SCENARIOS OF CRITICAL GPS POSITIONING PERFORMANCE FOR ECALL

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Abstract: *The eCall is a telecommunication service promoted and fostered by the European Commission in order to provide the automatic notification of the Public Safety Answering Point (PSAP) on the road traffic accident. The GPS is assumed to be the sole means for the position estimation of the vehicle in accident, a data to be sent from the In-Vehicle System (IVS) to the PSAP with the Minimum Set of Data (MSD) message.*
Considering the known vulnerabilities and limitations of satellite navigation systems, our team has assessed the potential threats resulting from the utilisation of the sole fundamental satellite positioning for public safety services, such as the eCall. Here we present a set of identified eCall scenarios in which the temporarily deteriorated GPS positioning performance can lead to potentially dangerous misleadings that undermine the eCall-related emergency assistance Standard Operational Procedures (SOPs). The analysis of the identified scenarios led to the establishment of the critical level of deteriorated GPS positioning performance for the eCall service.
The achievements presented in this paper result from our team's activities in the pan-European Harmonised eCall European Pilot (HeERO) project. Further HeERO-related activities will focus on establishment of that will mitigate the causes of deteriorations in GPS performance that affects the eCall service.

KEY WORDS
1. GPS 2. vulnerability 3. eCall 4. positioning performance

1 INTRODUCTION. The eCall is a telecommunication services aimed to automatically notify a Public Safety Answering Point (PSAP) on a road traffic accident, and at the same time provide automatically initiated prioritised voice channel between a PSAP operator and the occupants of the vehicle in accident. In the continuous effort to increase the safety level in the road traffic, the Europeam Commission has promoted the service, which is aimed to become mandatory in the majority of the EU countries by 2014. The European Harmonised eCall (HeERO), started in January 2011 with participation of nine European national eCall pilots and led by ERTICO, aims to verify the alignment of the in-band modem-based eCall performance and operation with the requirements set by already established EC-supervised standardisation framework.
Current standardisation requires provision of the vehicle's position estimate based on sole utilisation of the GPS receiver as a component of the eCall In-Vehicle System (IVS). Here we present the analysis of potentially critical scenarios for sole GPS-based eCall position estimation, propose the positioning KPIs and their acceptable values in critical scenarios, and propose additonal method that provides more robust and accurate position estimation for eCall, that relies on GNSS assistance and augmentation, and integration with other positioning-related sensors.

2 E-CALL. The eCall is a telecommunication service that automatically notify the Public Safety Answering Point on the occurance of a road traffic accident, as depicted in Fig 1. At the same time, it provides automatically established direct voice communication channel between a PSAP and a vehicle in accident, using a public mobile communication network. The inititiation of the eCall results from the traffic accidnet identification algorithm that aggregates the readings of several in-vehicle sensors, such as the airbag sensors and accelerometers (MEMS sensors). A set of data that

describes the occurance of the accident are to be sent to PSAP automatically afterwards, comprising the details including GPS-based estimation of vehicle's position, vehcle's orientation, the international Vehicle Identification Number (VIN), time of reporting and number of vehicle occupants (estimated by number of seat-belts users, for instance). Dubbed the Minimum Set of Data (MSD), it may provide the essential set of nformation required by the PSAP operator in order to apply the suitable Standard Operation Procedure (SOP) and activate neccessary emergency teams (medical emergency, police, fire brigade, roda/motorway operators) as well as third-parties services (traffic information system, road assistance etc.).

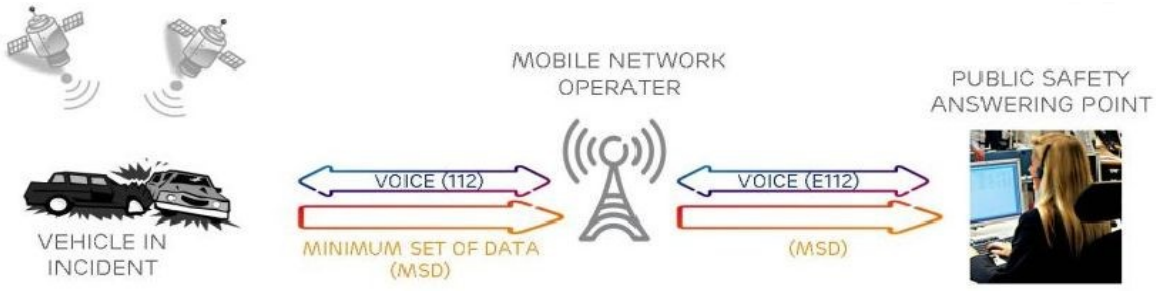

Fig 1 The eCall concept

3 GPS POSITIONING PERFORMANCE. Satellite navigation systems are to provide postion estimation for the vehicle in accident. The available eCall standards require the exclusive utilisation of currently available Global Positioning System (GPS), thus an assessment of potential threats in provision of a high-quality position estimates by the sole utilisation of satellite navigation (GPS) should be assessed.

Satellite navigation systems, such as the GPS, have known limitations and ae prone to the vulnerabilities effects. Those can be aggregated into the following groups:

- effects related to accuracy of position estimate,
- effects affecting the availability of (satellite) positioning signals,, and
- effects of intentional and non-intentional jamming.

The accuracy of position estimation is determined by the effects of the User Equivalent Ranging Error (ionospheric and tropospheric delays, multipath effects, errors due to incorrect satelite emphemeris, satellite clock error and GPS receiver noise) and the Geometric Dillutions Of Precision (GDOP), caused by spatial distribution of visible satellites, which can be disturbed by local terrain configuration.

The availability of necessary number of satellite signals (at least four for the 3D position estimation) is affected by the ability of the system to provide the guaranteed number of operational satellites transmitting standardised positioning signals, and with the characteristics of the local terrain, that can deteriorate the actual satellite visibility.

Un-intentional and intenional jamming can block the reception of positioning signals either partially or completely, thus preventing the position estimation process. The deployment of the eCall should provide timely reports of accurate vehicle position estimates in robust and reliable way.

4 SCENARIOS OF CRITICAL GPS PERFORMANCE. The GPS position estimation process keeps the record of better-than guaranteed performance, providing the required position environment conditions are met (all satellites operational and fuctional, provision of ionospheric delay corrections, measures taken to minimise multipath effects, no jamming, favourable configuration of local terrain that maakes no significant obstructions of the sky view). However, such ideal conditions are not always met, thus significantly undermines the performance of the eCall service, and reduceis the quality of emergency assistance to be provided to travellers involved in an accident.

Three essential critical scenarios have been identiified, when the significant deterioration of the GPS positioning performance may lead to delayed emergenc assistance with possible disastrous

consequences: accident in a tunnel, accident in a mountainous area and accident in a city centre.
The accident that occurs in tunnels poses the gravest threat due to complete inability to estimate the vehicle's position using GPS because of either the poor satellite signals' reception or the complete lack of satellite signals (conditions worsen proportionally to the length of the tunnel). In the case of the very long tunnels, the IVS will send two latest position samples, but both of the will be too old for correct estimation of the position of the accident, thus enlarging the position uncertainty area.
The accident occuring in a mountainous area can bring as serious positioning conditions as in the case of the tunnel accident. The obstruction of the sky by high mountains and forests may cause the complete inability to perform position estimation for a long time, and again prevent the correct position estimation of the place of the accident.
Finally, the urban environment may form the harsh environment for satellite positioning, when tall buildings may obstruct the visibility of satellites.
Considering the characteristics of the critical scenarios and the importance of reliable reporting of the correct position estimates, this group have developed a set of the Key Performance Indicators (KPIs) for position estimation performance for eCall. The initial set of KPIs for position estimation for eCall is presented in Table 1.

Table 1 KPIs for position estimation for eCall

KPI 1	Position estimation accuracy
KPI 2	Number of usable satellites
KPI 3	Geometric dilution of precision
KPI 4	Time between consecutive successful positioning fixes

Additionally, ranges of acceptable values of GPS performance KPIs for eCall have been evaluated, and the proposal is given in Table 2.

Table 2 Acceptable values for KPIs for position estimation for eCall in critical scenarios

	Range of acceptable values		
KPI	**Scenario 1 (tunnel)**	**Scenario 2 (mountainous area)**	**Scenario 3 (urban area)**
KPI 1	< 300 m	< 10 m	< 100 m
KPI 2	0	> 6	> 4
KPI 3	NA	< 2	< 3
KPI 4	20 s	5 s	10 s

The proposed acceptable values of GPS performance KPIs for eCall represent an attempt to provide reasonable and useful position estimations of the vehicle in accident, that will provide the essential framework for successful organisation of emergency services provision.

5 DISCUSSION. The critical GPS utilisation scenarios for eCall are identified from the perspective of the Standard Operation Procedures in the case of road traffic accidents. Apparently, the presumtpion that the utilisation of the sole GPS positioning procedure for provision of accurate and robust vehicle's position eestimate are over-optimistic. The GPS vulnerabilities and limitations undermine the requests for reliable and robust position estimation system. However, GPS should stay as the fundamental position estimation technology for eCall, that is to be enhanced by assisting and augmentation procedures, as well as by integration with the other positioning-related sensing devices already embedded in modern cars.
For instance, the tunnel accident scenario can benefit from navigation /positioning sensors integration and SOP modifications. Degraded GPS positioning performnce in mountainous ares can

be improved by utilisation of mobile network-based assisted and EGNOS-augmented GPS, as well as by integration with other positioning sensors. Finally, the urban environments may not end as a particularly critical positioning scenario, if the GPS-based position estimates are to be combined with PSAP-based intelligence (SOP modifications, which will take advantage of the withnesses' accounts and calls to emergency services).

6 CONCLUSION AND FUTURE WORK. The eCall is to provide an improvement to public safety, more efficient after-accident management, increased quality of emergency services, and better recuperation of those injured in road traffic accidents. The robust, accurate and reliable position estimation are essential in successful provison of the eCall service. While the utilisation of the sole GPS for the eCall position estimation was proved insufficient, the GPS should stand as the foundation of the eCall position estimation process, and to be enhanced by the GPS assistance and augmentation, and the integration with other positioning sensors.
This paper presents the targeted requierements for the GPS-for-eCall positioning performance requierments, expressed through the set of essential GPS positioning KPIs, that will satisfy the needs of road traffic acciden t SOPs.
Further work, to be conducted under thee HeERO project, is to focus on validation of the proposed enhancements to GPS-for-eCall position estimation.

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