accuracy KPI

Clause 7.2.3 maps in color-coded scale the capability of each positioning technology to meet a 0.2 m relative positioning accuracy as addressed in clause 6.2.

Table 7.2.3-1: Technologies capabilities for KPI relative positioning accuracy when target performance is better than 0.2 m

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Positioning technology** | **5G positioning service area** | | | | **Enhanced positioning coverage area** |
| **Outdoor rural** | **Outdoor Suburban / Urban** | **Outdoor Deep Urban** | **Indoor** |
| **3GPP (LTE)** |  |  |  |  |  |
| **TBS** |  |  |  |  |  |
| **WLAN** |  |  |  |  |  |
| **Bluetooth** |  |  |  |  |  |
| **GNSS** |  |  |  |  |  |
| **HA-GNSS** |  |  |  |  |  |
| **Barometer** | NA | | | | |
| **IMU** | Improves availability and reliability | | | | |

### 7.2.4 Technologies capabilities for velocity accuracy KPI

Clause 7.2.4 maps in color-coded scale the capability of each positioning technology to meet the velocity accuracy targets in the order of 1 m/s.

Table 7.2.4-1: Technologies capabilities for KPI velocity accuracy when target performance is in the order of 1 m/s

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Positioning technology** | **5G positioning service area** | | | | **Enhanced positioning coverage area** |
| **Outdoor rural** | **Outdoor Suburban / Urban** | **Outdoor Deep Urban** | **Indoor** |
| **3GPP (LTE)** |  |  |  |  |  |
| **TBS** |  |  |  |  |  |
| **WLAN** |  |  |  |  |  |
| **Bluetooth** |  |  |  |  |  |
| **GNSS** |  |  |  |  |  |
| **HA-GNSS** |  |  |  |  |  |
| **Barometer** | NA | | | | |
| **IMU** | Yes, when regularly calibrated for instance with odometer, GNSS, HA-GNSS | | | Good calibration is not always possible | |

## 7.3 Summary

The analysis presented in clause 7.2 highlights the fact that there is no single technology capable to meet all use case positioning targets in all environments. The results from above show that horizontal positioning accuracy for indoor positioning may be achieved within 50 metre threshold with technologies already supported by 3GPP (including TBS and GNSS). Using a typical indoor WLAN infrastructure with adequate geometry, WLAN could reach the 50m target as well.

From Table 7.2.1-2 it can be seen that only GNSS satisfies a horizontal accuracy of 3m in outdoor environments. Even in deep urban areas, GNSS can meet this target but with an availability significantly lower than 99%.

In the case of very demanding positioning requirements, from the positioning technologies included in LPP protocol only HA-GNSS is suitable to meet the 0.3m target at 99% availability. Naturally, the availability is considerably decreasing once in an urban environment. The situation is even worse for indoor environments. To conclude, the high accuracy positioning is not yet available in deep urban environments, especially at an availability better than 99%. For indoor, the situation is not better and it can be improved only by massive infrastructure deployments. Even though in standalone mode each positioning technology has displayed several limitations, the performance can be significantly improved when two or more technologies are combined. A proper integration of existing technologies, supported by adequate infrastructure deployment may cover most need except those marked in yellow and red, which can be a typical target for NR to complement existing technologies (see Table 7.2-1).

Table 7.3-1: Assessment of positioning performance targets potentially met by combination multiple positioning technologies

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **User Case Positioning Performance Targets** | | **5G positioning service area** | | | | **Enhanced positioning coverage area** |
| **Outdoor rural** | **Outdoor sub-urban / urban** | **Outdoor Deep urban** | **Indoor** |
| **Horizontal accuracy** | **50m** | Yes | Yes | Yes | Yes | Yes |
| **3m** | Yes | Yes | Yes (availability to be confirmed) | No | Yes (availability to be confirmed) |
| **0.3m** | Yes | Yes | No | No | No |
| **Relative positioning accuracy** | **0.2m** | Yes (availability to be confirmed) | Yes (availability to be confirmed) | No | No | No |
| **Vertical accuracy** | **3m** | Yes | Yes | Yes (calibrated barometer, e.g. with GNSS and/or TBS [7]) | Yes (calibrated barometer e.g. with TBS [7]) | Yes (calibrated barometer) |

Existing positioning technologies, 3GPP and non-3GPP such as GNSS (e.g. BeiDou, Galileo, GLONASS, and GPS), Terrestrial Beacon Systems (TBS), sensors (e.g. barometer, IMU), WLAN/Bluetooth-based positioning, can cover already a wide variety of demanding use cases especially when paired together. Even when combining all technologies, some very demanding accuracy targets are not met and this requires new positioning technologies, for instance based on NR. This is particularly the case to fill the gaps of high accuracy in indoor and deep urban environments, as well as to cover very high accuracy positioning and relative positioning in enhanced positioning coverage . The 5G System will thereby have to integrate a multitude of sensors and technologies based on both 3GPP and non-3GPP positioning technologies, such as the aforementioned ones, into a hybrid positioning scheme.

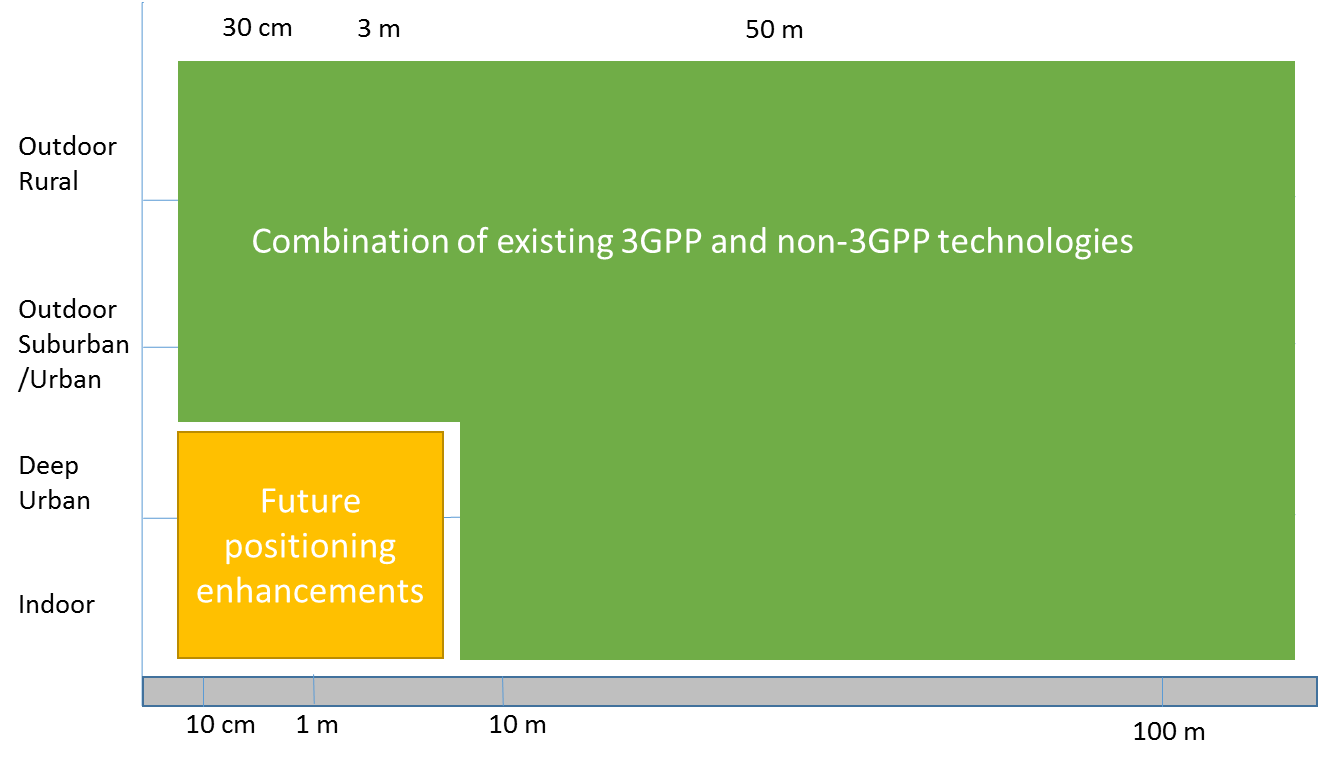


Figure 7.3-1: Targeted coverage of accuracy for 5G positioning technologies

# 8 Consolidated potential positioning requirements

## 8.1 Overall Positioning Services requirements

[PR-001] The 5G System shall provide different 5G positioning services, supported by different single and hybrid positioning methods, to supply absolute and relative positioning.

NOTE 1: hybrid positioning methods include both the combination of 3GPP positioning technologies and the combination of 3GPP positioning technologies with non-3GPP positioning technologies such as GNSS (e.g. Beidou, Galileo, GLONASS, and GPS), Terrestrial Beacon Systems (TBS), sensors (e.g. barometer, IMU), WLAN/Bluetooth-based positioning.

[PR-002] The 5G System shall provide different 5G positioning services with configurable performances working points (e.g. accuracy, availability, energy consumption, update rate, TTFF) according to the needs of users, operators and 3rd parties.

[PR-003] The 5G System shall provide 5G positioning services in compliance with regulatory requirements.

NOTE 2: example of regulatory requirements encompasses requirements on emergency calls (e.g. e911), reliability and safety requirement (RAMS) applicable to some use cases and verticals, implementation of Priority, Precedence, Preemption (PPP) mechanisms to ensure sufficient reliability metrics are reached, etc.

[PR-004] The 5G system shall be able to determine the reliability, and the uncertainty or confidence level of the position-related data.

[PR-005] The 5G System shall be able to provide the 5G positioning services in case of roaming.

[PR-006] The 5G System shall be able to support the combination of 3GPP positioning technologies with non-3GPP positioning technologies to achieve performances of the 5G positioning services better than those achieved using only 3GPP positioning technologies.

NOTE 3: for instance, the combination of 3GPP positioning technologies with non-3GPP positioning technologies such as GNSS (e.g. Beidou, Galileo, GLONASS, and GPS), Terrestrial Beacon Systems (TBS), sensors (e.g. barometer, IMU), WLAN/Bluetooth-based positioning, can support the improvement of accuracy, availability, reliability and/or confidence level. The combination of 3GPP positioning technologies with non-3GPP positioning technologies can also support higher update rates and/or lower latency of the position-related data.

[PR-007] The 5G System shall support the UE to provide its position-related data for periods when the UE is outside the coverage of 3GPP RAT-dependent positioning technologies.

[PR-008] The 5G system shall be able to manage and log position-related data in compliance with applicable traceability, authentication and security regulatory requirements.

## 8.2 Positioning performance requirements

[PR-009] The 5G System shall be able to provide horizontal positioning services as per the requirements and attributes reported in Table 8.2-1.

Table 8.2-1: Horizontal accuracy and availability requirements for different positioning services

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **5G Positioning Services** | **Horizontal Accuracy** | **Availability** | **Service Area and Environment of Use** | | **Range of UE velocity** | **Range of UEs density** |
| **5G positioning service area** | **Enhanced positioning coverage area** |
| **Wide area Positioning Service** | < 10 m | > 95 % | Indoor and Outdoor | NA | Indoor: static  Outdoor: 0-180 km/h | > 10 000 UE per km² |
| **High Accuracy Positioning Service** | < 3 m | > 99 % | Outdoor | Indoor and Outdoor | up to at least >160 km/h | > 10 000 UE per km² |
| **Very High Accuracy Positioning Service** | < 0.3 m | > 99 % | Outdoor (unobstructed) | Indoor and Outdoor | up to at least >160 km/h | > 100 000 UE per km² |
| Enhanced positioning coverage area may typically be 500 m long x 500 m wide x 30 m high | | | | | | |

[PR-010] The 5G system shall be able to provide positioning service with 3m vertical accuracy and an availability of 95% anywhere in 5G positioning service area (for speed up to at least 160 km/h).

NOTE 1: the vertical positioning requirement should be sufficiently accurate to determine the floor in indoor use cases and distinguish between superposed roads in road-related use cases.

[PR-011] The 5G system shall be able to provide relative changes in the UE’s altitude (or height) from an initial reference point with a vertical accuracy less than 0.2 m and an availability of 95% for some 5G positioning services.

[PR-012] The 5G System shall be able to provide a relative positioning service with a relative accuracy better than 0.2 m and an availability of 99 % either between two UEs within 10 m of each other or between one UE and 5G positioning nodes within 10 m of each others.

NOTE 2: 5G positioning nodes are here infrastructure equipment deployed in the service area to enhance positioning capabilities: for instance, some beacons deployed on the perimeter of a rendezvous area or on the side of a warehouse.

NOTE 3: the relative positioning capability can be achieved in any relevant 2D or 3D, Cartesian or Polar coordinate system for instance, using either very high accuracy positioning technologies or 2-way ranging and direction of arrival from one UE to the other.

[PR-013] The 5G system shall be able to provide the 5G positioning services with a TTFF less than 30 s and, for some 5G positioning services, shall support mechanisms to provide a TTFF less than 10s at the expense of a relaxation of some other performances (e.g., horizontal accuracy relaxed from 3 m to 10 m for a high accuracy positioning service).

[PR-014] The 5G system shall be able to provide the 5G positioning services with a latency lower than 1 s.

NOTE 4: the 5G system may support mechanism such as extrapolation of position and combination of positioning technologies to provide some 5G positioning services with latency less than 20 ms.

[PR-015] The 5G system shall support mechanism to determine the UE's velocity outdoor with an accuracy better than 0.5 m/s and better than 5 degree bearing, and an availability of 99%.

NOTE 5: for both the aforementioned KPI, the combination of positioning technologies will leverage the system’s ability to fulfil the requirements.

[PR-016] The 5G System shall be able to provide a positioning service involving an average of less than 20 mJ of the UE’s energy per position fix and involving a peak power less than 200 mW.

NOTE 6: the 5G positioning services should be fulfilled without affecting the UE’s battery overall lifetime by more than 5 % or without reducing the UE’s battery lifetime by more than 10 months out of a total of 15 years’ lifetime.

NOTE 7: the 5G System needs to consider UEs with limited form factor, limited CPU power, and limited radio access technology support (e.g. eMTC type communication only).

## 8.3 Operational Requirements

[PR-017] The 5G system shall be able to request the UE to provide its position-related-data on request, triggered by an event or periodically and to request the UE to stop providing its position-related data periodically.

NOTE 1: This requirement does not preclude whether the position is computed in the UE or elsewhere in the 5G System (e.g. core network). Indeed, the determination of the UE’s position or location requires the UE to transmit some information (e.g. position, OTDOA measurements made on PRS, some signal allowing the UE’s identification and UTDOA measurements in the nodes, etc.) which refers to position-related data.

[PR-018] The 5G system shall allow the UE to trigger a different update rate of the position-related data based on whether the UE is moving or not.

[PR-019] The 5G system shall support mechanism to configure dynamically the update rate of the position-related data to fulfil different performances (e.g. power consumption, latency, etc.) or different location modes.

NOTE 2: for example, the 5G System needs to be able to request the UE to provide its location periodically with an update rate ranging from one location every [1 s-10 s] in location normal mode to one location every [30 s-300 s, or more] in location power saving mode. The 5G System needs to allow UEs to sleep for extended periods (e.g. one week), without requiring the UE to update its position data.

[PR-020] The 5G system shall be able to determine the position-related data of the 5G positioning services with any update rate ranging from one set of position-related data every 0.1 s to one set of position-related data every month.

[PR-021] The 5G System shall be able to make the position-related data available to an application server.

NOTE 3: the latency to make the position-related data available can be tailored to the use cases.

[PR-022] The 5G System shall be able to negotiate the positioning methods according to the operator’s policy or the application’s requirements or the user’s preferences and support mechanism to allow the network or the UE to trigger this negotiation.

[PR-023] The 5G System shall be able to access to the positioning methods used for calculating the position-related data and to the associated uncertainty/confidence indicators.

[PR-024] The 5G system shall supply a method for either the operator or a 3rd party to configure and manage different positioning services for different users according to agreement between operator and 3rd party.

[PR-025] The 5G system shall be able to supply a method to support the 3rd party to request 5G system to trigger location methods negotiation.

[PR-026] The 5G System shall enable an MCX UE to use the 5G positioning services to determine its position with the associated uncertainty/confidence of the position, on request, triggered by an event or periodically.

## 8.4 Security-related Requirements

[PR-027] The 5G positioning services shall be able to protect, by some mechanism, the UE’s privacy and the privacy of the UE’s user or owner, including the respect of its consent to the positioning services.

NOTE 1: this includes the ability for the System to provide the positioning services on demand without having to track continuously the position of the involved UE.

NOTE 2: the respect of the user’s consent to some positioning services could abide by different rules in case of emergency (for example, rules that would also receive consent from the user, but well before the emergency occurs).

[PR-028] The 5G System shall support mechanisms to protect positioning-related data against tampering and spoofing.

[PR-029] The 5G System shall support mechanisms to detect tampering and spoofing attempts on the position-related data.

# 9 Conclusions and recommendations

The current TR provides a number of use cases for positioning services relating to 5G verticals such as LBS, industry and e-health, regulatory use cases (emergency call and first responder), road, rail, maritime and aerial.

The potential requirements reported for each use cases are compiled into a set of potential consolidated positioning requirements, defining different classes of positioning services, in 2D and 3D, for both outdoor and indoor environment of use, in whole 5G positioning service area or limited to enhanced positioning areas like, for instance, a shopping mall or a hospital campus.

The resulting potential requirements identified in this TR can be considered for the development of normative requirements. It is therefore proposed to consider the inclusion of these requirements in existing specifications for 5G services (e.g. TS 22.261).

Annex A:  
Mapping matrices between use cases’ potential requirements and potential consolidated positioning requirements

The following two tables show how the potential consolidated positioning requirements capture the potential requirements proposed for each use case in clause 5, either directly, or by also taking into account the considerations developed in clauses 6 and 7.

The 1st table (Table A-1) associates each requirement of clause 8 to its parents requirements (potential requirements from use cases in clause 5) and to the related considerations in clauses 6 and 7.

The 2nd table (Table A-2 shows how the potential requirements of each use case are covered by the consolidated requirements.

Table A-1: mapping consolidated potential requirements to use cases potential requirements

|  |  |  |
| --- | --- | --- |
| **Consolidated requirements: ID and description** | | **Parent potential requirements (use case clause and title) and consideration contributing to consolidation when applicable** |
| [PR-001] | The 5G system shall provide different 5G positioning services, supported by different single and hybrid positioning methods, to supply absolute and relative positioning. | 5.8.2 (Support location capabilities negotiation) + consideration developed in clause 6.2.7 |
| [PR-002] | The 5G system shall provide different 5G positioning services with configurable performances working points (e.g. accuracy, availability, energy consumption, update rate, TTFF) according to the needs of users, operators and 3rd parties. | 5.8.1 (Support multiple different locations methods) + consideration in clause 6.2.7 |
| [PR-003] | The 5G system shall provide 5G positioning services in compliance with regulatory requirements. | 5.2.4 (Location-based advertising push), 5.4.1 (Accurate positioning for emergency services), several items in potential requirements of 5.7.2 (Drugs transport by drones between hospitals) |
| [PR-004] | The 5G system shall be able to determine the reliability, and the uncertainty or confidence level of the position-related data. | 5.4.1 (Accurate positioning for emergency services) |
| [PR-005] | The 5G system shall be able to provide the 5G positioning services in case of roaming. | 5.3.3 (Trolley location in factories) |
| [PR-006] | The 5G system shall be able to support the combination of 3GPP positioning technologies with non-3GPP positioning technologies to achieve performances of the 5G positioning services better than those achieved using only 3GPP positioning technologies. | 5.8.1 (Support multiple different locations methods) + consideration developed in clause 6 on latency, update rate, 3D position (vertical) and velocity measurements |
| [PR-007] | The 5G system shall support the UE to provide its position-related data for period when the UE is outside the coverage of 3GPP RAT-dependent positioning technologies. | 5.6.1 (Asset and freight tracking (wagon, container) |
| [PR-008] | The 5G system shall be able to manage and log position-related data in compliance with applicable traceability, authentication and security regulatory requirements. | 5.2.2 (Accurate positioning to support Augmented Reality (AR), 5.2.5 (Flow management in large transportation hubs), 5.5.1 (Accurate positioning to support Traffic Monitoring, Management and Control), 5.7.1 (Accurate positioning to support Unmanned Aerial Vehicle (UAV) missions and operations) |
| [PR-009] | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in the following table (table 8.2-1) | Most use cases + considerations developed in clause 6 and in clause 7 |
| [PR-010] | The 5G system shall be able to provide positioning service with 3m vertical accuracy and an availability of 95% anywhere in 5G positioning service area (for speed up to at least 160 km/h) | 5.2.5 (Flow management in large transportation hubs), 5.3.1 (Patient location in hospitals), 5.3.4 (Waste Management & Collection), 5.4 (Emergency and Mission Critical related use cases), 5.5.1 (Accurate positioning to support Traffic Monitoring, Management and Control) |
| [PR-011] | The 5G system shall be able to provide relative changes in the UE’s altitude (or height) from an initial reference point with a vertical accuracy less than 0.2 m and an availability of 95% for some 5G positioning services | 5.2.2, 5.2.3, 5.2.4, 5.3.3 and 5.4.2 |
| [PR-012] | The 5G system shall be able to provide a relative positioning service with a relative accuracy better than 0.2 m and an availability of 99 % either between two UEs within 10 m of each other or between one UE and 5G positioning nodes within 10 m of each others. | 5.2.1 (Accurate positioning for shared bikes), 5.7.2 (Drugs transport by drones between hospitals), 5.8.1 (Support multiple different locations methods) + considerations developed in clause 6 (relative positioning) |
| [PR-013] | The 5G system shall be able to provide the 5G positioning services with a TTFF less than 30 s and, for some 5G positioning services, shall support mechanisms to provide a TTFF less than 10s at the expense of a relaxation of some other performances (e.g., horizontal accuracy relaxed from 3 m to 10 m for a high accuracy positioning service). | most use cases + considerations developed in clause 6 on TTFF |
| [PR-014] | The 5G system shall be able to provide the 5G positioning services with a latency lower than 1 s. | Most use cases need a latency in the range of 1s + Considerations developed in clause 6 relating to latency (e.g. use case 5.7.2 Transport and inspection by drones for medical purposes) |
| [PR-015] | The 5G system shall support mechanism to determine the UE's velocity outdoor with an accuracy better than 0.5 m/s and better than 5 degree bearing, and an availability of 99%. | 5.2.2 (Accurate positioning to support Augmented Reality (AR)), 5.2.5 (Flow management in large transportation hubs), 5.5.2 (5.5.2 Road-User Charging (RUC)), 5.6.1 (Asset and freight tracking (wagon, container), 5.7.1 (Accurate positioning to support Unmanned Aerial Vehicle (UAV) missions and operations) |
| [PR-016] | The 5G system shall be able to provide a positioning service involving an average of less than 20 mJ of the UE’s energy per position fix and involving a peak power less than 200 mW. | 5.6.1 (Asset and freight tracking (wagon, container), 5.3.4 (Waste Management & Collection) |
| [PR-017] | The 5G system shall be able to request the UE to provide its position-related-data on request, triggered by an event or periodically and to request the UE to stop providing its position-related data periodically. | Most use case, in particular 5.2.3 (Power saving mechanism of wearable devices), 5.3.1 (Patient location in hospitals), 5.3.4 (Waste Management & Collection) and 5.4 (Emergency and Mission Critical related use cases) |
| [PR-018] | The 5G system shall allow the UE to trigger a different update rate of the position-related data based on whether the UE is moving or not. | 5.4.4 |
| [PR-019] | The 5G system shall support mechanism to configure dynamically the update rate of the position-related data to fulfil different performances (e.g. power consumption, latency, etc.) or different location modes. | 5.2.3 (Power saving mechanism of wearable devices), 5.6.1 (Asset and freight tracking (wagon, container) + consideration developed in clause 6 about configurability |
| [PR-020] | The 5G system shall be able to determine the position-related data of the 5G positioning services with an update rate ranging from one set of position-related data every 0.1s to one set of position-related data every month. | 5.2.3 (Power saving mechanism of wearable devices), 5.3.4 (Waste Management & Collection), 5.4.1 (Accurate positioning for emergency services), 5.5.1 (Accurate positioning to support Traffic Monitoring, Management and Control) |
| [PR-021] | The 5G system shall be able to make the position-related data available to an application server. | 5.3.1 Patient location in hospitals, 5.3.4 (Waste Management & Collection) |
| [PR-022] | The 5G system shall be able to negotiate the positioning methods according to the operator’s policy or the application’s requirements or the user’s preferences and support mechanism to allow the network or the UE to trigger this negotiation. | 5.8.2 ( Support location method negotiation) |
| [PR-023] | The 5G system shall be able to access to the positioning methods used for calculating the position-related data and to the associated uncertainty/confidence indicators. | 5.4.1 (Accurate positioning for emergency services) |
| [PR-024] | The 5G system shall supply a method for either the operator or a 3rd party to configure and manage different positioning services for different users according to agreement between operator’s policy and 3rd party. | 5.8.1 (Support multiple different locations methods) |
| [PR-025] | The 5G system shall be able to supply a method to support the 3rd party to request 5G system to trigger location methods negotiation. | 5.8.2 ( Support location method negotiation) |
| [PR-026] | The 5G system shall enable an MCX UE to use the 5G positioning services to determine its position with the associated uncertainty/confidence of the position, on request, triggered by an event or periodically. | 5.4.2 |
| [PR-027] | The 5G system shall support mechanisms to protect the privacy of both the UE and the UE's owner, including the respect of its consent to the positioning services. | 5.2.2 (Accurate positioning to support Augmented Reality (AR)), 5.5.1 (Accurate positioning to support Traffic Monitoring, Management and Control), 5.7.1 (Accurate positioning to support Unmanned Aerial Vehicle (UAV) missions and operations) + consideration developed in clause 6 about privacy |
| [PR-028] | The 5G system shall support mechanisms to protect positioning-related data against tampering and spoofing. | 5.2.2 (Accurate positioning to support Augmented Reality (AR)) 5.5 (Road-related use cases) 5.6.1 (asset and freight tracking ( wagon, container)), 5.7 (Aerial related use cases) |
| [PR-029] | The 5G system shall support mechanisms to detect tampering and spoofing attempts on the position-related data. | 5.2.2 (Accurate positioning to support Augmented Reality (AR)) 5.5 (Road-related use cases) 5.6.1 (asset and freight tracking ( wagon, container)), 5.7 (Aerial related use cases) |

Table A-2: mapping use cases potential requirements to consolidated potential requirements

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Category** | **Clause** | **Use cases and use case requirements** | **ID and description of related consolidated requirements** | | **Compliancy to use use cases requirements and comments**  **(C = compliant, PC = partially compliant)** | |
|  | 5.2.1 | Accurate positioning for shared bikes | | | | |
|  |  | The 5G system shall be able to provide positioning service with 2m horizontal position accuracy, 90% availability, and less than 1s latency for the moving UE at the speed of 15-20km/hour outdoor. | PR-009 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1 | C | High Accuracy Positioning Service 3m 99 % is more demanding than 2m 90 % |
|  |  | The 5G system shall be able to provide positioning service with 0.2m horizontal position accuracy,99% availability, and less than 1s latency for the static UE in a enhanced positioning area outdoor. | PR-012 | The 5G system shall be able to provide a relative positioning service with a relative accuracy better than 0.2 m and an availability of 99 % either between two UEs within 10 m of each other or between one UE and 5G positioning nodes within 10 m of each others. | C | The use case's enhanced positioning area maps here an area of 10 m around the main UE |
|  |  | The 5G system shall be able to provide positioning service with a TTFF less than [10]s | PR-013 | The 5G system shall be able to provide the 5G positioning services with a TTFF less than 30 s and, for some 5G positioning services, shall support mechanisms to provide a TTFF less than 10s at the expense of a relaxation of some other performances (e.g., horizontal accuracy relaxed from 3 m to 10 m for a high accuracy positioning service). | C | The 10s is reported as a value to be confirmed, and the consolidated requirement allows to improve TTFF |
|  | 5.2.2 | Accurate positioning to support Augmented Reality (AR) | | | | |
|  |  | The 5G system shall be able to provide positioning service to support AR applications with [1-3] m horizontal position accuracy, 80% availability, for static or UE moving at speed below 50km/h outdoor. | PR-009 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1 | C | High Accuracy Positioning Service (3m, 99%) |
|  |  | The 5G system shall be able to provide positioning service to support AR applications with better than [10] m horizontal position accuracy, 80% availability, for UE moving at speed up to 130 km/h outdoor. | PR-009 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1 | C | Wide Area Positioning Service ( (<10m – 95%). |
|  |  | The 5G system shall be able to provide positioning service to support AR applications with better than [2] m/s horizontal velocity accuracy and [10]º bearing accuracy, 80% availability, for UE moving at speed up to 130 km/h outdoor. | PR-015 | The 5G system shall support mechanism to determine the UE's velocity outdoor with an accuracy better than 0.5 m/s and better than 5 degree bearing, and an availability of 99%. | C |  |
|  |  | The 5G system shall be able to provide positioning service to support AR applications with a TTFF less than [10]s. | PR-013 | The 5G system shall be able to provide the 5G positioning services with a TTFF less than 30 s and, for some 5G positioning services, shall support mechanisms to provide a TTFF less than 10s at the expense of a relaxation of some other performances (e.g., horizontal accuracy relaxed from 3 m to 10 m for a high accuracy positioning service). | C | The 10s is reported as a value to be confirmed, and the consolidated requirement allows to improve TTFF |
|  |  | The 5G system shall be able to fulfil the requirements of the positioning service using less than [5] % of the UE’s power consumption on average and less than [10] % of the UE’s power consumption in the worst case. | PR-016 | The 5G system shall be able to provide a positioning service involving an average of less than 20 mJ of the UE’s energy per position fix and involving a peak power less than 200 mW.  Note: The 5G positioning services should be fulfilled without affecting the UE’s battery overall lifetime by more than 5 % or without reducing the UE’s battery lifetime by more than 10 months out of a total of 15 years’ lifetime. | C |  |
|  |  | The 5G system shall support mechanisms to protect positioning-related data against tampering and spoofing. | PR-028 | The 5G system shall support mechanisms to protect positioning-related data against tampering and spoofing. | C |  |
|  |  | The 5G system shall support mechanisms to detect tampering and spoofing attempts on the position-related data. | PR-029 | The 5G system shall support mechanisms to detect tampering and spoofing attempts on the position-related data. | C |  |
|  |  | The 5G system shall be able to ensure the positioning related data are secured, and shall allow the protection of the user’s privacy. | PR-008  +  PR-027 | The 5G system shall be able to manage and log position-related data in compliance with applicable traceability, authentication and security regulatory requirements. The 5G system shall support mechanism to protect the privacy of both the UE and the UE's owner in compliance to regulation. | C |  |
|  |  | The 5G system shall be able to provide positioning service to support AR applications with [0.1-3] m vertical position accuracy, 80% availability. | PR-11 | The 5G system shall be able to provide relative changes in the UE’s altitude (or height) from an initial reference point with a vertical accuracy less than 0.2 m and an availability of 95% for some 5G positioning services. | C | Vertical accuracy achieved with provision of relative change to altitude / height |
|  | 5.2.3 | Power saving mechanism of wearable devices | | | | |
|  |  | The 5G system shall be able to provide positioning service with 2m horizontal position accuracy, indoor [1-3]m vertical position accuracy, 90% availability, and less than 1s latency for the UE in the location power saving mode. | PR-009+PR-010 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1. The 5G system shall be able to provide positioning service with 3m vertical accuracy and an availability of 95% anywhere in 5G positioning service area (for speed up to at least 160 km/h). | C | High Accuracy Positioning Service 3m 99 % is more demanding than 2m 90 % |
|  |  | The 5G system shall be able to provide positioning service with 2m horizontal position accuracy, indoor [1-3]m vertical position accuracy, 99% availability, and less than 1s latency for the UE in normal mode. | PR-009+PR-010 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1. The 5G system shall be able to provide positioning service with 3m vertical accuracy and an availability of 95% anywhere in 5G positioning service area (for speed up to at least 160 km/h). | PC | High Accuracy Positioning Service will provide better than 3m, so will tend towards 2m, and well as better than 99% availability (allowing further accuracy-availability trade-offs) |
|  |  | The 5G system shall be able to request the UE to provide its location periodically with an update rate ranging from one location every [1s-10s] in location normal mode to one location every [30s-300s] in location power saving mode. | PR-019 | The 5G system shall support mechanism to dynamically configure the update rate of the position-related data to fulfil different performances (e.g. power consumption, latency, etc.) or different location modes. Note: for instance, the 5G system shall be able to request the UE to provide its location periodically with an update rate ranging from one location every [1s-10s] in location normal mode to one location every [30s-300s] in location power saving mode. | C |  |
|  |  | The 5G network shall be able to request the UE to provide its location wherever it is indoor or outdoor. | PR-017  +  PR-009 | The 5G system shall be able to request the UE to provide its position-related-data on request, triggered by an event or periodically and to request the UE to stop providing its position-related data periodically. Note: indoor or outdoor capability is covered by PR-009 and the related environments. | C |  |
|  |  | The 5G system shall be able to provide positioning service with TTFF less than [10]s. | 013 | The 5G system shall be able to provide the 5G positioning services with a TTFF less than 30 s and, for some 5G positioning services, shall support mechanisms to provide a TTFF less than 10s at the expense of a relaxation of some other performances (e.g., horizontal accuracy relaxed from 3 m to 10 m for a high accuracy positioning service). | C | The 10s is reported as a value to be confirmed, and the consolidated requirement allows to improve TTFF |
|  | 5.2.4 | Location-based advertising push | | | | |
|  |  | Subject to regulatory requirements and user consent, the 5G system shall be able to provide the UE’s location information, with less than 3m horizontal position accuracy, [3m] vertical position accuracy over 90% availability, and less than 1min latency. | PR-009  PR-003  PR-027  + PR-010 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1.  The 5G system shall provide 5G positioning services in compliance with regulatory requirements.    The 5G system shall support mechanisms to protect the privacy of both the UE and the UE's owner in compliance to regulation. | C | High Accuracy Positioning Service  User consent associated to the privacy of the UE’s owner |
|  | 5.2.5 | Flow management in large transportation hubs | | | | |
|  |  | The 5G system shall be able to provide positioning service with better than [10] m horizontal positioning accuracy, [80] % availability and update rate of [0.1] Hz in a enhanced positioning area, primarily indoor. | PR-009 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1 | C | High Accuracy Positioning Service |
|  |  | The 5G system shall be able to provide positioning service with better than [3] m vertical positioning accuracy, [80] % availability and update rate of [0.1] Hz in a enhanced positioning area, primarily indoor. | PR-010 | The 5G system shall be able to provide positioning service with 3m vertical accuracy and an availability of 95% anywhere in 5G positioning service area (outdoor and indoor). | C |  |
|  |  | The 5G system shall be able to provide positioning service with TTFF less than [10] s. | PR-013 | The 5G system shall be able to provide the 5G positioning services with a TTFF less than 30 s and, for some 5G positioning services, shall support mechanisms to provide a TTFF less than 10s at the expense of a relaxation of some other performances (e.g., horizontal accuracy relaxed from 3 m to 10 m for a high accuracy positioning service). | C | The 10s is reported as a value to be confirmed, and the consolidated requirement allows to improve TTFF |
|  |  | The 5G system shall be able to ensure the protection and the privacy of the user’s position-related data. | PR-008  +  PR-027 | The 5G system shall be able to manage and log position-related data in compliance with applicable traceability, authentication and security regulatory requirements. The 5G system shall support mechanism to protect the privacy of both the UE and the UE's owner in compliance to regulation. | C |  |
|  |  | The 5G system shall be able to provide indication of the user’s motion (velocity, bearing). | PR-015 | The 5G system shall support mechanism to determine the UE's velocity outdoor with an accuracy better than 0.5 m/s and better than 5 degree bearing, and an availability of 99%. Note: For both the aforementioned KPI, the combination of positioning technologies will leverage the system’s ability to fulfil the requirements. | C |  |
|  | 5.3.1 | Person and medical equipment location in hospitals | | | | |
|  |  | The UE shall be able to provide its location to the Hospital System. | PR-021 | The 5G system shall be able to make the position-related data available to an application server. | C |  |
|  |  | The 5G system shall be able to request the UE to provide its location. | PR-017 | The 5G system shall be able to request the UE to provide its position-related-data on request, triggered by an event or periodically and to request the UE to stop providing its position-related data periodically. | C |  |
|  |  | The 5G system shall be able to request the UE to provide its location periodically. | PR-017 | C |  |
|  |  | The 5G system shall be able to request the UE to stop providing its location periodically. | PR-017 | C |  |
|  |  | The 5G system shall be able to handle additional location information from other external sources. | PR-006 | The 5G system shall be able to support the combination of 3GPP positioning technologies with non-3GPP positioning technologies to achieve performances of the 5G positioning services better than those achieved using only 3GPP positioning technologies.  NOTE 3: for instance, the combination of 3GPP positioning technologies with non-3GPP positioning technologies such as GNSS (e.g. Beidou, Galileo, GLONASS, and GPS), Terrestrial Beacon Systems (TBS), sensors (e.g. barometer, IMU), WLAN/Bluetooth-based positioning, can support the improvement of accuracy, availability, reliability and/or confidence level. The combination of 3GPP positioning technologies with non-3GPP positioning technologies can also support higher update rates and/or lower latency of the position-related data. | C |  |
|  |  | The 5G system shall be able to provide positioning service with a horizontal accuracy less than [3m], a vertical accuracy less than [2m] (i.e. floor accurate), an availability over [99%] and a latency lower than [1 minute]. The environment of use for the provision of the service shall be both indoor (including underground) and outdoor within the boundaries of the Hospital. | PR-017  +  PR-10 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1. The 5G system shall be able to provide positioning service with 3m vertical accuracy and an availability of 95% anywhere in 5G positioning service area (outdoor and indoor). | PC | Use case's requirements are intermediate between High Accuracy Service and very High Accuracy Service: full or partial compliancy depending on system complexity and ability to tune working point within the perimeter of the various requirements (e.g. PR-001, PR-005, etc.) |
|  |  | The 5G system shall support positioning of UEs using very little energy consumption on the UE. | PR-16 | The 5G system shall be able to provide a positioning service involving an average of less than 20 mJ of the UE’s energy per position fix and involving a peak power less than 200 mW. | C |  |
|  | 5.3.2 | Patient location outside hospitals | | | | |
|  |  | The 5G system shall be able to provide positioning service with a horizontal accuracy less than [10] m both indoors and outdoors. Furthermore, for indoors, the 5G system shall be able to provide positioning service with a vertical accuracy sufficiently accurate to determine the floor, so typically less than [3] m. | PR-009 + PR-10 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1. The 5G system shall be able to provide positioning service with 3m vertical accuracy and an availability of 95% anywhere in 5G positioning service area (for speed up to at least 160 km/h) + NOTE (sufficiently accurate to determine the floor) | C | Wide Area Positioning Service |
|  | 5.3.3 | Trolley location in factories | | | | |
|  |  | The 5G system shall be able to provide positioning service with [50] cm horizontal position accuracy, [1-3]m vertical position accuracy, and less than [20] ms latency for the moving UE at the speed of [50] km/hour indoor, taking into account at least a service area from [1 000 to 100 000] m². | PR-009  + PR-010  +  PR-014 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1. The 5G system shall be able to provide positioning service with 3m vertical accuracy and an availability of 95% anywhere in 5G positioning service area (for speed up to at least 160 km/h). The 5G system shall be able to provide the 5G positioning services with a latency better than 1s and shall support mechanisms to provide a latency less than 20 ms for some 5G positioning services. | C | Very High Accuracy Positioning Service in enhanced positioning areas. |
|  |  | The 5G system shall be able to provide positioning service in case of roaming. | PR-005 | The 5G system shall be able to provide the 5G positioning services in case of roaming. | C |  |
|  | 5.3.4 | Waste Management & Collection | | | | |
|  |  | The 5G system shall be able to determine the position of the UEs (bin, waste container) as well as the on-board units (waste collection vehicles) and report these positions to an application server (e.g. Waste Management and Collection system). | PR-021 | The 5G system shall be able to make the position-related data available to an application server. | C |  |
|  |  | The 5G system shall be able to request the UE (bin/waste container) to provide its location. | PR-017 | The 5G system shall be able to request the UE to provide its position-related-data on request, triggered by an event or periodically and to request the UE to stop providing its position-related data periodically. | C |  |
|  |  | The 5G system shall be able to request the UE (bin/waste container) to provide its location periodically with an update rate ranging from one location every [2 hours] to one location every [several days]. | PR-020 | The 5G system shall be able to determine the position-related data of the 5G positioning services with a latency better than 1s and an update rate ranging from one set of position-related data every 0.1s to one set of position-related data every month.  . | C |  |
|  |  | The 5G system shall be able to provide positioning service with a horizontal accuracy less than 3m, a vertical accuracy less than 2m, an availability over [99%] and a latency lower than 1 minute. The environment of use for the provision of the service shall be both outdoor (main use) and indoor (including underground parking…). | PR-009+  PR-010 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1. The 5G system shall be able to provide positioning service with 3m vertical accuracy and an availability of 95% anywhere in 5G positioning service area (outdoor and indoor). | PC | Full compliancy except for vertical accuracy |
|  |  | The 5G system shall be able to fulfil the requirement of the positioning service without affecting the UE’s battery overall lifetime by more than [5] % (Note: 9 months out of a total of 15 years’ lifetime). | PR-016 | The 5G system shall be able to provide a positioning service involving an average of less than 20 mJ of the UE’s energy per position fix and involving a peak power less than 200 mW. | C |  |
|  | 5.4.1 | Accurate positioning for emergency services | | | | |
|  |  | The 5G system shall be able to provide positioning service with three-dimensional position accuracy and associated KPI targets, determined by regulatory agencies (e.g. FCC), as follows: | | | |  |
|  |  | - Accuracy < 50m horizontal (80%), < 3 meters vertical (80%) | PR-009+  PR-010  +  PR-013 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1  .  The 5G system shall be able to provide positioning service with 3m vertical accuracy and an availability of 95% anywhere in 5G positioning service area (outdoor and indoor).  The 5G system shall be able to provide the 5G positioning services with a TTFF less than 30 s and, for some 5G positioning services, shall support mechanisms to provide a TTFF less than 10s at the expense of a relaxation of some other performances (e.g., horizontal accuracy relaxed from 3 m to 10 m for a high accuracy positioning service). | C | Wide area positioning service |
|  |  | - Latency and TTFF < 30 seconds | C |  |
|  |  | - Availability > 95% | C |  |
|  |  | - Environment of use: indoor and outdoor | C |  |
|  |  | The 5G system shall support the UE to provide the positioning methods used in calculating the position and the associated uncertainty/confidence of the position. | PR-023 | The 5G system shall be able to access to the positioning methods used for calculating the position-related data and to the associated uncertainty/confidence indicators. | C |  |
|  |  | The 5G system shall be able to request the UE to provide location information (e.g. measurements, position) with some periodicity as necessary. | PR-017 | The 5G system shall be able to request the UE to provide its position-related-data on request, triggered by an event or periodically and to request the UE to stop providing its position-related data periodically. | C |  |
|  |  | The 5G system shall be able to determine the reliability of the positioning information. | PR-004 | The 5G system shall be able to determine the reliability, and the uncertainty or confidence level of the position-related data. | C |  |
|  | 5.4.2 | Accurate Positioning for First Responders | | | | |
|  |  | For outdoor location the 5G system shall provide a positioning service with three-dimensional position accuracy and associated KPI targets required by mission critical organizations as follows:  - Accuracy < [1m] horizontal [95%], < [0.3] meters vertical [95%]  - Latency < [5] seconds  - TTFF < [10] seconds  - Availability > [98%]  NOTE: Both absolute position and relative position can be used to meet the accuracy requirements based on operational needs. | PR-009+ PR-011+ PR-013+ PR-014 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1  The 5G system shall be able to provide positioning service with 3m vertical accuracy and an availability of 95% anywhere in 5G positioning service area (for speed up to at least 160 km/h)  The 5G system shall be able to provide relative changes in the UE’s altitude (or height) from an initial reference point with a vertical accuracy less than 0.2 m and an availability of 95% for some 5G positioning services.  The 5G system shall be able to provide the 5G positioning services with a TTFF less than 30 s and, for some 5G positioning services, shall support mechanisms to provide a TTFF less than 10s at the expense of a relaxation of some other performances (e.g., horizontal accuracy relaxed from 3 m to 10 m for a high accuracy positioning service).  The 5G system shall be able to provide the 5G positioning services with a latency lower than 1 s. | C | Vertical accuracy achieved with provision of relative change to altitude / height |
|  |  | For indoor location the 5G system shall provide a positioning service with three-dimensional position accuracy and associated KPI targets required by mission critical organizations as follows:  - Accuracy < [1m] horizontal [95%], < [2] meters vertical [95%]  - Latency < [1] second  - TTFF < [10] seconds  - Availability > [95%]  NOTE: Both absolute position and relative position can be used to meet the accuracy requirements based on operational needs. | PR-009+ PR-010+ PR-013+ PR-014 | C | Vertical accuracy achieved with provision of relative change to altitude / height |
|  |  | The 5G system shall enable an MCX UE to use the positioning service to calculate its position with the associated uncertainty/confidence of the position. | PR-026 | The 5G system shall enable an MCX UE to use the 5G positioning services to determine its position with the associated uncertainty/confidence of the position, on request, triggered by an event or periodically. | C |  |
|  |  | The 5G system shall provide a mechanism to request an MCX UE to provide location information (e.g. measurements, position) with remotely adjustable periodicity. | PR-17 | The 5G system shall be able to request the UE to provide its position-related-data on request, triggered by an event or periodically and to request the UE to stop providing its position-related data periodically. | C |  |
|  |  | The 5G system shall provide a mechanism to request that an MCX UE provide an immediate location report | PR-17 + PR-14 | The 5G system shall be able to provide the 5G positioning services with a latency lower than 1 s. | C |  |
|  |  | The 5G system shall provide a mechanism for an MCX UE to provide an event-triggered location report. The 5G system shall be able to determine the reliability of the positioning information. | PR-026 | The 5G system shall be able to request the UE to provide its position-related-data on request, triggered by an event or periodically and to request the UE to stop providing its position-related data periodically. | C |  |
|  | 5.4.3 | Alerting nearby emergency responders | | | |  |
|  |  | The 5G system (in conjunction with the layman responder network) shall be enabled to alert the group of [~ 10] potential responders with shortest travel time to the victim, scanned from a radius of [5 km] from the victim.    This requires localization of each responder with a horizontal resolution of less than [50 m] and, indoors, a vertical resolution sufficiently accurate to determine the floor, so typically less than [3 m]. This localization accuracy needs to be achieved throughout the 5G positioning service area. | PR-009 + PR-010 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1  The 5G system shall be able to provide positioning service with 3m vertical accuracy and an availability of 95% anywhere in 5G positioning service area (for speed up to at least 160 km/h) | C |  |
|  |  | The 5G system shall not perform continuous tracking of each layman responder to respect his/her privacy. | PR-027 | The 5G positioning services shall be able to protect, by some mechanism, the UE’s privacy and the privacy of the UE’s user or owner, including the respect of its consent to the positioning services | C |  |
|  |  | The 5G system shall be scalable to address the positioning of at least [5%] of all subscribers being registered to the layman responder service. | PR-009 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1 | C |  |
|  |  | The 5G system shall work across boundaries of individual operator networks in the region. | PR-005 | The 5G system shall be able to provide the 5G positioning services in case of roaming | C |  |
|  | 5.4.4 | Emergency equipment location outside hospitals | | | |  |
|  |  | The 5G system shall be able to provide positioning service with a horizontal accuracy less than [10 m] and, indoors, with a vertical accuracy sufficiently accurate to determine the floor, so typically less than [3 m]. This localization accuracy needs to be achieved throughout the 5G positioning service area. | PR-009 + PR-010 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1  The 5G system shall be able to provide positioning service with 3m vertical accuracy and an availability of 95% anywhere in 5G positioning service area (for speed up to at least 160 km/h) | C |  |
|  |  | The 5G system shall allow UEs to sleep for extended periods of time (e.g. one week), without requiring the UE to update its position data. | PR-020 | The 5G system shall be able to determine the position-related data of the 5G positioning services with any update rate ranging from one set of position-related data every 0.1 s to one set of position-related data every month. | C |  |
|  |  | The 5G system shall allow UEs to trigger a different update rate of the position data based on whether the UE is moving or not. | PR-018 | The 5G system shall allow the UE to trigger a different update rate of the position-related data based on whether the UE is moving or not. | C |  |
|  | 5.5.1 | Accurate positioning to support Traffic Monitoring, Management and Control | | | |  |
|  |  | The 5G system shall be able to provide positioning service with a horizontal accuracy of [1] m across-track and [3] m along-track for UE speed up to the maximum speed authorized on highways (e.g. [130-160] km/h). | PR-009+  PR-010 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1  The 5G system shall be able to provide positioning service with 3m vertical accuracy and an availability of 95% anywhere in 5G positioning service area (outdoor and indoor). | PC | Compliant Along track,  Partially compliant Across-track: achieved using Very High Accuracy Positioning (Outdoor, if limited obstruction (highways, large avenue, etc. and/or with optimised infrastructure coverage in enhanced positioning areas for narrow streets if needed) |
|  |  | The 5G system shall be able to provide positioning service with a vertical accuracy of [2.5] m for speed up to the maximum speed authorized on highways (e.g. [130-160] km/h). | C | PR-011 achieves 3m (95%) whilst the 2.5m target is reported as a value to be confirmed |
|  |  | The 5G system shall be able to provide positioning service with an availability of [95] %. | C |  |
|  |  | The 5G system shall be able to provide positioning service with a TTFF less than [10]s. | PR-013 | The 5G system shall be able to provide the 5G positioning services with a TTFF less than 30 s and, for some 5G positioning services, shall support mechanisms to provide a TTFF less than 10s at the expense of a relaxation of some other performances (e.g., horizontal accuracy relaxed from 3 m to 10 m for a high accuracy positioning service). | C | The 10s is reported as a value to be confirmed, and the consolidated requirement allows to improve TTFF |
|  |  | The 5G system shall be able to provide positioning service with an update rate of [10] Hz. | PR-020 | The 5G system shall be able to determine the position-related data of the 5G positioning services with a latency better than 1s and an update rate ranging from one set of position-related data every 0.1s to one set of position-related data every month. | C |  |
|  |  | The 5G system shall be able to provide positioning service with a latency of less than [30] ms. | PR-006 | The 5G system shall be able to support the combination of 3GPP positioning technologies with non-3GPP positioning technologies to achieve performances of the 5G positioning services better than those achieved using only 3GPP positioning technologies.  NOTE 3: for instance, the combination of 3GPP positioning technologies with non-3GPP positioning technologies such as GNSS (e.g. Beidou, Galileo, GLONASS, and GPS), Terrestrial Beacon Systems (TBS), sensors (e.g. barometer, IMU), WLAN/Bluetooth-based positioning, can support the improvement of accuracy, availability, reliability and/or confidence level. The combination of 3GPP positioning technologies with non-3GPP positioning technologies can also support higher update rates and/or lower latency of the position-related data. | C |  |
|  |  | The 5G system shall be able to ensure the positioning-related data are secured. | PR-008 | The 5G system shall be able to manage and log position-related data in compliance with applicable traceability, authentication and security regulatory requirements. | C |  |
|  |  | The 5G system shall support mechanisms to protect positioning-related data against tampering and spoofing. | PR-028 | The 5G system shall support mechanisms to protect positioning-related data against tampering and spoofing. | C |  |
|  |  | The 5G system shall support mechanisms to detect tampering attempts on the position-related data and spoofing. | PR-029 | The 5G system shall support mechanisms to detect tampering and spoofing attempts on the position-related data. | C |  |
|  |  | The 5G system shall be able to support the protection of the UE’s privacy. | PR-027 | The 5G system shall support mechanism to protect the privacy of both the UE and the UE's owner in compliance to regulation. | C |  |
|  | 5.5.2 | Road-User Charging (RUC) |  |  |  |  |
|  |  | The 5G system shall be able to provide positioning service with a horizontal accuracy in the range [1 – 3] m, an update rate of [1] Hz and an availability of [99] % for speed up to [130 km/h]. | PR-009 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1. | C | Primarily achieved with High Accuracy Positioning Services (use case's targets are in brackets), which can be further enhanced to better fit some applications using Very High Accuracy Service (0.3 m outdoor if limited obstruction or in enhanced positioning area with optimised infrastructure coverage |
|  |  | The 5G system shall be able to provide velocity information with an accuracy of [2] m/s, an update rate of [1] Hz and an availability of [99] % for speed up to [130 km/h]. | PR-015 | The 5G system shall support mechanism to determine the UE's velocity outdoor with an accuracy better than 0.5 m/s and better than 5 degree bearing, and an availability of 99%. |  |  |
|  |  | The 5G system shall be able to provide positioning service with a TTFF less than [10]s. | PR-013 | The 5G system shall be able to provide the 5G positioning services with a TTFF less than 30 s and, for some 5G positioning services, shall support mechanisms to provide a TTFF less than 10s at the expense of a relaxation of some other performances (e.g., horizontal accuracy relaxed from 3 m to 10 m for a high accuracy positioning service). | C | The 10s is reported as a value to be confirmed, and the consolidated requirement allows to improve TTFF |
|  |  | The 5G system shall be able to provide positioning service with a user density up to at least [1000 per km²]. | PR-009 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1. | C |  |
|  |  | The 5G system shall support mechanisms to protect positioning-related data against tampering and spoofing. | PR-028 | The 5G system shall support mechanisms to protect positioning-related data against tampering and spoofing. | C |  |
|  |  | The 5G system shall support mechanisms to detect tampering and spoofing attempts on the position-related data. | PR-029 | The 5G system shall support mechanisms to detect tampering and spoofing attempts on the position-related data. | C |  |
|  | 5.6.1 | Asset and freight tracking (wagon, container) | | | |  |
|  |  | The 5G system shall be able to provide positioning service for the static UE in a enhanced positioning area, indoor or outdoor with the following potential requirements: | | | |  |
|  |  | Absolute position accuracy: [1] m (horizontal and vertical), [99] % availability, an update rate up to [1] Hz and a latency less than [1]s. | PR-009  +  PR-020 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1  .  The 5G system shall be able to determine the position-related data of the 5G positioning services with a latency better than 1s and an update rate ranging from one set of position-related data every 0.1s to one set of position-related data every month. | C | Use case may also benefit from PR-012 |
|  |  | TTFF less than [10] s. | PR-013 | The 5G system shall be able to provide the 5G positioning services with a TTFF less than 30 s and, for some 5G positioning services, shall support mechanisms to provide a TTFF less than 10s at the expense of a relaxation of some other performances (e.g., horizontal accuracy relaxed from 3 m to 10 m for a high accuracy positioning service). | C | The 10s is reported as a value to be confirmed, and the consolidated requirement allows to improve TTFF |
|  |  | The 5G system shall be able to provide positioning service for UE moving at speed up to 180 km/h outdoor, over very wide coverage with the following potential requirements: | | | |  |
|  |  | Absolute position accuracy: [10-30] m horizontal position accuracy, [99] % availability | PR-009 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1. | C | Wide Area Positioning Service – the required availability is higher than the service capability, but availability and accuracy (up to 30m) could be traded-off to achieve full compliancy |
|  |  | Velocity accuracy: [5] m/s horizontal velocity accuracy, [99] % availability | PR-015 | The 5G system shall support mechanism to determine the UE's velocity outdoor with an accuracy better than 0.5 m/s and better than 5 degree bearing, and an availability of 99%. | C |  |
|  |  | Position and velocity update rate: the time interval between 2 successive position fix can vary between [300 s] and [24 hours]. | PR-020 | The 5G system shall be able to determine the position-related data of the 5G positioning services with a latency better than 1s and an update rate ranging from one set of position-related data every 0.1s to one set of position-related data every month. | C |  |
|  |  | The UE shall support mechanisms to determine its position using non-3GPP positioning technologies when outside the coverage of 3GPP RAT-dependent positioning technologies. | PR-007 | The 5G system shall support the UE to provide its position-related data for period when the UE is outside the coverage of 3GPP RAT-dependent positioning technologies. | C |  |
|  |  | The 5G system shall support mechanisms to access the UE’s position-related data determined when the UE is outside the coverage of 3GPP RAT-dependent positioning technologies. | PR-007 | The 5G system shall support the UE to provide its position-related data for period when the UE is outside the coverage of 3GPP RAT-dependent positioning technologies. | C |  |
|  |  | The 5G system shall be able to provide a positioning service involving an average of less than [20 mJ] of the UE’s energy per position fix. | PR-016 | The 5G system shall be able to provide a positioning service involving an average of less than 20 mJ of the UE’s energy per position fix and involving a peak power less than 200 mW. | C |  |
|  |  | The 5G system shall support mechanisms to protect positioning-related data against tampering and spoofing. | PR-028 | The 5G system shall support mechanisms to protect positioning-related data against tampering and spoofing. | C |  |
|  |  | The 5G system shall support mechanisms to detect tampering and spoofing attempts on the position-related data. | PR-029 | The 5G system shall support mechanisms to detect tampering and spoofing attempts on the position-related data. | C |  |
|  | 5.7.1 | Accurate positioning to support Unmanned Aerial Vehicle (UAV) missions and operations | | | |  |
|  |  | The 5G system shall be able to provide positioning service to support drones applications with [10] cm horizontal and vertical position accuracy, 99% availability, for UE moving at [150] km/h outdoor. | PR-009 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1. | PC | Very High Accuracy Positioning Service would fulfil better than 0.3 m in most UAV-related environments (outdoor limited obstruction, or close to docking / landing stations -> enhanced positioning area).  Anyway, use case's target are in brackets. |
|  |  | The 5G system shall be able to provide positioning service to support applications with under [50] cm/s horizontal and vertical velocity accuracy and [2]º bearing accuracy, over 99% availability, for UE moving at speed up to [150] km/h outdoor. | PR-015 | The 5G system shall support mechanism to determine the UE's velocity outdoor with an accuracy better than 0.5 m/s and better than 5 degree bearing, and an availability of 99%. | C | Compliant for speed, partially compliant for bearing (provided as target in bracket) |
|  |  | The 5G system shall be able to provide positioning service to support applications with a TTFF less than [10] s. | PR-013 | The 5G system shall be able to provide the 5G positioning services with a TTFF less than 30 s and, for some 5G positioning services, shall support mechanisms to provide a TTFF less than 10s at the expense of a relaxation of some other performances (e.g., horizontal accuracy relaxed from 3 m to 10 m for a high accuracy positioning service). | C | The 10s is reported as a value to be confirmed, and the consolidated requirement allows to improve TTFF |
|  |  | The 5G system shall be able to provide positioning service such that the UE's power consumption will be less than [200] mW in the worst case. | PR-016 | The 5G system shall be able to provide a positioning service involving an average of less than 20 mJ of the UE’s energy per position fix and involving a peak power less than 200 mW | C | 20 mJ per fix with a maximum update rate of 10 Hz (PR-018] leads to a maximum of 200 mW |
|  |  | The 5G system shall support mechanisms to protect positioning-related data against tampering. | PR-028 | The 5G system shall support mechanisms to protect positioning-related data against tampering and spoofing. | C |  |
|  |  | The 5G system shall support mechanisms to detect tampering attempts on the position-related data. | PR-029 | The 5G system shall support mechanisms to detect tampering and spoofing attempts on the position-related data. | C |  |
|  |  | The 5G system shall be able to ensure the positioning related data are secured, and shall allow the protection of the user’s privacy. | PR-008  +  PR-027 | The 5G system shall be able to manage and log position-related data in compliance with applicable traceability, authentication and security regulatory requirements. The 5G system shall support mechanism to protect the privacy of both the UE and the UE's owner in compliance to regulation. | C |  |
|  | 5.7.2 | Transport and inspection by drones for medical purposes | | | |  |
|  |  | The 5G system shall support: |  |  |  |  |
|  |  | Round trip latency less than [150 ms], including all network components. | PR-014 | [PR-014] The 5G system shall be able to provide the 5G positioning services with a latency lower than 1 s.  NOTE 4: the 5G system may support mechanism such as extrapolation of position and combination of positioning technologies to provide some 5G positioning services with latency less than 20 ms. | C |  |
|  |  | Due to the consequences of failure being loss of property or life, reliability goal is [near 100%.] | PR-003 | The 5G system shall provide 5G positioning services in compliance with regulatory requirements.  Note: example of regulatory requirements encompasses requirements on emergency calls (e911), reliability and safety requirement (RAMS) applicable to some use cases and verticals, implementation of Priority, Precedence, Preemption (PPP) mechanisms to ensure sufficient reliability metrics are reached, etc. | C | Targeted reliability (value in bracket), need to be confirmed according to regulation (including safety) and achieved performance dependent on applied design process |
|  |  | Reliability to be at the same level for current aviation Air Traffic Control (ATC). Link supports command and control of vehicles in controlled airspace. The integrity of the position needs to be ensured in compliance with the regulations. |
|  |  | Priority, Precedence, Preemption (PPP) mechanisms shall be used to ensure sufficient reliability metrics are reached. |
|  |  | Position is to be authenticated, and logged in the system for security and traceability. | PR-008 | The 5G system shall be able to manage and log position-related data in compliance with applicable traceability, authentication and security regulatory requirements. | C |  |
|  |  | For en-route phases and hovering over an emergency scene, the 5G system shall be able to provide positioning service with [50 cm] horizontal position accuracy and a [30 cm] vertical accuracy, 99% availability, for the moving UE at the speed of up to [50km/hour]. The environment of use for en-route phase is outdoor, mainly unobstructed. | PR-009 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1 | C | Very High Accuracy Positioning Service (outdoor with limited obstruction) |
|  |  | During docking phases (take-off and landing), the 5G system shall be able to provide positioning service with [50 cm] horizontal position accuracy and a [10 cm] vertical accuracy, 99.9% availability for quasi stationery UE in enhanced positioning area of [10m2]. The environment of use for the docking-phase is outdoor, but may suffer obstruction from buildings in the vicinity of the drone’s docking stations. | PR-009  +    PR-012 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1.  The 5G system shall be able to provide a relative positioning service (in any relevant 2D or 3D Cartesian or Polar coordinate system) with a relative accuracy better than 0.2 m and an availability of 99 % either between two UEs within 10 m of each other or between one UE and 5G positioning nodes within 10 m of each others. | C | Very High Accuracy Positioning Service for Horizontal positioning and Relative Positioning Service to docking station for vertical accuracy |
|  |  | The 5G system shall support mechanisms to protect positioning-related data against tampering. |  | The 5G system shall support mechanisms to protect positioning-related data against tampering and spoofing. | C |  |
|  |  | The 5G system shall support mechanisms to detect tampering attempts on the position-related data. |  | The 5G system shall support mechanisms to detect tampering and spoofing attempts on the position-related data. | C |  |
|  | 5.8.1 | Support multiple different locations methods | | | |  |
|  |  | The 5G system shall be able to position the UE when it is indoor or outdoor. | PR-009 | Indoor and outdoor environment of use provided in PR-009. | C |  |
|  |  | The 5G system shall be able to provide different positioning services with different KPI performance for the UE whenever it is indoor or outdoor according to operator’s policy or 3rd party’s request. | PR-002  +  PR-009 | The 5G system shall provide different 5G positioning services with configurable performances working points (e.g. accuracy, availability, energy consumption, update rate, TTFF) according to the needs of users, operators and 3rd parties.  Indoor and outdoor environment of use provided in PR-009. | C |  |
|  |  | The 5G system shall be able to provide positioning service with TTFF less than [10]s. | PR-013 | The 5G system shall be able to provide the 5G positioning services with a TTFF less than 30 s and, for some 5G positioning services, shall support mechanisms to provide a TTFF less than 10s at the expense of a relaxation of some other performances (e.g., horizontal accuracy relaxed from 3 m to 10 m for a high accuracy positioning service). | C | The 10s is reported as a value to be confirmed, and the consolidated requirement allows to improve TTFF |
|  |  | The 5G system shall be able to provide positioning service with 2m horizontal position accuracy, 90% availability, and less than 1s latency for the UE outdoor. | PR-009 | The 5G system shall be able to provide horizontal positioning services as per the requirements and attributes reported in table 8.2-1  . | C | High Accuracy Positioning Service  3m 99 % is more demanding than 2m 90 % |
|  |  | The 5G system shall be able to provide positioning service with 0.1m horizontal position accuracy, 99% availability, and less than 1s latency for the UE indoor. | PR-012 | The 5G system shall be able to provide a relative positioning service (in any relevant 2D or 3D Cartesian or Polar coordinate system) with a relative accuracy better than 0.2 m and an availability of 99 % either between two UEs within 10 m of each other or between one UE and 5G positioning nodes within 10 m of each others. | C | Use case describes rendezvous operation and service in a (very) enhanced positioning area use cases requirements can be fulfilled using relative positioning service as per PR-012 |
|  |  | The 5G system shall supply a method for 3rd party to configure and manage different positioning services for different users according to agreement between operator’s policy and 3rd party. | PR-024 | The 5G system shall supply a method for either the operator or a 3rd party to configure and manage different positioning services for different users according to agreement between operator’s policy and 3rd party. | C |  |
|  |  | The 5G system shall supply a method for operator to configure and manage different positioning services for different users according to agreement between operator’s policy and 3rd party. | PR-024 | The 5G system shall supply a method for either the operator or a 3rd party to configure and manage different positioning services for different users according to agreement between operator’s policy and 3rd party. | C |  |
|  | 5.8.2 | Support location method negotiation | | | |  |
|  |  | The 5G system shall be able to support multiple single and hybrid location methods to supply location service according to operator’s policy or application’s requirements or user’s preference. | PR-001 | The 5G system shall provide different 5G positioning services, supported by different single and hybrid positioning methods, to supply absolute and relative positioning services with configurable working points according to the needs of users, operators and 3rd parties. | C |  |
|  |  | The 5G system shall be able to negotiate location methods according to operator’s policy or application’s requirements or user’s preference. | PR-022 | The 5G system shall be able to negotiate the positioning methods according to the operator’s policy or the application’s requirements or the user’s preferences and support mechanism to allow the network or the UE to trigger this negotiation. | C |  |
|  |  | The 5G system shall be able to support the 5G network or UE to trigger to negotiate location methods. | PR-022 | The 5G system shall be able to negotiate the positioning methods according to the operator’s policy or the application’s requirements or the user’s preferences and support mechanism to allow the network or the UE to trigger this negotiation. | C |  |
|  |  | The 5G system shall be able to supply a method to support the 3rd party to request 5G system to trigger location methods negotiation. | PR-025 | The 5G system shall be able to supply a method to support the 3rd party to request 5G system to trigger location methods negotiation. | C |  |
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Annex B:  
Change history

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2017-08 | SA1#79 | S1-173415 |  |  |  | Update to the Table of Content (clause 7) and introduction of Editor’s notes. | 0.1.0 |
| 2017-08 | SA1#79 | S1-173498 |  |  |  | Editorial updates and update of change history | 0.1.1 |
| 2017-08 | SA1#79 | S1-173239 |  |  |  | Updates to include agreements at the meeting (scope, overview, KPI and 2 Use case: 5.2.1 (S1-173420) and 5.3.1 (S1-173419) | 0.2.0 |
| 2017-11 | SA1#80 | S1-174277 |  |  |  | Updates to include agreements at the meeting (S1-174355, S1-174376, S1-174071, S1-174356, S1-174528, S1-174529, S1-174530, S1-174606, S1-174532, S1-174533, S1-174534, S1-174182, S1-174535) | 0.3.0 |
| 2018-02 | SA1#81 | S1-180246 |  |  |  | Updates to include agreements at the meeting (S1-180160, S1-180408, S1-180409, S1-180410, S1-180411, S1-180412, S1-180590, S1-180418, S1-180419) | 0.4.0 |
| 2018-05 | SA1#82 | S1-181287 |  |  |  | Updates to include agreements at the meeting (S1-181480, S1-181693, S1-181225, S1-181482, S1-181483, S1-181497, S1-181601, S1-181602, S1-181735, S1-181747, S1-181387, S1-181605, S1-181697)  Processing of editor’s note in S1-181693 – clause 5.1 about service / coverage areas (Update of 5G coverage into 5G positioning service area and Modification of bounded areas and dedicated service areas into enhanced positioning area)  Changes out of scope of agreed Tdocs:  1/ Editorial changes, including table caption and associated updates in the text to reference the associated captions, and cleaning of clause numbering, and removal of remaining editor’s notes (layout of clause 5 and clause clause 7)  2/ Update table 6.1-1 to introduce use case 5.4.2  3/ Clean-up of tables in annex A to introduce changes agreed during the meeting on the use cases and not properly reported in S1-181605  3a/ First table -> PR-014 (former requirements was not removed from in S1-1811605 and kept with new one + update of 5.7.2 title), PR-018 (correction of use case number 5.4.4)  3b/ Second table : update of High Reliability positioning service into  Wide area positioning service, in line with S1-181747 | 1.1.0 |
| 2018-05 | SA#80 | SP-180334 |  |  |  | Clean-up for presentation to SA for approval | 2.0.0 |
| 2018-06 | SA#80 | SP-180334 |  |  |  | Raised to v.16.0.0 following SA's approval | 16.0.0 |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | | | | | |
| **TSG SA#** | **SA Doc.** | **SA1 Doc** | **Spec** | **CR** | **Rev** | **Rel** | **Cat** | **Subject/Comment** | **Old** | **New** | **WI** |
| SP-81 | SP-180778 | S1-182582 | 22.872 | 0003 | 1 | Rel-16 | C | Additional consideration (clause 6.3) to support the consolidated requirements | 16.0.0 | 16.1.0 | FS\_5G\_HYPOS |
| SP-81 | SP-180778 | S1-182583 | 22.872 | 0004 | 2 | Rel-16 | C | Corrections to annex A | 16.0.0 | 16.1.0 | FS\_5G\_HYPOS |
| SP-81 | SP-180778 | S1-182584 | 22.872 | 0005 | 2 | Rel-16 | C | Update to clause 6.2.4 Accuracy and availability | 16.0.0 | 16.1.0 | FS\_5G\_HYPOS |
| SP-81 | SP-180778 | S1-182589 | 22.872 | 0006 | 2 | Rel-16 | F | A NOTE for clarifying the general scope of Emergency Responder use case | 16.0.0 | 16.1.0 | FS\_5G\_HYPOS |
| SP-81 | SP-180778 | S1-182616 | 22.872 | 0002 | 1 | Rel-16 | B | Support to accurate and reliable handling of containers | 16.0.0 | 16.1.0 | FS\_5G\_HYPOS |