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Procedures for eCall certification and execution

Harmonised eCall European Pilot

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1 Management summary

This deliverable proposes technical procedures and provides roadmaps for the implementation of the eCall certification.

The document has collected views from HeERO2 partners and beyond, concerning the certification requirements for eCall.

For the purpose of this deliverable, certification is a voluntary industry framework to validate eCall devices

eCall certification includes IVS as well as PSAP. For the IVS, the needs concerning the type approval were considered, and were regarded as the “minimum acceptable standard” and thus not candidate to the same technical scope.

The deliverable intends mainly to present a set of relevant requirements and the corresponding test procedures for eCall IVS and PSAP. These essential procedures are then suitable candidates for an eCall certification framework, for both IVS and PSAP.

The deliverable is however **not** intending to provide neither requirements nor recommendations to support type approval objectives. Indeed, as already identified in the HeERO2 description of work, the type approval scope, being mandatory, is understood to be lower than the certification scope. For this reason, car manufacturers have provided their own views concerning eCall regulation on vehicle testing, to be applied at either the UNECE or EU regulation level see (Vehicle type approval)

The deliverable structure follows a top down approach, enabling to select relevant requirements for eCall certification. This approach has been inspired from other certification framework for devices of a similar domain of technology e.g. Mobile Communication devices, “MirrorLink”.

At the top level is the definition of the scope of eCall certification. The deliverable has identified the IVS and PSAP as the target devices for certification. For technical and operational reasons, Mobile Networks cannot be candidate to a certification scheme.

IVS or PSAP devices are considered under the full scope of the certification, however sub-component are also candidate for certification, with a partial scope, as for instance NAD. A NAD certification process should therefore be defined to allow testing and certifying sub-components providing mobile connectivity for instance, and furthermore, as applicable, in-band modem or voice capabilities. Similar sub-component certification procedures could also be applied to GNSS sub-components as well. This concept allows suppliers, to voluntarily certify their devices, accordingly to the set of features they are supporting. This approach is successfully used by the Mobile communication industry through the Global Certification Forum framework.

At the second level, requirements are specified, taking into account possible reasons for having an eCall failure. One of the important requirement concerns the compliancy to the eCall standards. Furthermore, different essential performance requirement are proposed in the deliverable. Among these performance requirements, Antenna, GNSS, Speech quality/intelligibility related performance needs are found.

The requirements need then to be verified by the mean of appropriate test procedures. This is the subject of the bottom level. Test procedures are described in the “Certification process” clause, where all the different types of requirements have been addressed. The test procedures are either part of standards/technical specifications, or are provided as proposal for the eCall certification framework.

The last part is a certification roadmap providing a proposal for three different certification activities:

- Vehicle type approval with the current views from the car manufacturers,

- IVS certification, as voluntary certification framework, applicable to IVS devices, their sub-components, being thus suitable for retrofit and aftermarket.
- PSAP certification also supporting the PSAP conformity assessment procedure

This deliverable includes also views from testing service providers about the Periodic Test Inspection. These views are also not providing detailed proposals for the PTI procedures, which will be further discussed in the EeIP PTI task force.

The annexes contain detailed specification of some test procedures and description of some relevant test beds used in the context of the activities carried out in HeERO.

This deliverable is only the collection of views and recommendations gathered and presented by experts from different stakeholders. However, the legal framework being still under development, the HeERO project timeframe did not allow reaching a consensus about the views proposed in this document. Certain proposals, being directly based on eCall standards are likely to be applicable. Other proposals addressing performance or quality criteria require more consultation.

Finally, eCall is a service, which is intended to be widely used to save lives. Implementing eCall at reasonable costs is therefore critical to stay consistent with the eCall cost/benefit analysis made at the beginning of the HeERO1 project. Therefore, validation costs will need to be considered as well, in relationship with risk analysis, to select the appropriate test procedures to be implemented in the eCall certification framework.

2 Terms and abbreviations

Abbreviations:

CIP	Competitiveness and Innovation Programme
CTIA	The Wireless association (stood for: Cellular Telecommunications and Internet Association) – www.ctia.org
EC	European Commission
EeIP	European eCall Implementation Platform - http://www.imobilitysupport.eu/about-ecall/european-ecall-implementation-platform-eeip
GCF	Global Certification Forum – www.globalcertificationforum.org
IVS	In Vehicle System
KPI	Key Performance Indicators
MOS-LQON	Mean Opinion Score – Listening Speech Quality Objective
MNO	Mobile Network Operator
NAD	Network Access Device
OTA	Over The Air
P2W	Powered-Two-Wheeler (motorbike for instance)
PSAP	Public Safety Answering Point
PTI	Periodical Technical Inspections of vehicles for roadworthiness
RCV	Receive
RLR	Receive Loudness Rating
SLR	Send Loudness Rating
SND	Send

Definitions:

Certification:

A process, including its organisational and coordination framework, to test a product, a person or a service against given requirements and to deliver a certificate when the test results indicate that the requirements have been met. In the context of this document, certification is considered as a voluntary industry driven process to address compliancy and performance needs.

IVS sub-component:

Device being used by an IVS to provide some parts of the eCall required functionalities, but which cannot provide all the required functionalities when isolated.

3 Introduction

3.1 Purpose of Document

The purpose of this document is to present the views from HeERO partners, and beyond, concerning the needs for eCall certification. eCall certification needs are considered for both IVS and PSAP, taking into account as well retrofit and aftermarket devices. The certification framework for PSAP, proposed in this document, is likely to contribute to the harmonisation of the PSAP certification across the Member States.

In the context of this document, certification is considered as a voluntary process driven by the industry, to assess compliancy and performance of eCall devices.

This document has also taken into account the ongoing development of the Vehicle Type Approval requirements for the eCall in-vehicle systems, being regarded as the minimum acceptable standard. However, this deliverable is **not intending** to provide neither requirements nor recommendations to support type approval objectives

This document is also intended to gather views and proposal concerning the possible implementation of PTI procedures for eCall. However, these views are **not intended** to result from a consultation, but rather to be submitted for further discussions at the EeIP.

This document is presenting proposals for eCall certification procedures, which are considered as essential for certifying eCall IVS and PSAP. This document has been built up on methods commonly applied by the Information and communication industry, relating to similar technologies.

However, it is understood that different actors of the eCall IVS supply chain will have different responsibilities and thus apply specific processes.

This document also proposes recommendation for a roadmap about the implementation of eCall certification. The role of such an organisation will be to use the present document as a basis to establish an eCall certification authority, which will coordinate and record the certification procedures resulting from a consultation process.

The content of the document built significantly on the following activities carried out in the context of the task T6.2:

- The Standardisation task force activities having organised several meetings in conjunction with the HeERO Gas and conferences, to collect recommendation from the experts on standardisation, testing and certification,
- The TESTFEST interoperability test events organised by ERTICO and ETSI in coordination with the HeERO and Standardisation task force partners,
- The ERTICO partnership activities of the Interoperability Interest Group

3.2 Structure of the document

The structure of the document follows a top down approach for the definition of the eCall IVS and PSAP certification process divided in the following parts:

- Clause 4: Definition of the certification target and goals
- Clause 5: Specification of the requirements for certification
- Clause 6: Description of the certification test processes

In the clause 4, the target devices and systems for the eCall certification are defined. It is a critical part in specifying what kind of systems can be considered as candidate for the certification process. Furthermore, the clause 4 provides a high-level description of the capabilities to be tested for the devices and systems candidate for the certification.

The clause 5 provides a detailed list of potential requirements for the certification. These requirements gather goals for testing and have led the development of the certification framework and the testing programme.

The clause 6 provides description of the certification test procedures.

The recommendations concerning the roadmap for the implementation of the certification activities are provided in the clause 7 of this document

The clause 8 summarised the conclusions concerning the implementation of the eCall certification.

Detailed test descriptions and specification of testing environment and processes are provided as annexes of this document.

3.3 HeERO Contractual References

HeERO is a Pilot type A of the ICT Policy Support Programme (ICT PSP), Competitiveness and Innovation Framework Programme (CIP). It stands for Harmonised eCall European Pilot.

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4 Scope of eCall certification

4.1 Introduction

Certification is a process commonly used by many industry sectors to test and assess that products, persons or services are meeting certain requirements and to deliver certificates when the corresponding test results match these requirements. The industry certification applies in many sectors and is usually voluntary. Manufacturers, operators or service providers, to select suitable products for instance, may optionally use the eCall certificates.

In the context of the vehicles, where the IVS will be embedded, the regulation is currently under development. Type approval requirements are also mandatory so that only minimum requirements are usually considered. Therefore, the proposal for eCall certification, for IVS, is not addressing the same scope as the IVS type approval.

Thus this document is **not** intended to serve as a basis for the type approval procedures, as it is understood that the type approval procedures only covers the essential requirements.

This document proposes requirements and procedures that are likely to be considered in the context of a complete and detailed eCall product (IVS/PSAP) assessment. A part of the requirements specified in this document might however be retained for the regulation, if these requirements are safety critical for instance.

IVS are systems, which are likely to combine several components, each one implementing a part of the IVS functionalities, as for instance:

- Provision of positioning (e.g. GNSS)
- Network Access Device
- Controller implementing high level functions (e.g. HLAP)
- Accident trigger sensor
- Voice component

Some components are also likely to implement several functionalities. Therefore, the certification shall consider the possibility to share the certification into independent but complementary certification processes concerning the required eCall IVS functionalities.

The certification framework proposals, in this document, are a good basis for suppliers to proceed with the validation of their components of the eCall chain.

Aftermarket devices will be not submitted to the vehicle type approval process, therefore the certification framework presented in this document is suitable to certify these aftermarket IVS before they reach the market.

The regulation about PSAP deployment leaves to the Member States, through a delegated act, the responsibility to assess the conformity of the PSAP. The present document provides a common basis for the PSAP conformity assessment, which will contribute to the implementation of harmonised conformity assessment procedures in EU

Currently the process leading to provide the eCall certification proposals in this deliverable is not including a consensus phase. The process used to draft this document was rather open, intending to gather as much expertise and resulting technical requirement and corresponding test proposal as possible.

Additionally, a proposal concerning the coordination and the organisation of a certification authority is proposed. This would be the role of this certification authority and its stakeholder to select the appropriate requirements and test procedures.

Even if the deliverable is not intending to serve as a basis for the type approval, some actors of the automotive and car industry were involved in the drafting of the deliverable to provide views. The current views concerning the development of type approval procedures are also provided in a separate clause (see Vehicle type approval).

4.2 Certification targets

4.3 Introduction

The eCall service is provided by a chain of components. However, certification cannot apply to the whole eCall chain but rather to isolated systems. Three types of device or systems are considered to go through eCall standardisation, being provided by different vendors and use with a different context:

- In-vehicle systems (IVS)
- Mobile networks
- Public Safety Answering Points PSAP

These different types of systems need a specific certification processes and will therefore be the three-targeted types of eCall systems for certification.

4.3.1 IVS

The in-vehicle system (IVS) is the equipment in the vehicle providing data and functionalities to proceed with the initiation and handling of eCall. The CEN specifications providing eCall requirements, namely EN 16062 and EN 16072 are giving a very high-level definition of the IVS. According to these standards, the IVS is using a network access device (NAD) to access the mobile network and initiate eCall. The IVS shall also have access to vehicle data to generate the MSD.

The architecture and design of an IVS is therefore left to responsibility of the suppliers, as the eCall standards only specify the functionalities to be carried out by the IVS. Therefore IVS are likely to result from the assembly of many heterogenic component provide by several suppliers. Furthermore, IVS are also likely to contain several embedded devices. These embedded devices can be defined as IVS sub-components.

For the sake of the certification, IVS are thus considered as all the pieces of equipment necessary to provide all required eCall functionalities, according to EN 16062, EN 16072 and EN 15722.

It is likely that millions of IVS from hundreds of suppliers are likely to reach the market in the next Year. Therefore, the IVS is one of the key targets for the eCall certification.

In the context of this document, the IVS is not considered as the vehicle equipped with the eCall IVS, which will have to go through the type approval procedures for new vehicle types, from the date of its entry in force.

However, aftermarket IVS, sub-component of IVS, as well as vehicles not required to go through the new type approval process (being no new type or release before the application date) may use the present certification framework in the context of voluntary certification.

Conclusions:

1. It is difficult to specify what exactly an IVS is, therefore the IVS, as a target component for the eCall certification should rather be specify by a set of devices and forming a system capable to provide all required Pan EU eCall functionalities as per the corresponding CEN standards: EN 15722, EN 16062 and EN 16072 (full IVS scope).
2. Not only an IVS providing all eCall functionalities shall be considered as a target for certification, but also devices, considered as sub-component of IVS, and providing part of the eCall requirements, as for instance: NAD devices or geo positioning device.

The following table provides example of the different type of IVS devices to be considered as target for the eCall certification.

Table 1: possible types of IVS devices for eCall certification

<table>
<tr><th>Device type</th><th>IVS scope</th><th>Description</th></tr>
<tr><td>IVS system embedded in the vehicle</td><td>Full</td><td>The set of devices embedded in the vehicle providing all required eCall functionalities (full scope) according to the CEN requirements</td></tr>
<tr><td>Autonomous aftermarket IVS system</td><td>Full</td><td>An autonomous system installed in the vehicle providing all required eCall functionalities (full scope) according to the CEN requirements</td></tr>
<tr><td>Non-autonomous aftermarket IVS system</td><td>Partial</td><td>An autonomous system installed in the vehicle providing part of required eCall functionalities and using eCall functionalities from other vehicle components e.g. eCall trigger geo-positioning device, microphone and loudspeakers …).</td></tr>
<tr><td>IVS Sub components</td><td>Partial</td><td>Devices providing only a subset of the different eCall functionalities required by the CEN standards</td></tr>
<tr><td colspan="3">Examples of possible sub-components</td></tr>
<tr><td colspan="2">NAD (network access device)</td><td>Devices providing access to the Mobile Network and at least the GSM/UMTS functionalities to initiate eCall. The NAD is likely to include also the in-band modem functionalities (see 4.4.2).</td></tr>
<tr><td colspan="2">HLAP + NAD</td><td>Devices providing the main eCall functionalities according to EN 16062, but neither the triggering of automatic eCall, nor the position nor Mic/speaker.</td></tr>
<tr><td colspan="2">Geo –positioning device</td><td>Device delivering the position of the IVS, based on GNSS or any other technology (e.g. Mobile Network positioning)</td></tr>
</table>

NOTE: the above sub-components, being part of a complete IVS are given as examples. The eCall certification authority, being the coordinating entity for eCall certification, will need to specify the different types of components with the relevant stakeholders. A detailed specification of the features supported by the different type of sub-component will enable defining its corresponding certification programme.

Defining sub-components will offer the advantage to certify devices according to the real feature they are supporting. It is expected that IVS will be provided while assembling sub-components from different vendors. Thus using existing certification results will avoid tier 1 vendors for instance to certify features, which have been already certified in the embedded sub-component. This process is already used by the Global Certification Forum for the Mobile devices (2G/3G/4G).

4.3.2 MNO

The MNO (Mobile Network Operator) is the company providing the connection between the IVS and the PSAP over the Mobile Network. Mobile network are very complex systems made of several heterogenic communication components. Mobile networks are in operation since more than a decade. During that period no serious incidents happened indicating that the MNO might not have full control in his scope of responsibility to offer a service according to the performance requirements like availability, reliability coverage, ….

Furthermore, the overall performance of the mobile network is part of the license agreement, which the MNO agrees with the local telecommunications regulation authorities.

Therefore, Mobile Network certification will not be considered in the scope of this document. This approach is also fully in line with the Mobile Telecommunication industry approach.

4.3.3 PSAP

According to the Delegated Act, article 4 the conformity assessment of the operation of PSAP shall be in accordance with the requirements of article three (see details in 7.4). The implementation is described in detail by the reference to the already existing description of the conformity assessment in the standard “Intelligent transport systems - ESafety - eCall end to end conformance testing” (EN 16454).

In this standard it is exactly defined for one of the requirements in article 3 (EN 16062: Intelligent transport systems - eSafety - eCall high-level application requirements (HLAP)), how every possibility in the implementation of eCall should be validated in conformance testing. In article, 3 of the Delegated Act two additional standards are listed:

- EN 15722: Intelligent transport systems - eSafety - eCall minimum set of data (MSD)
- EN 16072: Intelligent transport systems - eSafety - Pan-European eCall operating requirements

For these two standards a detailed description, how to evaluate the conformity of PSAPs, has to be created according to EN 16454.

The assessment of conformity is an important part to assure the functionality of the end-to-end eCall chain. The interoperability has to be assured between all IVS and all PSAP. For that reason, it is not sufficient only to validate the IVS. The other end of the communication chain, the PSAP has to be validated as well for conformity with the eCall standards.

In addition the results within HeERO WP4 demonstrate the strong influence of the PSAP to the overall performance of the communication parameter concerning the so called “voice channel blocking time”.

4.4 Certification goal

4.4.1 Introduction

The certification targets are defined in the previous clause. In other words, the targets are the type of components of the eCall chain, being candidate for the eCall certification.

In this clause, the deliverable defines the different type of capabilities to be tested on the targets, in the context of eCall. The different relevant capabilities for eCall components, which are presented in the following clause, are:

- Compliancy to eCall standards
- Interoperability
- Minimum performances
- PTI (Periodic Test Inspection) capabilities for IVS
- Safety operation capabilities for PSAP

4.4.2 Standard requirements

The High Level Application requirements for the PAN European eCall services are specified in a set of CEN standards (see table below) forming also the set of reference standards for the eCall regulation. These standards are providing mandatory requirements, which are already included in the PSAP regulation and will be part of the IVS regulation. Therefore, the certification of IVS and PSAP need to consider these standards as mandatory requirements to be taken into account for the eCall certification.

Table 2: CEN TC278 standards for eCall

Standard Nr	Description	Published	Revision
EN 15722	eCall minimum set of data (MSD)	2011-06	
EN 16062	eCall high level application requirements (HLAP) using GSM/UMTS circuit switched networks	2011-09	
EN 16072	Pan-European eCall operating requirements	2011-09	
TS 16454	ECall end to end conformance testing (note: published as TS16454 – 2011-12) **Note**: will be supersede by EN 16454	2013-08	
TR 16405	ECall additional optional data set for heavy goods vehicles eCall	2013-01	
EN 16102	Operating requirements for third party support	2011-12	2015
Work Items and revisions			
FprEN 16454	eCall end to end conformance testing		CEN enquiry 31/12/2014
FprTS 16405	eCall - Additional data concept specification for heavy goods vehicles		Final Vote 2014-09
FprEN 15722	ECall minimum set of data		UAP 31.12.2014
FprEN 16062	**eCall high level application requirements (HLAP) using GSM/UMTS circuit switched networks**		UAP 31.12.2014
FprEN 16072	Pan-European eCall operating requirements		UAP 31.12.2014
prEN 16102	Third party services supported eCall - Operating requirements		Under drafting
Notes: UAP = Unique Acceptance Procedures (for revisions) FprEN 16062 - EN title has changed			

The above CEN standards contain references to other CEN, ISO and 3GPP standards, in particular the 3GPP standards providing requirement for the in-band modem: 3GPP TS 26.267 and 3GPP TS 26.268.

4.4.3 Interoperability

Certification aims at providing a reliable and seamless eCall chain (see figure 1 below).

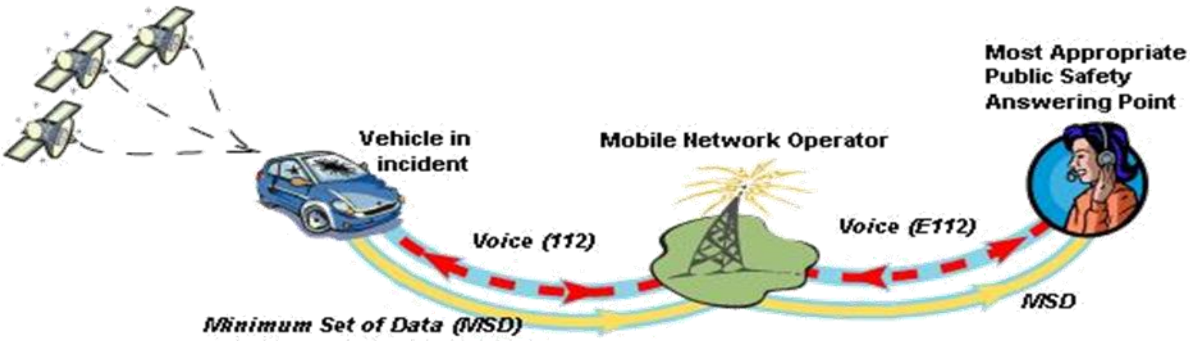


Figure 1: The eCall chain

The eCall procedure comprises several phases, which corresponds to the exchange of messages between the different entities of the eCall chain (see figure 2 below).

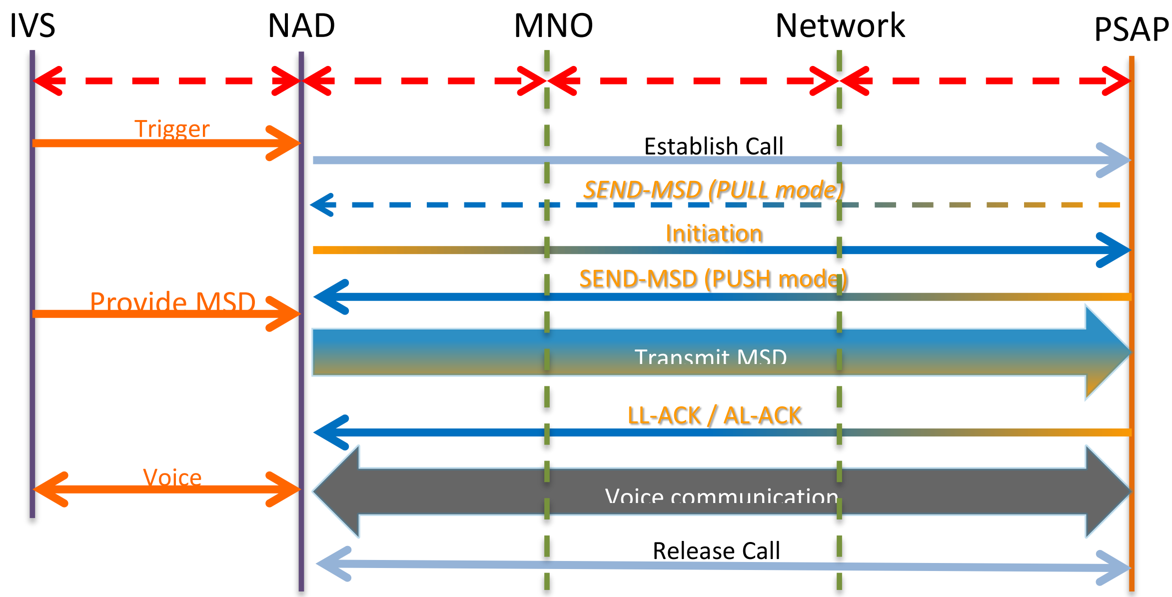


Figure 2: The eCall flow

Interoperability is the ability of the different components used in a cooperative system, like eCall, to communicate, exchange data and execute applications using these communication processes and data. Therefore, interoperability is the ultimate capability for eCall components of the eCall chain to provide eCall services seamlessly.

Capabilities relating to interoperability are critical for all component of the eCall chain. AS explained in the clause 5.1 below, the interoperability requirements are closely linked with the compliancy to standards. However, interoperability is a capability in itself, even if mainly resulting from standard compliancy, and is usually tested in addition to the conformity to the standards.

4.4.4 Minimum performances

4.4.4.1 Functional Key Performance Indicator

For the successful operation of eCall, it is not sufficient to validate only conformity to the relevant eCall standards. There are many situations where an IVS of one manufacturer will work, the other one from another brand not, but both being in conformance with the eCall standard. One important aspect is the position of the antenna both for GSM/UMTS and the used satellite navigations systems. If the antenna is located within the body or even worse between the motor, this antenna will only be able to process very strong signals. Because the driver cannot qualify the IVS similar to a hands free system or a navigation system, he has to rely that the IVS will work in case of an incident. In case of moderate to weak GSM/UMTS signals, a mobile phone used in a vehicle may not be able to establish a voice connection. However, in the same situation in the same vehicle at the same location a phone using an external antenna on the roof of the vehicle will have no difficulties to establish a voice connection.

The results of the WP4 Evaluation point out that there is a huge variance between the performances of an IVS from one brand to another one of another brand. The performance is caused by different implementations of the respective standard and other factors. As depicted in Figure 1 the eCall requires first the complete transmission of data MSD prior to the voice communication between operator and passenger in the vehicle. As the passengers have experienced an incident with their car, they are quite agitated and even panicked. Therefore, it is very important to minimize the duration between the trigger of the eCall and the start of the voice communication between passenger and operator. A few requirements are already defined in the standards, e.g. the time of the voice channel blocking in EN TS126969 but majority not.

Therefore, minimum performance requirements to be met by IVS need to be defined. A good guidance is provided in one of the deliverables of HeERO2 - WP4 with initial target values for the main KPIs (Key Performance Indicators), based on measured best practise values in the HeERO1 and HeERO2 projects.

4.4.4.2 Vehicle related performances

4.4.4.2.1 EMC

The goal of Electromagnetic compatibility (EMC) tests is to assure the proper operation of different equipment operating in the same electromagnetic environment without causing interference.

According to EN 16072 the eCall IVS shall meet requirements stated in Directive 2004/108/EC. Directive 2004/108/EC cease to apply for requirements laid down more specifically by other Directives, therefore UN Regulation 10 that supersedes the automotive EMC Directive 2004/104/EC can be adopted for EMC type approval process.

Additionally, radio transmitter equipment shall comply with essential requirements of Directive 1999/5/EC (R&TTE Directive). The manufacturer has to demonstrate the compliance of the eCall IVS radio equipment by applying conformity assessment procedures laid down in that Directive

4.4.4.2.2 Accident Detection

The aim of this section is to define a test protocol to assess and validate the eCall In-Vehicle System (IVS) through accident identification algorithms. The protocol should check that as well as working in the event of accident, the IVS properly identifies the kind of accident occurred and only activates the emergency call if the collision is severe enough to put in danger the physical well-being of the vehicle passengers.

The following objectives must be accomplished:

- Delimitation of the pulses of acceleration characteristics for each type of vehicle according to the impact zone and the severity of the accident.
- Development of a testing protocol, which will allow the validation of the devices of the emergency calls.

Prior to preparing this document, a study was carried out in which the most common and representative configurations of traffic accidents in Spain and Europe were defined.

Knowing which variables are the ones that must be measured in the sequence of the vehicle's collision, characteristic patterns of behaviour in the types of collision were identified.

Before defining the test protocol, research into vehicle crash testing was carried out with the objective of having a reference in the phase of the design. From this study, the most adequate tests in order to reproduce the automatic emergency call in the protocol were selected.

After the basic characteristics of the test had been established, the most suitable device for the testing was selected.

Finally, taking into account all these conditions, the tests that constitute the assessment and validation of the emergency call system protocol were developed.

4.4.4.2.3 Antenna performances

The goal of the antenna performance evaluation is to ensure the service availability for all operating conditions. The antenna performance is a key measurement as regardless of the location, position and condition of the vehicle after an accident the performance of the antenna shall still be failsafe. In order to achieve this, the characterization of the antenna performance is needed.

4.4.4.3 GNSS performances

The goal of the GNSS performance evaluation is to guarantee a minimum precision and operability of the positioning system that belongs to the IVS to provide the PSAP with exact location information.

A GNSS receiver needs to receive at least four signals from different satellites to determine a position. In general, one can say the more satellites and the stronger the received signals, the higher the positioning precision.

The following corner cases should be considered for the assessment of GNSS receiver performance:

- Sensitivity: A sufficient number of satellite signals are received, all signals are weak. The goal is to ensure the reception of a minimum satellite signal level in the GNSS receiver.
- Nominal accuracy: A sufficient number of satellite signals are received, all signals are strong. The goal is to check the exactness of the position determined in the GNSS receiver.
- Dynamic range: A sufficient number of satellite signals are present but the signal level of the received signals differs a lot, i.e. there is a high dynamic range among the received signals. The goal is to test whether the weaker satellite signals are correctly received by the GNSS receiver in the presence of other strong satellite signals.

- Multi-path performance: A sufficient number of satellite signals are present but some satellite signals are subject to multi-path propagation, i.e. besides the direct Line-of-Sight satellite signal a weaker copy of the signal (echo or so- called multi-path signal component) arrives with some time delay at the GNSS receiver. This can occur in scenarios with large objects near the receiver, e.g. houses in an urban environment or hills in a mountainous area.
- Moving scenario: A sufficient number of satellite signals are received, all signals are strong. The received signal scenario represents a moving vehicle with varying speed and direction. The goal is to check whether the position is updated and sent with sufficient position precision and within an appropriate time.

4.4.4.4 Speech quality performances

The eCall service is based on the transmission of a minimum set of data but also on the voice communication between the vehicle occupants and the PSAP operators. Therefore some minimum requirements are needed concerning the speech quality, speech intelligibility and listening effort during communication,

The voice communication provided by the IVS will use hands-free components with a microphone and a loudspeaker integrated in the vehicle or in the IVS box for aftermarket devices. Alternatively, the IVS may use the existing vehicle multimedia system, which may also include a hands-free component.

The usage of hands-free systems needs to pay attention on potential speech quality issues like for instance:

- Loudspeaker to microphone coupling, with the possibility to create echo,
- Double talk capability
- Transparent transmission of ambient vehicle noise to the PSAP operator

Speech quality testing should address the above issues and ensure “intelligibility” of the conversation between the occupants and the PSAP

4.4.5 IVS PTI for the vehicle Life time

For safety in road traffic, mandatory periodical technical inspections (PTI) for vehicles have been introduced in the EU, based on directives. Today’s requirements can be found in directive 2010/48/EU to roadworthiness tests of motor vehicles and trailers in the EU. The member states have established a system to authorize organisations (special inspection organisations in some member states, licensed workshops in others) to provide inspections following the national and European requirements for these periodical technical inspections. These inspections are carried out for newer as well as for older vehicles, without reflecting to the ownership or the level of maintenance of individual vehicles.

Since eCall is seen as safety relevant system, it is expected to be mentioned in vehicle type approval (there is a draft to eCall type approval by the commission) as well as in requirements to periodical technical inspections. It is expected that the next directive to PTI will focus more also on safety relevant electronic systems and functions in vehicles. For future vehicles, mandatory equipped with eCall, also related requirements to PTI of eCall will be considered for discussion at the EeIP PTI task force.

The task for testing eCall in PTI is to provide a test procedure to ensure the function of eCall over lifetime of a vehicle will not be degraded due to

- Defects of components
- Corrosion of cables or components
- Aging effects of components
- Missing components

- Wrong replacements
- Improper modifications and updates

It is clear that the closer this test is to real eCall operation, the more reliable this test procedure is for this objective. Since the use of PSAPs in vehicle testing is not recommended, a test call without involving PSAPs but by sending (and checking) MSD and establishing the voice channel to the vehicle are seen as the best solution. These tests would check within the usual period for PTI:

- Network access
- function of in-band modem
- GNSS functionality
- MSD format and information
- Audio function for voice connection.

4.4.6 PSAP service quality

The work currently being done by EENA, regarding service quality, ranges from the establishment of a network of emergency service personnel to the development of a library of reference documents for use by the emergency services, policy makers and regulators. In addition to this, EENA has been working for several years on the Next Generation 112 services and the deployment of integrated and interoperable systems.

During its time in operation, EENA has been in an advantageous position that has allowed it to observe and understand all facets of the emergency services chain across Europe by a multitude of organisations. This has given EENA an unparalleled insight into the different methods, standards and practices employed by Public Safety Answering Points “PSAPs” and it is with this knowledge that the concept of a quality standard is devolved from.

In an effort to help the emergency services and specifically Public Safety Answering Points ("PSAPs") to measure their quality of service to the citizen, EENA has designed a unique Quality Certification Programme ("the Programme") using the same principles of the ISO9001:2008 and the ISO19011 standards. EENA has also used the CEN 15838:2009 standard for Contact Centres as a reference point.

The criteria used in this Programme are specific to the service delivery objectives of the PSAP and is designed with their roles and responsibilities in mind. Whilst acknowledging that the national structures for PSAP's are different throughout the EU, which results in quite different mandates, the Programme has been designed to be all-inclusive and open to all PSAP to apply for. Therefore, not all the criteria may be applicable to all PSAPs.

It is a 3-year programme with annual check-ups performed.

5 Requirements for the eCall certification

5.1 Standard compliancy and Interoperability requirements

The eCall relevant standards are providing communication and application process requirement to ensure interoperability between the different types of components of the eCall chain.

The requirements, concerning the interoperability at the level of the GSM and UMTS mobile communications, are addressed in the framework of the ETSI/3GPP standards and technical specifications.

CEN TC278 WG15 “eSafety” has provided a set of standards specifying the requirements for the pan-European eCall service using TS12 emergency call over a GSM or UMTS mobile communication network.

Additionally to the CEN standards, a set of 3GPP technical specifications are addressing the requirements concerning the in-band modem, use by IVS and PSAP for the transmission of the minimum set of data (MSD).

All these standards and technical specifications contain the requirements addressing the interoperability of the eCall components along the eCall chain.

The figure 3 shows the applicability of the different specific eCall standards.

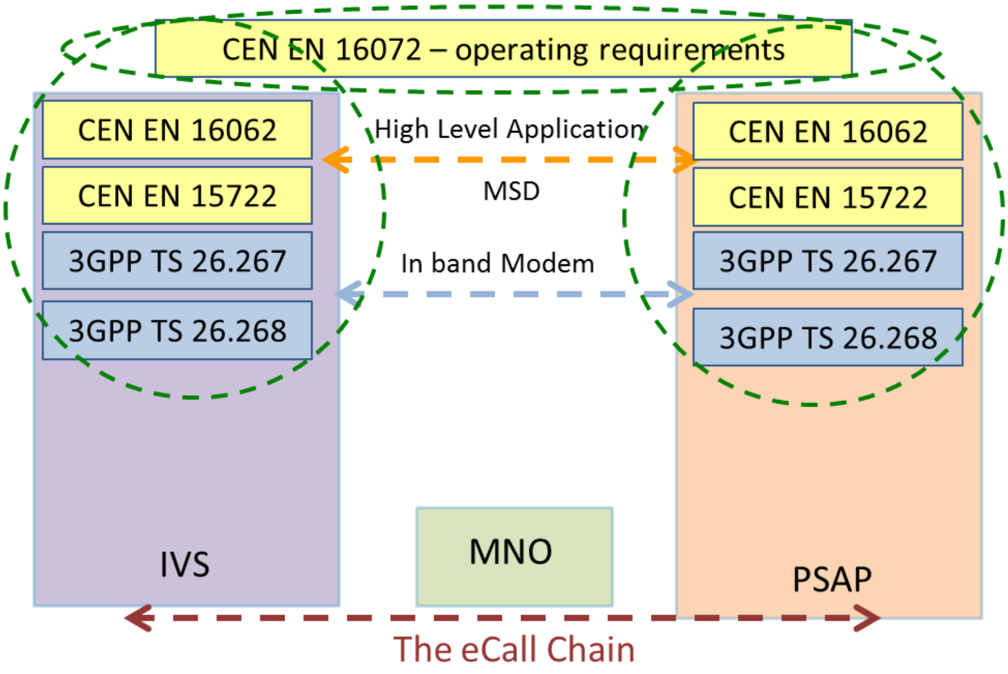


Figure 3: the eCall communication standards

All the requirements, concerning the interoperability at the level of the eCall specific functionalities, are part of the standards and technical specifications described in the figure 3 above.

Furthermore, the interoperability of eCall is pending on the interoperability at the level of GSM/UMTS mobile communication, whose requirements are part of the 3GPP standards and technical specifications.

GSM/UMTS mobile communication devices are also submitted to regulatory scheme as per the ETSI EN 301 511 standard.

5.2 Performance requirements

5.2.1 Functional Performances - field trials

Key Performance Indicators were developed in the HeERO projects to measure the performance of the components and processes. The HeERO1 and HeERO2 projects aimed at getting values for “best practise” rather than reaching target values. Based on the results of the KPIs, recommendations for target values were developed. The KPIs were defined only for those critical values, which are measured during drive tests on roads.

Many of these KPIs measure the critical spans of time, which are influenced by the respective implementation of the IVS and/ or PSAP suppliers. Other KPIs measure the accuracy of the GNSS or the correctness of the heading information. This has to be complemented by threshold measurable only in a laboratory like antenna gain, acceleration or eventually voice quality.

The following list provides a short definition of some of the KPIs together with thresholds.

- KPI05 describes the duration from the initiation (automatically or manually) of an eCall to the presentation of the MSD content in the PSAP.
- KPI07 represents the time the transmission of MSD blocks the voice channel. Voice channel is blocked can be defined as, the time between successful call setup (“connected” is reported by the network) and the opening of voice communication in both directions. This is after the MSD has been transmitted successfully, or the MSD transmission has been abandoned (after time out), and the voice communication has been opened on both sides in a bi-directional conversation.
- KPI07a evaluates the duration of the voice channel blocking if an automatic retransmission of the MSD is initiated by the IVS on request by the PSAP.
- KPI08 refers to the observed time difference between the time of the eCall initiation (automatic and manual) and the time of the eCall reception at PSAP.

Table 3: example of KPI values

[seconds]	mean	median	std. dev.	minimum	maximum
KPI05	11.8	11.8	3.1	8.6	16.8
KPI07	8.9	8.9	2.7	5.0	13.0
KPI07a	8.9	8.9	2.7	5.0	13.0
KPI08	8.4	8.4	4.3	2.4	17.0

For the following KPIs, the thresholds are directly specified.

- KPI09, the accuracy of position shall reach the typical GNSS accuracy of 3 to 5m. In addition, there shall be requirements for signal strength and how much loss of signal is allowed.
- For KPI13 the test criterion shall be to measure the travel direction not the direction of the vehicle to be able to identify the right lane of the highway with physical separation
- KPI21 should be at least 50 to get significant test results

Further KPIs have to be developed to specify the gain of the antenna both for GNSS and GSM.

5.2.2 Vehicle related performances

5.2.2.1 EMC

Type-approval of an ESA according actual Regulation 10 can be obtained by two different ways:

- **Approval of vehicle installation:** A vehicle installation may be type-approved. If this procedure is chosen by a vehicle manufacturer, no separate testing of electrical/electronic components systems or ESAs is required.
- **Approval by testing individual ESAs:** Type approval may be granted to an ESA to be fitted on any vehicle type. Vehicle approval including an additional approved component may be extended without any additional testing,

As stated in UN Regulation 10 during whole vehicle type, approval immunity tests all equipment, which can be switched on permanently by the driver, or passenger should be in normal operation. According EN 16072 the normal operation mode for an eCall system is the automatic eCall mode (e.g. eCall system with collision trigger armed). If this approach is chosen, only basic functionalities of IVS can be tested (e.g. unintended trigger activation or HMI malfunctions) and possible malfunction could pass undetected.

IVS type approval at component level is adopted in this document. A similar approach is used in the actual Regulation 116 for Anti-theft and alarm systems installed in vehicles.

Under component testing approach additional functions (e.g. communication link, MSD transmission, GNSS) can be tested in a more efficient way. Nevertheless, it will be responsibility of the manufacturers to provide simulated loads for the IVS component testing in order to assure good correlation with whole vehicle installation conditions.

For an eCall, IVS the electromagnetic radiation generated shall be measured and the immunity to electromagnetic radiation shall be tested. Test methods and type-approval limits shall be according UN Regulation 10 Rev.4 (Uniform provisions concerning the approval of vehicles with regard to electromagnetic compatibility), considering eCall, IVS functions as immunity related functions.

Table 4: Type-approval tests and methods for an e-Call IVS

Test	Method
Measurement of radiated broadband electromagnetic emissions from ESA (Annex 7)	CISPR 25 (Second edition 2002 and Corrigendum 2004). ALSE method
Measurement of radiated narrowband electromagnetic emissions from ESA (Annex 8)	CISPR 25 (Second edition 2002 and Corrigendum 2004). ALSE method
Immunity of ESA to electromagnetic radiation (Annex 9)	ISO 11452-2, second edition 2004
Immunity against transient disturbances conducted along supply lines (Annex 10)	ISO 7637-2 (second edition 2004 and Amd1: 2008)
Emission of transient conducted disturbances generated by ESA on supply lines (Annex 10)	ISO 7637-2 (second edition 2004 and Amd1: 2008)

5.2.2.2 *Accident detection*

The validation protocol of the automatic emergency call consists of replicating 3 types of test that represent the three configurations that have been defined in the study of accidents (frontal collision, lateral collision and rear end collision between light vehicles).

In order to be able to determine these tests, it was necessary motorize the behaviour of the vehicles at the scene of the real crashes and analyse what values of accelerations and angular velocity are usually registered (variables needed for the accident recognition).

Knowing what units are expected to be measured and with their order of magnitude determined, a set of reliable and repeatable proof was generated by using the testing support and devices appropriates.

The steps that were followed for the test design are as follows:

- Acceleration pulses
- Reference tests
- Selection of the test’s reference to be replicated at the testing protocol
- Selection of the testing devices
- Generation of the frontier pulses

5.2.2.2.1 Acceleration pulses

The activation of the automatic emergency call system in case of a frontal, lateral or rear end accident is based on the reading of the different accelerations that are produced in the vehicle.

The first step for establishing the acceleration pulses is discerning the possible situations where IVS has to be differentiated. At least, it must recognize the scene of accident and the no accident ones.

The main action that has to be carried out is the differentiation between whether the automatic call has to take place after the crash or not; to do this, a combination of acceleration values was established that has function as reference frontier between these states.

In each test it must be checked that the analysed device recognizes if there has been an accident or not and if it is affirmative, it has to differentiate the kind of collision that the vehicle has suffered.

In the process of establishment of these values, it has been taken into account the deceleration that is severe enough to produce injuries in the human body and require urgent medical attention.

It must be added that in each scene (depending of the severity of the collision and the zones of impact), the acceleration suffered by the vehicle has a correct pulse that differentiates that collision from the other types and the other types of automobiles. To do this, different reference values must be taken depending on the vehicle class that integrates the emergency call device.

Depending on the vehicle volume and mass, Euro NCAP (Europe's reference in the automotive sector) divides the vehicles into 10 different classes (see figure 5 below).

Table 5: Vehicle class in which Euro NCAP divides the vehicles

Supermini	Small Family Car	Large Family Car	Executive	Small MPV
				
Large MPV	Roadster sports	Small Off-Road 4x4	Large Off-Road 4x4	Pick-up
				

5.2.2.2.2 Reference tests

The design of the testing protocol implies defining the composition of a large number of elements such as, for example, in which support will be done (automobile, sled, pendulum, etc.), the impact velocity of the tested element, crash acceleration, the body characteristics that collide against the support or the angle between the bodies' trajectories that collide.

With the objective of observing the tendencies in testing, taking as a reference the results of vehicles that has been tested. A study of the current frontal, lateral and rear end crash tests and roll over tests to evaluate the protection for the passengers of the crashed vehicle was carried out.

In this analysis, two kinds of test programs were consulted, as follows:

- Mandatory tests: Rules and regulations for the vehicle passengers' protection
- Test for consumer information: vehicles certificate

The tests that the vehicles must pass in order to be marketed are based on the criteria of the injury to the automobile occupants. The advantage of using regulations and certification test data is that the consequences that the passengers will suffer are known; also, the pulses that are the cause of these injuries can be obtained. In fact, the aim of this recompilation of information is to obtain information about this variable considering that the magnitude that can be reproduced in the test is the acceleration and not the injuries of the passengers.

5.2.2.2.3 Selection of the reference tests to be reproduced in the emergency call protocol

After knowing which are the crash tests that are being replicated at present in the different existing protocols, the next step was the selection of which are the most suitable for the evaluation of the correct function of the automatic emergency call system.

In the tests of collision between vehicles (frontal, lateral and rear end), the principal variable to be bound is the acceleration that the vehicle must suffer because of the impact.

5.2.2.2.4 Reference tests with the acceleration as the main variable

The acceleration pulses that will be produced in the collision tests between vehicles must provide enough information to allow the IVS to identify in which risk situation the vehicle that is installed is involved:

- Severity of the impact:
  - Accident
  - No accident
- Type of collision:
  - Frontal collision
  - Lateral collision
  - Rear end collision

In the process of determination of these values, it must be taken into account, which ones are the decelerations with the sufficient severity to produce injuries in the human body, which require urgent medical attention.

To be able to complete the test protocol, a reference pulse of acceleration has been determined for each kind of situation.

5.2.2.2.4.1 Accident scenario

The reference accelerations pulses those are most suitable to define the accident scenes are the ones obtained from the results of the light vehicle test certification. The reasons are as follows:

- They are based on the criteria of the injury to the automobile passengers: The registration of the acceleration produced in the vehicle due to the collision allows connecting this magnitude with the severity of the injuries that the passengers of the automobile will suffer. The fact of taking data about the acceleration implies that the consequences of the passengers will be known.
- The criteria of the certification tests are more severe than the ones for the regulations. These tests represent more severe accidents and with worse consequences for the vehicle passengers. Experiencing a collision with the same characteristics as a certification test implies suffering a severe kind of accident.

Of all the tests from the existing certification bodies (Euro NCAP, US NCAP, USA IIHS, Latin NCAP, JNCAP, C-NCAP, KNCAP, ANCAP) the frontal, lateral and rear end accidents corresponding at the Euro NCAP protocol have been taken as reference for two reasons, the second being a consequence of the first:

- Geographic localization: This test protocol has been designed for validating devices that must be installed in the European vehicle fleet. Euro NCAP the certification body that assesses the car safety in Europe have been tested by this protocol. Recreate accelerations of the same type for the validation of the automatic emergency call system homogenize the evidence about the vehicle's components.
- The availability of the acceleration pulses related to the certificate testing.

5.2.2.2.4.2 No accident scenario

When a vehicle collides with another object, it does not necessarily mean that a collision with a risk of serious injuries for the passengers has happened. The device of the emergency call has to differentiate the case in which the vehicle crashes, but all the passengers will be unharmed.

Although it is necessary to identify which are the accelerations that are appropriate for these kinds of scenarios, the range of values that delimit the limits of no accident have been established from the accelerations defined at the accident scenes.

The first stage of the establishment of this protocol has been to specify a set of acceleration pulses that will be identified with the danger situation for the vehicles passengers. Once these boundaries are established, the accelerations of no accident scene will be the ones that belong to the lower part of the pulse limit that delimit the accident scene.

5.2.3 Antenna performances

Antenna performance is a key criterion to ensure a seamless communication through the mobile network operator when an eCall is initiated.

Mobile phones antenna performance measurements are well defined and mandatory since many years. Those test methodologies can be simply transferred to testing of vehicles.

Using the CTIA specification "Test Plan for Wireless Device Over the- Air Performance, Method of Measurement for Radiated RF Power and Receiver Performance measurements on wireless devices", which is also based on the technical specification of the 3GPP group 3GPP TS 34.114 V12.0.0 (2014-06), the following measurements shall be carried out to evaluate the transmitter and receiver performance:

- TRP: Total Radiated Power. This is an indicator for the transmitter performance. In a cellular environment, it is best to maximize the spatial coverage of the antenna system so that independently to antenna direction a good call performance can be assured.
- TIS: Total Isotropic Sensitivity. This is an indicator for receiver performance. The receiver sensitivity will be measured with the transmitter set to the maximum power output allowed by the particular EUT and technology combination.
- Additionally a test of the receiver performance over frequency shall be conducted with all potential interferers switched on (e.g. such as other electronic featuring displays or DC/DC converters).

The individual test results are added up to the total figure of merits (FOM): TRP or TIS.

Those absolute power levels allow the comparison with given limits and decide for pass or fail.

5.2.4 GNSS performances

The provision of a reliable position of the vehicle, when an eCall is initiated, is critical to allow a timely intervention of the rescue services. Therefore, the performance of the GNSS system delivering the position is critical for eCall services.

The content of the MSD data concept in EN 15722 includes the Boolean parameter "positionCanBeTrusted". If the position can be trusted, this parameter is set to true. With a low confidence in the reported position, the parameter is set to false. EN 15722 defines a low confidence in position to be "less than 95% confidence that exact position is within a radius of ±150 m of reported position".

A minimum time requirement has not yet been identified from the existing specifications and norms for eCall. Actually, CEN/CLMC/TC5 is currently drafting a standard concerning the establishment and assessment of performances for the use of GNSS-based positioning for road Intelligent Transport Systems. However, this standard is not currently suitable to be used in the context of this deliverable.

Two proposals are considered to provide requirements:

- using minimum requirements based on the existing GNSS performance specification 3GPP TS 37.571-1. However, the applicability for eCall has to be checked and confirmed.
- Building on the work provided by the HeERO2 project partner ISMB, in the context of the HeERO2 deliverable D6.7: Enablers and assessments in continuity of services: major statements and field test results

Both proposals are explored in this deliverable and will need to be further analysed to assess their suitability.

5.2.5 Speech quality performances

The following requirement for acoustic quality tests should be considered for IVS certification. It is however reminded that speech quality will be most probably varying significantly among the different classes and type of vehicles.

- Delay measurement
  - The IVS roundtrip delay should be < 240 ms.
- Loudness ratings in both direction
  - SLR = 13 dB +/– 4 dB for HATS positioned on the driver's seat,
  - The nominal (default) RLR between the POI and the artificial ear of the HATS should be:
    - RLR = -3 dB +/– 3 dB for HATS positioned on the drivers' and co-drivers' seat;
    - RLR = 0 dB +/– 4 dB for HATS positioned on the passengers' back seat (2nd row, behind drivers' seat);
- Automatic Gain Control is a potential requirement being currently under further study
- Variation of RLR in presence of background noise
  - Requirements: The IVS shall cover a receiving loudness rating range from RLR -3 dB +/– 3 dB up to RLR (corresponding to SN +6 db at drivers position).
- Signal to noise ratio in receive
  - Requirements SNR ≥ 6 dB
- Frequency responses in both direction
  - as defined in ITU-T P.1100 (NB) ITU-T P.1110 (WB)

(This tolerance mask to be applied for IVS is under study. Such tolerance may be optimized for lower listening effort / higher speech intelligibility in the presence of background noise)

- Speech quality in both direction
  - MOS-LQON ≥ 3.0
  - Intelligibility /listening effort for further study
- Idle channel noise in both direction
  - RCV < 53 dBPa (A)
  - SND < –64 dBm0(P)

- Out-of-band signals in both direction
  - The total level produced by the out-of-band signal and measured in the used frequency range at the electrical reference point (POI) shall be less than 35 dB referred to the reference level.
- Distortion of the signal in receive direction
  - < 3% in RCV
- Echo performance with and without background noise
  - Echo loss presented at the electrical reference point (POI) should be at least 46 dB during single talk.
  - For further echo requirements see ITU-T SG 12 C 218
- Switching characteristics of the signal processing in both direction
  - For further echo Requirements see ITU-T SG 12 C 218
- Double talk performance in both direction
  - For further requirements see ITU-T SG 12 C 218
- Quality of Background noise transmission
  - For further requirements see ITU-T SG 12 C 218

5.3 Powered-two-wheeler requirements

For P2W some requirements are needed in order to standardise the additional information proposed in the extended MSD. The fields proposed are shadowed in the next table.

Table 6: additional optional P2W MSD fields

Name	Size [B]	Type	Description	
Control	1	Integer		
VIN	20	String	VIN number according to ISO 3779	
Time stamp	4	Integer	UTC seconds	
Location	4	Integer	Latitude (WGS-84) in ms	
Service provider			Service provider	
Vehicle type	1	Integer	PTW	
PTW Control	1	Integer	b7	Master sensor in vehicle
			b6	Master sensor in helmet
			b5	Slave sensor communication lost
			b4	Presence of passenger
Slave location	4	Integer	Latitude (WGS-84) in ms	

			Longitude (WGS-84) in ms
			Direction on degrees
Master severity	1	Integer	Detection of severity of master device
Slave severity	1	Integer	Detection of severity of slave device

The P2W eCall system tested in the framework of the project has 2 subsystems:

- one located in the helmet
- one in the motorbike itself

It has been assumed that generally a P2W eCall system is built up with 2 elements. One of them is the responsible for making the call (master) and the other one provides additional useful information (slave). For example, it has been established that could be useful the information of location of both subsystems after the accident. That is why the slave location has been included. Additionally, information related to the accident severity could be useful in the case of losing voice communication, which is expected that could happen frequently in P2W.

The P2W eCall system tested in the framework of the project has 2 subsystems: one located in the helmet and another one in the motorbike itself. It has been supposed a general P2W eCall system is built up 2 elements. One of them is the responsible for making the call (master) and the other one provides additional useful information (slave). For example, it has been established that could be useful the information of location of both subsystems after the accident. That is why the slave location has been included. Additionally, information related to the accident severity could be useful in the case of losing voice communication, being likely to frequently in P2W.

5.4 PTI requirements

For PTI, test procedures are required which can be processed for a high number of vehicles at thousands of test locations in all members states. Since this test, process applies to "every vehicle", only limited technical resources and limited time can be invested.

A critical point for the function of eCall systems over lifetime of vehicles is seen in the access of the IVS to mobile networks for emergency calls. The special situation will be found for testing older vehicles, where a network access device is installed which needs to operate with a today's network in case of an eCall. Any kind of testing of IVS without testing also network access is expected to be of minor impact on the task for PTI to evaluate the function of the eCall system.

The Task Force on PTI of the European eCall Implementation Platform prepared a report to "Study on the PTI requirements for eCall-equipped vehicles". In chapter, 7 of this report different solution for eCall test call in PTI were discussed. The objectives are:

- to separate a high number of test calls from a low number of emergency calls and to avoid that PSAPs for emergency purposes will be affected by test eCall
- to have so called "eCall test centres", where test calls can be received and answered to test voice connection

As such, the PTI requirements are to initiate a test eCall. In order to prevent the unauthorized triggering, this test eCall should be considered to be initiated via the diagnostic interface of the vehicle (OBD). The detailed requirements will be specified when the process of test eCall will be completely described and all relevant steps of the process chain will be known.

The EeIP - PTI task force will carry out further activities to prepare and discuss proposals on PTI with the intention to reach a consensus among all stakeholders.

5.5 Aftermarket requirements

One may have to ask oneself whether individual eCall equipment due to the different actors involved in the process of eCall (IVS, MNO, PSAP) and even when assessed for conformity under a simulated condition, would be in a position to guarantee the establishment of a successful eCall communication session.

However, for retrofit or aftermarket equipment not offered/built-in by OEM, an assessment of the proper functioning and availability on demand of such equipment would contribute to a more reliable overall eCall communication system.

Retrofit or aftermarket systems are component devices and considered as components of the overall system. Performance requirements for the overall system including the installation in a vehicle can normally be neither assessed nor controlled for aftermarket devices. Therefore, requirements for aftermarket equipment should be limited to the equipment and taking into account the intended use/purpose

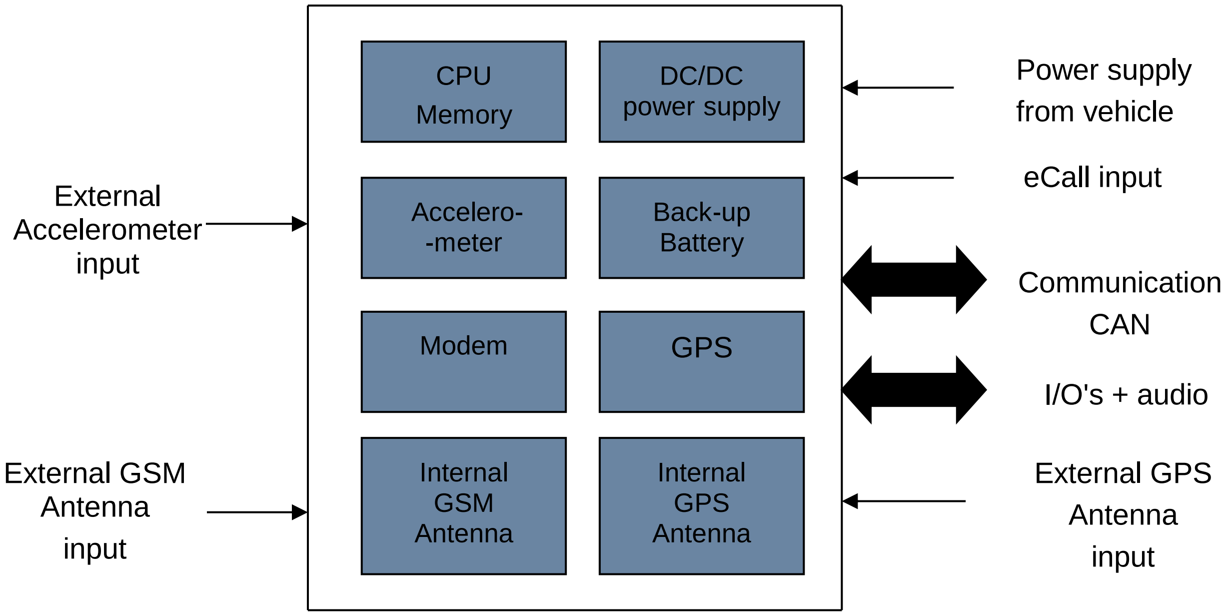


Figure 4: Example of a configuration of (in-vehicle) eCall equipment

In identifying essential requirements for aftermarket equipment as a minimum compliance with the currently available standards regarding eCall would be required (EN 16062; EN 16072; EN 15722; EN 16454). Conformance testing according EN 16454 and performance testing (e.g. for the GNSS receiver, wideband radio communication network access and audio) with specialized test equipment shall be carried out to demonstrate compliance and interoperability.

The equipment also needs to comply with the R&TTE directive and therefore shall be assessed according the applicable harmonized standards under this directive, which cover the essential requirements of the directive. This includes applicable ETSI standards for mobile communications but also EMC requirements and safety related requirements for ITE (Information Technology Equipment) and EMF (Electro Magnetic Fields). Since the in-vehicle, devices are to be considered component devices intended to be fitted in vehicles, also the ECE regulation number ten with regard to EMC shall apply.

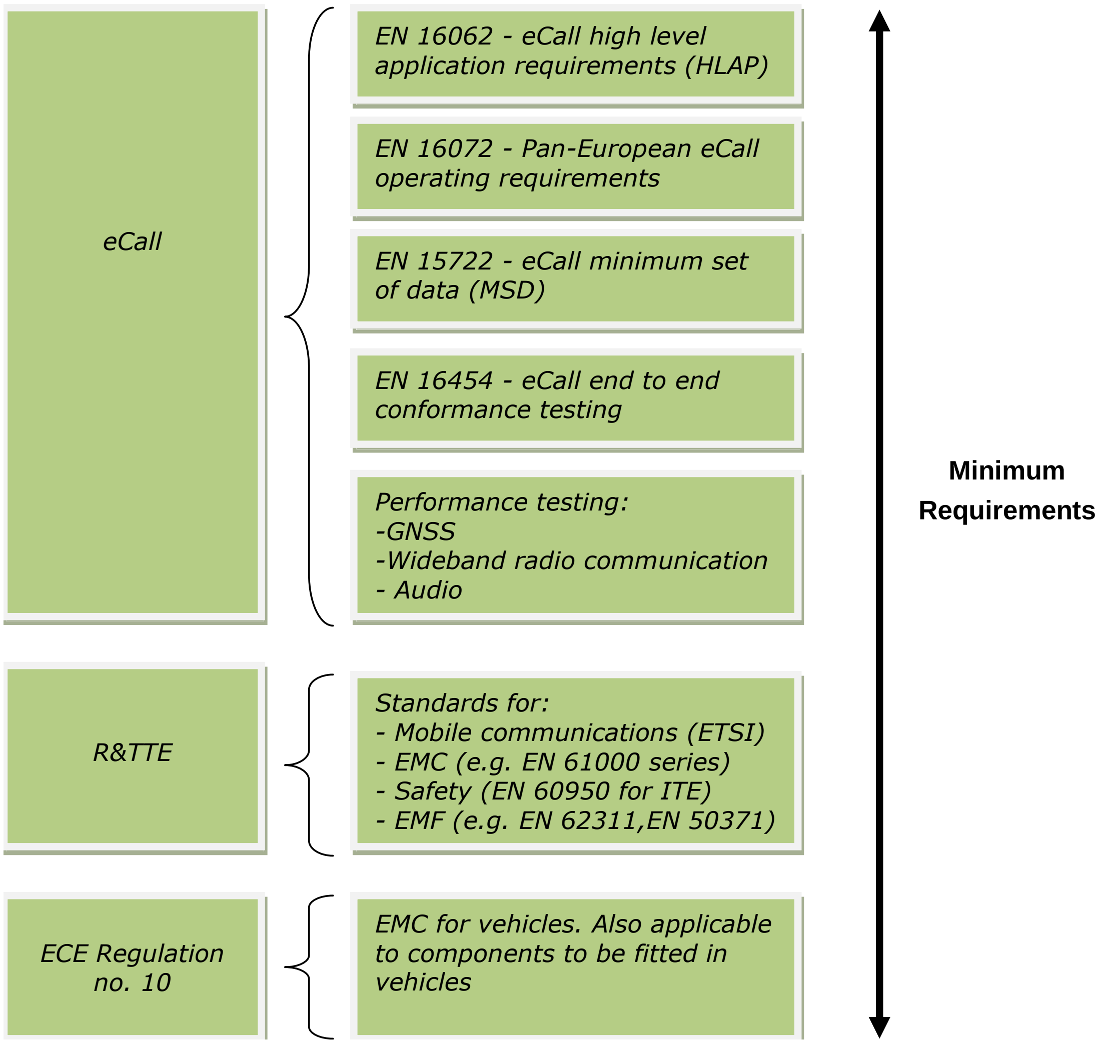
There are different circumstances, determined by the installation conditions, which are of influence on the proper functioning and availability on demand of the equipment. It is the responsibility of the manufacturer of the aftermarket equipment to specify test and verification requirements that will ensure the product will properly function under the specified installation conditions.

The following issues should be taken into consideration:

- eCall trigger
- resistance against environmental impacts
- antenna
- audio/speaker
- interconnection
- resistance against vehicle crash
- lifetime/reliability

For In-vehicle equipment, the manufacturers of these devices may limit the use of its products to listed vehicle types or by giving restrictions for installation in vehicles. This will be subject to verification for any kind of certification and approval.

The next two figures provide an overview of requirements for aftermarket equipment.
The first figure contains the minimum requirements for aftermarket equipment and the second figure proposed additional requirements, which shall be considered by the manufacturer. The figures have been supplemented with references to European and International standards where related requirements and testing procedures can be found. However, it should be noted that the list is not comprehensive and these are not the only standards where such requirements can be found.



eCall triggering	*The functionality of manual and automatically eCall triggering shall be assessed* *- Simulated crash testing (e.g. ECE regulations R94,R95, sled test, mechanical shock testing EN 60068-2-27)*
Environmental impacts	*Resistance against environmental impacts shall be assessed taking into account the installation conditions:* *- Climatic (e.g. temperature, variation of temperature, humidity)* *- Protection against dust and water* *- Vibration and shock under normal operation* *- Storage and transportation* *Standards:* *- EN 60068 series* *- EN 60721 series* *- EN 60529* *- ISO 16750 series*
Vehicle crash	*The proper functioning and availability on demand after a simulated crash situation shall be assessed* *- Simulated crash testing (e.g. ECE regulations R94,R95, sled test, mechanical shock testing acc. EN 60068-2-27)* *- Availability of power supply after a crash*
Lifetime/ Reliability	*Accelerated life tests should be performed to determine the useful life of the equipment as defined by the manufacturer (e.g. by (H)ALT testing and/or complying with AEC Q100, JEDEC testing for automotive components)*

Additional Requirements

5.6 PSAP service quality requirements

As mentioned above the criteria upon which the PSAP will be audited is based on the mission and objective of the PSAP. For example, if the PSAP is a call-taking only PSAP (referred to as a Stage 1 PSAP), the dispatch-related criteria will not apply to them. Conversely, a dispatch-only PSAP would not have some of the criteria related to call-taking processes applied to it. In addition, the scope of the PSAP is taken into account i.e. if it is a standalone PSAP covering a defined geographic area, if it is a national system, or if it is a multi-site PSAP model with several PSAPs working together in a defined geographic area. A sample extract of the criteria is presented in the table below.

Table 7: examples of PSAP quality audit criteria

Audit criteria	Criteria type	Summary of Requirements
Overall Quality management	Qualitative	Have the necessary effective processes in place to manage quality. To have sufficient resources to ensure the processes are supported. Monitor and evaluate these processes, change them where necessary. Continuously ensure that the quality of the emergency service is improved.
Documentation requirements	Qualitative	Have a quality policy, up-to-date and effective operating procedures, a quality manual, key performance indicators and 3rd party service level agreements.
Management responsibility	Qualitative	A management commitment at all levels towards providing a quality focused system in place for capturing feedback and manage the control of operational documents. Management should also be setting targets, ensuring robust communications exist internally for all staff and control all records and costs. Management should have in place a process for promoting 112 or related emergency numbers, if the responsibility lies with the PSAP as well as the management of third-party external suppliers.
Human Resource Management	Qualitative	Have a sound human resources strategy in place, have competency-based training programmes in place with training records and have sufficient infrastructure to deliver the emergency service, as mandated. In addition, have support systems in place for staff and monitor any work absenteeism and attrition rates for example.

System resilience, capacity and BCP	Qualitative	Have a robust security system in place for its buildings and information systems. Have any risks to its networks minimised and ensure there is sufficient capacity to deal with peak demand. Also, have a place a Business Continuity Plan (fail over, evacuations) is in place.
Call Handling and Case management	Qualitative	Have an escalation path in place for calls/incidences, follow a set protocol, capture all available data and recover case information whenever needed. Have a prioritisation and classification system for calls/incidences, capture repeat callers and possess the ability to receive and utilise caller location information. Have the ability to deal with foreign language needs, disabled callers, repeat and false calls/callers and call back facilities. Have a protocol in place for deal with multi-agencies.
Call abandoned rate	Quantitative	To ensure that the % of calls abandoned before being answered is less than 12%.
Volume of complaints	Quantitative	To ensure that level of genuine complaints received is less than 1 per every 300,000 calls received.
Routing accuracy	Quantitative	To ensure that no more than 8% of calls handled are routed to the incorrect emergency response organisation
Time to answer by a call-taker	Quantitative	To ensure that the average call answering time is less than 12 seconds.
Length of time to assign a resource vehicle	Qualitative	To ensure that the target for the average length of time elapsed to assign a resource is evidence-based on the priority of the incident and that it is being met.
The elapsed time to dispatch a resource vehicle.	Qualitative	To ensure that the average length of elapsed time from to dispatch the resource vehicle is evidence-based on the priority of the incident and is being met.
Arrival time for the resource vehicle.	Qualitative	To ensure that the average elapsed time from the resource vehicle to arrive at the incident is evidence-based on the priority of the incident and is being met.

6 Test process for certification

6.1 Introduction – methodology

Even if taken in the context of the industry and the assessment, the term “testing” is likely to refer to many different kinds of activities or at least different ways to achieve testing.

eCall Certification is actually an activity, which aims at certifying that eCall devices (IVS components or sub-components) or PSAP components, comply with certain requirement. Checking this compliancy is achieved by testing these components against the actual requirements. Testing is therefore the essential activity of certification.

In the context of certification, testing needs to comply with following constraints:

- Test objectives shall respond to and cover all certification requirements (as described in 5)
- All tests shall be reproducible and delivery the same results for identical test conditions,
- Identical results shall also be ensured when the tests are carried out from different test houses
- Test results shall provide a clear statement (verdict) about the capability of the tested device (DUT – Device Under Test) to comply with the corresponding requirements

A straightforward methodology is used to carry out certification testing with respect to the above requirements. In particular, detailed test documentation is necessary, usually named test specification.

In the context of eCall certification, the following categories of test have been identified:

- Conformance tests, which aims at verifying the compliance of Device Under Test with given requirements, usually specified in public standards, as for instance (HLAP - EN 16062, MSD - EN 15722) and where each test focus on specific and detailed protocol requirement,
- Interoperability tests are extending the scope conformance tests, while verifying functional features based on protocols, rather than individual protocol requirements,
- Performance tests aiming at checking other essential requirements, not being clearly stated in the public standards

6.2 Conformance testing

Conformance testing is carried out with simulators, reproducing test conditions accordingly to the test behaviour specified in the Conformance Test Specifications.

Currently, several Conformance test specifications exist for eCall devices:

- CEN prEN 16454 - Intelligent transport systems - ESafety - ECall end to end conformance testing
- ETSI TS 126 269, Digital cellular telecommunications system (Phase 2+);Universal Mobile Telecommunications System (UMTS);eCall data transfer; In-band modem solution; Conformance testing
- ETSI TS 102 936-1 and -2 eCall Network Access Device (NAD); conformance specification, parts 1 and 2

The certification requires two steps:

- In the first step, for IVS only, the eCall NAD conformance shall be proven according to ETSI TS 102 936-1 and ETSI TS 102 936-2.
- In the second step, for IVS or PSAP, the module level tests defined in the accelerated test procedures of CEN/TS 16454 as well as tests for different voice codecs defined in 3GPP TS 26.269 Chapter 5.2.1 (see tables 8, 9 and 10 below).

Table 8: selected CEN EN 16454 conformance tests for IVS module (outside of a vehicle)

#	EN 16454 Test id	PSAP Test objective
1	CTP/ PE-IVS/I-ON/1.1.0.2	Test for conformance to valid SIM/USIM
2	CTP/ PE-IVS/ECI/1.1.7.1, 1.1.2.1,	Test for set-up TS12 call with eCall identifier (flag) set to ‘automatic’
3	CTP/ PE-IVS/ECI/1.1.8.1, 1.1.3.1,	Test for set-up TS12 call with eCall identifier (flag) set to ‘manual’
4	CTP/ PE-IVS/ECI/1.1.9.1, 1.1.5.1, 1.1.4.1	Test for set-up TS11 call to test number
5	CTP/ PE-IVS/ECP/1.1.10.2	Re-dial attempt completed within 2 minutes after eCall is dropped
6	CTP/ PE-IVS/ECP/1.1.10.3,	Test for duration of eCall Initiation signal
7	CTP/ PE-IVS/TRG/1.1.11.1,	Test for ‘Send MSD’ with indicator set to ‘Automatically Initiated eCall’ (AIeC)
8	CTP/ PE-IVS/TRG/1.1.12.1,	Test for Send MSD with indicator set to ‘Manually Initiated eCall’ (MIeC)
9	CTP/ PE-IVS/TRG/1.1.13.1,	Test for Send MSD with indicator set to ‘Test’
10	CTP/ PE-IVS/ECP/1.1.14.1,	Verify MSD transfer
11	CTP/ PE-IVS/ECP/1.1.15.2,	Verify MSD transfer while eCall conversation is in progress
12	CTP/ PE-IVS/ECP/1.1.15.4	Verify MSD transfer upon T6 expiration
13	CTP/ PE-IVS/ECP/1.1.15.5	Verify that MSD is transferred continuously until T7 expires
14	CTP/ PE-IVS/CLR/1.1.16.1,	Test for Clear-down call automatically
15	CTP/ PE-IVS/CLR/1.1.16.2	Verify that IVS clears down the eCall upon T2 expiry
16	CTP/ PE-IVS/CLB/1.1.17.3, 1.1.17.2, 1.1.17.1,	Verify that the MSD transfer occurs upon PSAP request during call-back
17	CTP/ PE-IVS/CLB/1.1.17.4	Test for IVS remains registered for a minimum of 1 hour
Additional Conformance Tests for eCall only IVS		
18	CTP/ PE-IVS/I-ON/1.1.1.2,	Verify that IVS does not perform PLMN registration after power-up
19	CTP/ PE-IVS/ECI/1.1.10.4, 1.1.1.3,	Verify that PLMN registration procedure is executed upon initiating an eCall (eCall only IVS)
20	CTP/ PE-IVS/CLB/1.1.17.5	Test for IVS remains registered for a minimum of 1 hour and a maximum of 12 hours

Table 9: selected CEN EN 16454 conformance tests for PSAP device

#	EN 16454 Test id	PSAP Test objective
21	CTP 3.1.10	Display TS12 data and MSD to operator

22	CTP 3.1.3.2	PSAP equipment failure: verify the eCall is routed to the operator and audio link is established in case of PSAP equipment failure
23	CTP 3.1.3.3	PSAP modem failure before link layer ACK is sent: verify the eCall is routed to the operator and audio link is established
24	CTP3.1.7.4	Verify transfer of corrupted MSD
25	CTP3.1.7.5	Verify PSAP behaviour when MSD format check fails
26	CTP3.1.11	Decode VIN (sent in the MSD)
27	CTP3.1.12	Verify voice call establishment call between vehicle occupants and PSAP operator
28	CTP3.1.13	Verify MSD transfer while eCall conversation is in progress
29	CTP3.1.14.1	Verify PSAP operator is able to clear down the call
30	CTP3.1.14.2	Verify status bit in AL-ACK upon clear down
31	CTP3.1.15	Verify whether call-back can be performed by the PSAP
32	CTP3.1.16	Verify MSD transfer after call clear-down

Table 10: 3GPP TS 26.269 Chapter 5.2.1

#	PSAP Test objective
33	MSD transmission time GSM FR Codec
34	MSD transmission time GSM EFR Codec
35	MSD transmission time GSM HR Codec
36	MSD transmission time GSM NBAMR-FR Codec all rates
37	MSD transmission time GSM NBAMR-HR Codec all rates
38	MSD transmission time GSM WBAMR-FR Codec all rates
39	MSD transmission time UMTS NBAMR Codec all rates
40	MSD transmission time UMTS WBAMR Codec all rates

The test environment shall be able to simulate a PSAP and use a network simulator to emulate the cellular network in the lab. A live network approach is not appropriate in this case, because repeatability of testing and reliable test results would not be guaranteed. The conformance tests shall, test if the IVS modem is capable of triggering an eCall, to send the correct MSD data and to establish a voice connection with the PSAP. Moreover, it should be possible to select different voice codecs and change power levels on the network side.

An example of a test setup for the conformance testing of an IVS is described below (see figure 5):

- Test chamber: RF shielded box, which absorbs reflections of electromagnetic waves, or a cable connection to the antenna for GSM/UMTS and optional GNSS receiver is needed to be able to do the measurements and to avoid influences and connections to the real network.

- Radio communication tester to enable active testing with DUT performing a call.
- PSAP emulator to receive eCall and MSD
- (Optional): GNSS Simulator to simulate GPS scenarios
- (Optional): Test sequencer to perform the tests automatically

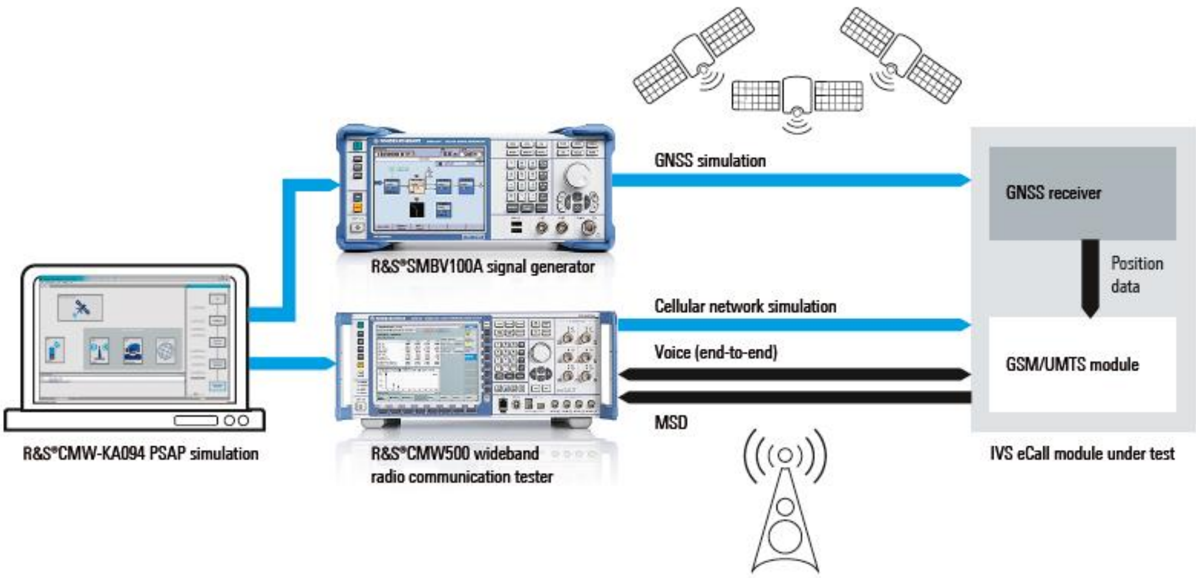


Figure 5: Example of a test bench for IVS

The application software simulates a PSAP and remotely controls the network emulator to emulate the cellular network under defined network conditions in the lab. Controlled by the application software, test software verifies whether the IVS is in conformance with the eCall standards. E.g., PUSH Mode, PULL Mode, MSD transmission time, MSD decoding or recording of the non-decoded IVS audio signal is only a few features test software needs to perform. Optionally, application software controls in parallel a signal generator to simulate the GNSS signals and the functionality of the IVS module.

6.3 Interoperability testing (*functional testing*)

Interoperability is assumed to result from the proper implementation of the eCall standards in the IVS and PSAP devices. Therefore, standard compliant IVS and PSAP devices, being validated through conformance testing (see 6.2), are theoretically assumed interoperable.

However, several issues may lead to the situation that compliant devices are not interoperable, as for instance:

- Situation not check through conformance testing
- Situation not foreseen in the standard

Furthermore, testing real devices, face to face, in a realistic environment complements the validation provided by conformance testing with limited test scenarios.

The Telecommunication industry has always considered the interoperability test as a key validation process to complement the conformance testing and thus to raise confidence on the devices reaching the market.

The interoperability testing process consist of testing eCall functionalities of IVS in front of real PSAP and thus to check proper implementation of eCall application enabling to proceed with end-to-end services. This allows testing both PSAP and IVS.

Testing can be done in two different ways:

- Testing in front of a simulated device
- Testing in front of a reference device (Golden unit)

When the solution of simulated device is chosen, it shall be verified that the simulator consists of a realistic emulation of the other device rather than a set a test scenario.

The interoperability testing has been experienced during three eCall TESTFEST interoperability events:

- May 2012, at MIRA, Nuneaton, UK
- September 2013, at CETECOM, Essen, Germany
- October 2014, at CTAG, Vigo, Spain

TESTFEST are event to offer VIS and PSAP vendors the opportunity to test the interoperability of their devices during face-to-face test sessions. Test descriptions are provided to offer the participant guidelines to carry out the tests following a determined process.

The TESTFEST event needs to offer a test bed to allow all devices to carry out test sessions. For instance, IVS will connect to PSAP through a public Mobile Network, currently without eCall flag and not using the 112. However, test solution providing GSM/UMTS simulation allowed to execute conformance test with eCall flag and 112.

PSAP simulators have also provided IVS vendors with the opportunity to execute interoperability tests.

During the third TESTFETS event, a 'speech quality test tool' was available to complete the scope of test beyond the interoperability testing (see 6.4.5)

The figure 6 below shows an overview of the eCall TESTFETS test bed used during the third event in Vigo.

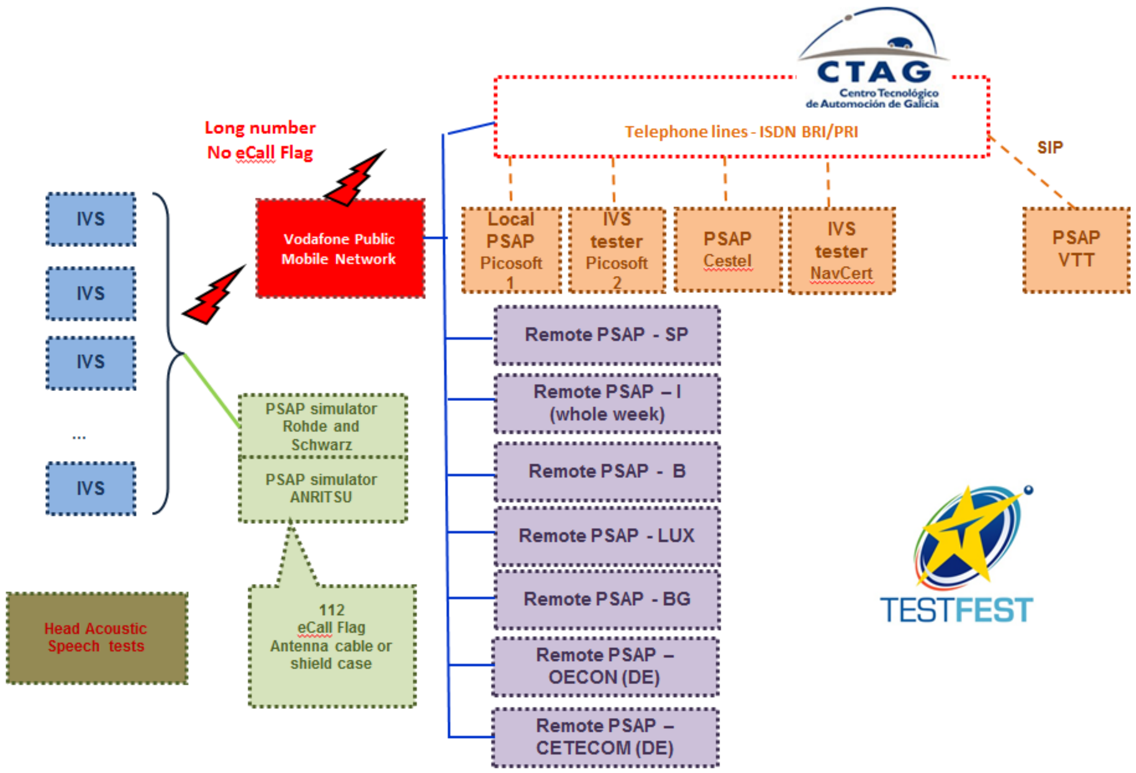


Figure 6: 3rd eCall TESTFEST test bed

The interoperability test scenario for the mandatory test is provided in Annex (see 9.1.3). An example of a test scenario is shown in the table below.

Table 11: Example of an interoperability test description

Interoperability Test Description				
Identifier:	TD_MAN_PUSH_01			
Objective:	To verify that, when the PSAP does not initiate the mandatory PULL mode process (send the SEND-MSD message upon receipt of the eCall), the IVS initiate the PUSH mode.			
Configuration:	eCall_CFG_01			
References:	EN 16062 Clause 7.4.2			
Pre-test conditions:	• Ignition is ON and IVS is in mobile network coverage • MNO and PSAP test points are available • PSAP is configured not to initiate the PULL mode and therefore not sending the SEND-MSD message on receipt of the eCall • IVS has all the information needed to compile the MSD • PSAP knows the content of the IVS encoded MSD			
Test Sequence:	**Step**	**Type**	**Description**	
	1	stimulus	PSAP waits for the eCall setup and the initiation message and **does not send** the SEND-MSD message	
	2	stimulus	IVS establishes an eCall and sends an initiation message within 5s	
	3	verify	PSAP transmits SEND MSD (START) message	
	4	verify	PSAP verifies first MSD is received	
	5	verify	Verify the MSD is correctly decoded	
	6	check	MSD content at PSAP is identical to content transmitted by IVS	
	7	verify	PSAP sends acknowledgement	
	8	verify	Verify that the IVS has stopped transmitting the MSD	

The test scenarios used for the eCall TESTFEST event are suitable for interoperability testing in the context of IVS or PSAP certification. Both options of using a reference systems or emulating the device have been validated.

6.4 Performance testing

6.4.1 Functional performance – field trials

The test process will consist of two parts. One part is a drive test the other includes a variety of test in laboratories.

The drive test has to allow a statistical relevant number of eCall events, in which the IVS call typically a dedicated test PSAP. The selected routes have to fulfil following criteria:

- As for GNSS measurements the incidence angles of the satellites vary between the different latitudes, the route shall cover all areas of latitude where the system will be used from North of Europe to the South.

- The test routes shall also cover different environments like urban, interurban, regional roads, rural roads, highways and specific situations that have an effect on the GNSS accuracy or on the mobile network reception:
  - Low mobile coverage (valleys, tunnels, forest)
  - Interference (port, airport, high voltage cables and pylons)
  - Low GNSS coverage (valleys, tunnels, forest, urban canyons)
  - The different measurement sets should be collected with different satellite constellations (e.g. at different times of the day).

It is necessary to initiate a reasonable number of test emergency calls in every location to get a big enough amount of data, which allow statistical evaluation.

The test region shall cover a representative part of Europe from North to South and from West to East. The route shall cover examples for all environmental conditions in Europe. The execution of the test drives and the evaluation shall be done by accredited laboratories. The same behaviour applies to measurement of antenna gain and eventually voice quality.

6.4.2 Vehicle related performances

6.4.2.1 EMC

UN Regulation 10 rev.4 performance criteria are adopted. A functional classification description is shown in Annex 9.1.1...

6.4.2.1.1 Immunity to electromagnetic radiation

Tests shall be performed according Annex 9 of UN Regulation 10 Rev.4. Test setup according ISO 11452-2 suitable for eCall IVS testing is shown in Annex 9.1.1.

- There shall be no degradation of the eCall IVS safety functions during the test. Class A must be fulfilled.
- The loss of function of receivers (GNSS, GSM/UMTS) during the immunity test does not necessarily lead to fail criteria when the signal is within the receiver bandwidth (exclusion band).

6.4.2.1.2 Immunity against transient disturbances conducted along supply lines

The test shall be performed according Annex 10 of UN Regulation 10 rev.4. Test setup according ISO 7637-2 suitable for eCall IVS testing is shown in Annex 9.1.1.

For each pulse, the following functional criteria shall be fulfilled:

Table 12: functional criteria

Test pulse	Functional status for safety functions	Functional status for non-safety functions
1	Class C	Class D
2a	Class B	Class D
2b	Class C	Class D
3a	Class A	Class D
3b	Class A	Class D
4	Class B[1]	Class D

6.4.2.1.3 Measurement of radiated electromagnetic emissions

The test shall be performed according Annex 7 (Narrowband emissions) and Annex 8 (Broadband emissions) of UN Regulation 10 rev.4. Typical test setup according CISPR 25 is shown in Annex 9.1.1.

- Measured emissions shall be below the limits specified in sections 6.5.2.1 (Broadband emissions) 6.6.2.1 (Narrowband emissions) of UN Regulation 10 rev.4.
- Wanted emissions within necessary bandwidth are excluded from test.

6.4.2.1.4 Measurement of transient conducted disturbances generated on supply lines

The test shall be performed according Annex 10 of UN Regulation 10 rev.4. Typical test setup according ISO 7637-2 is shown in Annex 9.1.1.

The measured voltage shall be below the following limits.

Table 13: Maximum allowed pulse amplitude on supply lines

Polarity	Vehicles with 12V systems	Vehicles with 24V systems
Positive	+75V	+150V
Negative	-100V	-450V

6.4.2.2 Accident detection

The validation protocol of the automatic emergency call device is constituted for a set of tests. Each of them represents one situation of risk for the vehicle's passengers where the device is installed. The system must identify the scene and make a decision about if the scene has enough risk to activate the automatic call at the service centre.

In order to activate all this process, the device identifies the accelerations experienced by the vehicle and compares the severity levels that it has predetermined. These levels of accident severity are delimited by an upper limit and a lower limit, so that the registered variables can be easily arranged.

In the section the configurations of the tests that constitute the validation protocol of the automatic emergency call system and the limits of severity that belong to each mobile class are defined. The principal variable to establish is the acceleration that the vehicle must suffer due to the impact.

The configurations for the test are the same for all of them: the automatic emergency call device is attached to the sled platform that is launched with a test's characteristic impact velocity and it brakes depending on the designed acceleration for each test.

6.4.2.2.1 Procedure in the validation tests of IVS

For the validation of the IVS function at the collision scenes between light vehicles, three sets of test are carried out in which the test procedure is the same in each one:

1. Localisation of the device to test on the sled surface
2. Configuration of the deceleration pulse depending on the kind of accident and the level of severity. This pulse is different depending on the scene that is to be tested.
3. Launching the sled

The tests, which must be carried out and the criterion for the validation of the IVS are the following:

- Collision frontal test between light vehicles:
  - Severe accident test:

    - The device initiate the eCall according to the HLAP standard (EN 16062) VALID
    - The device does not initiate an eCall : NOT VALID
  - Minor accident test :
    - The device initiate the eCall according to the HLAP standard (EN 16062): NOT VALID
    - The device does not initiate an eCall: VALID
  - Test of no accident:
    - The device initiate the eCall according to the HLAP standard (EN 16062): NOT VALID
    - The device does not initiate an eCall: VALID
- Lateral collision test between light vehicles:
  - Test accident:
    - The device initiate the eCall according to the HLAP standard (EN 16062): VALID
    - The device does not initiate an eCall: NOT VALID
  - Test of no accident:
    - The device initiate the eCall according to the HLAP standard (EN 16062): NOT VALID
    - The device does not initiate an eCall: VALID
- Rear end collision tests between light vehicles:
  - Accident test:
    - The device initiate the eCall according to the HLAP standard (EN 16062): VALID
    - The device does not initiate an eCall: NOT VALID
  - Test of no accident:
    - The device initiate the eCall according to the HLAP standard (EN 16062): NOT VALID
    - The device does not initiate an eCall: VALID

6.4.3 Antenna performances

The antenna performance tests, presented in this clause, are based on the two following specifications:

- CTIA Test Plan for Wireless Device Over-the-Air Performance, Version 3.3.2 Sept 2014 (download here)
- Vodafone Specification for Terminals on Over the Air RF Performance, Version 2.5 March 2012

The CTIA standard “Test Plan for Wireless Device Over the- Air Performance” specifies that the TRP measurement of the Equipment Under Test (EUT) is accomplished by sampling the radiated transmit power of the DUT at various locations surrounding the device. A three dimensional characterization of the transmit performance of the EUT (including the antenna) is executed by summing up the data from the spatially distributed measurements. Data points taken every 15 degrees in the elevation (θ) and azimuth (φ) orientation.

The TIS (receiver performance of the Equipment Under Test (EUT)) is measured utilizing Bit Error Rate (BER), Block Error Rate (BLER), or other error criteria. The test specification uses the appropriate error criteria to evaluate effective radiated receiver sensitivity at each spatial measurement location. Other than for transmit power measurements the data points are taken every 30 degrees in the in the elevation (θ) and azimuth (φ) orientation.

It is recommended to make the antenna measurement of the IVS module in the overall surrounding environment and not as an isolated component because the car body plays a very important role in the measurement. The antenna performance with and without the vehicle body is different. Hence, the results of an isolated antenna measurement only will not reflect real operation conditions.

Different operation modes of the car may be considered (Motor on/off, car entertainment system on/off, air condition on/off, etc.) as well. This is important to assess de-dense (self-interference) effects, as an extension of the basic antenna measurements.

The test setup for the Antenna performance assessment is described below:

- Anechoic test chamber: RF shielded room that absorbs electromagnetic waves on ceiling and walls, but not on the floor. An automotive 3D antenna test site will be needed to be able to do the measurements including the car.
- Turntable for the car
- Test and communication antenna: rotating test antenna or antenna ring with 15° spacing OTA system software with measurement and reporting capabilities
- Radio communication tester to enable active testing with DUT performing a call.
- RF switch matrix

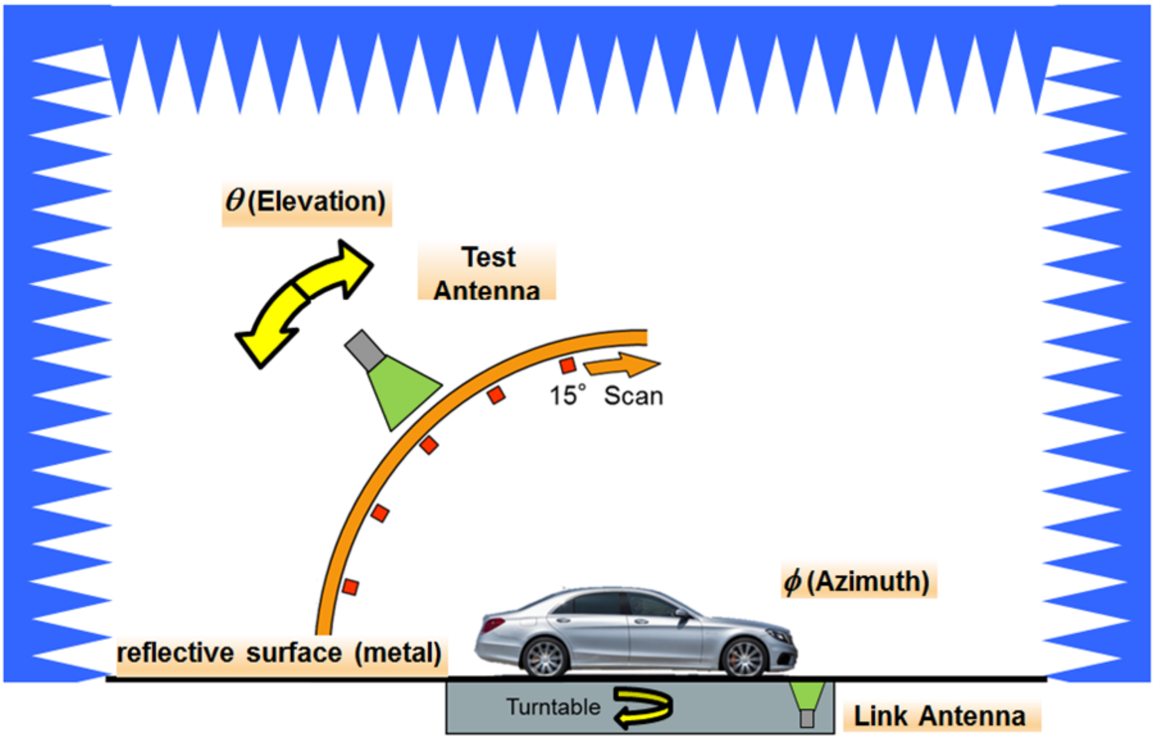


Figure 7: Anechoic chamber test setup with test antenna ring

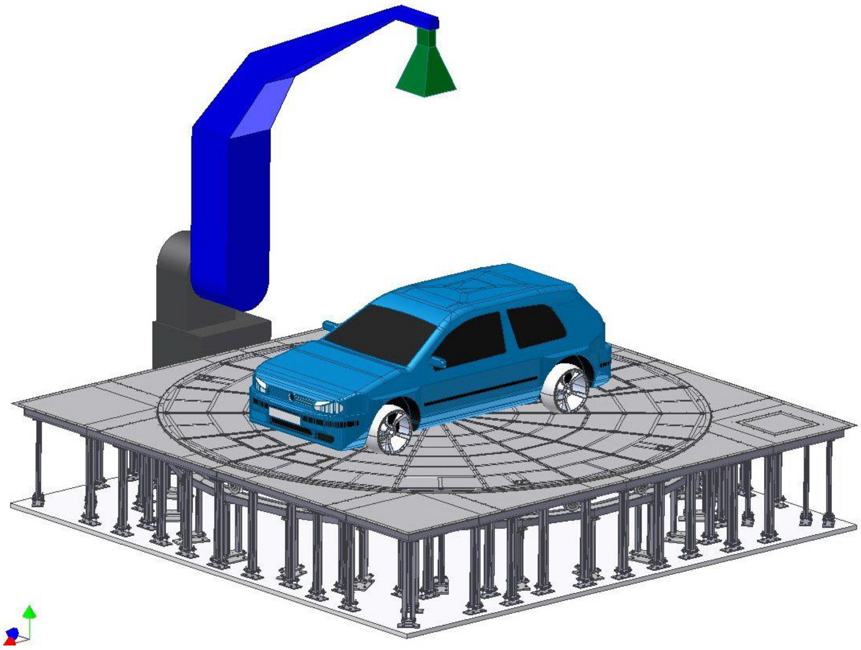


Figure 8: turntable and rotating test antenna

The test procedure describes that the car needs to be rotated in its axis from 0 to 360° and the test antenna has to rotate from 0 to 90° in 15° (TRP) or 30° (TIS) steps.

The measurements will be performed in a semi anechoic chamber and the car will be positioned on a reflective floor and the reflections are absorbed on wall and ceiling. Alternatively, an open test environment can be applied.

In such test setups upper hemisphere measurement will be sufficient. This way the (UHTRP) Upper Hemisphere Total Radiated Power and (UHIS) Upper Hemisphere Isotropic sensitivity quantities shall be calculated. The (UHTRP) measurement will look similar to the following figure:

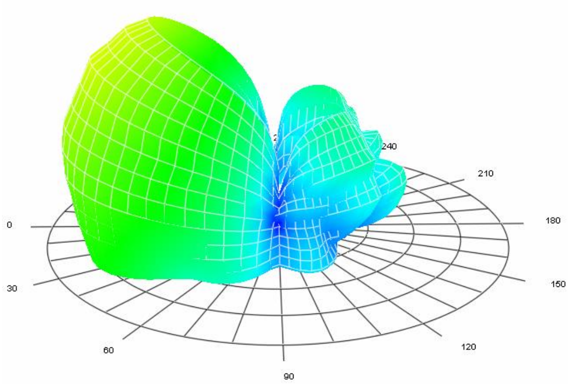


Figure 9: Example for UHTRP measurement

Table 14: Examples from the CTIA OTA standard for minimum TRP levels for wireless devices

Band	Device Power Class	Recommended limit (free space measurement)
GSM 850	4 (33 dBm)	26 dBm
GSM 1900	1 (30 dBm)	24.5 dBm
UMTS 850	3 (24 dBm)	17 dBm
UMTS 2100	3 (24 dBm)	19.5 dBm

Table 15: Examples from the Vodafone Specification for Terminals on Over the Air RF Performance for minimum TIS levels

Band	Device Power Class	Recommended limit (free space measurement)
GSM 850/900	4 (33 dBm)	-100 dBm
GSM 1800/1900	1 (30 dBm)	- 100 dBm
UMTS 850/900	3 (24 dBm)	-100 dBm
UMTS 2100	3 (24 dBm)	-103 dBm

6.4.4 GNSS performances

6.4.4.1 Introduction

As ascribed in clause 5.2.4, Standard for assessing GNSS performance in the context of road intelligent transport systems are not ready currently. Therefore, two methods are presented in the two following clauses to evaluate GNSS performances for eCall:

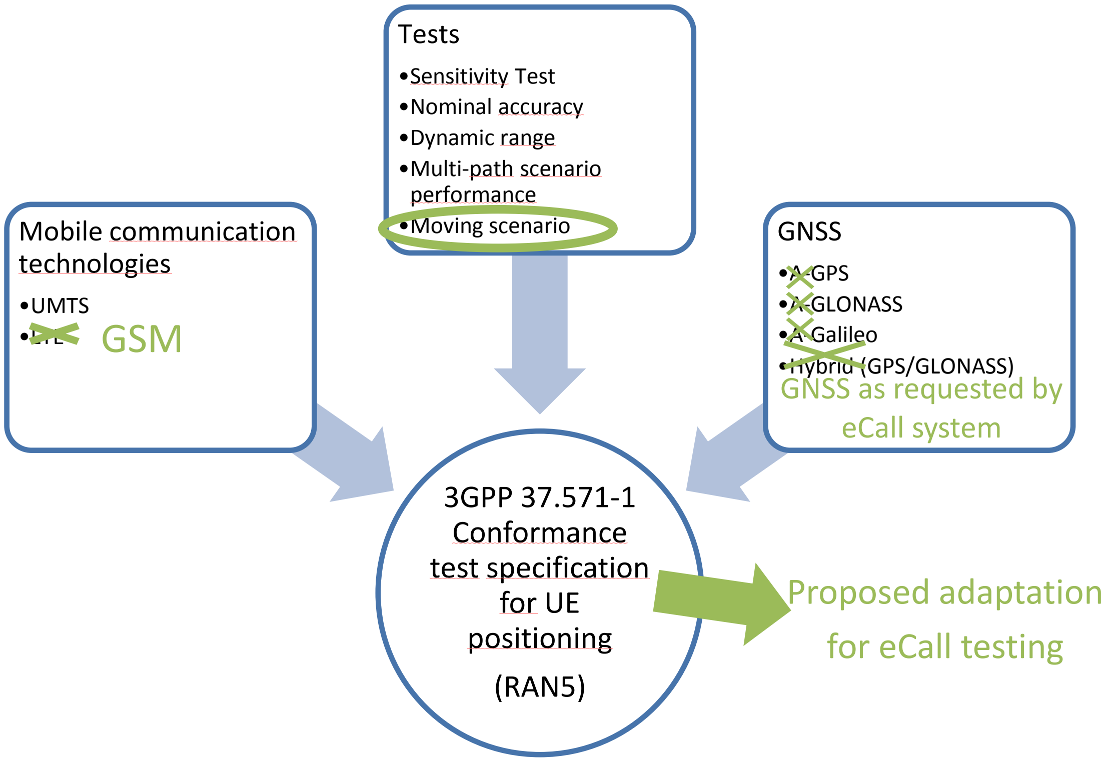
- The first method is based on 3GPP test specification
- The second method has been developed in the context of the HeERO2 deliverable for the assessment of the continuity of services.

Both methods are likely to provide suitable contributions for the IVS certification.

6.4.4.2 Method based on 3GPP test specification

For testing the Global Navigation Satellite System (GNSS) performance in the context of eCall, the existing GNSS tests from 3GPP TS 37.571-1 can be considered as a basis.

The following summarizes the existing tests from 3GPP TS 37.571-1 and proposes changes that are required to adapt these test cases for eCall.



The proposed adaptation for eCall positioning testing is marked in green. This summary is based on the existing Assisted GPS (A-GPS) test cases to eCall using GPS. For other GNSS the minimum requirements may differ. To cover different testing aspects the following tests are considered: sensitivity test, nominal accuracy, dynamic range, multi-path scenario performance and moving scenario. In the following, first the general test conditions are discussed which apply to all tests. Second, the details for each test are listed containing the minimum requirements as per 3GPP TS 37.571-1. All tests are lab tests.

General test conditions according to 3GPP TS 37.571-1

- GNSS signals transmitted with a frequency accuracy of ± 0.025 PPM (PPM, Parts Per Million)
- Static: Additive White Gaussian Noise (AWGN), no fading, no multi-paths (clause 4.2.3)
- Multi-path conditions (clause 4.2.4)
- Multiple satellite signals (clause 4.2.5)
- Multi system time offsets when using hybrid mode time offset between systems < 3 ns (clause 4.2.6)
    - Multi system time offsets are not applicable when eCall does not support the scenario (no hybrid mode.)
- Minimum performance requirements for both
    - UE based A-GNSS terminals (measurement parameters are contained in the RRC UE POSITIONING POSITION ESTIMATE INFO IE)
    - UE assisted A-GNSS terminals(measurement parameters are contained in the RRC UE POSITIONING GANSS MEASURED RESULTS IE and/or the RRC UE POSITIONING GPS MEASURED RESULTS IE)

    (eCall does not support assisted data. Hence, the for eCall scenario, transmission of assisted data has to be skipped and, a trigger has to be introduced for the eCall modem to send the acquired positioning data

- 2D position error: defined by the horizontal difference in meters between the ellipsoid point reported or calculated from the UE Measurement Report and the actual simulated position of the UE in the test case considered.
- No stored GNSS data shall be used.
  For eCall, at a maximum, the last three stored positions are applicable and at least the last stored position has to be transmitted in the MSD
- No additional sensor data as positioning aid
  The use of additional sensor data, as positioning aid, could be helpful for eCall as such. However, the minimum performance of the GPS receiver shall be tested, so that the same criteria apply for eCall.
- Reference scenarios as given in 3GPP TS 37.571-5 V10.8.0, clause 5.2.6.4 (cf. to Table 16, these scenarios are referenced in the tests given below)
  The reference coordinates for the test are located in overseas. As the eCall system is initially planned for Europe, a coordinate adaptation for eCall with European coordinates is recommended. The adapted scenarios could include a city or a rural area as well as a highway scenario.

Table 16: Reference scenarios used in 3GPP TS 37.571-1

Scenario	GPS #1	GPS #2	GPS #3 (Moving)
City	Atlanta, USA	Melbourne, Australia	Melbourne, Australia
Degrees of latitude	33.750005	37.816663	37.816663
Degrees of longitude	-84.383336	144.966670	144.966670
Altitude in m	300	100	100
Uncertainty semi-major in m	3000	3000	3000
Uncertainty semi-minor in m	3000	3000	3000
Uncertainty altitude in m	500	500	500

Test details for A-GPS in 3GPP TS 37.571-1:

Sensitivity	3GPP TS 37.571-1, clause 5.2	
Satellite setup (minimum signal level)	Subtest 1 Coarse time assistance: 1 GPS = -142.0 dBm 7 GPS = -147.0 dBm Subtest 2 Fine time assistance: 8 GPS = -147.0 dBm	
Scenarios	GPS #1 (Atlanta, USA) GPS #2 (Melbourne, Australia) used alternatingly	
Minimum requirements	Success rate	95%
	2D position error	100 m
	Max. response time	20 s

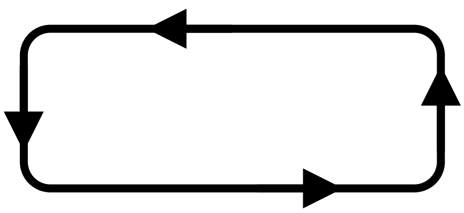
Nominal accuracy	3GPP TS 37.571-1, clause 5.3	
Satellite setup (ideal signal level)	Same signal level of all satellites: 8 GPS = -130.0 dBm	
Scenarios	GPS #1 (Atlanta, USA) GPS #2 (Melbourne, Australia) used alternatingly	
Minimum requirements	Success rate	95%
	2D position error	30 m
	Max. response time	20 s

Dynamic range	3GPP TS 37.571-1, clause 5.4
Satellite setup (maximum signal level difference)	Different signal levels of the satellites: 1GPS = -129.0 dBm 1GPS = -135.0 dBm 1GPS = -141.0 dBm

	3 GPS = -147.0 dBm	
Scenarios	GPS #1 (Atlanta, USA) GPS #2 (Melbourne, Australia) used alternatingly	
Minimum requirements	Success rate	95%
	2D position error	100 m
	Max. response time	20 s

Multi-path performance	3GPP TS 37.571-1, clause 5.5	
Satellite setup (multi-path environment)	Different signal levels of the satellites: 2GPS = -130.0 dBm — no multi-path 3 GPS = -130.0 dBm LOS — faded = -136 dBm 2^{nd} tap	
Scenarios	GPS #1 (Atlanta, USA) GPS #2 (Melbourne, Australia) used alternatingly	
Minimum requirements	Success rate	95%
	2D position error	100 m
	Max. response time	20 s

Moving scenario	3GPP TS 37.571-1, clause 5.6
Satellite setup (good signal level)	Same signal level of all satellites: 5 GPS = -130.0 dBm
Scenarios	GPS #3 (Melbourne, Australia) Moving scenario on a rectangular trajectory, UE within a vehicle that accelerates, slows down and turns Vehicle speed: 25 to 100 km/h



Minimum requirements	Success rate	95%
	2D position error	30 m
	Reporting interval	1.5 s to 2.5 s

Summary of proposed adaptations for eCall

Conformance tests in 3GPP TS 37.571-1 can be used as a basis for eCall GNSS performance testing. The following changes are proposed for eCall:

- Use No assisted GNSS data, only GNSS data
- Introduce manual or automatic GSM / UMTS eCall as a trigger
- Send up to the last three positions sent within the MSD
- Choose reference coordinates within Europe (city, rural area)
- Determine appropriate position error, response time and reporting interval
- Define appropriate test time from IVS modem start / after re-gaining GPS reception
- Put the emphasis on the moving scenario (optional)
- Add a highway scenario, a record and replay scenario (optional)

6.4.4.3 Method based on HeERO2 continuity of service tests

This method, is intended to assess the performance of GNSS receivers embedded in IVS, in order to strengthen HeERO2 recommendations in the field of GNSS, as for instance to endorse the benefit of the most advanced navigation technologies.

The tests are considered using both simulations (i.e.: a signal generator and constellation simulator) and live sessions relying on the usual interfaces provided together with the embedded receivers (i.e.: NMEA protocol).

The methods used to compute the metrics, take into account the available instrumentation.

The method aims at providing GNSS receiver performance metrics (KPI). However, in the test method, the metrics are not evaluated against reference metrics that the GNSS receiver shall comply. The goal of the test method for the HeERO2 deliverable D6.7 was to compare the KPIs from different GNSS receiver vendors.

To serve certification purposes, the test plan should be extended with GNSS reference metrics, to be match by the GNSS receiver under test in order to get a “PASS” verdict.

For instance, the following table shows a test summary for a static test.

TEST ID	**T-STA-ACQ-M<operational *mode*>-S<*system*>**
Purpose	Measure the receiver acquisition performance with a simulated set of signals
Description	The receiver is fed with signal coming from a set of simulated SV. The power is increased by steps in order to determine at which power level the receiver is able to gain a fix within the timeout.
Required output	• Position • Time • Satellites in view
KPI	• Sensitivity • Accuracy • Time to fist fix

Actually, the test result is the set of KPI of the bottom row. However, no requirement is indicated concerning the values, with which the test ted GNSS receiver is to be complied with. The test allows to measures the performance for evaluation only.

The detailed test plan for this method is provided in the annex of this deliverable, see paragraph: 9.2

Goals for the GNSS receiver and KPI

The key role of the satellite navigation within the eCall framework is to provide reliable position information to be sent in the MSD to the PSAP. Therefore the most relevant parameters for the positioning are:

- Availability: despite the global coverage of navigation systems, it is not always possible to obtain the position, also due to some physical obstacles that limit satellite visibility.
- Accuracy: it depends on several factors (e.g. satellite visibility, constellation geometry (characterized by the Dilution of Precision (DOP)), un-modelled ionospheric and tropospheric errors, multipath, jamming,).

The above goals have led to consider the following **Key Performance Indicators**:

- Sensitivity
- Accuracy
- Availability
- Time To Fix (TTF)

Methods for quantitative metrics calculations

The methods provide a mean to assess the above-mentioned KPIs with proper metrics extracted from the receiver observables, mostly under a statistical perspective.

Following methods are used:

- Circular Error Probable (CEP) – see: 9.2.1.3.1
- Height Error Probable (HEP) – see: 9.2.1.3.2
- Spherical Error Probable (SEP) – see: 9.2.1.3.3

Initial conditions

The test results will be strongly depending on initial conditions, which should be defined as well in the test plan (see: 9.2.1.4).

The **test plan** is organised according to a **test tree** (see: 9.2.2**)** and the test are named according to a well-structured **naming convention** (see: 9.2.2.3)

6.4.5 Speech quality performances

6.4.5.1 Test arrangement

The acoustical interface for the in-vehicle system (IVS) is realized by using an artificial head (HATS – head and torso simulator) according to [ITU-T P.58]. The properties of the artificial head shall conform to [ITU-T P.58] for send as well as for receive acoustical signals.

All IVS emergency call implementations are connected to a system simulator conforming to the required transmission standard with implemented, calibrated audio interface.

For narrowband mode in GSM networks, the FR Codec or AMR codec can be used. If AMR codec is used, the bitrate of 12, 2 Kbit/s is used.

The settings of the system simulator shall be chosen so that the audio signal is not influenced by any signal processing (e.g., DTX).

The test signals are fed electrically to the system simulator or acoustically to the artificial head. The test arrangement is shown in Figure 4.1

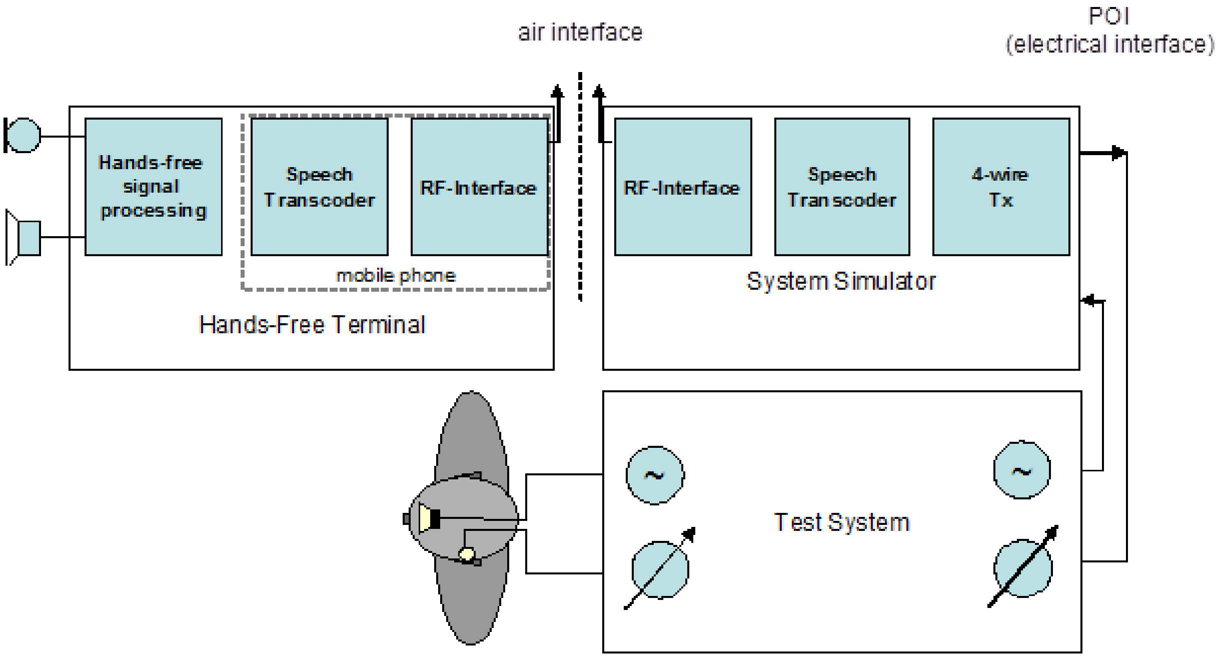


Figure 10: Test arrangement for emergency call IVS (see [ITU-T P.1100])

<u>Test arrangement in a car</u>

The transmission performance of car hands-free terminals is measured in a car cabin. In order to simulate a realistic driving situation, background noise is inserted using a four-loudspeaker arrangement with subwoofer, while measurements with background noise are conducted. In Figure 4.1, the simulation arrangement is shown. More information on the test arrangement can be found in [b-ETSI ES 202 396-1]. The source signal used is recorded by a measurement microphone positioned close to the hands-free microphone. If possible, the output signal of the hands-free microphone can be used directly. The recordings are conducted in a real car. The loudspeaker arrangement is equalized and calibrated so that the power density spectrum measured at the microphone position is equal to the recorded one. For equalization, either the measurement microphone or the hands-free microphone used for recording is used. The maximum deviation of the A-weighted sound pressure level shall be ±1 db. The third octave power density spectrum between 100 Hz and 10 kHz shall not deviate more than ±3 dB from the original spectrum. A detailed description of the equalization procedure as well as a database with background noises can be found in [b-ETSI ES 202 396-1].

The background noise playback system is time-synchronized to the recording process in the measurement system in order to guarantee reproducibility of recordings in the presence of noise.

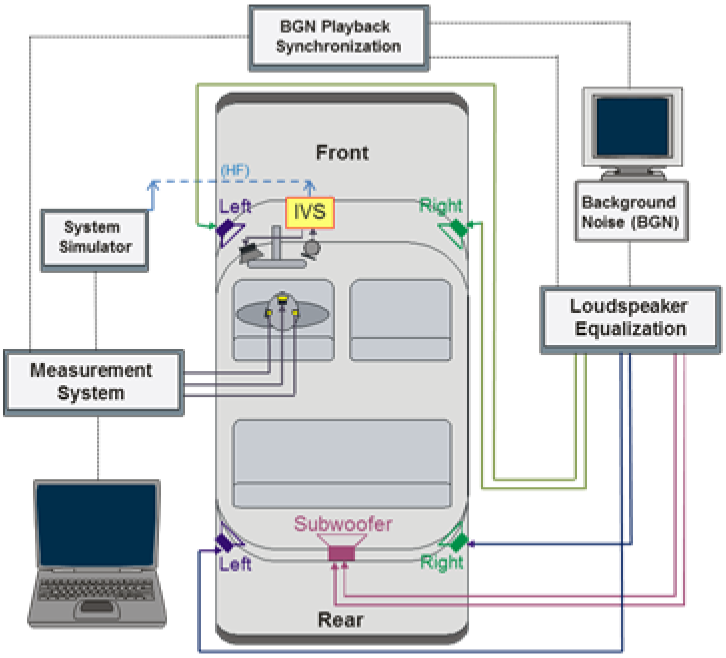


Figure 11: Test arrangement with background noise simulation

Positioning of the emergency call IVS

The IVS, especially the acoustical interfaces (microphone/loudspeaker), are installed according to the requirements of the manufacturer. The positioning of the microphone/microphone array and loudspeaker are given by the manufacturer (e.g. also for aftermarket solutions) or defined by the installation in the vehicle. If no position requirements are given, the test laboratory will define the arrangements. Typically, the microphone is positioned close to the rear-view mirror; the loudspeaker can be positioned in the central console near the gearshift or below the dashboard on the drivers or front passengers side. In any case, the exact positioning has to be documented. IVS terminals installed by car manufacturers are measured in the original arrangement.

For manually generated emergency calls, it is assumed that the driver is communicating over the IVS with the public safety answering point (PSAP). Thus, a normal diver position is assumed and reproduced by the HATS during tests positioned in the driver's seat for the measurement, if not stated otherwise. Due to the difficulty in reproducing a realistic emergency (accident, automatically generated emergency call), the HATS is also positioned in the driver's seat for the measurement, if not stated otherwise.

The position has to be in line with the average user's position; therefore, all positions and sizes of users have to be taken into account. Typically, all except the tallest 5% and the shortest 5% of the driving population have to be considered. The size of these persons can be derived, e.g., from the 'anthropometric data set' for the corresponding year (based on data used by the car manufacturers for example). The position of the HATS (mouth/ears) within the positioning arrangement is given individually by each car manufacturer. The position used has to be reported in detail in the test report. If no requirements for positioning are given, the distance from the microphone to the MRP is defined by the test laboratory.

By using suitable measures (marks in the car, relative position to A-pillar, B-pillar, height from the floor etc.) the exact reproduction of the artificial head position must be possible later.

It is recommended to verify some performance parameters especially for automatically generated emergency calls with the HATS positioned on the front passengers seat or on the passengers' seat in the 1st row behind the front passengers seat.

6.4.5.2 Operation Modes and Configuration for emergency call IVS

The IVS, especially the acoustical interfaces (microphone/loudspeaker), are installed according to the requirements of the manufacturer. The positioning of the microphone/microphone array and loudspeaker are given by the manufacturer (e.g. also for aftermarket solutions) or defined by the installation in the vehicle. If no position requirements are given, the test laboratory will define the arrangements. Typically, the microphone is positioned close to the rear-view mirror; the loudspeaker can be positioned in the central console near the gearshift or below the dashboard on the drivers or front passengers side. In any case, the exact positioning has to be documented. IVS terminals installed by car manufacturers are measured in the original arrangement.

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By using suitable measures (marks in the car, relative position to A-pillar, B-pillar, height from the floor etc.) the exact reproduction of the artificial head position must be possible later.

It is recommended to verify some performance parameters especially for automatically generated emergency calls with the HATS positioned on the front passengers seat or on the passengers' seat in the 1st row behind the front passengers seat.

6.4.5.3 Operation Modes and Configuration for emergency call IVS

An IVS can be used for manually or automatically generated emergency calls. The test cases, test environment and requirements may differ for both operation modes due to the different environmental conditions.

- For **manually generated emergency calls** a typical driving situation (constant speed) or a parking vehicle can be assumed, driver sitting on drivers' seat during conversation with PSAP, a.s.o. It is further assumed that the driver is still able to communicate with the PSAP in the same way as in a normal hands-free communication.
- For **automatically generated emergency calls** (detected and initiated by various sensors in the car) the vehicle is typically not moving, windows may be broken, a higher influence of ambient noise from outside the vehicle can be assumed (road noise, passing vehicles,…), passengers in the vehicle or even first-aiders may communicate with the PSAP, if the driver is unable to communicate.

IVS may therefore be configured for two different operation modes. Test cases and requirements differ for both modes. The manually generated emergency call is comparable to a normal hands-free communication (convenience hands-free); consequently as described, ITU-T P.1100 is applied for manually generated emergency calls.

The requirements are different for automatically generated emergency calls. In case an IVS manufacturer uses different settings, e.g. for manually and automatically generated emergency calls within the IVS or two different IVS implementations are used this needs to be indicated by the manufacturer and needs to be documented in the test report.

Artificial mouth

The artificial mouth of the artificial head shall conform to [ITU-T P.58]. The artificial mouth is equalized at the MRP according to [ITU-T P.340].

The sound pressure level is calibrated at the HATS-HFRP so that the average level at HATS-HFRP is –28.7 dBPa. The sound pressure level at the MRP has to be corrected correspondingly. The detailed description for equalization at the MRP and level correction at the HATS-HFRP can be found in [ITU-T P.581].

The Lombard effect refers to the change in speaking behaviour caused by acoustic noise. As no data are available to analyse the typical speech level in an emergency case and under emergency call specific noise scenarios, the output level of the mouth is increased to account for the "Lombard effect" in a non-emergency situation considering the known formulas [ITU-T P.1100]. The level is increased by 3 dB for every 10 dB that the long-term A-weighted noise level exceeds 50 dB (A). This relationship is shown in the following formula:

$$I(N) = \begin{cases} 0 & \text{for} \quad N < 50 \\ 0.3(N-50) & \text{for} \quad 50 \le N < 77 \\ 8.0 & \text{for} \quad N \ge 77 \end{cases}$$

Where:

I = The dB increase in mouth output level due to noise level

N = The long-term A-weighted noise level measured near the driver's head position

As an example, if the vehicle noise measures 70 dB (A), then the output of the mouth would be increased by 6 db. No gain is applied for noise levels below 50 dB (A). The maximum amount of gain that can be applied is 8 db. Vehicle noise levels are measured using a measurement microphone positioned near the driver's head position.

Note: ITU-T Recommendation P.340 [ITU-T P.340] indicates that the average acoustic speech level from a terminal user is about 3 dB higher when using a HFT than when using a handset telephone. This “offset” is not considered until now in these formulas.

Artificial ear

For IVS terminals, the ear signals of both ears of the artificial head are used. The artificial head is free field or diffuse-field equalized, information that is more detailed can be found in [ITU-T P.581].

Influence of the transmission system

Measurements may be influenced by signal processing (different speech codecs, DTX, comfort noise insertion, etc.) depending on the transmission system and the system simulator used in the test set-up. If requirements cannot be fulfilled due to impairments introduced by the transmission system or the system simulator, reference measurements of the hands-free unit or measurements without acoustical components should be made to document this behaviour.

Calibration and equalization

The following preparation has to be completed before running the tests:

- Calibration
  - Acoustical calibration of the measurement microphones as well as of HATS microphone.
  - Calibration and equalization of the artificial mouth at the MRP.
  - HATS-HFRP calibration
- Equalization
  - Free-field equalization of the artificial head, in case of more than one loudspeaker diffuse-field equalization is used.

Reference measurement

For the compensation of the different power density spectra of the measurement signals it is required to refer the measured power density spectra to the power density spectra of the test signal. This is denoted as a reference measurement.

- In the send direction, the reference spectrum is recorded at the MRP.
- In the receive direction, the reference spectrum is recorded at the electrical interface.

System simulator settings

All settings of the system simulator have to ensure that the audio signal is not disturbed by any processing and the transmission of the HF signal is error-free. DTX shall be switched off. For all networks, the RF-level shall be set to maximum. The settings shall be reported in the test report.

For measurements according to the GSM/UMTS standard, the full rate codec shall be used. For measurements with an AMR codec, the highest bit rate of 12, 2 Kbit/s is used.

6.5 Powered-two-wheeler test process adaptation

The test setup for the IVS of the P2W is described below:

- The IVS has 3 main parts, the helmet itself, the accident detection unit and the call unit.
  - The intelligent helmet measures the impacts in the head and provides an accident severity index, which may be useful for PSAP operators.
  - The on-board accident detection unit send the order for making a call to the call unit. For the detection, it uses several inertial sensors and an algorithm for processing the information given by them. A manual activation button is included in this module for a manual emergency call. It receives the severity index from the helmet by Bluetooth.
  - The call unit is the responsible for making the call and sending the MSD to the PSAP. An audio channel is established with the helmet via Bluetooth.
- The PSAP emulator is composed by an electronic board and a PC with PSAP software. The Software provides the main functionality for a PSAP operator: MSD decoding, call tracking, etc.

The call between IVS and the PSAP emulator is a real call under a real Network, which increases the cost of each test, but results more realistic and closer to the final behaviour. The schema of the test architecture is shown in the next figure.

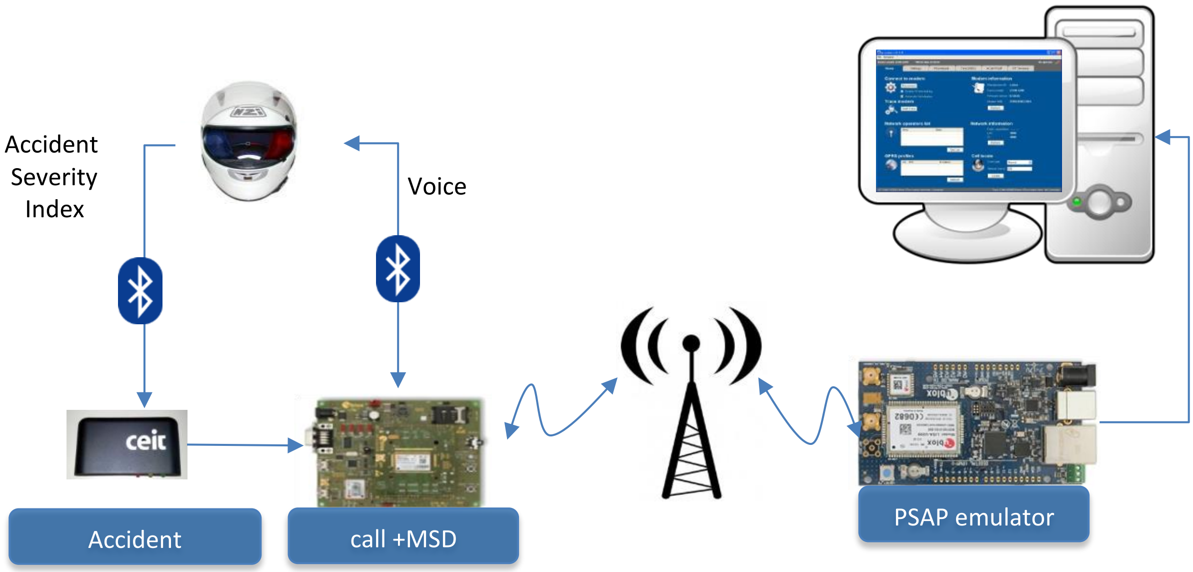

Figure 12: P2W eCall IVS test chain

7 Certification roadmap

7.1 Introduction

Vehicle and their systems, as well as many other safety relevant devices, are submitted to a mandatory regulatory approach in Europe, named the type approval.

Today type approval follows directive 2007/46/EC (framework directive see: http://ec.europa.eu/enterprise/sectors/automotive/documents/directives/directive-2007-46-ec_en.htm) amended by about 70 technical regulations/directives concerning safety requirements for all categories of vehicles. Type approval for an individual vehicle type will require fulfilling all of the relevant amendments, depending on the category of the vehicle.

For the fulfilment of the requirements approved test laboratories (so called "technical services") have to carry out the related tests in own or external test sites and have to prepare a report for the national type approval authorities. Type approval can be granted by one of the type approval authorities for components (following single amendments of the framework directive) or the full vehicle (if all-necessary reports for the vehicle can be provided).

The eCall system is seen as a new safety relevant feature for new vehicle types. In a (draft) regulation from the EU, amending the type approval directive, the eCall In-Vehicle-System (IVS) is required for new vehicle types of M1 and N1 category vehicles. The existing draft for eCall type approval includes requirements (based on published standards) to function and interoperability of the eCall system, but also aspects to EMC, reliable positioning information and data protection are in discussion. Following the existing draft document, delegated acts will give detailed descriptions of technical requirements for eCall type approval.

Since type approval is a mandatory scheme, all new vehicle types will have to fulfil the requirements out of the amendments to the framework directive with the related technical specifications.

The vehicle type approval (article 6 of the directive) can also be extended with the system type approval according to the article 7 of the directive 2007/46/EC. As most pat of the eCall functionalities will reside in an independent system, IVS system type approval is likely to apply and contain most part of the test requirements.

However, aftermarket devices, PSAP as well as sub-component, providing only a part of the eCall features are candidate for a voluntary industry certification scheme. The IVS certification scheme will have more flexibility than the EC type approval procedures. However it needs to be consistent with the type approval and at least includes the EC type approval he minimum level of requirements. Doing so, the IVS certification will ensure that sub-components and aftermarket systems will have the same compliancy and performance requirement than the IVS systems submitted to type approval.

NAD devices are furthermore recommended to go through the Global Certification Forum (GCF) certification scheme, which is mandated by Mobile Network Operators for the mobile devices distributed over their commercial network.

7.2 Vehicle type approval

7.2.1 eCall IVS type approval approach

OICA, the International organisation of motor vehicle manufacturers, has prepared a proposal for the vehicle type approval, in the context of the Accident Emergency Call System (AECS). The proposal is intended to serve a new UN Regulation on Accident Emergency Call System, but to be also suitable for the future EU type approval.

The main concerns of the vehicle manufacturers are about the availability of a harmonised approach for vehicle type approval at reasonable costs. Therefore, the target is to prioritise an optimised type approval procedure offering the best cost/benefit ratio.

The car manufacturers therefore recommend:

- using the same approach for the Pan European eCall, ERA GLONASS and the UNECE AECS
- Considering to check the eCall requirements at much as possible as the level of components, and thus to carry out vehicle type approval only with type approved eCall IVS systems

The vehicle manufacturers therefore propose 3 possible methods for the vehicle type approval:

1. Full scale Impact test with automatic activation
2. Full scale impact test with manual activation
3. Alternative without full scale impact

The following figure summarised the 3 proposals.

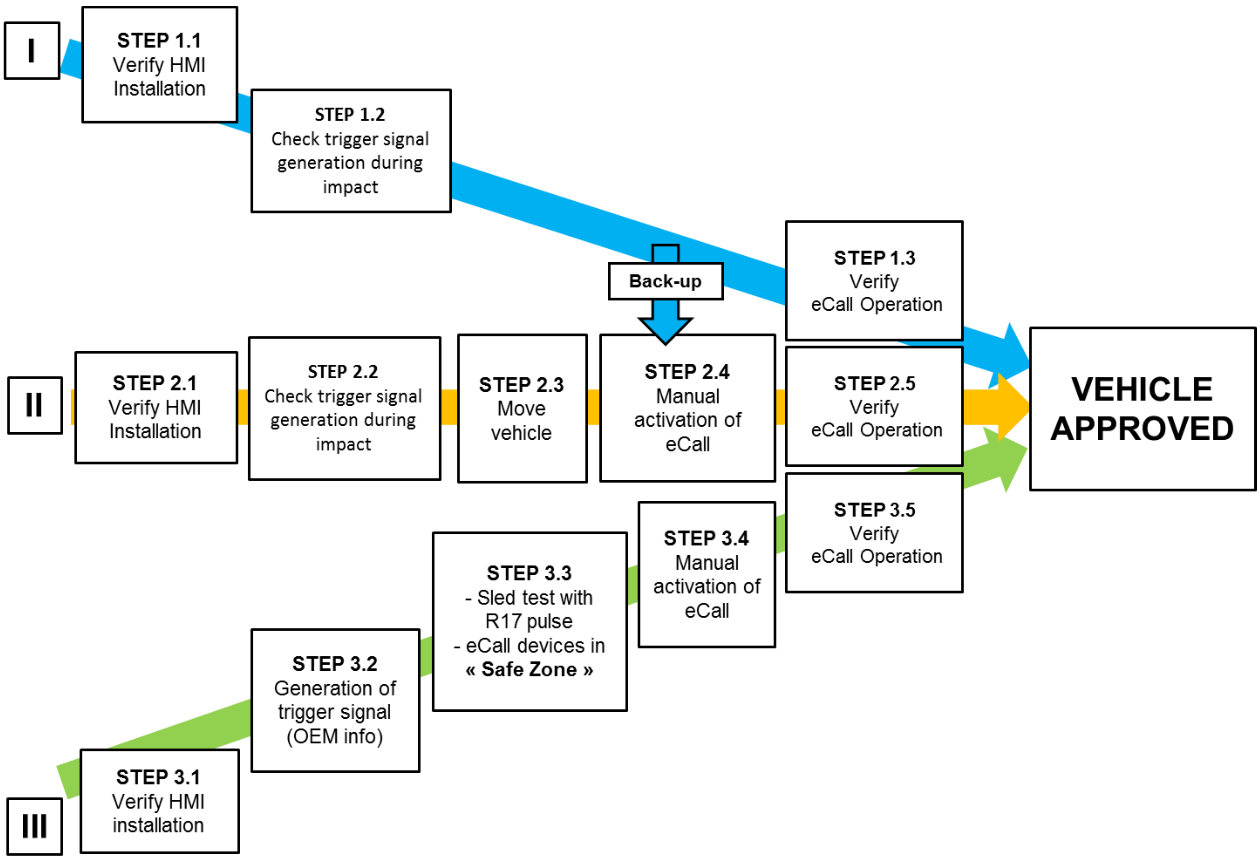

Figure 13: 3 possible methods for vehicle type approval

7.2.2 Method 1: full scale impact test with automatic activation

The first proposed method consists of verifying the capability to transmit an MSD and to carry out a 2-ways voice communication, because of a full-scale impact test see the figure below).

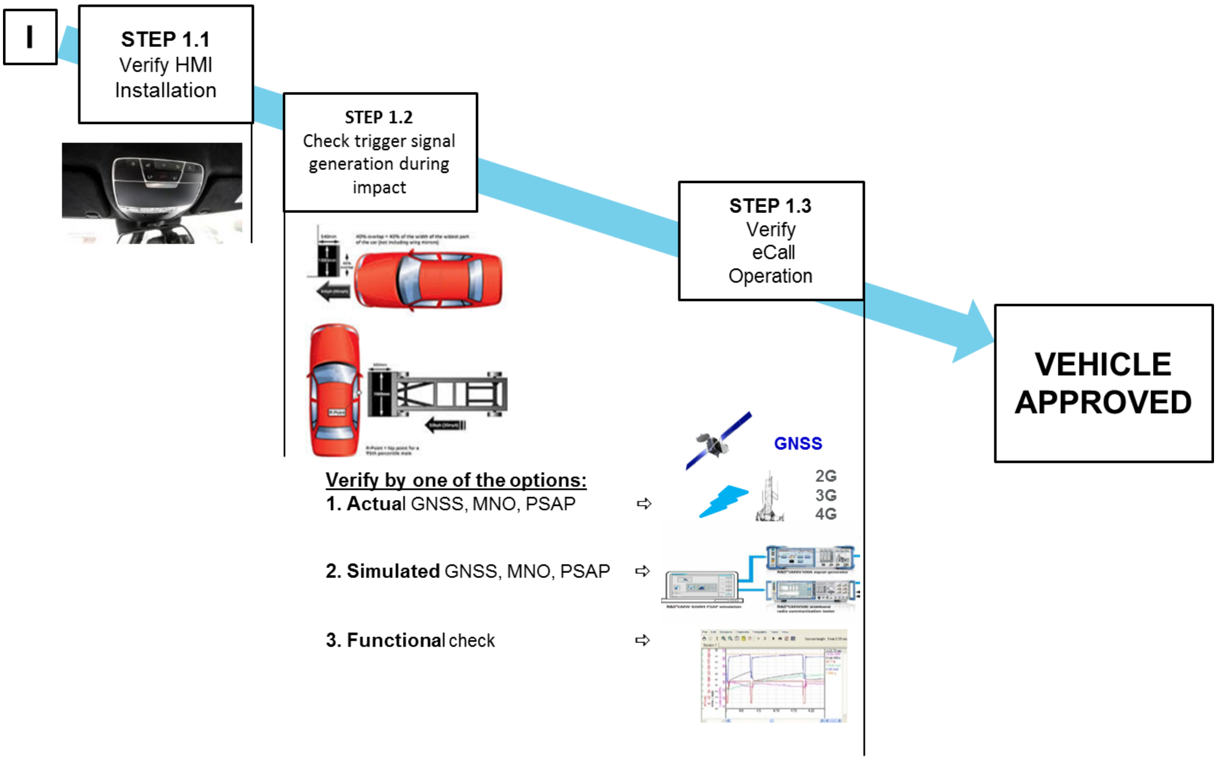

Figure 14: Full-scale Impact test with automatic activation

This method can be used with several options:

Option 1: Use of the actual GNSS constellation and a real Mobile Network and PSAP (through a dedicated long call number).

This method provides a test environment, which is very close to the real life conditions. However, the test results are relying on the GNSS and Mobile Network signal quality, which is depending on the location of the test facilities and the time of the test. These are therefore non-reproducible test parameters.

Option 2: Use of a simulated GNSS constellation, Mobile Network and PSAP, with detailed checks

This method would have results not pending on GNSS or MNO signal quality during the test, and would therefore provide reproducible test conditions. The test environment should however provide a shielded test room to isolate the vehicle from the GNSS actual constellation and public mobile networks. Additionally, the test facilities need to have GNSS and MNO/PSAP simulator at disposal. Detailed check through monitored test interface is foreseen to check the proper behaviour of eCall service.

Option 3: Use one of the following four methods as a functional check:

- Check of functional state of the in-vehicle system by using HMI (visual control of tell-tale)
- Check of functional state of the in-vehicle system by internal memory checking
- Check of functional state of the in-vehicle system by separated functional test
- Check of functional state of the in-vehicle system by functional transmission test with a wired procedure

This method provides another way, to check the embedded eCall system, without initiating a communication involving real or simulated networks.

7.2.3 Method 2: full scale impact test with manual activation

The method is applicable if the Impact test facilities have no stable GNSS or mobile network environment or have neither GNSS nor MNO/PSPA simulator at disposal.

After the test of the trigger signal during the impact test (step 2.2 in the figure below) the vehicle is moved to a test place where the eCall test can be carried out (with availability of real signal or simulator). At this second test place, the eCall signal is triggered manually.

This method consists also of a possible fall back procedure for the method 1, when following the impact and a successful triggering of the eCall, a test failure occurred due to a reason outside the vehicle: e.g. availability of GNSS or MNO suitable signal.

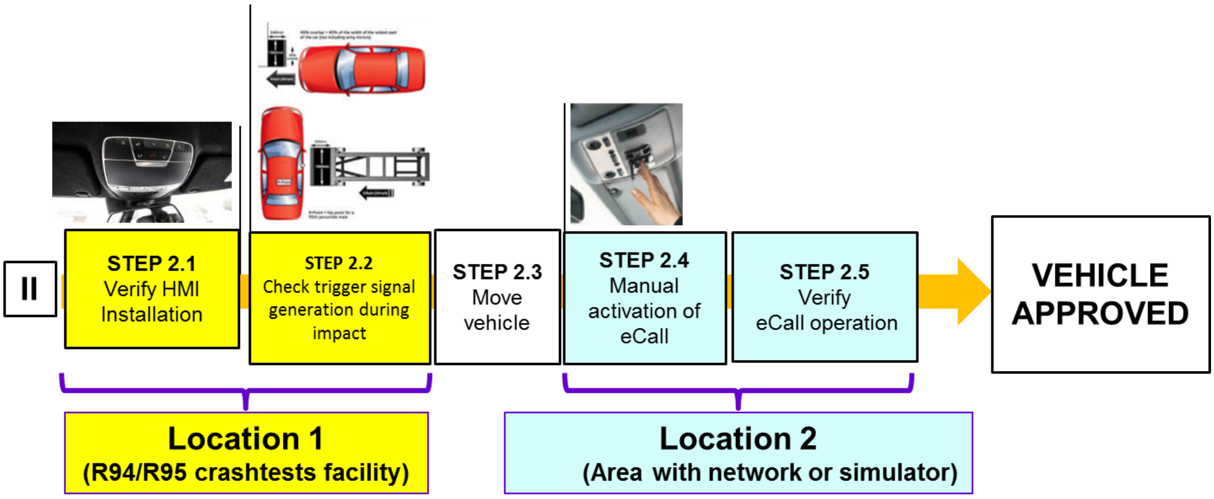

Figure 15: Full-scale Impact test with automatic activation

7.2.4 Method 3: alternative without full scale impact

The third method (see figure below) is an alternative solution, which build up on the very likely reliability of the eCall IVS systems installed in the vehicle, when having successfully passed the system type approval tests.

The generation of the eCall triggering signal can verified according to the ECE 94 and 95 provisions.

Furthermore, the concept of “safe zone” can be used to avoid a full impact test and thus rather check the resistance to the IVS according to the ECE R17 pulse.

A manual activation is proposed to verify the proper eCall initiation and procedures.

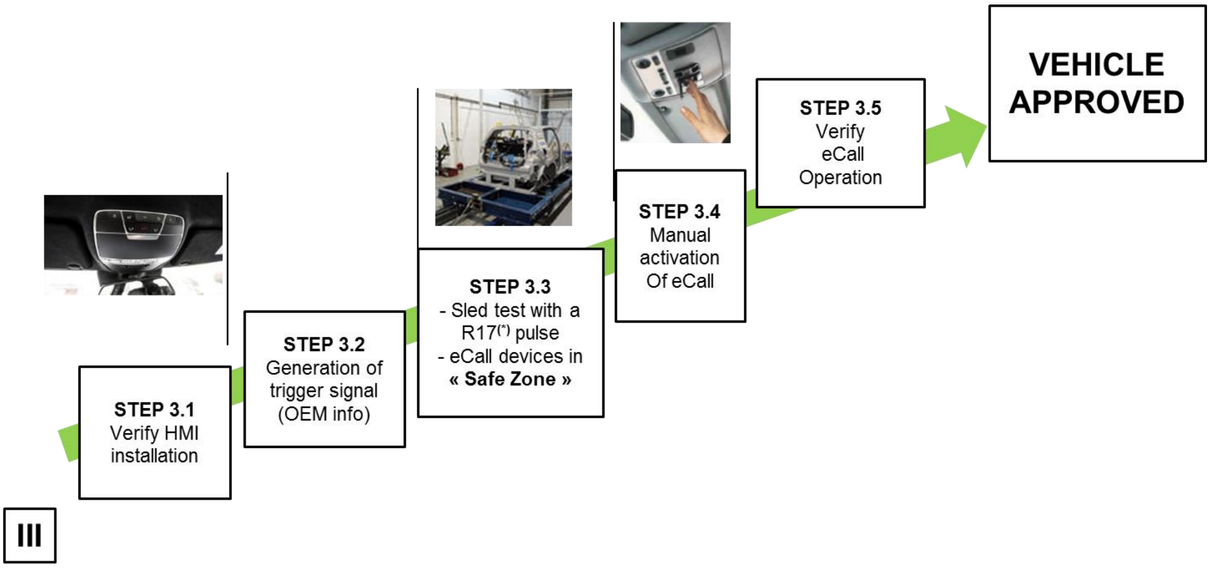

Figure 16: Full-scale Impact test with automatic activation

Safe zone

These are zones within the vehicle structure where deformations are unlikely to happen. If the IVS system is placed in the safe zone, possible impacts on the vehicle are not likely to damage the system. Therefore, the system needs only to be verified against the deceleration effect through the sled tests.

The figure below shows an example of a safe zone.

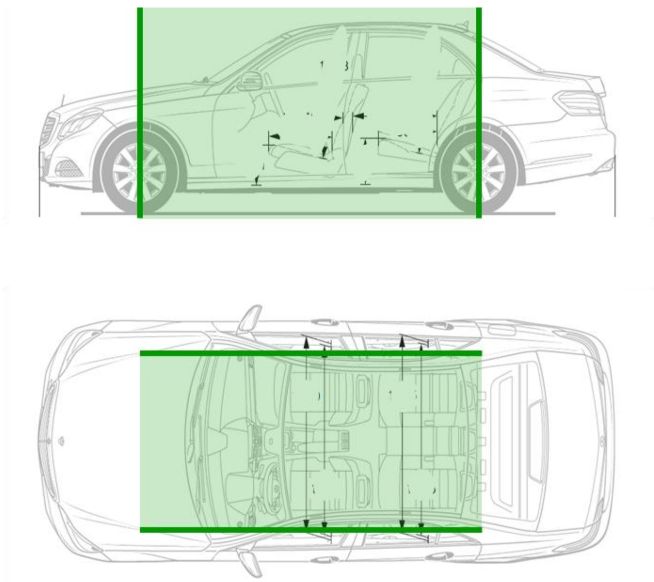

Figure 17: example of safe zone border

7.3 eCall IVS certification

The eCall certification applicable to IVS is a voluntary Industry certification framework, intended to certify compliancy and suitability of an IVS. Furthermore the IVS certification scheme is likely to provide eCall certification to IVS sub-components, not implementing the minimum requirements for eCall IVS, which will be defined in the relevant EC type approval.

eCall certification for partial implementation of eCall system, would allow chip set suppliers to ensure compliancy to the requirements as well as providing an extended testing scheme with more flexibility than the type approval.

The IVS certification framework is likely to consider the requirement and the testing scope presented in this deliverable.

The certification framework for IVS needs to be coordinated by an independent organisation, representing the relevant stakeholders.

The following eCall IVS certification scheme is based on the existing and well-established mobile terminal certification scheme from GCF (Global Certification Forum).

The eCall IVS certification proposal is illustrated in the below figure18 and is described below.

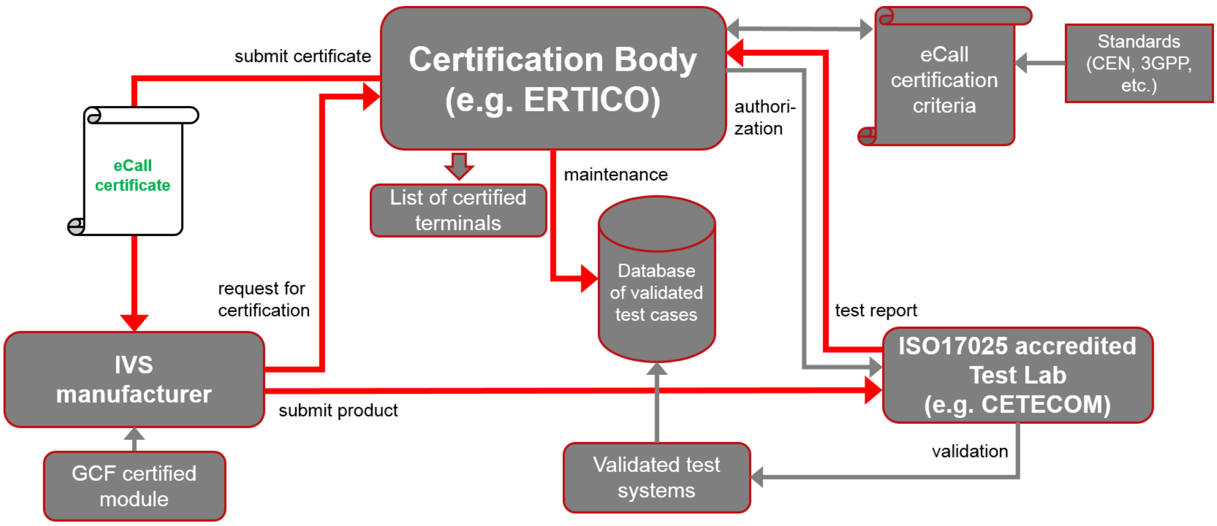

Figure 18: IVS eCall certification process

As shown in the figure 18 above, the test labs should be accredited according to the following standard:

- ISO/ IEC 17065:2012 - Conformity assessment – Requirements for bodies certifying products, processes and services.

The Certification Body (for instance ERTICO as independent stakeholder) is the centralized entity of this proposal. Its responsibility contains:

- definition of certification criteria (based on existing test standards like CEN, 3GPP, etc.)
- handling of certification requests of IVS manufacturers
- definition of test scope for the certification, based on the device flavour and functionality
- submit eCall certificate after successful IVS certification
- maintenance of certified eCall IVS terminals

- authorization of ISO17025 accredited test labs (e.g. CETECOM and other independent test labs)
    - based on frequent repetition of the accreditation in strict accordance on not yet defined certain criteria
    - nomination of a qualified lab auditor
- maintenance of a database which lists validated test cases and test systems

The ISO 17025 accredited Test Lab is responsible for:

- execution of test cases according to the eCall certification criteria defined by the Certification Body
- testing will be performed by:
    - qualified persons
    - only on validated test systems
    - in a shielded lab environment, considering the required environmental conditions (e.g. temperature and relative humidity)
- validation of test cases on selected test systems based on not yet defined certain criteria
- creating test reports and submission to the Certification Body

Proposal:
Only an eCall certified IVS is qualified to be used in the PAN European eCall system!

7.4 PSAP conformity assessment

7.4.1 Baselines

A legal text, shaping the needs for PSAP certification, is provided in the following delegated act, applicable to all EU Member States:

“COMMISSION DELEGATED REGULATION (EU) No 305/2013 of 26 November 2012, supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to the harmonised provision for an interoperable EU-wide eCall”

In particular, the article 4 below defines the needs for Member state to designate a competent authority to assess the conformity of eCall PSAPs.

“Article 4

Conformity assessment

Member States shall designate the authorities that are competent for assessing the conformity of the operations of the eCall PSAPs with the requirements listed in Article 3 and shall notify them to the Commission. Conformity assessment shall be based on the part of the standard ‘Intelligent transport systems — eSafety — eCall end to end conformance testing’ (EN 16454) that relates to PSAPs conformance to pan-European eCall.”

The article 3 below contains a list of requirements applicable for the PSAP conformity assessment.

"Article 3

eCall PSAP requirements

*1. Member States shall ensure that any eCall PSAP is equipped to **handle eCall and receive the MSD** originating from the in-vehicle equipment **according to the standards** 'Intelligent transport system — eSafety — Pan European eCall- Operating requirements' (**EN 16072**) and 'Intelligent transport systems — eSafety — eCall High Level Application Requirements (HLAP)' (**EN 16062**).*

*2. The eCall PSAP shall **handle eCall as expeditiously and effectively as any other call** made to the single European*

emergency number 112. The eCall PSAP shall process eCall in line with the requirements of national regulations for emergency call processing.

*3. The eCall PSAP shall be able to **receive the data contents of the MSD and present them to the eCall PSAP operator clearly and understandably**.*

*4. The eCall PSAP shall **have access to an appropriate Geographical Information System (GIS) or an equivalent system allowing the eCall PSAP operator to identify the position and heading of the vehicle to a minimum degree of accuracy** as defined in EN 15722 for the MSD coordinates.*

*5. The abovementioned requirements shall enable the **eCall PSAP to provide location, type of eCall activation (manual or automatic) and other relevant data to the appropriate emergency service**(s) or service partner(s).*

*6. The eCall PSAP (initially receiving the eCall) shall **establish audio communication** with the vehicle and **handle the eCall data**; if necessary, the eCall PSAP may reroute the call and MSD data to another PSAP, emergency control centre or service partner according to national procedures determined by the national authority. **Rerouting may be done via data or audio connection, or, preferably, both**.*

7. When appropriate, and depending on national procedures and legislation, the eCall PSAP and appropriate emergency service(s) or service partner(s) may be granted access to the characteristics of the vehicle contained in national databases and/or other relevant resources. This is in order to obtain information that is necessary for dealing with an eCall, notably to allow the interpretation of the Vehicle Identification Number (VIN) and the presentation of additional relevant information, particularly vehicle type and model."

7.4.2 PSAP certification scope

The analysis of the delegated act reveals the following requirements to be part of the PSAP certification:

- Handle eCall according to HLAP procedures (as per EN 16062 and EN 16072) including the relevant in-band modem procedures as per the 3GPP specifications (3GPP TS 26.267 and TS 26.268)
- Receive, decodes MSD and display the content, according to EN 15722
- Handle two-ways communication with vehicle occupants according to EN 16062 and EN 16072
- Locate vehicle with a GIS using position and heading of the vehicle the information transmitted in the MSD
- Reroute Calls and data to other PSAPs

The above requirements form a clear scope for PSAP certification, matching the legal requirements for Member states.

The main part of the test procedures is provided in the certification test procedures above, and in particular:

- Compliancy procedures concerning HLAP and MSD, as well as in-band modem in the clause 6.2 above
- Interoperability test procedures in the clause 6.3 above
- A part of the Speech quality procedures concerning the two-ways communication as per the clause 6.4.5 above

Additional simple functional test procedures can be easily specified to test the GIS and the call re-routing capabilities.

7.4.3 PSAP certification framework

The conformity assessment is under the responsibility of the Member States. However, the procedures applicable to eCall are global, following European standards. Therefore, the same conformity procedures can be applied by all Member states. Defining global conformity procedures would ease the eCall deployment process for all Member states and furthermore guarantee cross border continuity and interoperability.

An independent ITS stakeholder organisation, like ERTICO for instance, with representatives from a major part of EU countries, would be able to define and coordinate the PSAP certification framework.

Certification services could for instance be provided by test houses providing similar certification services for the eCall IVS. These test houses will need to become accredited and be “notifying bodies” for the different Member states.

7.5 PSAP service quality audit

The audit will be based on the mandated services that the PSAP has in place and on the functions that it performs within the emergency service chain. The audit criterion is assessed with both qualitative and quantitative metrics; the latter being aligned to specific numerical targets and Key Performance Indicators ("KPI's") wherever possible.

The audit is performed by a ISO-9001 Lead Auditor trained consultant who also is experienced in the 112 field.

Below is the 3-stage process for the programme.

Stage 0: Initially the audit involves a Pre-Audit Questionnaire, which outlines and details the type of PSAP, scope, mission, scale, complexity, technology, call volume, resources etc. It is a fact-finding step to gather information about the PSAP itself.

The initial step in the process is the submission of the relevant documentation to the Auditor, which corresponds with their pre-determined mission.

Stage 1: The Auditor then performs a desktop audit of the PSAP and provides a Report to the PSAP. Other documentation may be required; clarification may be required at this point. The PSAP then responds to this desktop audit Report.

Stage 2: Following the submission of the Audit Plan by the Auditor, the field audit is planned and executed. This process is then completed with a Final Report, which determines if the PSAP has passed the threshold, and conformed to any mandatory requirements. The final decision to award the Certificate of Quality is made by EENA following the assessment of all the documentation

Stage 0

1. PSAP completes Pre Audit Questionnaire

Stage 1

1. EENA appoints Auditor(s)
2. Auditor(s) performs "desktop review" and issues a Report
3. EENA & PSAP review Report
4. If approved, a "fieldwork audit" is scheduled

Stage 2

1. Fieldwork is conducted
2. Draft Report and Recommendation issued by Auditor(s)
3. Report is peer reviewed by different Auditor
4. EENA & PSAP review Report
5. EENA makes Final Decision re Certificate award

Figure 19: PSAP service quality 3 stage process

8 Conclusions

In the scope of this deliverable, certification is defined as a voluntary process driven by the industry, to assess compliancy and performance of eCall devices. This use of the voluntary certification scheme to draft this deliverable, matches with other relevant certification schemes, like the Global Certification Forum for instance.

Developing this deliverable required to involve many stakeholders from different sectors, as for instance:

- eCall component and sub-component suppliers
- Public authorities
- Mobile Network Operators,
- Vehicle manufacturers,
- Test houses,
- Standardisation and testing experts

The discussions with the stakeholders were mainly using the Standardisation Task Force, which was created as an open group to involve the necessary expertise beyond the HeERO2 partnership. These discussions also led to look at the interoperability issues in relationship with the quality of standards. Concern raised in the standardisation task force therefore led to check interoperability for as many devices as possible with the first goal to improve the quality of the eCall standards.

The first conclusion is that the open networking group, created for gathering the necessary technical expertise on interoperability, contributed significantly to the standardisation of eCall.

A suitable methodology, based on certification activities for similar technologies, was identified, in order to develop the eCall certification framework. Actually, eCall is an application running on top of a GSM/UMTS connection. Therefore, the certification scheme used by the mobile industry was a suitable example. Additionally, considering the specific context of eCall, allowed defining an appropriate certification concept.

As a second conclusion, the deliverable allowed to define a suitable concept eCall certification

A series of “eCall TESTFEST” events were organised, at three different places in Europe (UK, Germany and Spain) to evaluate the actual capabilities of existing devices (IVS and PSAP servers) to inter-operate according to the eCall standards. Actually, the TESTFEST events contributed to several achievements:

- Creating more networking about eCall testing and certification with eCall system developers,
- Assessing interoperability with a wide range of products,
- Evaluating standard quality and proposing revision of the standards to improve readability as well as the performance of the eCall applications

The networking activities of the standardisation task force and the TESTFEST events resulted in providing useful proposals about eCall testing, as well as the suitable ways to organise the eCall certification from a coordination point of view (certification authority).

As a third conclusion, the development of this deliverable supported the organisation of useful interoperability testing service: the TESTFEST events. It also contributed enhancing the network of experts to eCall deployment in the context of interoperability.

During the initial discussion concerning the eCall certification, the discussions concerning the certification led to exclude the MNO (Mobile Network Operator) from the scope of the certification. Actually, the requirements concerning eCall as well as the quality of services and the performances needs are part of the service level agreement the Mobil Network operators have to fulfil.

The target devices, for eCall certification, were confirmed to be the IVS (In Vehicle System) and the PSPA (Public Safety Answering Points).

The deliverable provides details about the essential requirements for the certification. Beyond the technical requirements, this deliverable describes the appropriate test procedures to check the compliancy of the devices applying for the eCall certification against these requirements.

The proposed test procedures are according to either existing procedures applied also for other similar devices, as for instance, EMC tests, or according to development made by testing tools providers or test houses.

The proposals for eCall certification framework and organisation, provided in this deliverable, take into account complementary needs:

- The need to certify sub-component, providing a part of eCall functionality,
- The need to certify aftermarket devices,
- The need to propose harmonised certification procedures for PSAP

As a fourth conclusion, this deliverable proposes a complete set of essential technical requirements, as well as the corresponding test procedures, to be applied in the context of eCall certification, for IVS and PSAP.

This deliverable includes also views and proposal from testing service providers concerning the Periodic Test Inspection. The deliverable is however not containing detailed proposal for PTI testing. Therefore, discussions about PTI will be the subject of the EeIP PTI task force.

As a fifth conclusion, no complete views about PTI procedures were provided in this deliverable, taking into account that this goal is part of the EeIP PTI task force objectives.

The deliverable was not intending to provide neither requirements nor recommendations to support type approval objectives. Actually, the type approval scope, being mandatory, is understood to be lower than the certification scope. However, car manufacturers have included current views concerning eCall regulation on vehicle testing, to be applicable at either the UNECE or EU regulation level.

As a sixth conclusion, views shared by some car manufacturers, about needs for UNECE or EU type approval, have been included in this document, showing the difference between type approval and certification scopes.

The proposals for eCall certification in this deliverable are either resulting from existing applied certification processes (like for the NAD component for instance) or proposed as views about suitable processes. The processes were not analysed for cost/benefit, to ensure for instance reasonable deployment costs. Furthermore, the discussions allowing the eCall certification procedures in this deliverable did not include consultation reaching a consensus among the relevant stakeholders. Finally, eCall certification consultation will have to differentiate needs for IVS, led by industry stakeholders, and PSAP, led by public authorities

As a seventh conclusion, the eCall certification proposals in this deliverable, although provided by professionals and certification experts, will require further consultation,, as part of a certification authority for instance, to reach a consensus about the essential certification procedures.

9 Annexes

9.1 Test process detailed specifications

9.1.1 Electromagnetic compatibility for eCall devices

9.1.1.1 Functional performance status classification

FPSC (Functional Performance Status Classification) which describes the operational status of a device during and after the exposure to an electromagnetic environment, five classes are defined:

Class A: All functions of a device or system perform as designed during and after the exposure to a disturbance.

Class B: All functions of a device or system perform as designed during exposure; however, one or more of them may go beyond the specified tolerance. All functions return automatically to within normal limits after exposure is removed. Memory functions shall remain class A.

Class C: One or more functions of a device or system do not perform as designed during exposure but return automatically to normal operation after exposure is removed.

Class D: One or more functions a device or system do not perform as designed during exposure and do not to normal operation until exposure is removed and the device is reset by a simple user action.

Class E: Where one or more functions of a device or system do not perform as designed during and or after the exposure and cannot be returned to proper operation state without repairing or replacing the device or system.

E-Call IVS functions shall be defined prior to the tests between manufacturers and technical service responsible for the type-approval tests. All safety-functions of the device shall be considered (e.g. call establishment, HMI, MSD transmission, audio link, GNSS positioning…)

9.1.1.2 Immunity to electromagnetic radiation

Test shall be performed according Annex 9 of UN Regulation 10 Rev.4. Test setup according ISO 11452-2 suitable for eCall IVS testing is shown in Figure 20.

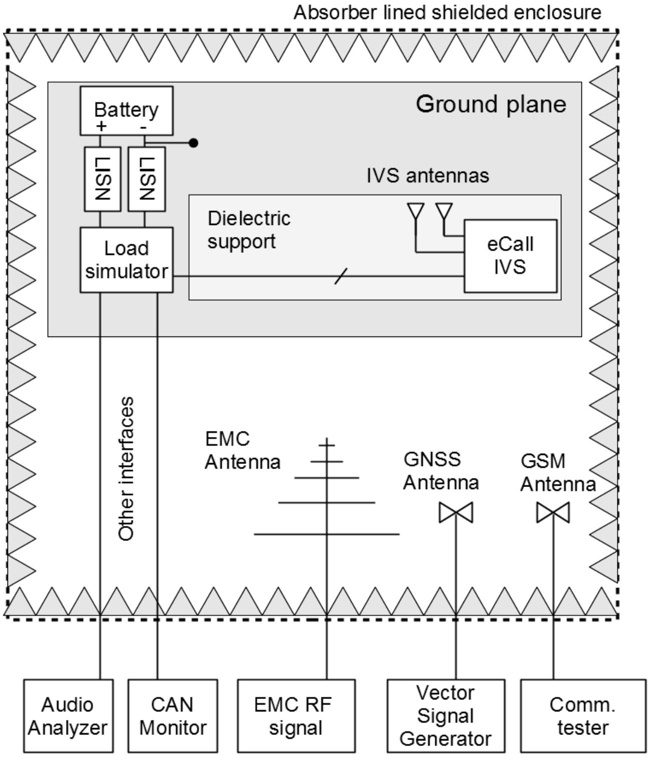

Figure 20: Typical test setup for eCall IVS radiated immunity test.

NOTE: Special care should be taken to ensure harmonics generated by RF amplifiers do not disturb the eCall IVS communications.

Test setup specifications

- A communication tester and vector signal generator can be used to simulate a PSAP communication and GNSS constellations. Technical details shall be agreed between manufacturers and technical service.
- Free space antenna method defined in ISO 11452-2 is preferred. Other methods like BCI (ISO 11452-4) or DPI (11452-7) do not take into account coupling effects trough antenna ports since RF energy is coupled only into the wiring harness. TEM (ISO 11452-3) and STRIPLINE (ISO 11452-5) methods are limited due to EUT and auxiliary equipment size.
- Antennas (if external), wiring harness and other loads shall be representative of the vehicle installation.

9.1.1.3 Immunity against transient disturbances conducted along supply lines

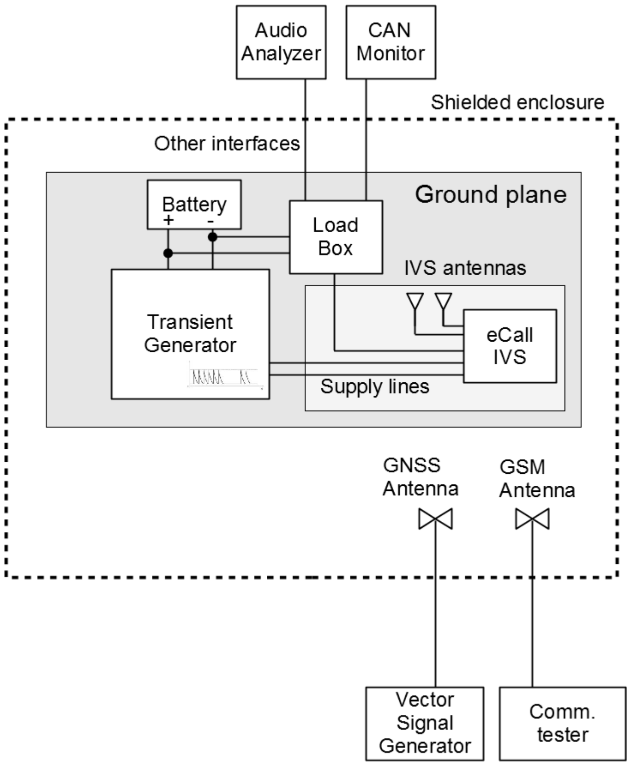

Figure 21: Typical test setup for eCall IVS transient immunity test.

Test setup specifications

- A communication tester and vector signal generator can be used to simulate PSAP communication and GNSS constellations. Technical details shall be agreed between manufacturers and technical service.
- Direct cable connection to the communication tester is not recommended, external protections fitted on the communication tester could influence test results.
- Transient pulses shall be applied to all supply lines (e.g. ACC, IGN, BAT) simultaneously and independently.
- IVS antennas (if external), wiring harness and other loads shall be representative of the vehicle installation.

9.1.1.4 Measurement of radiated electromagnetic emissions

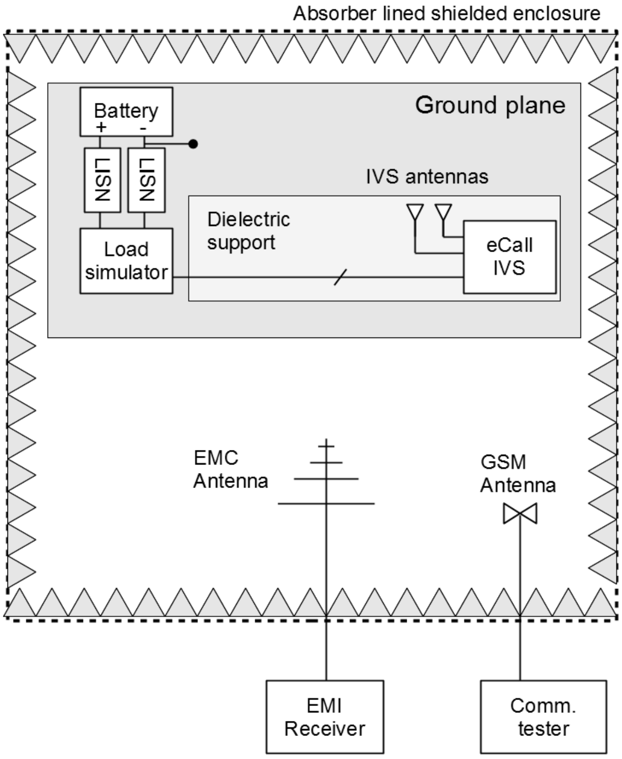

Figure 22: Typical test setup for eCall IVS radiated emissions test.

<u>Test setup specifications</u>

- RF transmitters shall transmit during the test. At least a communication tester is required for GSM/UMTS communication simulation.
- Ambient noise emissions shall be at least 10dB from the type approval limits, including emissions coming from auxiliary equipment (e.g. communication tester).
- Antennas (if external), wiring harness and other loads shall be representative of the vehicle installation.

9.1.1.5 Measurement of transient conducted disturbances generated on supply lines

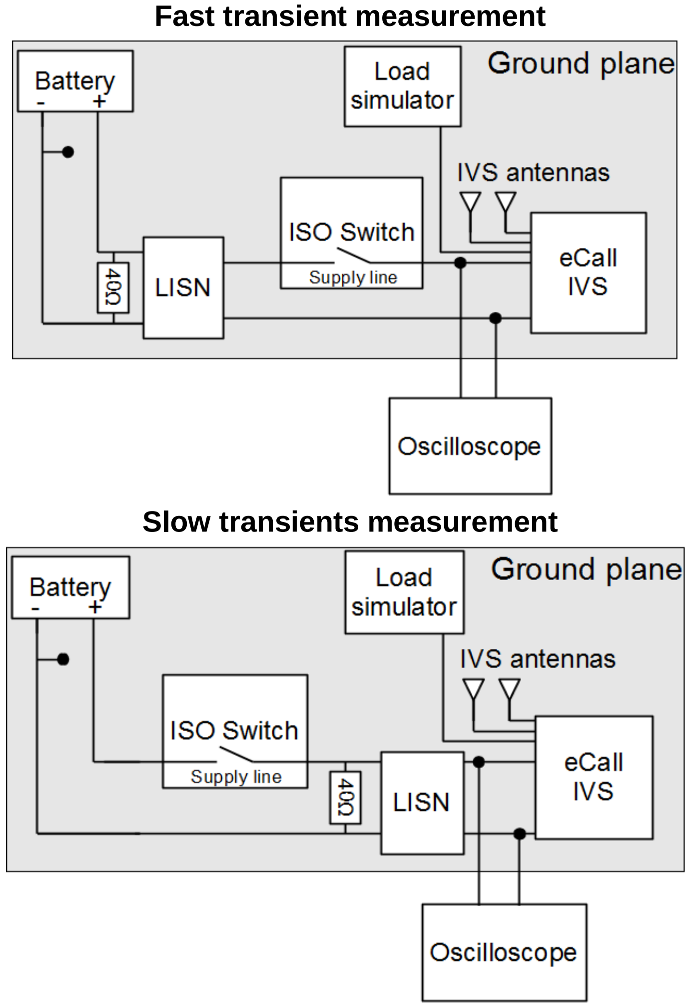

Figure 23: Typical test setup for eCall IVS transient emissions test.

9.1.2 Triggering of eCall In-Vehicle System in validation tests

9.1.2.1 Algorithm for accident detection

When difference between crashes of different severity had to be done, different approaches can be used. The most simple consists of defining a set of acceleration threshold in a way that when a pulse exceeds a given acceleration value it will be considered as more serious. However, this approach is not valid in every situation (especially in frontal crashes). In some occasions, the peaks of acceleration registered in a pulse are more elevated than the ones from the higher category. As shown in Figure 1, the pulse MINOR1 (as minor accident) has a peak near 35 G, while the pulse SEVERE (as severe accident) only reaches 30 G. Similarly, the pulse MINOR2 has a peak at almost the same high as the pulse NO ACC (scene with no accident). Thus, when the pulses have to be arranged both the amplitude and the duration has to be taken into account. The pulses of higher severity have a higher duration than the pulses of minor severity.

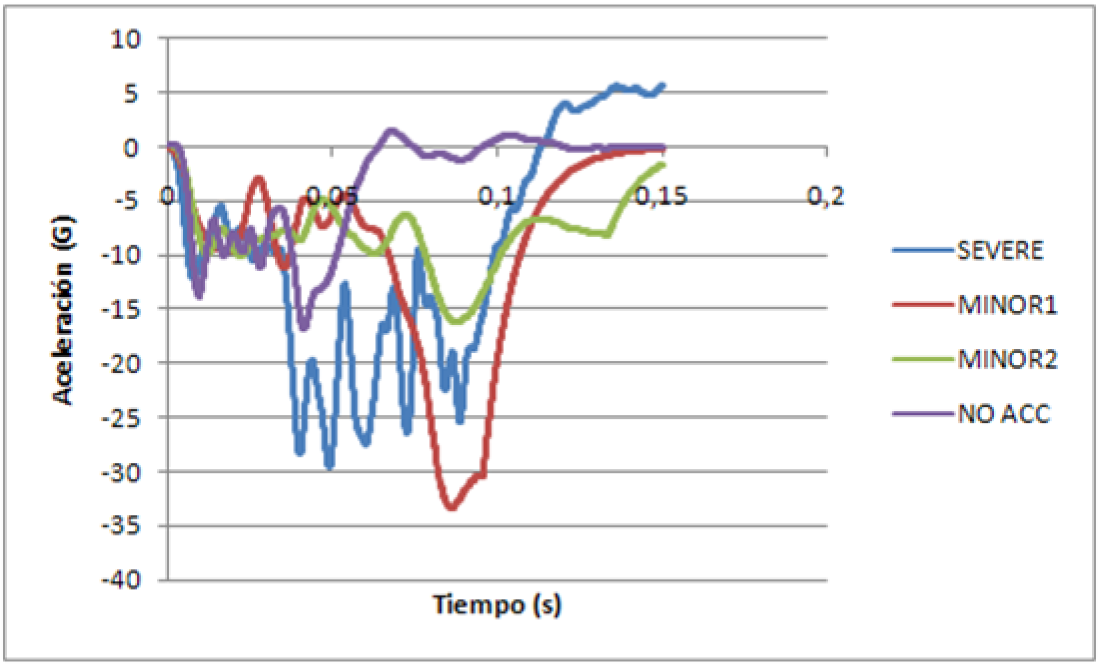

Figure 24: Examples of acceleration pulses for a frontal collision with different severities

One way to take into account both the amplitude and the pulse duration is to use the area that the pulse forms with the X-axis (the value of acceleration of 0 G). The function area can be obtained by the integer of the function on an interval but since the function is not defined analytically but by a set of tests, it has to be approximated using numerical methods.

There are different numerical integer methods that can be used: trapezoidal rule, Simpson's rule, etc. In this case, a mean value of the registered acceleration in each interval between consecutive messages is available; the logical choice would be to use the Rectangular Rule that approximates the area of a function by dividing it in intervals and calculating the mean value of the function in each interval (see Figure 5.2).

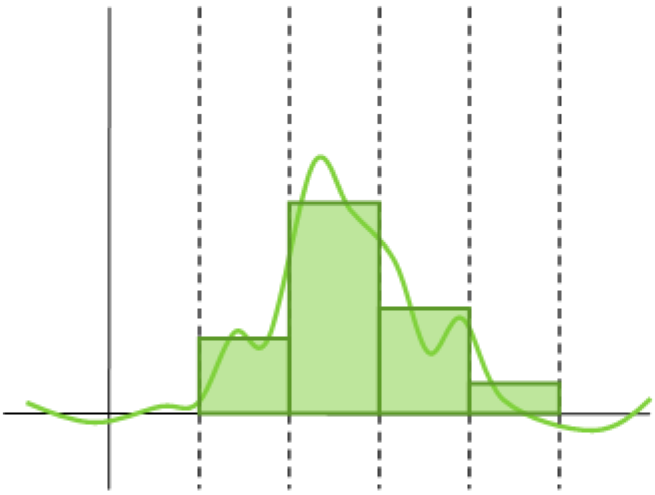

Figure 25: Graphic representation of the integer calculation in a set of intervals by using the rectangles rule.

In an analytic way, the integer calculation is obtained by the following formula:

$$\int_{x_0}^{x_n} f(x)dx \approx \sum_{i=1}^{n} (x_i - x_{i-1}) \cdot f_{avg}[x_{i-1}, x_i]$$

Where $f_{avg}[x_{i-1}, x_i]$ is the mean value of the function at the interval $[x_{i-1}, x_i]$. The acceleration function begins to be integrated when an absolute measurement value is higher than the threshold that holds the value between 3 and 6 G depending on the type of impact (frontal, lateral or rear end) and the segment in which the vehicle belongs. After a period of time (that approximates the pulse duration), the integer value will determine the type of accident depending on whether or not the limits specified in the test traces are exceed. If the accident has been severe enough, the IVS will activate the emergency call in order to alert about the danger situation.

For each segment and each type of collision, different factors have to be defined:

- The initial acceleration integer value for the integration of the function.
- The approximate duration of the pulse, during which will take place integration
- The threshold for the arrange of the different types of accidents severity

However, by homogeneity, the first two factors (the initial acceleration value and the duration pulse) will remain fixed because they are similar for all the studied pulses and for that, the differences between segments will be given only for acceleration thresholds that will allow differentiating the degrees of accident.

An important clarification on how to process the acceleration data is that the rear end and frontal impacts occurs at the same axis. The system must be configured so the values that will register can differentiate the directions and addresses in which the accelerations occur.

A valid criterion will be as follows:

- Frontal accidents: Axis X, NEGATIVE direction
- Lateral accidents: Axis Y
  - NEGATIVE direction for hits that come from the RIGHT side
  - POSITIVE direction for hits that come from the LEFT side
- Rear end accidents: Axis X, POSITIVE direction

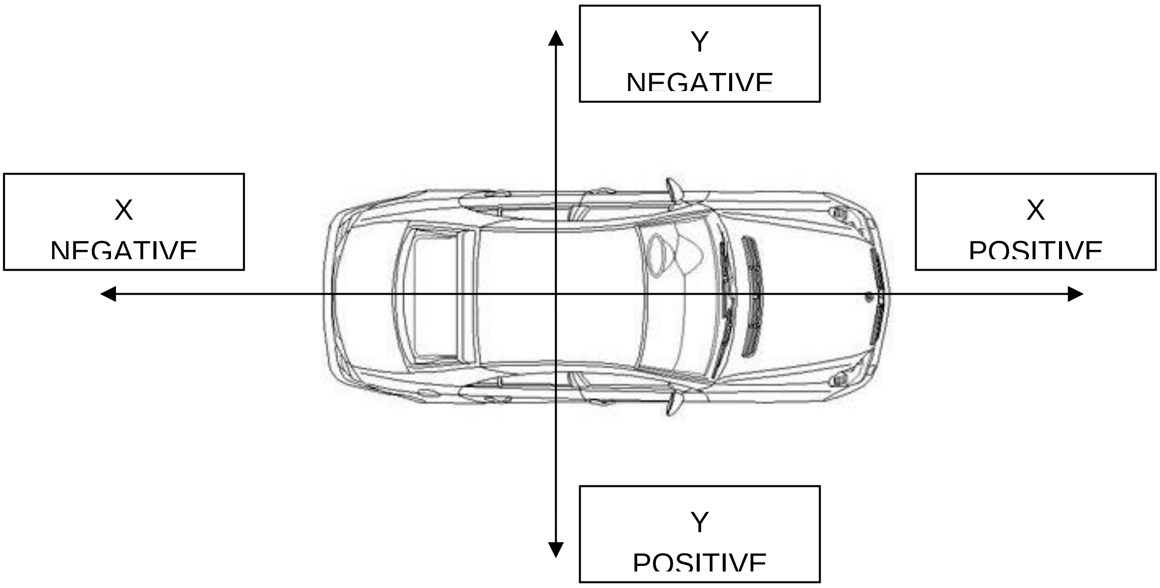

Figure 26: Configuration of the different accelerometers for the determination of each type of accidents

Following, the values used for the different accidents classifications are explained.

9.1.2.1.1 Frontal accident

Frontal accidents may have three levels in this designed system: no accident, minor accident and severe accident. The existence of these three levels makes the impacts the most complex for the system to detect. The values that will be used at the characterization are summarized at the table 2. The initial acceleration and duration of the pulse have been obtained by the observation of the pulses, so that the lower values that are not representing an accident will not be appreciated and with enough duration that the longest pulses will be registered.

Table 17: Values for the characterization of the frontal accidents by class

Segment	Integral starting acceleration	Pulse duration (ms)	Range No acc. – Slight acc.	Range Slight acc. – Severe acc.
Large family car	6 G	130 ms	700	1500
Large MPV	6 G	130 ms	600	1550
Large Off-Road	6 G	130 ms	600	1500
Pickup	6 G	130 ms	600	1550
Small family car	6 G	130 ms	800	1500
Small MPV	6 G	130 ms	800	1550
Small Off-Road	6 G	130 ms	800	1500

Super-mini	6 G	130 ms	850	1500

As an example of how the separation thresholds had been chosen, figure 4 shows the integral registered values with the base configuration (6 G of minimum acceleration and 130 ms of pulse duration). Axis X represents the different tests carried out and axis Y includes the registered values of the integral. The choice of the thresholds was carried out by a criterion of the maximum separation between the maximum values of one level and the minimum values of the next level, so that they will be located around the mean value between these two values. Thus, in the figure it can be appreciated that the difference between the minor accidents and the severe ones is marked by the 1500 integral value and the threshold of no accident – minor accident is located around 700.

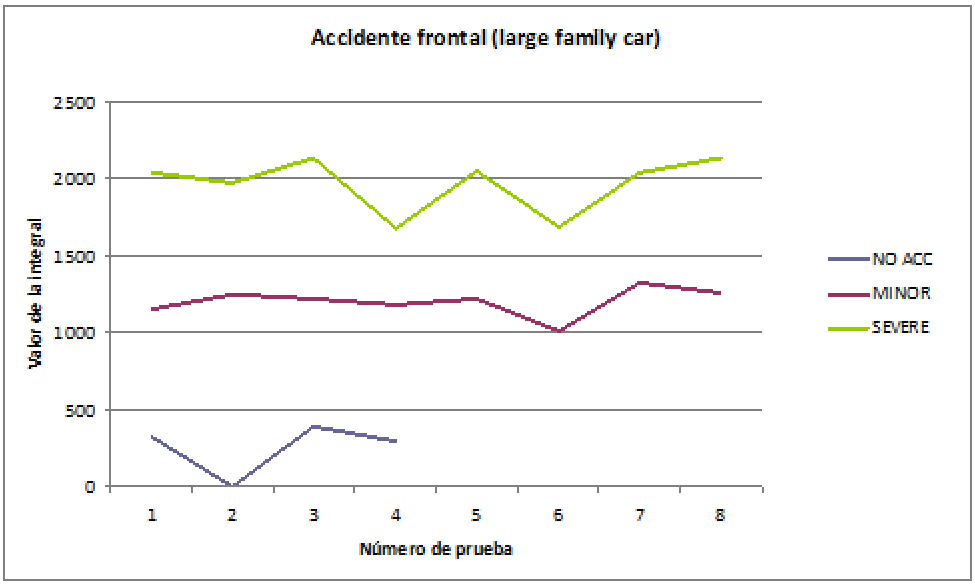

Figure 27: Values of the integer for different tests of frontal accidents at the large family car class

9.1.2.1.2 Lateral accident

The lateral accidents only represent two values of severity: no accident and accident due to the danger of the vehicle's passenger proximity at the impact point. In addition, the lateral accidents show enough differentiated characteristics that allow easy classification. The chosen values appear in table 3:

Table 18: Values for the characterization of the lateral accidents by class

Segment	Integral string acceleration	Pulse duration (ms)	Range no acc. – accident
Large family car	3 G	90 ms	300
Large MPV	3 G	90 ms	250
Large Off-Road	3 G	90 ms	250

Pickup	3 G	90 ms	300
Small family car	3 G	90 ms	350
Small MPV	3 G	90 ms	350
Small Off-Road	3 G	90 ms	350
Super-mini	3 G	90 ms	350

Figure 5 represents the different tests carried out with the vehicle class with the most number of samples, i.e. super-mini. Following the criterion of the maximum threshold, the limit to consider an impact accident or no accident can be defined, the integral value is around 350.

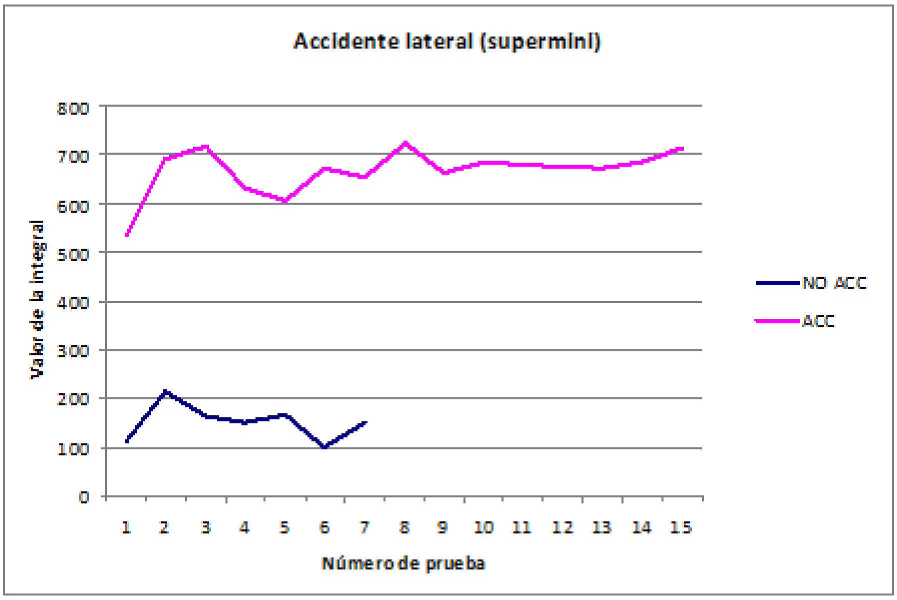

Figure 28: Values of the integral for different lateral accidents tests at the class super-mini

9.1.2.1.3 Rear end accident

Only two possible levels of severity exist: no accident and accident. However, this kind of accident presents the same pulses for defining the accident scenes. To do that, all the vehicles classes present the same values of initial acceleration, duration and separation threshold. Another characteristic of these pulses is that the accident situations are considered especially for the duration of the pulse and not for the amplitude, since the minor accidents can present very high peaks but very short time. Therefore, the values used for the classification of these impacts in each vehicle class are:

- Initial integral acceleration: 4 G
- Pulse duration: 110 ms
- Threshold (no accident – accident): 350

Due to the few samples that are available, figure 6 only includes values for 3 different tests, 2 non-accidents and 1 accident.

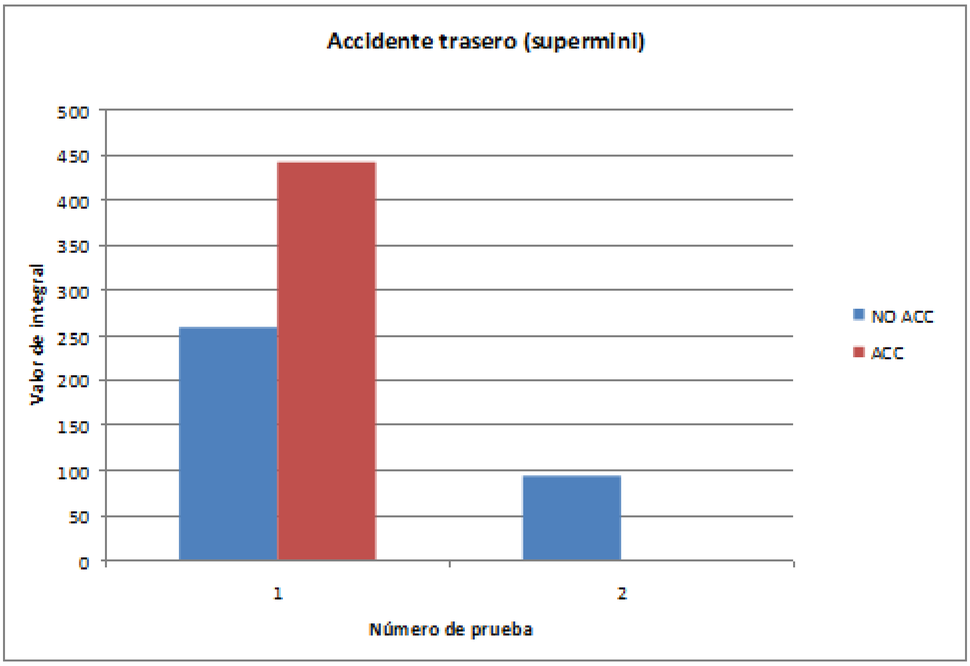

Figure 29: Values of the integral for different rear end accident test in the super-mini class

9.1.3 Interoperability test scenarios

The following tables are the test description used for the face-to-face interoperability session during the eCall test fest events.

The configuration applied for these test scenarios are as following.

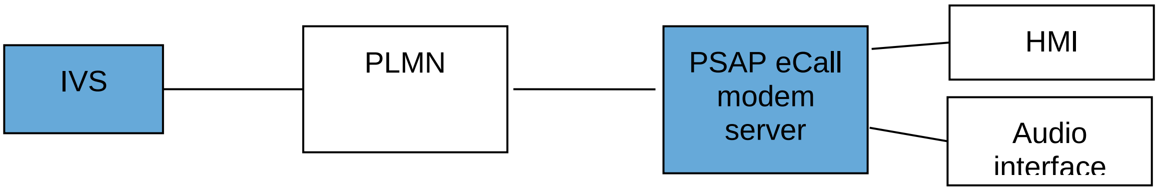

Figure 30: eCall_CFG_01 basic test configuration for interoperability testing

9.1.3.1 eCall Push mode: MSD transmission / reception /acknowledgement

Interoperability Test Description	
Identifier:	TD_MAN_PUSH_01
Objective:	To verify that, when the PSAP does not initiate the mandatory PULL mode process (send the SEND-MSD message upon receipt of the eCall), the IVS initiate the PUSH mode.
Configuration:	eCall_CFG_01
References:	EN 16062 Clause 7.4.2
Pre-test conditions:	• Ignition is ON and IVS is in mobile network coverage • MNO and PSAP test points are available • PSAP is configured not to initiate the PULL mode and therefore not sending the SEND-MSD message on receipt of the eCall • IVS has all the information needed to compile the MSD • PSAP knows the content of the IVS encoded MSD

Test Sequence:	Step	Type	Description
	1	stimulus	PSAP waits for the eCall setup and the initiation message and **does not send** the SEND-MSD message
	2	stimulus	IVS establishes an eCall and sends an initiation message within 5s
	3	verify	PSAP transmits SEND MSD (START) message
	4	verify	PSAP verifies first MSD is received
	5	verify	Verify the MSD is correctly decoded
	6	check	MSD content at PSAP is identical to content transmitted by IVS
	7	verify	PSAP sends acknowledgement
	8	verify	Verify that the IVS has stopped transmitting the MSD

9.1.3.2 eCall Pull mode: MSD transmission / reception /acknowledgement

Interoperability Test Description			
Identifier:	TD_MAN_01		
Objective:	To verify that the PSAP, on receipt of the eCall, sends a SEND-MSG message without waiting for the initiation message from the IVS.		
Configuration:	eCall_CFG_01		
References:	[EN 16062 Clause 7.4.2		
Pre-test conditions:	• Ignition is ON and IVS is in mobile network coverage • MNO and PSAP test points are available • PSAP being configured on the mandatory PULL mode immediately transmit a SEND MSD (Start) message		
Test Sequence:	**Step**	**Type**	**Description**
	1	stimulus	IVS initiates an eCall
	2	verify	PSAP answers call and immediately transmits SEND MSD (START) message without waiting to the valid Initiation Signal
	3	verify	PSAP verifies first MSD is received
	4	verify	Verify the MSD is correctly decoded
	5	check	MSD content at PSAP is identical to content transmitted by IVS
	6	verify	PSAP sends acknowledgement
	7	verify	Verify that the IVS has stopped transmitting the MSD

9.1.3.3 *Voice communication after receipt of AL-ACK*

Interoperability Test Description			
Identifier:	TD_MAN_02		
Objective:	Verify that following transmission of the MSD and receipt of an application layer acknowledgement (AL-ACK) from the PSAP, the IVS and PSAP audio interfaces are reconnected and that 2-way speech is possible between the IVS and PSAP		
Configuration:	eCall_CFG_01		
References:	EN 16062 Clause 7.5.1		
Pre-test conditions:	• Ignition is ON and IVS is in mobile network coverage • MNO and PSAP test points are available • IVS has all the information needed to compile the MSD		
Test Sequence:	**Step**	**Type**	**Description**
	1	stimulus	IVS establishes an eCall
	2	verify	PSAP verifies the call is established
	3	verify	PSAP verifies first MSD is received
	4	verify	PSAP verifies the MSD is correctly decoded
	5	verify	Establishment of voice communication
	6	verify	Verify that 2-way speech can be exchanged
NOTE: this test case can be combined with 7.1.1 - TD_MAN_01			

9.1.3.4 Retransmission of MSD on request from PSAP

Interoperability Test Description			
Identifier:	TD_MAN_03		
Objective:	Verify that the IVS is able to recognise and act upon a request from the PSAP, during an ongoing speech conversation, to send or re-send an updated MSD		
Configuration:	eCall_CFG_01		
References:	EN 16062 Clause 7.6.2		
Pre-test conditions:	• Ignition is ON and IVS is in mobile network coverage • MNO and PSAP test points are available • IVS has all the information needed to compile the MSD • Background voice is applied at IVS prior to and during MSD transmission to verify that the IVS can recognise a request from the PSAP to re-send an MSD when a speech call is in progress		
Test Sequence:	**Step**	**Type**	**Description**
	1	stimulus	IVS establishes an eCall
	2	verify	PSAP verifies the call is established
	3	verify	PSAP verifies first MSD is received
	4	verify	PSAP verifies the MSD is correctly decoded
	5	verify	Establishment of voice communication
	6	verify	Verify that 2-way speech can be exchanged
	7	stimulus	PSAP pulls a second MSD
	8	verify	Verify the second MSD is received and correctly decoded

9.1.3.5 Speech after retransmission of MSD

Interoperability Test Description			
Identifier:	TD_MAN_04		
Objective:	Verify that following retransmission of the MSD and receipt of an application layer acknowledgement (AL-ACK) from the PSAP, the IVS and PSAP audio systems are reconnected and that 2-way speech is possible between the IVS and PSAP operator		
Configuration:	eCall_CFG_01		
References:	EN 16062 Clause 7.5.1		
Pre-test conditions:	• Ignition is ON and IVS is in mobile network coverage • MNO and PSAP test points are available • IVS has all the information needed to compile the MSD		
Test Sequence:	**Step**	**Type**	**Description**
	1	stimulus	IVS establishes an eCall
	2	verify	PSAP verifies the call is established
	3	verify	PSAP verifies first MSD is received
	4	verify	PSAP verifies the MSD is correctly decoded
	5	verify	Establishment of speech communication
	6	verify	Verify that 2-way speech can be exchanged
	7	stimulus	PSAP pulls a second MSD
	8	verify	Verify this MSD is received and correctly decoded
	9	verify	Establishment of 2-way speech communication
	10	verify	Verify that 2-way speech can be exchanged
<u>NOTE</u>: : this test case can be combined with 7.1.3 - TD_MAN_03			

9.1.3.6 Clear down / PSAP initiated network clear down

Interoperability Test Description				
Identifier:	TD_MAN_05			
Objective:	Verify that when the PSAP clears down the eCall, the IVS also clears down following receipt of the mobile network clear-down message			
Configuration:	eCall_CFG_01			
References:	EN 16062 Clause 7.5.5			
Pre-test conditions:	• Ignition is ON and IVS is in mobile network coverage • MNO and PSAP test points are available • IVS has all the information needed to compile the MSD			
Test Sequence:	**Step**	**Type**	**Description**	
	1	stimulus	IVS establishes an eCall	
	2	verify	PSAP verifies the call is established	
	3	verify	PSAP verifies MSD is received and correctly decoded	
	4	verify	Establishment of 2-way speech communication for 5 sec	
	5	stimulus	PSAP clears down the call / network clear-down	
	6	verify	Verify that the IVS clears down following receipt of network clear-down message	

9.1.3.7 Clear down / PSAP initiated application layer AL-ACK Clear-down

Interoperability Test Description			
Identifier:	TD_MAN_06		
Objective:	Verify that following receipt of an application layer AL-ACK clear-down message from the PSAP, the IVS clears-down		
Configuration:	eCall_CFG_01		
References:	EN 16062 Clause 7.5.5		
Pre-test conditions:	• Ignition is ON and IVS is in mobile network coverage • MNO and PSAP test points are available • IVS has all the information needed to compile the MSD		
Test Sequence:	**Step**	**Type**	**Description**
	1	stimulus	IVS establishes an eCall
	2	verify	PSAP verifies the call is established
	3	verify	PSAP verifies MSD is received and correctly decoded
	4	verify	Establishment of 2-way speech communication for 5 sec
	5	stimulus	PSAP clears down the call /application layer clear down
	6	verify	Verify that the IVS clears down following receipt of application layer AL-ACK clear-down message

9.1.3.8 Call Back / PSAP initiated call back to IVS

Interoperability Test Description			
Identifier:	TD_MAN_07		
Objective:	To verify that if an eCall has been successfully terminated by the PSAP, then the IVS shall allow a call-back into the vehicle		
Configuration:	eCall_CFG_01		
References:	EN 16062 Clause 7.10, 7.6.3 EN 16072 Clause 8.13		
Pre-test conditions:	• Ignition is ON and IVS is in mobile network coverage • MNO and PSAP test points are available • IVS has all the information needed to compile the MSD • PSAP must have received the CLI from the network		
Test Sequence:	**Step**	**Type**	**Description**
	1	stimulus	IVS establishes an eCall
	2	verify	PSAP verifies the call is established
	3	verify	PSAP verifies first MSD is received and correctly decoded
	4	verify	Verify that 2-way speech can be exchanged for 5 sec
	5	stimulus	PSAP clears down the call / network or application layer clear-down
	6	verify	Verify that IVS has cleared down
	7	stimulus	PSAP establishes a call back using CLI
	8	verify	Verify that 2-way speech can be exchanged

9.2 Test method for measuring GNSS receiver performance

NOTE: This method has been developed by the HeERO partner ISMB to assess the key performances of GNSS receivers. The methods are not currently allowing testing compliancy of GNSS receiver with given metrics or requirements. However, the test plan is a good basis for developing suitable GNSS conformance test specifications.

9.2.1 Overview and GNSS Definitions

9.2.1.1 Goal of the GNSS receivers assessment phase

It is important to underline the key role of the satellite navigation within the eCall framework. The position should not be only considered as a commodity, but also as a fundamental resource at the same level of the communication channel between PSAP and IVS. For this reason, it is important to provide recommendations about the selection of GNSS receivers and their exploitation in the frame of eCall applications. Moreover, it is worth to consider the exploitation of communications in order to improve the GNSS performance, in particular about the time of delivery of the first position once the receiver is powered on. The position is the most important information reported within the Minimum Set of Data (MSD). The most relevant parameters for the positioning function are:

- **Availability**: despite the global coverage of navigation systems, it is not always possible to obtain the position, also due to some physical obstacles that limit satellite visibility.
- **Accuracy**: it depends on several factors (e.g. satellite visibility, constellation geometry (characterized by the Dilution of Precision (DOP)), un-modelled ionospheric and tropospheric errors, multipath, jamming,).

The GNSS assessment phase within the eCall framework will represent an important opportunity to check the performances of a number of mass-market receivers in a wide range of conditions. Moreover, a further objective of these tests is to demonstrate the benefits of the modern GNSS, with respect to the eCall purposes. For example, the tests will quantify the improvement provided by a receiver operating in multi constellation mode with respect to the single constellation mode and by the application of EGNOS corrections.

It is important to remark that the objective is not to assess the current market offer in term of GNSS receivers, but to provide an instrument to improve the eCall stakeholder perception of the GNSS role. All the tests have been studied with the most objective criteria and will be performed by a team of experts in the field of navigation.

9.2.1.2 Key Performance Indicator

The KPI considered are:

- Sensitivity
- Accuracy
- Availability
- Time To Fix (TTF)

9.2.1.2.1 Sensitivity

Sensitivity is the lowest signal power [dBm] detectable by the Receiver under Test (RUT). It is usually measured within three different receiver operational phases:

- acquisition
- tracking
- re-acquisition

The acquisition sensitivity refers to the minimum signal level that allows the receiver to successfully perform the first PVT computation from cold start conditions within a specified timeframe. It is possible to define also a signal acquisition sensitivity as the lowest level at which a receiver can correctly identify the presence of the signal form a determined SV in the incoming RF signal within a given time-out interval; however this metric, not taking into account PVT is of less interest in the frame of the e-call.

The tracking sensitivity is the minimum signal level that allows the receiver to continuously provide a position with a specified accuracy. As with acquisition, a metric is also defined as signal tracking sensitivity: the lowest power level, at which the receiver tracks the signal from a determined SV.

The reacquisition sensitivity is the lowest level at which a receiver, having produced a position fix as described above, can directly regain signal tracking and use it in the navigation solution following a short outage. The outage time is to be defined (e.g. 5s). A possible test may foresee a PVT with four SV and the outage of a single SV.

9.2.1.2.2 Accuracy

Accuracy is defined as the magnitude of the distance between the true position and the position fix reported by the RUT at a specific instant. Different statistical metric are possible:

- 2D/3D mean error (and standard deviation)
- 2D/3D radius Circular Error Probability (CEP) or Spherical Error Probability (SEP). These contain the best 50% of all the position fixes.
- 2D/3D radius (of circle/sphere, centred at true position) containing the best 95% of all the position fixes.

To evaluate accuracy in static datasets, it is sufficient to have a reference coordinate (either a surveyed antenna location or the position fix programmed into a simulator). For dynamic sets, it is necessary to have an accurately time-tagged truth data set. CEP and SEP are typically evaluated for static data sets only.

It is possible to include the maximum error but it strongly depends on the measurements set used to perform the analysis, so it has a lower relevance.

9.2.1.2.3 Availability

Availability is defined as the relative percentage of a given testing interval during which a receiver has a valid position fix. Different metrics can be identified for this KPI.

9.2.1.2.4 Time to First Fix

An important aspect of receiver performance is how long it takes for a position fix after a "start" command is issued. The most important time intervals are:

- Time to first fix (TTFF). This metric varies (sometimes significantly) as a function of signal conditions and information available in receiver memory and/or through assistance messages;
- Time to reacquisition (TTR): subsequent to a signal loss during normal receiver operation, this is the amount of time from when signals are restored until the receiver reports a fix. This metric varies as a function of the outage duration, receiver motion during the outage, and signal conditions;
- Time to WADGPS Application (TWA): time required by receiver to provide a SBAS augmented position (EGNOS in Europe).

9.2.1.3 Methods for quantitative metrics calculations (accuracy)

The above-mentioned KPIs are quantitatively assessed by means of proper metrics extracted from the receiver observables, mostly under a statistical perspective. The association between KPIs and metrics is stated in 9.2.1.2. Here are described some useful equations and methods to appropriately compute performance metrics from the observed data when accuracy is considered. Other straightforward procedures are directly reported within the test descriptions.

9.2.1.3.1 Circular Error Probable

The Circular Error Probable (CEP) is the radius of circle that encloses 50 percent of the probability of a hit in two dimensions. Several methods are possible for computing the CEP. The chosen method is described by the following equation:

$$\text{CEP} = 0.5887\left(\sigma_x + \sigma_y\right) \qquad (1)$$

which has an accuracy of approximately 3 percent? This CEP is an integral of the bivariate (two- variable) Gaussian probability function in a plane. The parameters σ_x and σ_y are standard deviations of error along two perpendicular axes in a plane, and 0.5887 is a dimensionless constant that was derived using a 50-percent CEP in the integration of a bivariate Gaussian probability distribution.

9.2.1.3.2 Height Error Probable

The HEP can be calculated to determine an altitude error independent of the CEP and SEP. The SEP combines both horizontal and vertical errors. Since the vertical error is generally greater than the horizontal error, the SEP will be influenced dominantly by the vertical error; therefore, by computing the HEP, CEP, and SEP, one can better determine the distribution of the errors. A 50-percent HEP is given as

$$\text{HEP} = 0.6745\,\sigma_H \quad (2)$$

The derivation of this equation assumes a Gaussian probability function in the vertical direction. The parameter σ_H is the standard deviation of error in height.

9.2.1.3.3 Spherical Error Probable

The above result can be extended to the three-dimensional (3D) case: the SEP. The SEP is an integral of the trivariate (three-variable) Gaussian probability density function over a sphere, which is centred at the mean. Two equations were found to compute 50-percent SEP. The most common is:

$$\text{SEP} = 0.51\left(\sigma_x + \sigma_y + \sigma_z\right) \quad (3)$$

however, the most precise in terms of analytical approximations is

$$\text{SEP} = \sqrt{\sigma^2\left(1 - \frac{V}{9}\right)^3} \quad (4)$$

Where

$$\sigma^2 = \sigma_x^2 + \sigma_y^2 + \sigma_z^2$$

$$V = \frac{2\left(\sigma_x^4 + \sigma_y^4 + \sigma_z^4\right)}{\sigma^4} \quad (5)\ (6)$$

which allows to compute SEP to within 1 percent whenever $\sigma_y / \sigma_x \geq 0.5$.

9.2.1.3.4 Conversion factors among accuracy measures

The above accuracy metrics overall represent a measure of the average positioning error with a certain percentage of confidence.

Assuming Gaussian-distributed errors, a direct conversion is possible among the above-defined metrics. Such conversion factors are summarized in Table19.

Table 19: Comparison of GPS accuracy measures

Accuracy Description	Probability (%)	Conversion Factors			
		CEP	**rms**	**R95**	**2drms**
CEP – Circular Error Probable	50	1	1.2	2.1	2.4
rms or 1 Sigma – 1 standard deviation	63-68		1	1.7	2
R95 – horizontal 95% accuracy	95			1	1.2
2drms or 2 Sigma – 2 standard deviations	95-98				1

9.2.1.4 Initial conditions (TTFF)

The TTFF for a particular receiver strongly depends on initial conditions. The terms cold start, warm start, and hot start are widely used to describe starts with various pieces of information assumed available. The amount and type of information present in the receiver memory for the different mode can vary depending on the manufacturer. Sometime “factory start” is present. Usually producers foresee commands to force the receiver to restart from different conditions. In order to effectively compare different receivers the real information present need to be known.

9.2.2 Test Tree

In case the RUT is Galileo, GLONASS and/or EGNOS enabled the KPIs identified must be measured for all the systems and their possible combinations. The choice of testing a receiver only at its maximum capabilities (e.g. GPS + Galileo + GLONASS + EGNOS[1]), will exclude the possibility to highlight the different performances achievable through the exploitation of the different systems.

KPI must be measured also under two receiver dynamics: static and dynamic, at three signal-processing stages (states) of the receiver: acquisition, tracking and reacquisition.

However when the receiver is moving the choice is to highlight the overall receiver behaviour using metrics that consider together tracking and reacquisition performance.

For each group of three conditions (<receiver dynamic>, <GNSS>, <processing stage>), the appropriate metrics to quantitatively characterize the KPIs have to be extracted from the receiver.

[1] EGNOS currently provides augmentation for GPS only, but it can be exploited in principle for the ionospheric corrections for any system. Usually the way EGNOS corrections are used by different receivers is not declared by manufactures.

View of the test tree in the cases: static and dynamic.

DYNAMICS ⇓	KPI ⇓	RX STAGE ⇓	METRICS ⇓	TEST ID ⇓	METRIC ID ⇓
Static					
	Sensitivity				
		Acquisition			
			Signal strength @ position fix		
		Tracking			
			same		
		Reacq.			
			same		
	Accuracy				
		Acquisition			
			Mean error and max @ first fix		
		Tracking			
			Mean error and max		
			Radius 95% probable		
		Reacquisition			
			Mean error and max @ first fix		
	TTF				
		Acquisition			
			Mean TTFF and max		
		Reacq.			
			Mean TTF and max		

DYNAMICS ⇓	KPI ⇓	RX STAGE ⇓	METRICS ⇓	TEST ID ⇓	METRIC ID ⇓
Dynamic					
	Sensitivity				
		Tracking/ Reacquisition			
			SV (Rx/Tx)		
			Time (Rx/Tx)		
	Accuracy				
		Tracking/ Reacquisition			
			Mean error		
			Radius 95% probable		
			Max error		
	Availability				
		Tracking/ Reacquisition			
			Position		

For each test a specific set up will be defined in order to simulate/consider different operating conditions.

All the tests will be carried out using a NaV-X NCS signal generator with the exception of a set of dynamic tests to be performed also live in order to consider all the effects that cannot easily simulated.

9.2.2.1 Test Equipment and Setup

9.2.2.1.1 Overview

The following paragraphs describe test setups and hardware and software tools required.

9.2.2.1.2 Setup 1: Signal Generator

The use of a NavX signal generator foresees the connection of one or more (through a power splitter) GNSS receivers. This setup can be used to repeat comparative tests and log data for statistical purposes.

The noise level (noise power spectral density) produced by the generator must be known (e.g. -174 dBHz).

This allows the carrier-to-noise ratio to be detected by the receiver:

$$\frac{C}{N_0} = \frac{P_{RX}}{N_0} \quad \text{e.g., } P_{RX} = -125\,\text{dBm}, \frac{C}{N_0} = -125 + 174 = 49\,\text{dBHz}$$

provided that the losses in the cables, attenuators, DC blocks, and splitters and in the front-end have been compensated. A detailed discussion of the effects of losses in the components of the experimental setup can be found.

9.2.2.1.3 Setup 2: Live Different comparison receiver and reference

Figure 9.31 sketches the hardware required for the Setup 3 that can be adopted in live tests. Multiple RUT and one (possibly two) reference professional GNSS receivers are connected to the same antenna through a power splitter.

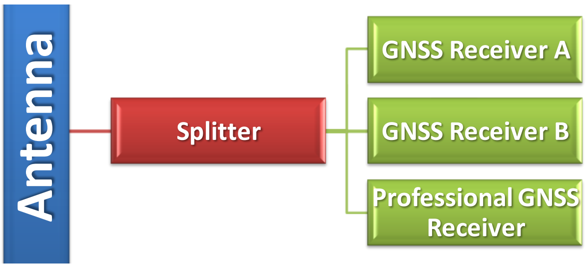

Figure 9.31: Test Setup 3: Live test.

The reference receiver can be exploited in order to provide information useful to reconstruct a path to be used as reference for positioning errors computation.

9.2.2.1.4 Required information about GNSS receiver

Being the tests objective a performance measurement, it is important to associate the result to a specific GNSS chipset. The most important information is listed in the following:

- brand;
- model;
- hardware version;
- firmware release version.

9.2.2.1.5 Required input to GNSS receiver

RUTs should be able to receive basic configuration commands for:

- constellation usage

- augmentation selection
- type of restart (cold, warm, hot).

For some tests, receiver configuration may not be required.

9.2.2.1.6 Expected output from GNSS receiver

For each test, the needed information from the RUT will be specified. used. The output parameters required are listed in the following:

- position;
- fix Indicator: it indicates if the position is (see message NMEA GPGGA):
  - invalid (not computed by receiver);
  - standalone computation;
  - DGPS (enhanced with LADGPS or WADGPS corrections).
- velocity;
- time;
- list of satellites in view with associated information:
  - Satellite ID;
  - Signal-Noise Ratio (C/N0).

NMEA output standard protocol includes all the data listed above. In conclusion, in order to perform the tests, the RUT must foresee one of the following modalities:

- direct communication access to the receiver chipset (e.g. via UART);
- NMEA output logging (data can be analysed after the test).

9.2.2.2 Receiver start modality

As mentioned above, the GNSS RUTs need to be started or restarted in different modalities; each of them is characterized by the valid information already available internally. It is possible to identify three different modalities:

- **Cold start**: the receiver has not any information about its own position or satellites orbits. Consequently, it has to perform an extensive search of the signals over all possible code delays/ Doppler frequency shifts pairs. Cold start is similar to factory default configuration (from navigation standpoint, the receiver is like a new one);

- **Warm start**: in this intermediate situation a receiver has access to some data as a rough initial position (e.g. last position before powering down the receiver), and to the almanac (fundamental orbital parameters) relatively up to date (e.g. via external sources or stored at power down). With this information, the receiver is able to predict which satellites should be in view, and estimate their rough code delay and Doppler frequency shift; hence, it will able to narrow down the acquisition search space and speed up the process.

- **Hot start**: the receiver has information about its rough position and the ephemerides of the satellites, hence greatly reducing the acquisition search space, improving the time to acquire and therefore the final TTFF.

9.2.2.3 Naming conventions

9.2.2.3.1 Test Identifier

Each test listed in the next section is identified by an ID code:
T-<dynamics>-<receiver stage>-M<operation mode>-G<system>-E<environment>
where:

- dynamics can be STA (static) or DYN (dynamic)
- receiver state can be ACQ (acquisition), TRK (tracking) or REA (reacquisition)
- Operation mode identifies the applicable signal/receiver setup, appropriately specified for each test (for example it indicates if receiver is in cold start):
    - CS (cold start)
    - WS (warm start)
    - HS (hot start)
    - AS (assisted from cold conditions)
- system can be
    - G (GPS)
    - GS (GPS + EGNOS)
    - GE (GPS + Galileo)
    - GR (GPS + GLONASS)
    - GRE (GPS + GLONASS + Galileo)
    - GRES (GPS + GLONAS + Galileo + EGNOS)
- Environment is indicated in the case of dynamic tests where it can be
    - SIM (simulated)
    - LIV (live)

9.2.3 Tests Plan

Each test is identified by an ID code and described by a test summary table, which reports the ID, the scope of the test, the observables to be monitored during the test, the KPIs assessed by the test and the applicable test setup.

For each test, the detailed testing procedure is then reported, described systematically. The testing procedures include both in-line processing and post-processing.

Finally, the performance metrics to be produced by each test are summarized in a test report table.

As general indication, all the test metrics should be related to the average values of xDOP (Dilution Of Precision), so as to take into account the effect of the geometry (it is reasonable to expect that the test results obtained with full constellation are better than those obtained with a reduced constellation and poorer geometries). For the test conducted in the static scenario case, the simulated constellation is always the same.

9.2.3.1 Static Tests

9.2.3.1.1 T-STA-ACQ-Mx-Sx: Acquisition in static condition

Acquisition tests shall be executed for all the start modes permitted by the receiver.

Test summary

TEST ID	**T-STA-ACQ-M<operational *mode*>-S<*system*>**
Purpose	Measure the receiver acquisition performance with a simulated set of signals
Description	The receiver is fed with signal coming from a set of simulated SV. The power is increased by steps in order to determine at which power level the receiver is able to gain a fix within the timeout.
Required output	• Position • Time • Satellites in view
KPI	• Sensitivity • Accuracy • Time to fist fix

Test procedure

The simulator is set to generate a constellation of eight satellites with different signal levels.

Cold start with or without assistance:

- Cold start command is sent to the RUT (in case assistance is provided)
- Simulation is started at the minimum signal level (-170dBm for the most powerful satellite, others will have decreasing power by steps of 1.5dB) for a duration of 5 minute or less in case a position fix I achieved.

- The previous steps are repeated for a power level step of 3dB.

Hot and Warm start:

- Cold start command is sent to the RUT
- Simulation is started at the maximum signal level (in order to let the receiver to decode the navigation message) for 5 minutes (start time: 5 minutes before the time set in the cold start simulation in order to have the same conditions)
- Hot/Warm start command is sent to the receiver.
- Simulation is continues at the minimum signal level (-170dBm for the most powerful satellite, others will have decreasing power by steps of 1.5dB) for a duration of 5 minute or less in case a position fix is achieved.
- The previous steps are repeated for a power level step of 3dB.

Test is repeated a number of times in order to draw statistics.

Test output

Mean power level for a valid fix (and standard deviation)
Mean positioning error at the first fix (and standard deviation)
Mean time to first fix (and standard deviation)

9.2.3.1.2 T-STA-G-TRK-Mx-Sx: Tracking in static condition

Test summary

TEST ID	**T-STA-TRK-M<operational *mode*>-S<*system*>**
Purpose	measure the receiver tracking performance with a simulated signal
Description	The receiver is fed with signal coming from a set of simulated SV. The power is decreased by steps in order to determine at which power level the receiver is able to maintain the SV tracking.
Required output	• Position • Time • Satellites in view
KPI	• Signal level • Accuracy

Test procedure

The simulator is set to generate a constellation of eight satellites with different signal levels.

- Simulation is started at the maximum signal level (-130dBm for the most powerful satellite, others will have decreasing power by steps of 1.5dB) for 5 minutes in order to let the receiver to get a valid fix
- Simulation continues at -133dBm for 20s
- Steps of -3dB follows until the position is no more available.

Test is repeated a number of times in order to draw statistics.

Test output

Mean power level for the last valid fix (and standard deviation)

Mean positioning error at the last fix (and standard deviation)

9.2.3.1.3 T-STA-REA-Mx-Sx: RE-acquisition in static condition

Test summary

TEST ID	**T-STA-REA-M<operational *mode*>-S<*system*>**
Purpose	Measure the receiver reacquisition performance with a simulated signal
Description	The receiver is fed with signal coming from a set of simulated SV. The signals are switched off for a while (1s). This is done at different power levels in order to determine at which power level the receiver is able to regain a fix within the timeout.
Required output	• Position • Time • Satellites in view
KPI	• Sensitivity • Accuracy • Time to fix

Test procedure

The simulator is set to generate a constellation of eight satellites with different signal levels.

- Simulation is started at the maximum signal level (-130dBm for the most powerful satellite, others will have decreasing power) for 5 minutes in order to let the receiver to get a valid fix
- Signals (one or more: see note) are switched off.
- Signals are switched on with the same signal level (-130dBm for the most powerful satellite, others will have decreasing power) for duration of 5 minutes or less in case, a position fix is achieved.

- The previous steps are repeated for a power level step of 3dB.

Test is repeated a number of times in order to draw statistics.

Test output
Mean power level for a valid reacquisition and fix (and standard deviation)
Mean positioning error at the fix after reacquisition (and standard deviation)
Mean time to fix (and standard deviation)

Note
For this test is possible to perform the test with the blockage of three, nine or all the satellite.

9.2.3.1.4 Note on EGNOS cases.

When the <*System*> field foresees EGNOS (GS and GRES), the fix is intended to be achieved when the issued position is flagged as DGPS

9.2.3.2 Dynamic Tests

9.2.3.2.1 T-DYN-TRK-Sx-Ex: Tracking in Dynamic conditions

Tracking tests shall be executed with the simulator or live along a defined path. Dynamic tests will be conducted under different environmental conditions identified by the E field.

Test summary

TEST ID	**T-DYN-TRK-S<*system*>-E**
Purpose	measure the receiver tracking performance with a simulated signal and live
Description	The receiver is fed with signals coming from a set of simulated SV or real ones.
Required output	• Position • Time • Satellites in view
KPI	• Sensitivity • Accuracy • Availability

Test procedure Simulated signals

The simulator is set to generate a constellation of eight satellites with different signal levels. After a proper, time the receiver starts moving.

- A path is set
- Signal level are varied along the path (different variation pattern including blockage will be defined)
- On or two multipath are added to some signal with varying intensity.

Test procedure Live

The entire receiver must be tested at once along the test track in order to guarantee uniform results. After a proper, time the vehicle starts.

Two paths are defined in:

- Urban conditions
- Highway

Test output

Simulated/received signals ratio
Mean positioning error (and standard deviation)
Position availability (time %)

9.2.3.3 Presentation of the Test Results

The exposition and the format of the results mainly depend on the KPI analysed within the tests, as described in the following paragraphs.

9.2.3.3.1 Sensitivity

Sensitivity results will be presented in tables including power thresholds.

9.2.3.3.2 Accuracy

Accuracy results will be presented in tables including average value at different power levels. In addition, for the dynamic tests, graphics showing the error evolution versus time will be produced.

9.2.3.3.3 Availability

Availability results will be presented in tables including percentage of valid position with respect to the total test time.

9.2.3.3.4 Time to Fix

The time to fix results will be presented in tables including average and maximum values

9.3 Examples of Test beds

9.3.1 Anritsu test bed

Anritsu propose a test system for testing IVS modules from a High Level Application Protocol perspective (EN 16062). It covers some parts of IVS HALP test cases specified in the end-to-end conformance document CEN/TS 16454:2012.

The Anritsu eCall tester system is composed of PSAP testing interface (MX703330E) running on a computer controlling the Network simulator MD8475A. The tester can validate the transmission of the MSD (PUSH/PULL) and allow end-to-end voice communication. The MSD received can be compared with a reference MSD. It allows negative testing and Time-out testing for eCall modules test. The solution can also automate the IVS if it supports AT interface.

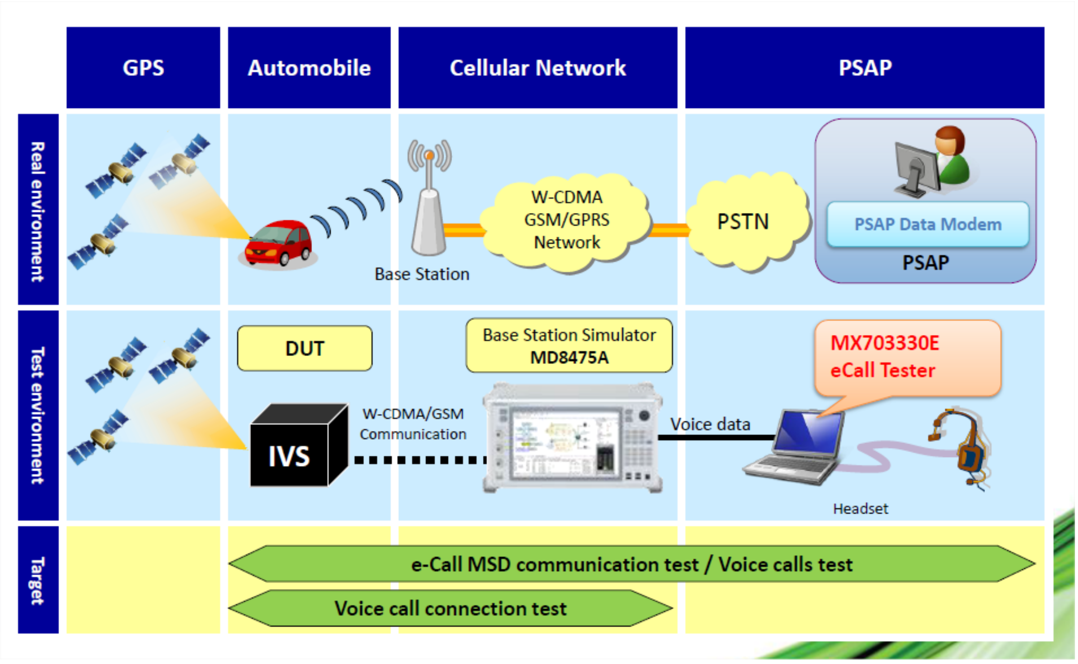

Figure 32: Anritsu eCall Test Setup for tests according to EN 16062 and CEN/TS 16454:2012

9.3.2 CTAG test bed

CTAG has a complete test bed for IVS, which combines a crash test (non-destructive) with an end-to-end conformance tests for CEN and 3GPP standards (see.6.2).

This solution allows validating the IVS while reproducing a complete eCall chain in a laboratory. It uses different methods to achieve highly representative results at a relative low cost.

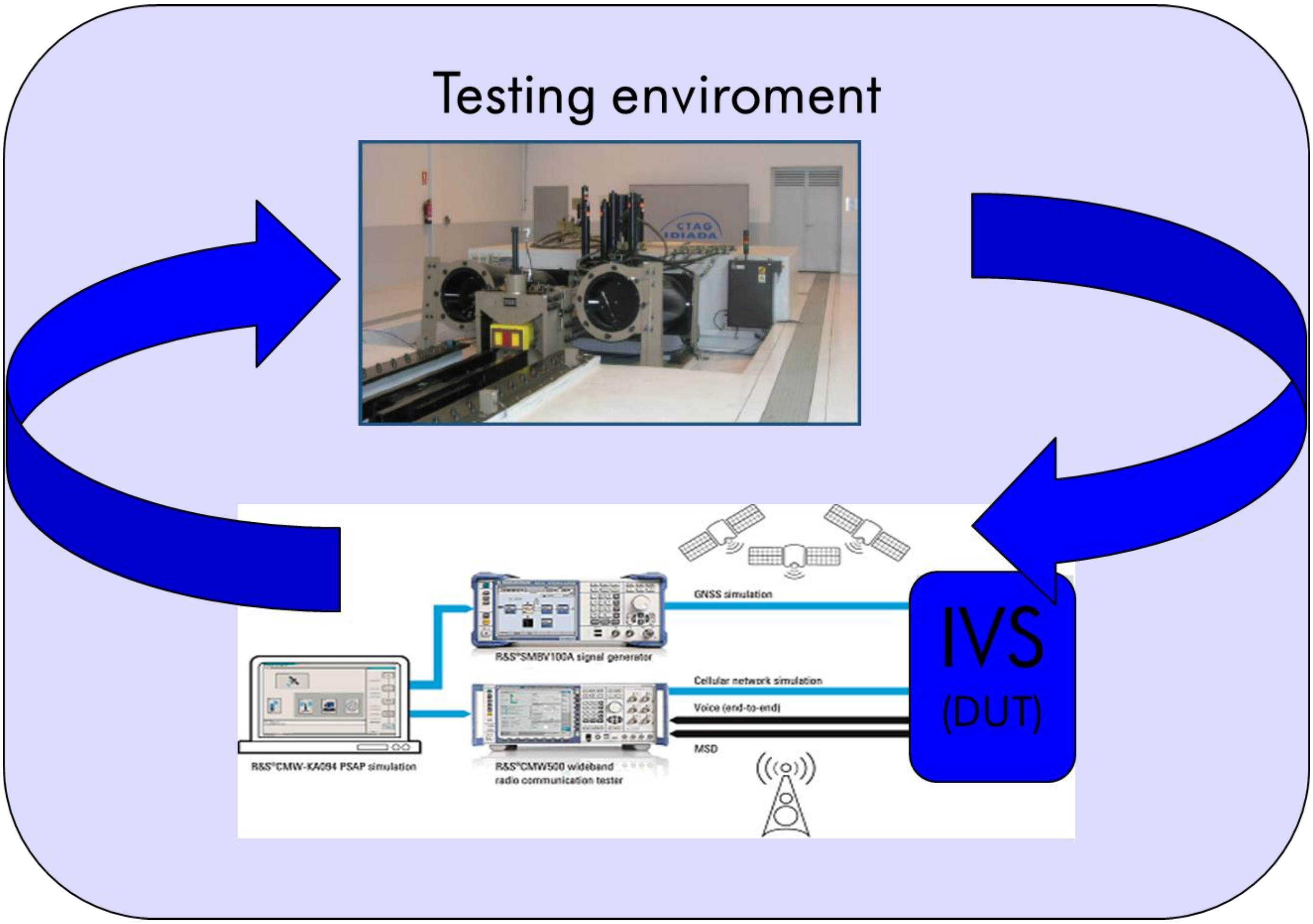

Figure 33 CTAG test bed

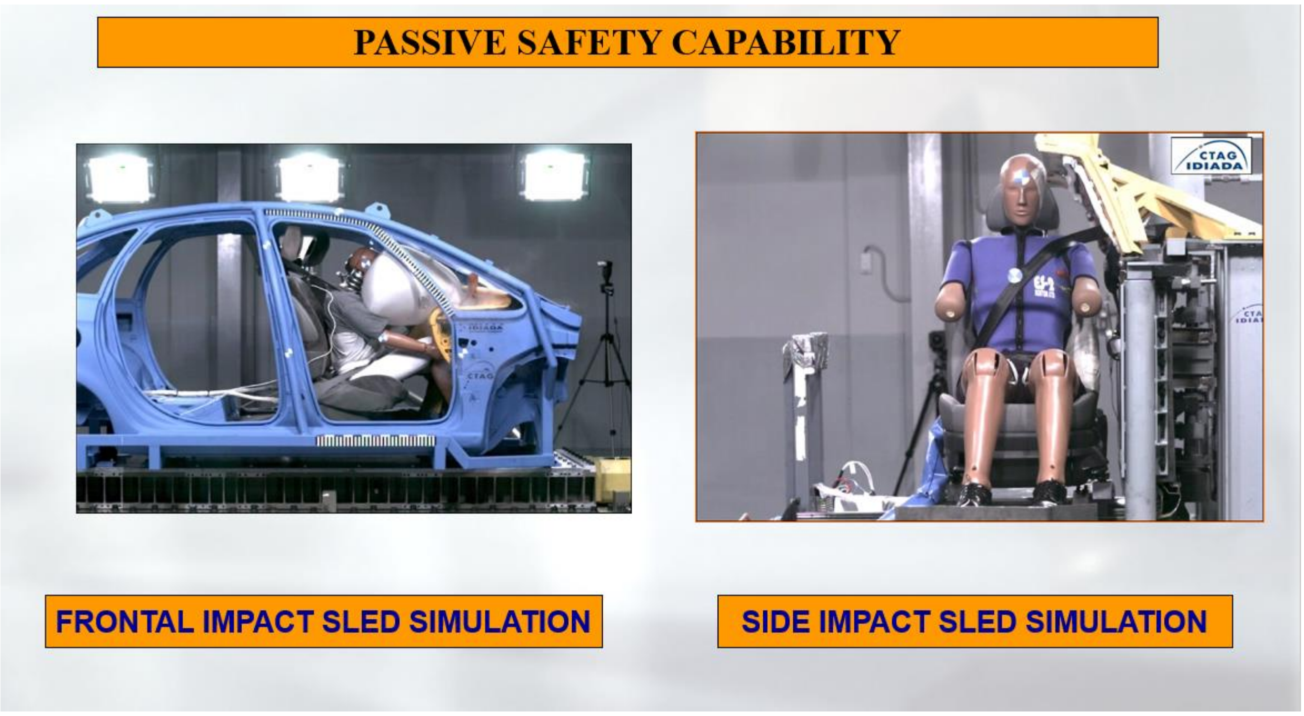

Figure 34 Non-destructive crash-testing capacities

The different facilities offered in this test bed in order to carry out the test procedure are the following ones:

- A hydraulic inverse acceleration catapult for the simulation of frontal, side and rear collisions, with the following main characteristics (see Figure 35):
  - 2,000 kN rated force.
  - Maximum acceleration: 65 G with 1,500 kg load.
  - Maximum deceleration of 50 G (for side impact).
  - Maximum velocity of 81 km/h with a maximum load of 1,500 kg.

- Rohde and Schwarz test bed for eCall testing, described deeply in the section **Error! Reference source not found.** of this document, with the following components:
  - R&S®SMBV100A vector signal generator, which provides GNSS signal during the test
  - R&S®CMW500 verifies if the IVS is in line with the eCall standards

- Additional equipment needed to carry out the tests, such as:
  - A GNSS repeater to amplify and increase the GNSS signal coverage inside the laboratory
  - Tools that reproduce the airbag deployment trigger signal in the CAN network or equivalent, this signal will launch the eCall Automatic calls.

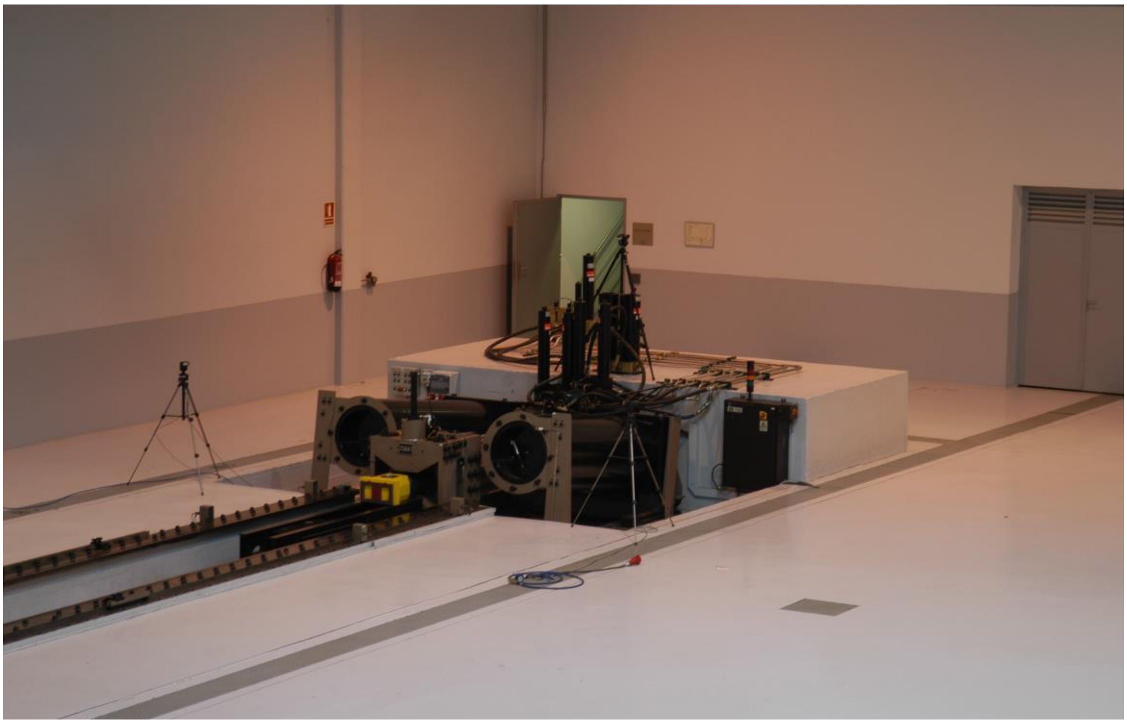

Figure 35 CTAG's Hydraulic inverse acceleration catapult

The testing procedure defined for Automatic eCall is described below:

1. Installation and test setup: In this first stage, the IVS is installed in a frame or test dashboard in the same position and with the same harness and attachments as the original car and dash.
2. Functional Test before crash test: the IVS will be tested against the R&S test-bed in order to verify the IVS fulfil all requirements prior the crash test
3. Crash test: the crash test is carried out in the inverse catapult and the airbag deployment signal is activated (or equivalent) in order to launch an automatic eCall
4. Functional Test after crash test: the IVS is tested again with the R&S test-bed to check if the eCall has been launched during crash and there is no degradation in the functionality.

Figure 36 Testing procedure proposal

9.3.3 HEAD acoustic test bed

The HEAD acoustics test setup for eCall audio performance testing in laboratory environment represents the suggested test setup for hands-free audio performance testing in Recommendation ITU-T P.1100 (“Narrowband Hands-free Communication in Motor Vehicles”) or GOST R-55531 (“In-Vehicle Emergency Call System Compliance Test Methods for Quality of a Speakerphone in a Vehicle”). The figure 37 shows the ITU-T recommended setup. The HEAD acoustics implementation is shown in the figure 38.

The setup is also applicable for wideband communication as given e.g. in Recommendation ITU-T P.1110 (“Wideband hands-free communication in motor vehicles”).

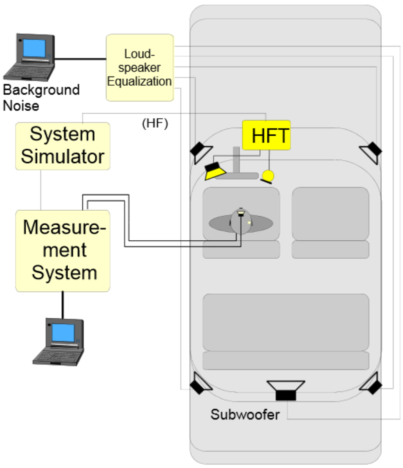

Figure 37: Recommended test setup acc. to ITU-T P.1100 / P.1110 for HFT testing

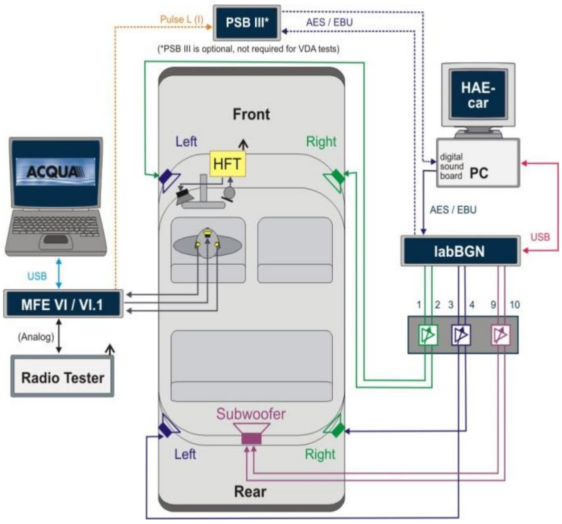

Figure 38: HEAD acoustics test setup for eCall and HFT testing (example: artificial head positioned on drivers' seat)

It consists of

- head and torso simulator (HATS according to ITU-T P.581)
- background noise simulation system according to ITU-T P.1100
- HEAD acoustics test system ACQUA and necessary frontends (MFE VI.1, labBGN)
- radio network simulation (Radio Tester)

The tests implemented in the test system itself are subdivided in the different conversational dimensions like

- one-way speech transmission tests in sending (uplink),
- one-way speech transmission tests in receiving direction (downlink),
- echo performance tests,
- tests in the presence of background noise and
- tests under double talk conditions.

It is recommended to distinguish between two eCall scenarios, i.e. the use of the eCall system from the vehicle involved in the accident (1) and the use of the eCall system from passing-by vehicle (vehicle not involved in the accident, (2)). Different test conditions and test cases are relevant:

- (1) Vehicle involved in the accident: tests relevant for different positions in the car (microphone sensitivity, playback volume), the eCall background noise scenario for laboratory testing (e.g. parked car near highway, windows open, background voice babble).
  Suggested tests: Tests based on ITU-T P.1100 and P.1110 with eCall specific test adaptations and extensions
- (2) Passing-by vehicle: tests relevant only for the driver, microphone sensitivity for drivers' voice, playback volume to be tested at drivers' position, background noise scenarios for laboratory testing from driving car (e.g. 130 km/h).
  Suggested tests: according to ITU-T P.1100 and P.1110

The following tests are suggested (not exhaustive)

One-way speech transmission tests in sending (uplink)

Sending Loudness Rating (SLR) for different speaker positions (drivers' seat, passenger first row), Automatic Gain Control (AGC) for different speaker positions, Sending Frequency Response, Listening speech quality TMOS, Listening effort (under study), all tests with HATS on drivers' seat and passenger seat (first row)

One-way speech transmission tests in receiving (downlink)

Receiving Loudness Rating (RLR) for different HATS positions, nominal playback volume setting for SNR ≥ 6 dB at drivers' position (eCall background noise scenario), Automatic Gain Control (AGC) for HATS positions, Receiving Frequency Response, Listening speech quality TMOS, Listening effort (under study for eCall scenarios), all tests with HATS on drivers' seat and passenger seat (first row).

Echo performance tests

Echo attenuation under single talk condition (nominal, maximum volume), echo level vs. time (nominal, maximum volume), spectral echo attenuation (nominal, maximum volume).

Double talk performance tests

Characterisation of double talk performance for nominal playback according to Recommendation ITU-T P.340 and P.1100/P.1110 respectively (HATS on different positions in the vehicle, different requirement for different positions)

Tests in the Presence of Background Noise

Background noise modulation with far end speech, speech and noise transmission quality acc. to ETSI EG 202 396-3 (focus on S-MOS scores for (1), N-MOS informative only), transparency of transmitted background noise (only relevant for scenario (1), test under study).

Use of real speech as test signals as described in Recommendation ITU-T P.501.

9.3.4 IDIADA test bed

IDIADA offers a solution for reproducible accident detection tests of eCall In-Vehicle Systems.

The IDIADA crash test laboratory is made up of two acceleration tracks of 160 and 90 meters converging symmetrically on a 33 x 33 m test area. A system guided by pulleys consisting of an underground wire driven by a 500 kW DC electric motor pulls a 2.8 x 1.8 meters convertible sled platform. It is used to perform multiple deceleration pulses as ECE R16, ECE R17, ECE R44, etc.

Figure 39: IDIADA test area

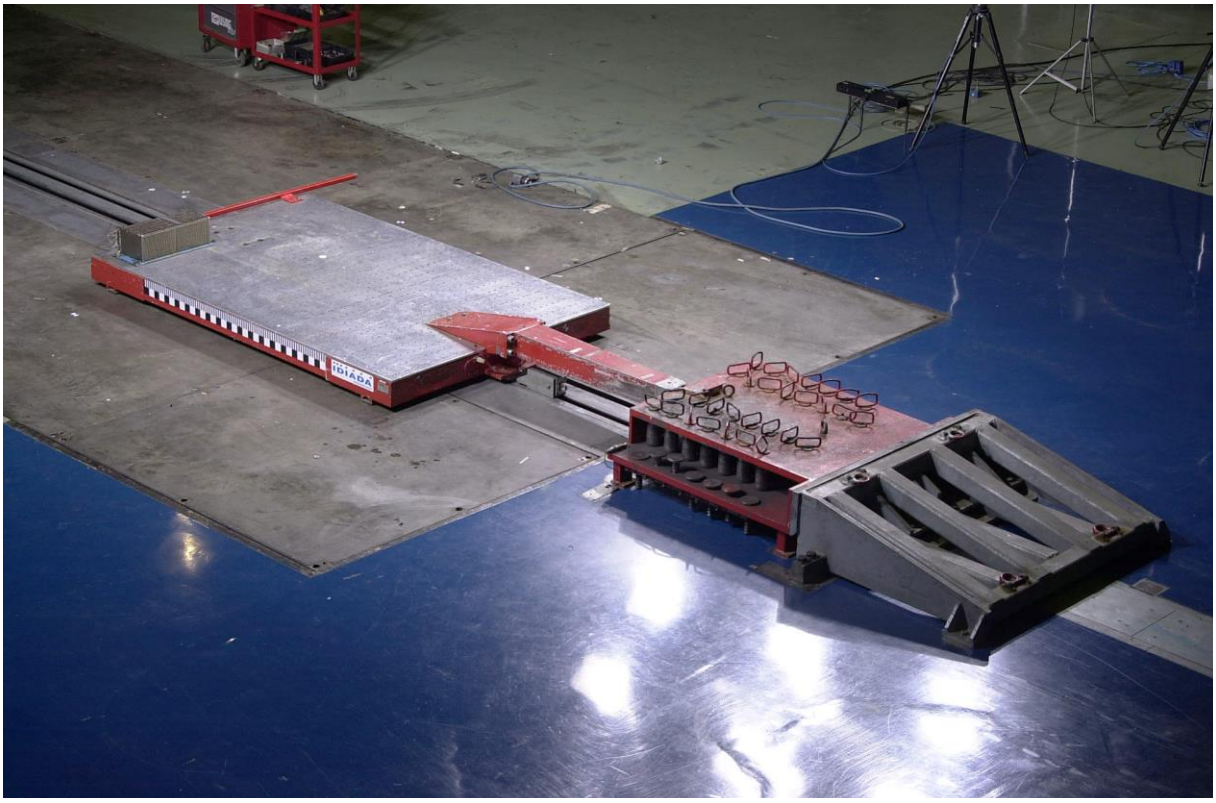

Figure 40: Sled platform

9.3.5 NavCert Test bed

NavCert operates an accredited laboratory in the scope of eCall. NavCert use an eCall simulator based on TTCN definition of the EN 16454. NavCert performs the performance tests for the above-defined KPIs.

9.3.6 Rohde & Schwarz test bed

Rohde & Schwarz offers a solution for reproducible end-to-end conformance tests of eCall modules in line with CEN/TS 16454:2012 and 3GPP TS 102.936-1.

The R&S®CMW-KA094 eCall application software simulates a PSAP and remotely controls the R&S®CMW500 wideband radio communication tester to emulate a cellular network in the lab. The test software also controls the R&S®SMBV100A vector signal generator, which provides GNSS coordinates required by the IVS to compile the MSD. This setup makes it possible, for example, to test if the IVS modem is able to trigger an eCall, send the correct MSD data and establish a voice connection with the PSAP.

Controlled by R&S®CMW-KA094 software, the R&S®CMW500 verifies if the IVS is in line with the eCall standards. This includes for example the test of PUSH mode, PULL mode, MSD transmission time, MSD decoding and recording of un-decoded IVS audio signals.

The test sequencer R&S®CMWrun enables the user to automatically run the CEN/TS 16454 conformance tests unattended in addition to the interactive user interface.

In addition to conforming to the eCall specification, the GNSS receiver performance of an IVS module is important in terms of accuracy and for determining correct coordinates even under weak signal conditions. Being a full-fledged satellite simulator for GNSS, the R&S®SMBV100A is used for testing the capabilities and performance of GNSS receivers.

Summary: The computer-based R&S®CMW-KA094 eCall test software in combination with the R&S®CMW500 and R&S®SMBV100A is a solution for standard-compliant conformance testing of IVS modules. Moreover, the satellite simulation capabilities of the R&S®SMBV100A also allow detailed testing of GNSS receiver performance.

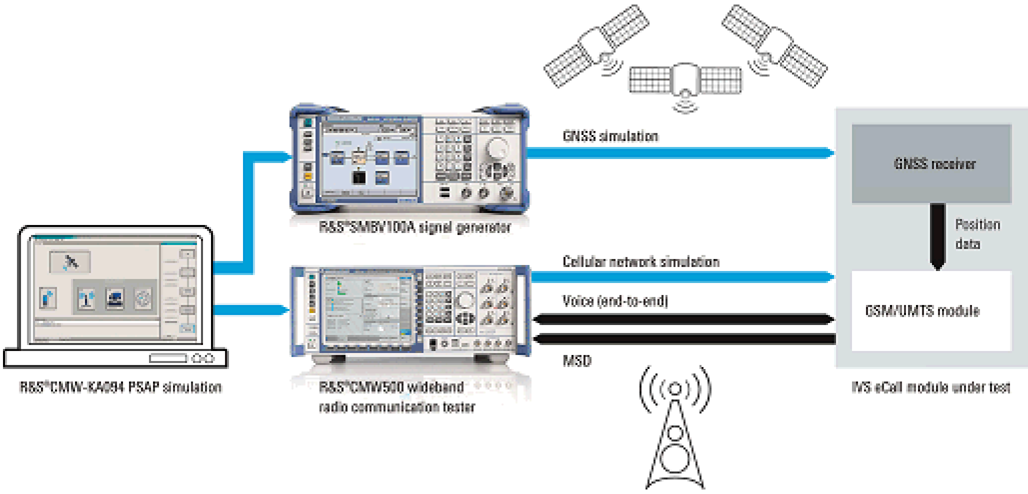

Figure 41: Rohde & Schwarz eCall Test Setup for tests according to CEN/TS 16454:2012

Based on the R&S®CMW500 wideband radio communication tester, the 3GPP TS 51.010-1 and 3GPP TS 34.123-1 protocol conformance test cases required for GCF certification are available with options R&S®CMW-KC233 and R&S®CMW-KC433.

The Rohde & Schwarz TS8991 OTA performance test system is a turnkey solution that includes an anechoic chamber, test instruments and test software to perform over-the-air (OTA) performance measurements in line with CTIA and 3GPP standards. Passive antenna measurements with network analysers are supported as well.

The R&S®TS8991 test system sets up a connection to the EUT over the air interface and then measures both the radiated power and the receiver sensitivity at different bands and channels of the wireless device in all spatial directions. This yields the relevant parameters such as total radiated power (TRP) and total isotropic sensitivity (TIS), while the 3D radiation diagrams directly show the spatial distributions. Both cellular radio interfaces and WLAN/Bluetooth are supported.

The R&S®TS8991 test system is typically equipped with a R&S®CMW500 wideband radio communication tester to emulate a cellular network, R&S®OSP120 RF switching unit and R&S®ZVL network analyser for calibration. Various test instrument configurations cover the customer specific requirements.

The comprehensive R&S®AMS32 antenna measurement software provides test template for all common wireless standards. The templates require no programming and are ready to use. Tests can be easily configured using a menu-driven setup for parameters such as cellular band, channel list and power level.

The integrated report function of the R&S®AMS32 software compiles all measured data such as graphical and numerical results, test environments, EUT data and hardware setup in a single document. The report layout can be customized, and the result file saved in several different standard formats.

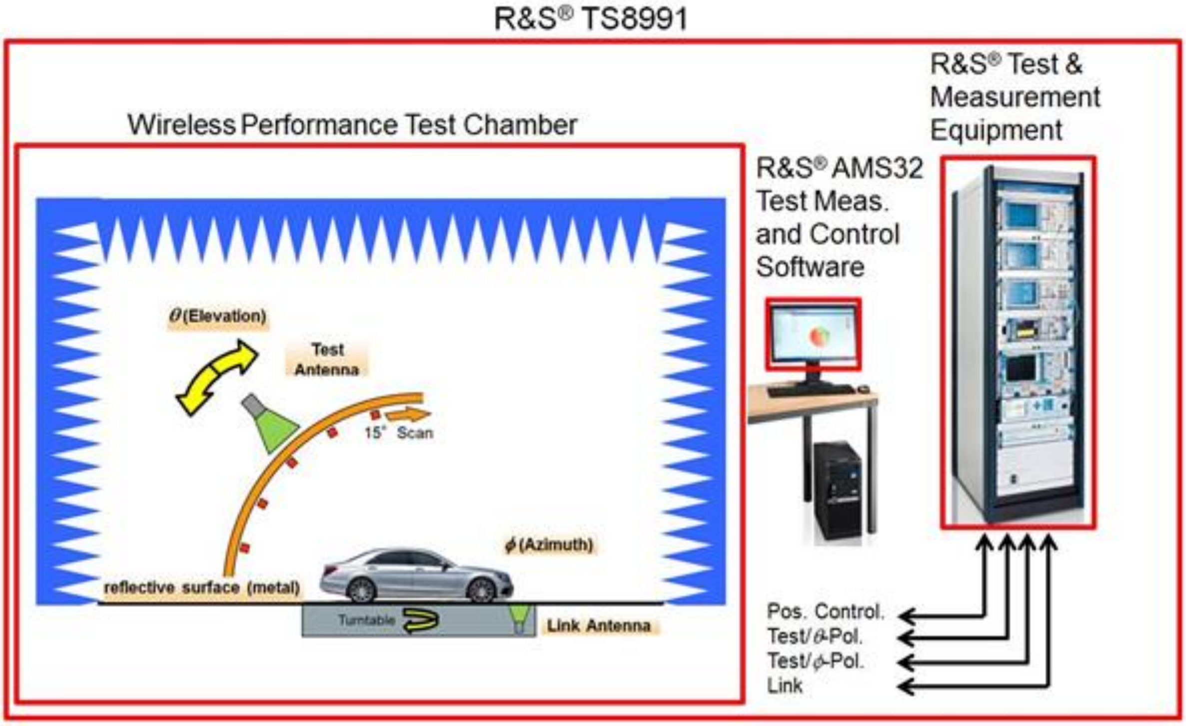

Figure 42: R&S TS8991 OTA performance test system