



eCall Phase 2

Technical requirements and test procedures for the type-approval of eCall in-vehicle systems

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type-approval of eCall in-vehicle systems

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Executive summary

The eCall Regulation (Regulation (EU) 2015/758) empowers the European Commission (EC) to adopt delegated acts defining “*the detailed technical requirements and tests for the EC type-approval of vehicles in respect of their 112-based eCall in-vehicle systems and the EC type-approval of 112-based eCall in-vehicle systems, components and separate technical units*” and delegated and implementing acts regarding privacy and data protection.

TRL has developed draft proposals for technical requirements and test procedures for the following seven technical aspects, and provided justifications for the selection of these procedures. The proposed assessment procedures are either based on:

- Potentially destructive, physical tests (e.g. impact sled deceleration tests, or the full-scale impact tests) and subsequent verification of sustained functionality (e.g. by performing test eCalls); or
- Provision of documentation covering a wide range of functional requirements (e.g. items covered by the self-test function, or failures of the TPS system) and physical verification tests of exemplary cases (e.g. simulating one failure of the eCall system to verify the self-test capabilities).

Resistance of eCall systems to severe crashes (sled test assessment):

A deceleration or acceleration test using a representative arrangement of parts (without a vehicle body) was found to be most suitable to assess this aspect. An appropriate test severity was established based on published impact test results and a representative test corridor with a peak deceleration level of 65g to 77g, maintained for at least 4 milliseconds, was defined. It was found that deceleration events have to be carried out in six directions (3 perpendicular orientations, each in positive and negative direction) on all parts required for the eCall system to successfully populate and transmit the MSD in order to sufficiently assess the system performance. A test call to a PSAP test point was found to be the most suitable way to verify the sustained functionality regarding emission of the minimum set of data (MSD), positioning, incident time determination, and mobile network connectivity.

Full-scale impact test assessments:

The full-scale assessments were developed to be carried out alongside UN Regulation No. 94 (frontal) and UN Regulation No. 95 (lateral) impact tests. The most suitable way to ensure successful automatic triggering and verify sustained functionality of the eCall system was found to be two subsequent test calls to a PSAP test point after the impact: An automatic call to verify successful automatic triggering and a manual call to verify the sustained functionality of the manual triggering device (eCall button). It was established that six further aspects needed to be verified post-crash to ensure sufficient system performance for type-approval: Call status indication, MSD emission, determination of vehicle-specific data, mobile network connectivity, sustained power supply and audio equipment functionality (see next item).

Crash resistance of audio equipment:

A verification procedure to be carried out on a vehicle post-full-scale impact test was defined to ensure the sustained functionality of the audio equipment (loudspeakers and microphones). It was established that a procedure based on a test call to a PSAP test point and exchange of test sentences between test engineers via the voice

channel in single talk mode would be sufficient to rule out catastrophic failures of the audio equipment after an impact according to UN Regulation No. 94 and 95. For type-approval, the verification procedure requires that the test engineers are able, with any feasible effort, to understand the meaning of the sentences transmitted.

Co-existence of third party services (TPS) with the 112-based in-vehicle systems:

A combination of documentation and physical testing was found to be most suitable for assessing this aspect. The documentation shall cover all relevant failure conditions of the TPS system and how it will behave on their occurrence. Additionally, it shall provide an explanation of the principles of the changeover mechanism. Two test calls in an un-crashed vehicle (TPS in working order and in a state where it does not function, respectively) were established as suitable means of assessing the changeover mechanism and the requirement of mutually exclusive activation in a physical verification test.

Automatic triggering mechanism:

In addition to the physical automatic triggering verification during the full-scale impact tests, documentation is required to ensure via type-approval that the triggering mechanism and threshold do not only cover collisions of a similar configuration and similar or higher severity as represented by the UN Regulation No. 94 and 95 full-scale tests. A dossier of information containing documentation such as airbag control unit specification drawings, specification data notes, signal chain description, sensitivity drawings, or similar documents was found to be sufficient to demonstrate, for example, a positive link between the event notification signal for deployment of a restraint device and eCall triggering.

In-vehicle system self-test:

A combination of documentation and physical testing was found to be most suitable for assessing this aspect. A comprehensive set of self-test capabilities, sufficient to ensure appropriate malfunction indication, was defined based on technical feasibility considering different system designs and architectures. These items are suggested to be included in a self-test on a compulsory basis unless there are inherent technical reasons in the chosen system design or architecture that are prohibitive of monitoring certain items. A physical verification test on a vehicle or representative arrangement of components, assessing the detection and indication of one exemplary malfunction, was considered sufficient to approve this aspect.

Privacy and data protection:

This aspect was included in form of an overview only and an initial exploration of the potential technical requirements, test procedures and practical arrangements, which could be used in delegated/implementing acts, is provided. Key aspects included are: Suggestion of a maximum time period of 13 hours for data retention in the IVS; suggestion of potential security measures such as appropriate use of cryptography or physical separation between TPS and 112-based system; suggested verification that no network registration is performed in the idle/dormant state of the 112-based system using a mobile network simulator; suggested software interrogation of the 112-based system to verify that the number of stored vehicle locations is limited to three.

The justifications provided for the requirements and test procedures also include a discussion of potential options for the setup of test eCalls in a type-approval environment. Physical test work was involved in developing the sled test procedure (resistance of eCall systems to severe crashes); the work for the remaining tasks was desk-based, i.e. without physical testing being performed.

The draft proposals developed for this project address not only the type-approval of vehicles (in respect to their eCall IVS), but some of them are also applicable for the approval of components and separate technical units (Table 1).

This study aimed to sufficiently cover the technical aspects outlined above and the developed draft proposals might, in their current or in an adapted version, form part of the EC's proposed delegated/implementing acts for eCall type-approval. Other aspects (such as audio performance measurements, positioning performance tests, wireless communication performance tests, power supply performance tests, HMI requirements and conformance to relevant technical standards) were not included in this work assignment and the draft proposals were developed under the assumption that these areas, if considered relevant by the EC, were covered elsewhere. Note that this report and the proposals are the outcome of TRL's technical work and do not necessarily reflect the view of the EC.

The work for this project was closely related to the parallel work on a UN Regulation under the 1958 Agreement. The informal working group Automatic Emergency Call Systems (AECS), organised under the Working Party on General Safety Provisions (GRSG), is currently in the process of developing a draft regulation for AECS (eCall is the European implementation of AECS). TRL attended the last six working group meetings (3rd to 8th meeting) in order to participate in the discussions and to ensure, where possible and suitable, sufficient alignment between the UN and the EU requirements. For the current project this was particularly relevant with regard to the requirements for resistance of eCall IVS to severe crashes.

Table 1: Overview of the applicability of the draft proposals for the approval of vehicles, components and separate technical units (x=applicable)

	Vehicle approval	Component approval	Separate technical unit approval
Resistance of eCall systems to severe crashes (sled test assessment)	x	x	x
Full-scale crash test assessments	x		
Crash resistance of audio equipment	x		
Co-existence of third party services	x	x	x
Automatic triggering mechanism	x		
In-vehicle system self-test	x	x	x

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1 INTRODUCTION

On 19th May 2015, the eCall Regulation (Regulation (EU) 2015/758¹) was published in the Official Journal. The European Commission (EC) is now empowered to adopt delegated acts defining *“the detailed technical requirements and tests for the EC type-approval of vehicles in respect of their 112-based eCall in-vehicle systems and the EC type-approval of 112-based eCall in-vehicle systems, components and separate technical units”* and delegated and implementing acts regarding privacy and data protection.

Based on this entitlement and building on a previous report from TRL², where 20 distinct areas were identified as candidates for consideration for eCall type-approval; the EC defined the aspects which require further attention by TRL in order to define an appropriate set of type-approval requirements and tests:

- Resistance of eCall systems to severe crashes (sled test assessment)
- Full-scale impact test assessments
- Crash resistance of audio equipment
- Co-existence of Third party services (TPS) with the 112-based in-vehicle systems
- Automatic triggering mechanism
- In-vehicle system self-test
- Privacy and data protection (overview only)

For these aspects, TRL was commissioned to develop draft proposals for detailed technical requirements and test procedures, and provide technical justifications. (The aspect of privacy and data protection was covered in form of an overview only.) These draft proposals might, in their current, or in an adapted version, form part of the EC’s proposed delegated/implementing acts for eCall type-approval. Note that this report and the proposals are the outcome of TRL’s technical work and do not necessarily reflect the view of the EC.

The draft proposals developed for this project address not only the type-approval of vehicles (in respect to their eCall IVS), but some of them are also applicable for the approval of components and separate technical units (Table 2).

Other aspects identified in the previous project were not included in this work assignment, e.g. audio performance measurements, positioning performance tests, wireless communication performance tests, power supply performance tests, HMI requirements and conformance to relevant technical standards. The draft proposals were developed under the assumption that these areas, if considered relevant by the EC, were covered elsewhere.

Physical test work was involved in developing the sled test procedure (resistance of eCall systems to severe crashes); the work for the remaining tasks was desk-based, i.e. without physical testing being performed.

¹ <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015R0758&from=EN>

² <http://ec.europa.eu/DocsRoom/documents/5601/attachments/1/translations/en/renditions/native>

Table 2: Overview of the applicability of the draft proposals for the approval of vehicles, components and separate technical units (x=applicable)

	Vehicle approval	Component approval	Separate technical unit approval
Resistance of eCall systems to severe crashes (sled test assessment)	x	x	x
Full-scale crash test assessments	x		
Crash resistance of audio equipment	x		
Co-existence of third party services (TPS)	x	x	x
Automatic triggering mechanism	x		
In-vehicle system self-test	x	x	x

The work for this project was closely related to the parallel work on a UN Regulation under the 1958 Agreement. The informal working group Automatic Emergency Call Systems (AECS³), organised under the Working Party on General Safety Provisions (GRSG), is currently in the process of developing a draft regulation for AECS (eCall is the European implementation of AECS). TRL attended the last six working group meetings (3rd to 8th meeting) in order to participate in the discussions and to ensure, where possible and suitable, sufficient alignment between the UN and the EU requirements. For the current project this was particularly relevant with regard to the requirements for resistance of eCall IVS to severe crashes.

The following sections of the report give, for each of the above mentioned aspects, a short overview of the background, an overview of relevant legislative material used as a source or otherwise relevant, the draft proposal (the main outcome of the project work), and the justification explaining in detail the context and motivation of every relevant part of the draft proposal. The section on testing reports on the three phases of test work carried out in developing the sled test procedure.

TRL would like to acknowledge the numerous stakeholders who contributed material or their valuable time and advice for this project (in alphabetical order):

Anritsu EMEA, Comité de Liaison Européen des Fabricants d'Équipements et de Pièces Automobiles (CLEPA), ERTICO, European Automobile Manufacturers' Association (ACEA), FDK Corporation, Fujitsu Ten, FSD Fahrzeugsystemdaten GmbH, Gemalto, European Global Navigation Satellite Systems Agency (GSA), International Telecommunication Union (ITU), Jaguar Land Rover, Nissan, Organisation Européenne de Constructeurs des Voitures Accessibles (OECVA), Peiker, Qualcomm, Rohde & Schwarz, SAIC, Society of Motor Manufacturers and Traders (SMMT), Stadium United Wireless, Testing Technologies, TÜV Rheinland, VTT Technical Research Centre of Finland, and Wheelchair Accessible Vehicle Converter's Association (WAVCA).

³ <https://www2.unece.org/wiki/pages/viewpage.action?pageId=14319865>

2 RESISTANCE OF ECALL SYSTEMS TO SEVERE CRASHES (SLED TEST ASSESSMENT)

2.1 Background

The eCall Regulation stipulates that an eCall shall be performed “*in the event of a severe accident*”. It needs to be verified for type-approval that the IVS is constructed and mounted in a way that enables it to withstand a high-severity collision. An automatic eCall is most beneficial in severe cases where the risk of occupants being incapacitated and not able to call for assistance without eCall is highest.

In accidents matching the conditions of the existing full-scale crash tests according to UN R94 and UN R95, occupants of modern vehicles stand a relatively low risk of severe or life-threatening injury (assuming similar anthropometry to the crash dummy and that they were not out-of-position, etc.). The tests were designed to ensure a minimum vehicle structural crashworthiness standard, but they do not represent the most challenging conditions for IVS survivability, where high peak deceleration levels will be the most harmful damage mechanism they are likely to experience in real-world collisions.

Introducing a new higher severity full-scale crash test would arguably be the most reliable way to test IVS components in-situ within the vehicle. However, taking the costs of testing into account, a deceleration test performed on a representative set of IVS parts is a more efficient solution. Such a deceleration test will provide assurance that the core components of the IVS can withstand severe mechanical shocks and it could be used to investigate crash configurations other than those represented by current full-scale tests. This test, therefore, supplements full-scale crash testing in conjunction with UN R94 and UN R95, which is suitable for verifying the automatic triggering and vehicle deformation and intrusion aspects.

A new deceleration test procedure has been developed to verify that eCall IVS will remain functional after events involving a higher decelerations than UN R94 or R95. The procedure applies to eCall in-vehicle systems, components and separate technical units and is performed on a representative set of IVS parts without the vehicle body.

2.2 Legislative source material

2.2.1 UN Regulation No. 100

UN R100 (Electric Vehicles – Construction & Safety), Annex 8C (Mechanical Shock) contains a sled deceleration test to verify the safety performance of Rechargeable Energy Storage Systems (REESS) under inertial loads during a vehicle collision. The general structure of this test procedure can serve as a template for the eCall sled test procedure. The deceleration pulse needs to be adjusted for the specific higher severity conditions for eCall testing.

UN Regulation No. 100, Annex 8C:

"1. Purpose

The purpose of this test is to verify the safety performance of the REESS under inertial loads which may occur during a vehicle crash.

2. Installation

2.1. *This test shall be conducted either with the complete REESS or with related REESS subsystem(s) including the cells and their electrical connections. If the manufacturer chooses to test with related subsystem(s), the manufacturer shall demonstrate that the test result can reasonably represent the performance of the complete REESS with respect to its safety performance under the same conditions. If the electronic management unit for the REESS is not integrated in the casing enclosing the cells, then the electronic management unit may be omitted from installation on the tested-device if so requested by the manufacturer*

2.2. *The tested-device shall be connected to the test fixture only by the intended mountings provided for the purpose of attaching the REESS or REESS subsystem to the vehicle.*

3. *Procedures*

3.1. *General test conditions and requirements*

The following condition shall apply to the test:

- (a) The test shall be conducted at an ambient temperature of $20 \pm 10^{\circ}\text{C}$,*
- (b) At the beginning of the test, the SOC shall be adjusted to a value in the upper 50 per cent of the normal operating SOC range,*
- (c) At the beginning of the test, all protection devices which effect the function of the tested-device and which are relevant to the outcome of the test, shall be operational.*

3.2. *Test Procedure*

The tested-device shall be decelerated or, at the choice of the applicant, accelerated in compliance with the acceleration corridors which are specified in Tables 1 - 3. The Technical Service in consultation with the manufacturer shall decide whether the tests shall be conducted in either the positive or negative direction or both.

For each of the test pulses specified, a separate tested-device may be used.

The test pulse shall be within the minimum and maximum value as specified in Tables 1 to 3. A higher shock level and /or longer duration as described in the maximum value in tables 1 to 3 can be applied to the tested-device if recommended by the manufacturer. [...]"

2.2.2 Draft AECS UN Regulation

OICA proposed a test procedure for the AECS UN Regulation based on UN R100, Annex 8C. The latest draft of this Annex is a combination of the OICA proposal and a pulse corridor defined by TRL during the course of this study. The pulse corridor agreed at the 8th AECS meeting (document AECS-08-09) is identical to the corridor proposed for this study (see Section 2.3).

Draft AECS UN Regulation (AECS-02-02r3), Annex 4 (reproduced here without the superseded pulse corridor):

"Test method for resistance to mechanical impact (paragraphs 6.4. and

16.2.3.)

1. Purpose

The purpose of this test is to verify the safety performance of the representative AECD installation under inertial loads which may occur during a vehicle crash.

2., Installation

2.1. This test shall be conducted either with the complete representative AECD installation or with related representative AECD installation subsystem(s) including the electrical connections. If the manufacturer chooses to test with related subsystem(s), the manufacturer shall demonstrate that the test result can reasonably represent the performance of the complete representative AECD installation with respect to its safety performance under the same conditions.

2.2. The tested-device shall be connected to the test fixture only by the intended mountings provided for the purpose of attaching the representative AECD installation.

3. Procedures

3.1. General test conditions and requirements

The following condition shall apply to the test:

- (a) The test shall be conducted at an ambient temperature of 20 ± 10 °C,*
- (b) At the beginning of the test, the battery shall be charged at the level recommended by the manufacturer;*
- (c) At the beginning of the test, all protection devices which effect the function of the tested-device and which are relevant to the outcome of the test, shall be operational.*

3.2. Test procedure

The AECD shall be decelerated or, at the choice of the applicant, accelerated in compliance with the acceleration corridors which are specified in Table 1. The Technical Service in consultation with the manufacturer shall decide whether the tests shall be conducted in either the positive or negative direction or both.

For each of the test pulses specified, a separate tested-device may be used.

The test pulse shall be within the minimum and maximum value as specified in Table 1. A higher shock level and /or longer duration as described in the maximum value in Table 1 can be applied to the AECD if recommended by the manufacturer. [...]"

OICA further proposed an idea for a component-based post-crash assessment of the mobile network antenna for the AECS UN Regulation.

Draft AECS UN Regulation (AECS-07-03), Annex 8, Appendix 2 (3):

<i>"Subject"</i>	<i>Item subject to confirmation</i>	<i>Criteria</i>	<i>Example of the confirmation method</i>
<i>Telephone antenna (external)</i>	<i>Function</i>	<i>No damage/deformation</i>	<i>No breakage by visual observation</i>
		<i>Measured Voltage Standing Wave Ratio (VSWR) satisfies the prescribed value</i>	<i>When there are breakage and deformation, remove antenna and confirm receiving sensitivity"</i>

2.3 Draft proposal

1. Requirements

1.1. Performance requirements

- 1.1.1. *The deceleration test of eCall in-vehicle systems, components or separate technical units, carried out in accordance with Paragraph [Test procedure], shall be considered satisfactory if the following requirements are demonstrated post-deceleration/acceleration event.*
- 1.1.2. *MSD emission and encoding: The eCall system shall be able to successfully transmit an MSD to a PSAP test point.*
- 1.1.3. *Incident time determination: The eCall system shall be able to determine an up-to-date timestamp for an eCall incident.*
- 1.1.4. *Position determination: The eCall system shall be able to determine accurately the up-to-date vehicle location.*
- 1.1.5. *Mobile network connectivity: The eCall system shall be able to connect to and transmit data via the mobile network.*

2. Test procedure

2.1. Purpose of the deceleration test procedure

The purpose of this test is to verify the sustained functionality of the 112-based eCall system after being subjected to inertial loads which may occur during a severe vehicle crash.

2.2. The following tests shall be performed on a representative arrangement of parts (without a vehicle body) for the approval of vehicles, components or separate technical units.

- 2.2.1. *A representative arrangement shall include all parts required by the eCall system to successfully populate and transmit the MSD in an eCall.*
- 2.2.2. *This shall include the control module and the power source and any other parts required to perform the manual test eCall.*
- 2.2.3. *This shall include external antennas for mobile communication and positioning.*

- 2.2.4. *The wiring harness may be represented only by the relevant connectors (connected to the tested components) and a length of wire at least representative of the unsupported cable length.*
- 2.3. *Deceleration/acceleration procedure*
- 2.3.1. *The following conditions shall apply:*
- (a) The test shall be conducted at an ambient temperature of 20 ± 10 °C.*
 - (b) At the beginning of the test, the power supply shall be charged sufficiently to allow performing the subsequent verification tests.*
- 2.3.2. *The tested parts shall be connected to the test fixture by the intended mountings provided for the purpose of attaching them to a vehicle.*
- 2.3.3. *If additional brackets or fixtures are used as part of the deceleration/acceleration facility, these shall provide a sufficiently rigid connection to the deceleration/acceleration facility to not affect the outcome of the test.*
- 2.3.4. *The eCall system shall be decelerated or accelerated in compliance with the pulse corridor that is specified in Table 1 and Figure 1. The acceleration/deceleration shall be measured at a rigid part of the deceleration/acceleration facility and filtered at CFC-60.*
- 2.3.5. *The test pulse shall be within the minimum and maximum values as specified in Table 1. However, if the test was performed at a higher acceleration level and/or longer duration the test shall be considered satisfactory.*
- 2.3.6. *The eCall system shall be tested in a total of six orientations: The direction of acceleration/deceleration shall coincide with three axes perpendicular to each other (at least one being a main axis of the component design), each tested in positive and negative direction.*
- 2.3.7. *Different orientations may be tested simultaneously (i.e. during the same acceleration/deceleration event) by mounting more than one sample in perpendicular orientations to the acceleration/deceleration facility. If the orientations are tested individually, new samples may be used for each orientation.*

2.3.8. Description of the test pulse

Figure 1: Minimum and maximum curve of the test pulse (pulse corridor)

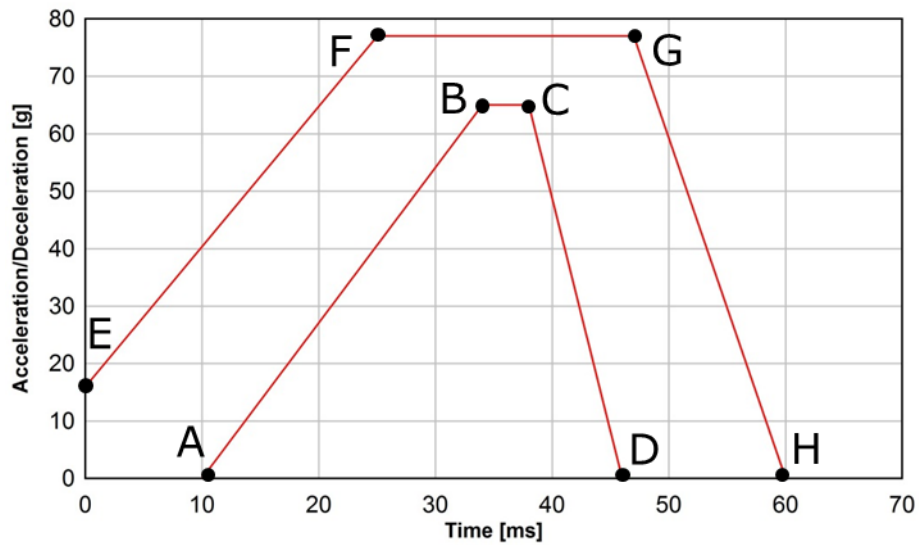


Table 1: Acceleration/deceleration values of the minimum and maximum curve of the test pulse

Point	Time (ms)	Acceleration/ Deceleration (g)
A	10	0
B	34	65
C	38	65
D	46	0
E	0	16
F	25	77
G	47	77
H	60	0

2.4. Verification procedure

2.4.1. Verify that no cable connectors were unplugged during the event.

2.4.2. The performance requirements shall be verified by performing a manually triggered test call using the power source subjected to the deceleration test.

2.4.3. Before performing the test call, ensure that:

(a) the eCall system receives (real or simulated) GNSS signals to an extent representative of open sky conditions;

(b) the eCall system has had sufficient time in a powered state to achieve a GNSS position fix;

(c) one of the connection procedures defined in Paragraph [Connection procedures], as agreed between the technical service and the manufacturer,

will be applied for any test call;

(d) the dedicated PSAP test point, configured in normal mode (non-robust mode), is available to receive an eCall emitted by the 112-based system;

(e) a false eCall to a genuine PSAP cannot be made over the live network; and

(f) if applicable, the TPS system is deactivated or will automatically switch to the 112-based system.

2.4.4. *Perform a test call (push mode) by applying a manual trigger according to the instructions of the manufacturer.*

2.4.5. *Verify each of the following items:*

(a) Verify that an MSD was received by the PSAP test point. This shall be verified by a record of the PSAP test point showing that an MSD emitted from the eCall system following the manual trigger was received and successfully decoded. Automatic re-transmissions at higher redundancy levels are permitted if necessary to successfully transmit the MSD.

(b) Verify that the MSD contained an up-to-date timestamp. This shall be verified by a test record showing that the timestamp contained in the MSD received by the PSAP test point does not deviate from the exact recorded time of the manual trigger activation by more than 60 seconds. The transmission may be repeated if the eCall system failed to achieve a GNSS position fix before the test.

(c) Verify that the MSD contained an accurate, up-to-date location. This shall be verified in accordance with the Vehicle Location Test Procedure as defined in Paragraph [Positioning Test Procedure] by a test record showing that the deviation between IVS location and true location, d_{IVS} , is less than 150 metres and the confidence bit transmitted to the PSAP test point indicates 'position can be trusted'.

2.4.6. *Clear down the test call using the appropriate PSAP test point command (e.g. hang up).*

2.5. *Positioning test procedure*

2.5.1. *The sustained functionality of the GNSS components shall be verified by comparing the location input and the location output of the system.*

2.5.2. *The 'IVS location' (φ_{IVS} , λ_{IVS}) shall be: The location contained in an MSD transmitted to a PSAP test point while the GNSS antenna is in open sky conditions (real or simulated).*

2.5.3. *The 'true location' (φ_{true} , λ_{true}) shall be:*

(a) the actual location of the GNSS antenna (known location or determined with another means than the eCall system), when using real GNSS signals; or

(b) the simulated location, when using simulated GNSS signals.

- 2.5.4. *The deviation between IVS location and true location, d_{IVS} , shall be calculated using the following equations:*

$$\Delta\varphi = \varphi_{IVS} - \varphi_{true}$$

$$\Delta\lambda = \lambda_{IVS} - \lambda_{true}$$

$$\varphi_m = \frac{\varphi_{IVS} + \varphi_{true}}{2}$$

$$d_{IVS} = R\sqrt{(\Delta\varphi)^2 + (\cos(\varphi_m)\Delta\lambda)^2}$$

where:

$\Delta\varphi$: Difference in latitude (in radian)

$\Delta\lambda$: Difference in longitude (in radian)

Note: $1^\circ = \frac{\pi}{180}$ rad; 1 mas = $4.8481368 \cdot 10^{-9}$ rad

φ_m : Mean latitude (in unit suitable for the cosine calculation)

R: Radius of the earth (mean) = 6,371,009 metres

- 2.5.5. *The positioning test procedure may be repeated if the eCall system failed to achieve a GNSS position fix before the test.*

2.6. *Antenna test procedure*

- 2.6.1. *If the connection procedure applied for the test call did not make use of over-the-air data transmission, the sustained functionality of the mobile network antenna shall be verified by checking the antenna tuning status after the deceleration event according to the following procedure.*

- 2.6.2. *If the positioning test procedure did not make use of over-the-air GNSS signal transmission, the sustained functionality of the GNSS antenna shall be verified by checking the antenna tuning status after the deceleration event according to the following procedure.*

- 2.6.3. *Measure the voltage standing wave ratio, VSWR, of the external mobile network antenna or the GNSS antenna after the deceleration event at a frequency within the antenna's specified frequency band.*

- 2.6.3.1. *The measurement shall be performed with a power meter, antenna analyser or SWR meter as close as possible to the antenna feed point.*

- 2.6.3.2. *If a power meter is used, VSWR shall be calculated using the following equation:*

$$VSWR = \frac{\sqrt{P_f} + \sqrt{P_r}}{\sqrt{P_f} - \sqrt{P_r}}$$

where:

P_f : Forward measured power

P_r : Reverse/reflected measured power

- 2.6.4. *Verify that VSWR satisfies the specifications prescribed by the manufacturer*

for new antennas.

2.7. Connection procedures

2.7.1. Simulated Mobile Network Procedure

- 2.7.1.1. It shall be ensured that a TS12 call emitted by the 112-based system will be performed over-the-air via a non-public (i.e. simulated) mobile network and routed to the dedicated PSAP test point.*
- 2.7.1.2. The dedicated PSAP test point shall be a PSAP simulator under the control of the technical service, compliant with the applicable EN standards and certified in accordance with EN 16454. It shall be equipped with an audio interface to allow voice communication tests.*
- 2.7.1.3. If applicable, it shall be ensured that a TS11 call emitted by the TPS system will be performed over-the-air via a non-public (i.e. simulated) mobile network and routed to the TPSP test point.*
- 2.7.1.4. The TPSP test point shall be a dedicated TPSP answering point simulator under the control of the technical service or a genuine TPSP answering point (permission by TPSP required).*
- 2.7.1.5. Good mobile network coverage of at least -99 dBm or equivalent is recommended for this procedure.*

2.7.2. Public Mobile Network Procedure

- 2.7.2.1. It shall be ensured that a TS11 call to a long number will be emitted by the 112-based system (instead of a TS12 call) and will be performed over-the-air via a public mobile network and routed to the dedicated PSAP test point.*
- 2.7.2.2. The dedicated PSAP test point shall be a PSAP simulator under the control of the technical service, compliant with the applicable EN standards and certified in accordance with EN 16454. It shall be equipped with an audio interface to allow voice communication tests.*
- 2.7.2.3. If applicable, it shall be ensured that a TS11 call emitted by the TPS system will be performed over-the-air via a public mobile network and routed to the TPSP test point.*
- 2.7.2.4. The TPSP test point shall be a dedicated TPSP answering point simulator under the control of the technical service or a genuine TPSP answering point (permission by TPSP required).*
- 2.7.2.5. Good mobile network coverage of at least -99 dBm or equivalent is recommended for this procedure.*

2.7.3. Wired Transmission Procedure

- 2.7.3.1. It shall be ensured that a TS12 call emitted by the 112-based system will only be performed via a wired connection with a dedicated network simulator (bypassing any mobile network antenna) and routed to the dedicated PSAP test point.*
- 2.7.3.2. The dedicated PSAP test point shall be a PSAP simulator under the control of*

the technical service, compliant with the applicable EN standards and certified in accordance with EN 16454. It shall be equipped with an audio interface to allow voice communication tests.

2.7.3.3. If applicable, it shall be ensured that a TS11 call emitted by the TPS system will be performed via a wired connection with a dedicated network simulator (bypassing any mobile network antenna) and routed to the dedicated TPSP test point.

2.7.3.4. The TPSP test point shall be a dedicated TPSP answering point simulator under the control of the technical service or a genuine TPSP answering point (permission by TPSP required).

2.4 Justification

2.4.1 Purpose of the deceleration test procedure

The purpose of the deceleration test is to ensure that the eCall system is able to perform its intended safety function after a real-life crash that subjects the components to higher deceleration levels than the current regulatory full-scale crash tests. A test using a representative arrangement of parts (rather than a full vehicle) is more cost-effective than an additional higher severity full-scale evaluation and can supplement the existing full-scale crash evaluations (UN R94 and UN R95). It also facilitates relatively cost-effective retesting should the eCall system design be altered during a product update.

The set of four performance requirements (1.1.2. to 1.1.5.), to be demonstrated after the deceleration event, was defined to ensure the core functionality of an eCall system after the core components have been subjected to a severe mechanical shock. It was defined based on the 'specific obligations of manufacturers' according to Regulation (EU) 2015/758, Article 5. It was compiled to cover the specific obligations of Article 5, Paragraphs 2 and 5.

The core functionality of an eCall system is to notify the PSAP that an incident has happened and where it is by transmitting an MSD, and establishing a voice connection with the vehicle occupants.

The functionality of the automatic triggering is not assessed in this procedure because it is sufficiently addressed in the simulated collisions in the full-scale impact tests.

The voice connection functionality was exempted from this procedure following concerns raised by the AECS working group about the ability to design audio equipment (loudspeaker and microphone) that is crash-proof at the required level within the current design cycle of systems to be type-approved (see minutes from 8th AECS meeting, currently unpublished). This exemption provides a reasonable compromise for the current situation: If the voice connection fails after higher severity collisions, the eCall still provides a benefit by notifying the PSAP of the accident and transmitting the vehicle location via the MSD. Nevertheless, the voice channel between occupants and PSAP is a vital part of an eCall to provide the PSAP with information regarding, for example, the accident severity and number of occupants or number of casualties. This exemption should therefore be re-considered after a certain period of time; in the UN AECS working group an agreement was made to re-evaluate the exemption for the first series of amendments to the AECS UN Regulation (see minutes from 8th AECS meeting, currently unpublished). Refer to Section 8 on test

work performed by TRL in this regard.

2.4.2 *Deceleration procedure*

The general layout of the test procedure is based on an established regulatory sled test procedure for REESS (UN R100, Annex 8C). Principal eCall-specific modifications of this procedure were necessary with regard to the components to be included on the sled, the orientation of components and the pulse corridor, i.e. the impact severity parameters. These were partially based on the procedure as proposed by OICA in the UN working group (Draft AECS UN Regulation, Annex 4).

2.4.2.1 *Parts included in the sled test*

The aim of the procedure is to simulate the real-world conditions as closely as possible on a test sled and ensure sustained functionality of all parts required for a successful eCall. At the same time, there needs to be a balance with the feasibility of carrying out the testing.

The definition of parts in the legislative test cannot be design-restrictive. A performance-based definition is therefore given based on the general principle that all in-vehicle parts of a specific system design that are necessary to pass the MSD transmission-related element of the post-deceleration verification test shall be included in the deceleration event on the test sled. This is further clarified by the following sub-paragraphs. The power source is an important aspect of the post-crash functionality because a failure of the power source would lead to a complete failure of the eCall. Therefore, a dedicated (backup) battery, if part of the system design, shall be tested; if the system does not have a dedicated battery, the main battery supplying the IVS shall be tested, for example the main vehicle lead-acid battery.

It is expected that most system designs will include a dedicated primary or rechargeable battery, which would mean that the main vehicle battery would not need to be included in this test. TRL has not performed deceleration testing with standard lead-acid batteries for this programme and no research could be identified that gave an indication of whether these batteries would operate following such a test. It is possible that if current batteries do not withstand the deceleration conditions proposed, then a design choice may have to be made between crash-hardening the vehicle battery or including a dedicated battery that feeds the eCall system. There are no particular concerns regarding the feasibility of performing the required deceleration tests on vehicle batteries. Note that in case of electric vehicles, it is expected that the eCall system will be connected to a 12 V power source rather than being fed by the high-voltage propulsion batteries, which is why the latter would not be included in the deceleration test.

Following input from vehicle manufacturers and component suppliers at UN AECS working group meetings, it was agreed to exempt audio-related components (loudspeaker and microphone) from the sled test (see Section 2.4.1). This exemption is reflected in the present proposal by not requiring a functionality assessment of audio components following the deceleration test.

The wiring harness itself is not included in the test setup because the most likely failure mechanism for cables is mechanical damage due to vehicle deformation during an impact (assessed during the full-scale assessments) rather than breakage induced by pure inertial loading. However, connectors and a length of wire representing the unsupported cable length from the last point of strain relief to connection with another

component are included, to assess whether connectors unplug under inertial loading.

The definition chosen (*"A representative arrangement shall include all parts required by the eCall system to successfully populate and transmit the MSD in an eCall."*) and the clarification in the sub-paragraphs are intended to include at least the following components where they form part of the system design under test:

- Control module (ECU including communications module and GNSS receiver)
- Power source (dedicated IVS battery or vehicle battery most commonly used for the vehicle type, as applicable)
- External antennas (mobile communication and GNSS antenna)
- Connectors (including a length of wire representing the unsupported cable length from the last point of strain relief to connection with another component)
- Mounting brackets used for mounting the components in the vehicle

2.4.2.2 *Orientation of the components*

The orientation of components (in relation to the direction of deceleration) is an important factor in the test procedure. Different orientations could lead to different failure modes (e.g. connectors pulling out/breaking in one direction; soldering of GSM/GNSS modules failing in another direction) and failures at different test severities.

The highest decelerations can be expected to occur in frontal impacts. eCall system designs will, however, not be specific to one vehicle, but will rather be used in a number of different vehicles, i.e. mounted in potentially different orientations. The test procedure therefore needs to ensure that the IVS withstands a collision in the least favourable orientation that can be expected in a vehicle. As it is not trivial to determine the least favourable orientation, the IVS components shall be tested in several representative orientations: Testing along three main axes (perpendicular to each other) ensures covering all orientations with at least 58 percent of the force while allowing flexibility to the manufacturer when installing the components. Testing each direction in a positive and negative direction is necessary because the failure modes might differ between components being subjected to compression and tension (e.g. connectors pulling out under tension but not under compression).

The orientation of the deceleration axes is defined in the proposal as *"perpendicular to each other (at least one being a main axis of the component design)"*. This definition was chosen because, as outlined above, the least favourable orientation cannot be defined easily, but an installation where one of the main axes coincides or almost coincides with a parallel to the vehicle's longitudinal axis appears likely. Main axes of a component design should, for example, be axes of rotational or reflectional symmetry of the general shape, edges of oblong components, or axes that are considered to be at high risk of component damage under the proposed loading. The main axis shall be defined by the manufacturer in agreement with the technical service.

The different orientation may be tested one after another in individual deceleration events or simultaneously (i.e. during the same acceleration/deceleration event) by mounting more than one sample in perpendicular orientations to the test sled. The latter option allows for cost-effective testing. If the orientations are tested individually, a new sample may be used for each orientation or the same sample may

be decelerated repeatedly before verification testing.

2.4.2.3 Pulse corridor

In accidents matching the conditions of the UN Regulation full-scale crash tests, occupants of modern vehicles stand a relatively low risk of severe or life-threatening injury (assuming similar anthropometry to the crash dummy and that they were not out-of-position, etc.). The tests according to UN R94 (frontal impact) and UN R95 (lateral impact) were designed to ensure minimum vehicle structural crashworthiness performance. However, they do not present the most challenging conditions for IVS survivability, where the most harmful mechanism to these components will be high peak deceleration levels.

The assessments of eCall systems during full-scale crash tests and component sled tests will therefore complement each other: The full-scale tests provide an assessment of the IVS in a front and a side collision taking into account vehicle deformations and vehicle-specific installation and testing the triggering. The sled test of the IVS adds value by providing a vehicle-independent and installation-independent assessment that avoids repeated full-scale tests after re-designs of IVS components. It covers real-world collision configurations that are more challenging to an AECD than the full-scale tests in order to ensure that AECS deliver high societal benefits to those casualties who need it most.

The proposed corridor is based on a proposal developed by TRL during the course of this study for the AECS UN Regulation. For the definition of the pulse corridor a test configuration was chosen that creates higher peak deceleration levels than UN R94 tests: A full-width, rigid barrier impact at a test speed of 56 km/h in accordance with FMVSS 208. A sample of full-scale crash test results of superminis of model years 2012 and 2013 (NHTSA tests 7505, 7729, 8314, see Figure 1) was selected to determine the maximum peak deceleration levels that can be expected to occur in modern vehicles in this configuration.

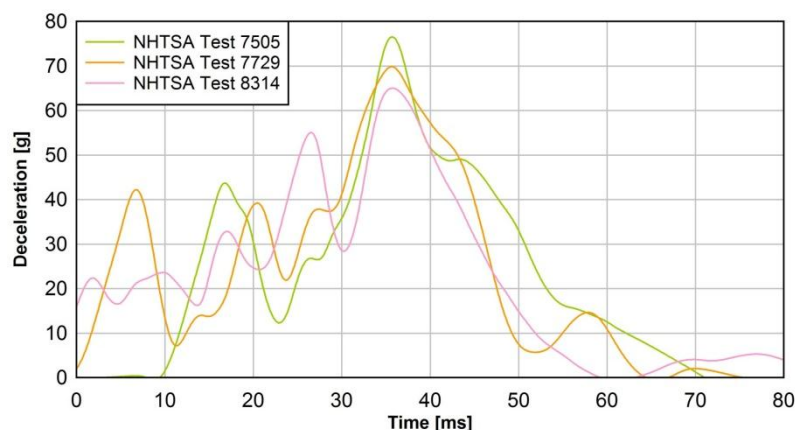


Figure 1: NHTSA crash test results (56 km/h, rigid barrier, full-width), superminis, MYs 2012 and 2013, acceleration measured at rear sill, filtered at CFC-60, time-aligned at point of maximum deceleration

The shape and width of the corridor was chosen to reproduce the peak deceleration levels and pulse durations of the sample vehicles and to enable easy replication of the pulse with existing test sleds. Following feedback from the AECS working group, the initially proposed shape was simplified and an additionally proposed safety factor was omitted. Please see UN documents AECS-07-05, AECS-08-04 and minutes from 8th

AECS meeting (currently unpublished) for accompanying information on the definition of the corridor.

2.4.3 Verification procedure

Two principal options were considered closely for the demonstration of sustained post-test functionality of the IVS: A procedure relying on the demonstration of a successful test eCall or a procedure based solely on inspections or functional tests of individual IVS components.

Preference was given to a test procedure that involves the demonstration of successful test eCalls, because this procedure is:

- Not reliant on the self-diagnosis of the system under test;
- Not design-restrictive or design-specific; and
- A close simulation of the real-world conditions, which allows a direct assessment of the whole-system functionality.

2.4.3.1 Manual test call procedure

The proposed procedure involves performing only one manually triggered test call.

Automatic triggering is already sufficiently addressed in the full-scale assessments so further verification is not needed for the deceleration tests..

An MSD successfully transmitted to a PSAP test point under the control of the technical service (see Section 2.4.4) provides system- and design-independent assurance that the eCall IVS under test is still supplied with power and is able to construct an MSD and emit it via the mobile communication module.

An up-to-date timestamp is an important element of the MSD to allow emergency services to identify how long injured persons have been affected. A comparison of the time transmitted via MSD and the actual trigger time provides assurance that an up-to-date time stamp could be created for the post-impact situation. The maximum allowed deviation of 60 seconds is not intended to assess the accuracy of the systems clock (not a specific requirement), but only to ensure that the time stamp can be updated post-impact and was hence chosen large enough to allow for inaccuracies in the systems time determination. Depending on the system design it is expected that the IVS will retrieve the current time from the GNSS signal, which might be combined with an internal clock to bridge periods without GNSS fix.

2.4.3.2 Positioning test procedure

The eCall Regulation states that the *"provision of accurate and reliable positioning information is an essential element of the effective operation of the 112-based eCall in-vehicle system"*. According to EN 15722, the vehicle location is determined *"at the latest moment possible before message generation"*. EN 16072 details further *"The reference point shall be the last known vehicle's position at the triggering time as determined by the on-board system at the time of message generation"*. If there is inadequate sources of information to provide a reliable determination of location the confidence bit shall be set to 'no confidence in position' and a best estimate of the location based on the available information shall be sent (this may be, for example, the last location obtained where there was adequate data source available).

This means that in cases where the GNSS equipment is damaged during a crash, the

last known vehicle location will be transmitted, but it might be marked with 'no confidence in position'. Additionally, EN 16062, Section 7.6.1 states that after the crash *"The PSAP operator may at any time request that a new MSD is sent. [...] This can be, for example because the data appears corrupted or inconsistent, or the PSAP operator believes that the data can have changed."* Cases where the 'data has changed' (for example, when the vehicle was moved away from a motorway) also requires post-crash positioning functionality. Therefore, a post-collision assessment is required.

The positioning test procedure is intended to verify the system's sustained functionality, rather than its performance. System performance can be assessed in the pre-crash condition following the procedure proposed by GSA for the AECS UN Regulation (see AECS-02-02r3, Annex 5). If GNSS components were damaged during an impact it can be assumed that the positioning would either fail entirely (MSD content '2147483647' in accordance with EN 15722) or that a damaged antenna or wiring could result in improbable, erroneous calculations that would likely lead to very large deviations from the actual position.

Therefore, a check whether or not a location reported post-test under open sky conditions lies within a radius of 150 metres of the true location is a suitable way of identifying full or partial component failures. This limit is equivalent to the deviation defined in EN 15722 that allows setting the confidence bit transmitted in the MSD to indicate 'position can be trusted'. This accuracy will be easily achieved even if the system is tested using real (non-simulated) signals in open sky conditions. The verification whether the confidence bit is indeed set to 'position can be trusted' is intended to provide further independent assurance that an up-to-date location is reported by the IVS and not a stored previous location: EN 16072, Section 7.6.1.2 stipulates that the confidence bit *"should only be cleared to 'position can be trusted' if a 2D or 3D position fix from current GNSS reception is available or the manufacturer/equipment supplier has another means of being confident that the information provided is within the limit set by EN 15722."*

The proposed test method allows high flexibility using real GNSS signals under open sky conditions or simulated GNSS signals. Simulating GNSS signals over-the-air might be a challenge in some instances, particularly with respect to full-scale impact tests, because low levels of real signals might be present in the test laboratory (if this is not electromagnetically shielded), which could lead to positioning failures. It has been suggested to TRL that a potential solution in order to avoid shielding of the test room might be to emit the simulated signal close to the vehicles receiver (e.g. by an emitting antenna with a trailing cable placed next to the vehicle's receiving roof antenna). This assumes that the position algorithm allows the strongest signals to dominate in determining the location.

The correct location content of an MSD transmitted to a PSAP test point under the control of the technical service provides system- and design-independent assurance that the positioning system is still functional after a higher severity deceleration event. The equations used to determine the difference between true location and IVS location is simplified for greater ease of use to assume a spherical earth projected to a plane derived from the Pythagorean Theorem. This formula delivers an appropriate approximation for the small distances and large tolerances in this functionality test.

2.4.3.3 Antenna test procedure

The connectivity to the mobile network after a collision could be impaired by damaged

hardware components (mobile network receiver, mobile network antenna, or antenna feeder wire). As a post-crash connectivity test is intended to verify only sustained functionality, not measure the performance, the ability of the IVS to successfully perform a test call via a mobile network is considered sufficient assurance. However, if the wired transmission procedure is used, an external mobile network antenna is deliberately bypassed by the test setup which makes a separate assessment necessary.

The same line of argumentation applies to the positioning equipment of the eCall system: Only if the GNSS antenna is bypassed during the positioning test procedure, i.e. if simulated GNSS signals are transmitted using a wired connection, the sustained functionality of the antenna needs to be verified in a separate test.

A component-based test procedure is proposed for this purpose by expanding the proposal by OICA for the AECS UN Regulation (AECS-07-03, Annex 8, Appendix 2 (3)): The voltage standing wave ratio (VSWR) is a technical parameter of an antenna that is often used for post-production screening for failures (pass/fail criteria based on VSWR specifications).

Verification of the VSWR after the deceleration event is proposed to check for mechanical damage due to deformation or breakage by comparing the measured value to the manufacturer's specifications. The VSWR can be measured quickly, with limited effort and low price test equipment (standard commercial- or higher-grade power meter, antenna analyser or SWR meter).

The basic equations for deriving the VSWR from power measurements are well established. Antenna analysers or SWR meters display the VSWR immediately to the tester.

2.4.4 *Test call setup*

To perform a test call using the 112-based system, three principal entities are generally required: An eCall IVS to initiate and perform the call, a mobile phone network to transmit the call, and a PSAP to receive the call. The eCall IVS is represented by the IVS under test in all connection procedures. The other entities are discussed in the following sections.

2.4.4.1 *PSAP test point*

The PSAP is represented by a dedicated PSAP test point in all connection procedures because there is currently no agreement in the EU that allows performing a TS12 test eCall to an actual PSAP for type-approval testing. The PSAP test point is a PSAP simulator, i.e. a computer or embedded system under the control of the test house that is available to receive calls and interacts with the IVS during a call by simulating the behaviour of a genuine PSAP. The PSAP simulator is either directly connected to the network simulator (if applicable) or connected to the public phone network via a mobile or landline connection.

The PSAP simulator software allows test houses to create test reports that verify different aspects of the eCall transaction (e.g. successful MSD transmission and encoding) independently from any internal record of the system under test. The simulator shall conform to the applicable requirements of the relevant technical standards, EN 16062 and EN 16072, which shall be certified in accordance with EN 16454. In order to allow performing the post-crash audio assessment (see Section 4), it must be capable of establishing a voice connection between the operator of the

simulator and the vehicle. PSAP simulators are available from various suppliers.

2.4.4.2 Proposed connection procedures

Three different connection procedures (simulated mobile network procedure, public mobile network procedure, and wired transmission procedure) were defined to accommodate a wide range of situations at technical services where different test equipment might be available and the level of mobile network coverage in test laboratories is likely to vary. These shall be applied as agreed between the technical service and the manufacturer to best accommodate the local situation at the test house. It should be noted that manufacturers applying for approval may have a preferred connection procedure, or have already configured the IVS to work with a particular provider of test equipment. Therefore, the choice of the technical service may not only be governed by convenience, cost and feasibility, but also by external (market) pressures, etc.

It is permissible to apply different connection procedures for subsequent test calls from the same eCall system (e.g. simulated network inside the test laboratory and public mobile network outdoors for the positioning test). Note for this case that the IVS remains registered on the mobile network for a period of 1–12 hours after call clear down (IVS NAD Minimum Network Registration Period T9 and IVS NAD Network Deregistration Fallback Timer T10, according to EN 16062) to allow a call-back from the PSAP. Depending on the exact circumstances, the IVS might therefore need to be forced to de-register from the first network by appropriate means.

The connection procedure options are identical for all test calls to be performed during the type-approval test programme (i.e. after the deceleration test, after the full-scale impact test and during the course of the TPS co-existence test) and were therefore defined to also cater for the specific conditions during a full-scale crash test (see Section 5). Please refer to Section 5.4.5 for the justification regarding connections to the TPSP test point.

2.4.4.2.1 Simulated mobile network procedure

The simulated mobile network procedure uses an over-the-air simulated mobile network to connect to the PSAP test point. This connection procedure requires an over-the-air mobile network simulator (radio communication tester), which is currently not available at all test houses and would therefore require a certain investment to equip them all.

Note that depending on regional radio communications regulations, it might be a legal requirement to shield the test room against the emission of radio waves in order to prevent interference with public mobile networks. This could potentially be avoided by using a low-power signal emission in combination with highly directional antennas.

The merit of this connection procedure is that it allows the design of a test setup without trailing cables and without hardware modification of the external IVS antenna. If an electromagnetically shielded test room is used, a test setup can be designed that captures the automatic test call after an impact test without any pre-test modification or preparation of the IVS under test (please see Section 2.4.4.3 for consideration regarding shielding). If, in addition, real or simulated GNSS signals are available inside the test laboratory, the whole eCall test procedure, including the positioning test, can be carried out without moving the vehicle to an outdoors location.

2.4.4.2.2 *Public mobile network procedure*

The public mobile network procedure makes use of a PLMN to connect to the PSAP test point via a long number (TS11 call). It does not require investment in a network simulator, but equally means that network availability and performance are not under the control of the test house. The procedure requires modification of the behaviour of the IVS to perform a TS11 call rather than a TS12 call, which might not be possible in all system designs (see Section 2.4.4.3).

Due to different locations, architecture and layout of crash test laboratories, it cannot be expected that sufficient PLMN coverage is available inside every crash test laboratory to perform an automatic test call following the impact test. (Note: The network strength of -99 dBm is taken from EN 16454 and is a recommendation rather than a requirement. Successful test calls will, depending on the system under test, be possible at lower signal levels.) If stronger and adequate network coverage is available outdoors, the vehicle/IVS can be moved outside of the crash test laboratory to perform a manual test call instead. (Note: Unless real or simulated GNSS signals are available inside the test laboratory, the vehicle/IVS needs to be moved outside for the positioning test procedure anyway.) Otherwise, one of the other connection procedures needs to be applied.

2.4.4.2.3 *Wired transmission procedure*

The wired transmission procedure uses a simulated mobile network accessed via a wired connection between the IVS and a network simulator to connect to the PSAP test point. This connection procedure requires a mobile network simulator (radio communication tester), which is currently not available at all test houses and would therefore require a certain investment.

To establish a wired connection this option requires test-specific hardware modification of the IVS (disconnecting the external mobile network antenna, connecting the network simulator) and might not be suitable for IVS without an external antenna connector.

For an automatic test call following the impact test, the test setup would require trailing cables to the network simulator outside of the vehicle, because this piece of equipment is not likely to be crash-resistant. In order to ensure that the IVS connects to the simulated network, test-specific encoding might be necessary (see Section 2.4.4.3).

The wired connection procedure bypasses the external mobile network antenna of the IVS, which is why the antenna and the feed line have to be assessed separately using the antenna test procedure.

2.4.4.3 *Successful capturing and routing of test calls*

Unless the test room is electromagnetically shielded in most instances there will, at least, be low signal levels of different genuine PLMNs. Considerations about the process by which the IVS selects the network to which it connects are relevant in order to ensure successful test calls.

As per definition in the eCall EN standards and telecommunications standards, the IVS will, after a trigger has been received, attempt registration on the highest priority allowed PLMN found during the most recent background scan. A hierarchy of criteria is applied in defining this priority order (see 3GPP standard TS 23.122 V7.12.1 (2008-

04), Section 4.4.3.1.1). In this hierarchy, the signal quality has a low significance. The consequence is that a mobile station will connect to the home PLMN (as defined on the SIM) even if the signal quality is lower than that of other available PLMNs. With regard to testing, this means that even if a high signal strength simulated mobile network is provided, it may be disregarded by the IVS if the home PLMN is available and therefore an eCall to a genuine PSAP would be performed in these cases.

It is vital to prevent the IVS from performing an eCall to a genuine PSAP because this would prevent a successful type-approval test and could disrupt the work of PSAPs (through the receipt of false eCalls and potentially with erroneous deployment of emergency services). It will be an obligation of the test house (in collaboration with test equipment suppliers and the IVS supplier/vehicle manufacturer providing the test samples) to design an appropriate test setup to realise one of the proposed connection procedures. Potential approaches to control the test environment and/or the behaviour of the IVS appropriately are presented in the following paragraphs. Whether options are applicable in specific situations and locations depends on the equipment available at the test house as well as the system design in some cases.

Potential approaches to control the test environment:

- Shielding the test area against radio waves and simulating an over-the-air mobile network: In this case the IVS will not receive genuine PLMNs and therefore connect to the only available over-the-air network, the simulated test network. This procedure will achieve a connection to the test network and does not require hardware modification or test-specific encoding of the IVS. Note that electromagnetically shielding an entire full-scale impact test room might constitute a major investment. Care needs to be applied when removing the tested vehicle or components from the shielded area (e.g. pushing the crashed vehicle to another room) to ensure that the eCall has been received and cleared down using the PSAP simulator. Otherwise, if the call has been answered by the PSAP test point but not cleared down, it will automatically be cleared down by the IVS after 3600 seconds, i.e. after one hour (IVS Call Cleardown Fallback Timer T2, according to EN 16062). If the IVS was, for some reason, not able to register on the test network in the first place, the IVS will keep trying to register to other networks for a certain period of time. This period is not explicitly defined in the corresponding Sections 7.12.2 and 7.12.3 of EN 16062 and ultimately left to the discretion of the IVS equipment provider. The vehicle would perform a genuine eCall if it is removed from the shielded area during this period, which has to be prevented.
- Simulating a mobile network and using a wired connection between the network simulator and the external antenna connector: If the correct PLMN is simulated in accordance with the SIM records, the IVS will connect to the simulated network. Some system designs will be equipped with an internal backup antenna in cases where the external antenna fails. If this fallback mechanism is programmed to also cover cases where an external antenna is connected but does not receive a signal of a suitable network, inappropriate configuration of the simulated network needs to be prevented because an eCall to a genuine PSAP could otherwise be the result. System designs without an external antenna connector might not be suitable for applying a wired connection.

Potential approaches to control the behaviour of the IVS:

- Test-specific SIM card or SIM chip encoding and simulating a mobile network over-the-air or via a wired connection: In this case a SIM specific to the test setup is used in order to ensure selection of the simulated network and prevent the IVS from connecting to any other available PLMNs. Therefore, it is not necessary to prevent transmission via genuine PLMNs by electromagnetic shielding of the test room.
- Test-specific encoding to ensure that a TS11 call (long number) is performed instead of a TS12 call: One of the available PLMNs at the test location can be used in this case because the TS11 call will be routed to the specified number of the PSAP test point rather than a genuine PSAP.

The possibilities for controlling the behaviour of the IVS are dictated by the system design and might not be possible in all cases, for example where a chip SIM is used (rather than an exchangeable SIM card) and where production units do not allow reprogramming of the chip. In these cases, it is either necessary to control the test environment or to perform the type-approval testing with development units that allow for adequate encoding capabilities. If development units are used it will be important to be able to demonstrate equivalence with the production design when required to by the technical service and type-approval authority.

3 FULL-SCALE IMPACT TEST ASSESSMENTS

3.1 Background

The eCall Regulation stipulates that *"in the event of a severe accident, detected by activation of one or more sensors or processors within the vehicle [...] an eCall to the single European emergency number 112"* shall be *"triggered automatically"*. To fulfil this requirement after a collision, the IVS and the vehicle in which it is installed need to be constructed in a way that ensures that the IVS withstands a crash.

Furthermore, the eCall Regulation stipulates that vehicles shall be *"constructed in such a way as to ensure that an eCall to the single European emergency number 112 can also be triggered manually."*

Full-scale impact testing of a vehicle to ensure the survivability of the eCall IVS after a crash is the only realistic method for assessing the whole system as it is configured in the vehicle. By definition, this includes all of the components in their final mounting situation and configuration. To minimise costs associated with testing, the eCall IVS full-scale assessment shall be performed within the full-scale impact tests already carried out under UN Regulations No. 94 and 95.

A proposal has been developed for a test protocol for the eCall IVS full-scale assessment, containing:

- A method whereby eCall IVSs can be assessed alongside the full-scale impact tests according to UN Regulations No. 94 and 95; and
- A definition of the operational checks to be made after the test (under consideration of the capability for eCall IVSs to operate in test houses) and pass/fail criteria.

The procedure applies to vehicles with eCall in-vehicle systems installed. As TPS functions will not be mandatory, a TPS system is not included in the scope of type-approval except for the aspects detailed in Section 5. To allow assessing the 112-based system, it needs therefore be ensured that any TPS system, if present, is deactivated for the full-scale impact tests or will automatically switch to the 112-based system.

3.2 Legislative source material

Two proposals were presented at the 7th AECS meeting for addressing the post-crash functionality assessment in the draft AECS UN Regulation. Both proposals have not yet been discussed within the working group.

Firstly, the Russian Federation proposed Annex 6 (AECS-07-02) that sets out high-level items. The current stage of the proposal does not define in detail a method of how to assess these items alongside a UN R94 or UN R95 crash test and does not set out specific pass/fail criteria.

Draft AECS UN Regulation (AECS-07-02), Annex 6:

"Test method for emergency call (paragraphs.)

1. *MSD emission assessment shall include verification of at least the following:*

1.1. *Vehicle position accuracy is within the limits defined by paragraph 6.2, and*

- 1.2. *Trigger time is transmitted correctly, and*
 - 1.3. *Vehicle identification number is transmitted correctly*
2. *MSD emission assessment can be performed either*
 - 2.1. *By transmitting MSD to a simulator, or*
 - 2.2. *By transmitting MSD via real PLMN*
3. *Hands-free voice communication assessment (subjective test) shall include verification of the following:*
 - 3.1. *Voice originating inside the vehicle can be clearly heard by the remote listener with satisfactory intelligibility, and*
 - 3.2. *Speech of the remote speaker can be clearly heard in the vehicle with satisfactory intelligibility*
4. *Hands-free voice communication assessment can be performed either*
 - 4.1. *By establishing voice communication to a simulator, or*
 - 4.2. *By establishing voice communication via real PLMN*
5. *HMI operation assessment shall include the following*
 - 5.1. *Manual trigger (call generation) is working correctly. This is verified by checking if manual trigger leads to*
 - 5.1.1. *MSD transmission, which is verified according to paragraph 1 of this Annex, and*
 - 5.1.2. *Voice communication being established, which is verified according to paragraph 3 of this Annex.*
 - 5.2. *Call status indication is working properly. This is verified by checking that the following statuses are displayed during test according paragraph 5.1 of the current Annex: [*
 - 5.2.1. *Call initiated (dialing)*
 - 5.2.2. *MSD transmitted*
 - 5.2.3. *Waiting for PSAP operator to answer*
 - 5.2.4. *Call in progress]*
 - 5.3. *Malfunction indication is working properly. This is verified by checking malfunction indication in at least one of the following conditions:*
 - 5.3.1. *Communication module antenna is disconnected, or*
 - 5.3.2. *GNSS receiver antenna is disconnected, or*
 - 5.3.3. *Microphone(s) is (are) disconnected, or*
 - 5.3.4. *Loudspeaker(s) is (are) disconnected, or*
 - 5.3.5. *AECD control module is disconnected from the HMI module"*

Secondly, OICA proposed in parallel Annex 8 (AECS-07-03) that defines on a high

level four alternative methods to check the post-crash functionality:

- Using the HMI (self-test function)
- Using internal memory checking
- By performing a separated functional test
- By performing a functional transmission test (wired procedure)

The method shall be chosen at the discretion of the manufacturer under certain conditions. Note that only the functional transmission test involves performing a test call and verifying the transaction using test equipment external of the vehicle (PSAP test point), whereas the remaining methods rely on the IVS self-test, information created by and stored in the IVS itself or functional checks of individual components.

Draft AECS UN Regulation (AECS-07-03), Annex 8:

"Test method for verifying the on-board AECD AECS via functional check (paragraph 16.5.3.)

- 1. The functional check of the in-vehicle system shall be performed via one out of the four methods laid down in paragraphs 2. to 5. below.*
- 2. Verification of functional state of the in-vehicle system by using HMI (visual control of tell-tale)*

When the AECS is capable to

- check and diagnose all devices belonging to the AECD scope (Antennas, power supply, Mic, speaker, ...), and*
- discriminate a network failure (*) from an internal failure of the AECD Unit*

the communication with GNSS and mobile networks and PSAP is deemed to be compliant if no failure warning is indicated by the HMI.

() An obstruction of the antenna by a metallic part could be detected and indicated as a network failure. In this case, a visual control can be performed around the antenna (or AECD Unit in the case of an internal antenna), if the antenna is not within the safe zone.*

- 3. Verification of functional state of the in-vehicle system by internal memory checking*

When

- the vehicle's diagnostic bus is still functioning and the AECS AECD Unit is still powered (e.g. by main or auxiliary battery), or after AECD Unit disassembly and test bench analysis, and*
- the in-vehicle AECD is capable to*
 - o check and diagnose all devices belonging to the AECD scope (Antennas, power supply, Mic, speaker, ...), and*
 - o memorize all steps of an emergency call transaction (e.g.: trigger signal reception, construction of MSD, etc.)*

the communication with GNSS and mobile networks and PSAP is deemed to be compliant if the AECD unit has memorized the correct emergency call transaction, and no failure is present in memory.

4. *Verification of functional state of the in-vehicle system by separated functional test according to Appendix 1*

When

- *the in-vehicle AECD is capable to memorize all steps of an emergency call transaction (e.g.: trigger signal reception, construction of MSD, etc.), and*
- *all devices belonging to the AECD scope are removable and their connectors are accessible (for electrical testing), for the visual control or/and for functional tests*

the communication with GNSS and mobile networks and PSAP is deemed to be compliant if the AECD unit has memorized the correct emergency call transaction, if all electrical tests are satisfactory and if all devices belonging to the AECD scope are in good condition and functioning correctly.

5. *Verification of functional state of the in-vehicle system by functional transmission test with wired procedure*

When

- *the mobile phone antenna connector is accessible, and*
- *all other parts (wire) between this antenna and the AECD Unit are accessible/removable for the visual control or/and for functional tests*

the communication with GNSS and mobile networks and PSAP is deemed to be compliant if the emergency call transaction is correct (with PSAP simulator) and if all the electrical tests between antenna and the AECD unit are satisfactory

The confirmation shall be conducted according to Appendix 2."

Draft AECS UN Regulation (AECS-07-03), Annex 8, Appendix 1:

"Appendix 1 Verification of functional state of the in-vehicle system by separated functional test

This appendix defines minimum test conditions (as far as applicable) and failure criteria for verification of functional state of the in-vehicle system by separate functional test

(1) AECD

<i>Subject</i>	<i>Item subject to confirmation</i>	<i>Criteria</i>	<i>Example of confirmation method</i>
<i>AECD</i>	<i>Generation of triggering (when a collision detection signal (CDS) is received)</i>	- <i>No record of triggering signal in AECS unit before collision test.</i> - <i>Record of triggering signal is correctly stored in the AECD memory. The time stamp of the record should be same or right after the time of collision test if unit has a capability to store</i>	- <i>The record confirmation of the internal memory using a diagnostic tool.</i> - <i>The visual observation of the eCall operation display</i>

		<i>time stamp of record.</i> - Activation of emergency calling is confirmed.	
	Initiate transmission of MSD	MSD is correctly stored in the AECD memory. The time stamp of the record should be same or right after the time of crash test if unit has a capability to store time stamp of record.	- Confirm that MSD data (notice data of a collision transmitted to a call center) remains in the internal memory as un-transmitting - The record confirmation of the internal memory

(2) Harness

Subject	Item subject to confirmation	Criteria	Example of the confirmation method
Battery and battery harness (in case of absence of sub-battery)	Battery function	Voltage above operating minimum value (at AECD side)	- Battery voltage confirmation - Termination off confirmation
Sub battery (in case of presence of sub-battery)	Battery function	No damage/deformation of AECD	Visual observation of the AECD
Telephone antenna feeder wire	- Wire snapping - Wire short-circuit	a. For external antenna : No evidence of snapping damage and of wire short-circuit b. For internal antenna : No damage/deformation of AECD	a. By conducting the following tests: i. measurement of resistance value between termination of lines ii. measurement of resistance value between line and vehicle structure ground or b. Visual observation of the AECD

(3) Component

Subject	Item subject to confirmation	Criteria	Example of the confirmation method
Telephone antenna (internal)	Function	No damage/deformation of AECD	Visual observation of AECD
Telephone antenna (external)	Function	No damage/deformation	No breakage by visual observation
		Measured Voltage Standing Wave Ratio (VSWR) satisfies the prescribed value	When there are breakage and deformation, remove antenna and confirm receiving sensitivity
Tell-tale	Display	- No damage deformation	- Visual observation of the display

		- Tell-tale lights on	- apply prescribed voltage
Microphone	Possibility of voice communication	Keep initial prescribed performance	- Output sound pressure measurement by the standard input - Confirm by hearing the output of speaker with input (voice) to microphone (using function confirming software)
Speaker	The possibility of voice communication	Keep initial prescribed performance	- Output voltage measurement by the standard input sound - Confirm by hearing the output of speaker with input(voice) to microphone (using function confirming software)"

Draft UN Regulation (AECS-07-03), Annex 8, Appendix 2:

"Appendix 2 Verification of functional state of the in-vehicle system by functional transmission test with wired procedure (for AECS with external antenna)

This appendix defines minimum test conditions (as far as applicable) and failure criteria for verification of functional state of the in-vehicle system by functional transmission test with wired procedure (for AECS with external antenna).

(1) AECD

Subject	Item subject to confirmation	Criteria	Example of the confirmation method
AECD	Activation of automatic call and dial-up.	No calling sequence to PSAP performed before collision test	Connect AECD to Radio communication tester by wire or confirm status of indicator.
		calling sequence to PSAP is performed after collision test	Confirm emergency calling sequence by PSAP simulator.
	Emission of MSD with antenna wire connection to simulator after the collision.	MSD has been emitted.	After completion of the emergency calling sequence, confirm the content of MSD

(2) Harness

Subject	Item subject to confirmation	Criteria	Example of the confirmation method
Battery and battery harness (in case of absence of sub-battery)	Battery function	Voltage above operating minimum value (at AECD side)	Availability of battery can be confirmed by communication test with wire.

<i>Sub battery (in case of presence of sub- battery)</i>	<i>Battery function</i>	<i>Correct AECS operation AECS with regard to prescribed functional items</i>	-
<i>Telephone antenna feeder wire</i>	- <i>Wire snapping</i> - <i>Wire short- circuit</i>	<i>No evidence of snapping damage and of wire short-circuit</i>	<i>By conducting the following tests:</i> <i>i. measurement of resistance value between termination of lines</i> <i>ii. measurement of resistance value between line and vehicle structure ground</i>

(3) Component

<i>Subject</i>	<i>Item subject to confirmation</i>	<i>Criteria</i>	<i>Example of the confirmation method</i>
<i>Telephone antenna (external)</i>	<i>Function</i>	<i>No damage/deformation</i>	<i>No breakage by visual observation</i>
		<i>Measured Voltage Standing Wave Ratio (VSWR) satisfies the prescribed value</i>	<i>When there are breakage and deformation, remove antenna and confirm receiving sensitivity</i>
<i>Tell-tale</i>	<i>Display</i>	- <i>No damage deformation</i> - <i>Tell-tale lights on</i>	- <i>Visual observation of the display</i> - <i>apply prescribed voltage</i>
<i>Microphone</i>	<i>Possibility of voice communication</i>	<i>Voice message from vehicle can be confirmed at PSAP simulator.</i>	- <i>Confirm voice condition during talking test with wire procedure.</i> - <i>One inspector of the technical service makes telephone call to another inspector of PSAP simulator side through PSAP simulator.</i>
<i>Speaker</i>	<i>Possibility of voice communication</i>	<i>Voice message from PSAP simulator can be confirmed at vehicle side.</i>	<i>One inspector of the technical service makes telephone call to another inspector of PSAP simulator side through PSAP simulator."</i>

3.3 Draft proposal**1. Requirements****1.1. Performance requirements**

1.1.1. *The full-scale impact assessments of vehicles with eCall in-vehicle systems installed, carried out in accordance with Paragraph [Test procedure], shall be considered satisfactory if the following requirements are demonstrated post-impact.*

1.1.2. *Automatic triggering: The eCall system shall automatically initiate an eCall after an impact in accordance with UN Regulation No. 94 (Annex 3) or UN Regulation No. 95 (Annex 4), as applicable.*

1.1.3. *Manual triggering: The eCall system shall allow manual triggering of an eCall*

by vehicle occupants.

- 1.1.4. Call status indication: The eCall system shall inform the occupants about the current status of the eCall (status indicator) using a visual and/or audible signal.*
- 1.1.5. MSD emission and encoding: The eCall system shall be able to successfully transmit an MSD to a PSAP test point via the mobile network.*
- 1.1.6. Vehicle-specific data determination: The eCall system shall be able to populate accurately the mandatory vehicle-specific data fields of the MSD.*
- 1.1.7. Position determination: The eCall system shall be able to determine accurately the up-to-date vehicle location.*

2. Test procedure

2.1. Purpose of the full-scale test procedure

The purpose of this test is to verify the automatic triggering function and the sustained functionality of the 112-based eCall in-vehicle system in vehicles that are subjected to a frontal impact or a side impact.

- 2.2. The following tests shall be performed on a vehicle with an eCall in-vehicle system installed for the approval of vehicles.*

2.3. Impact test procedure

- 2.3.1. An impact test shall be carried out in accordance with the tests defined UN Regulation No. 94, Annex 3 for frontal impact or UN Regulation No. 95, Annex 4 for side impact.*

- 2.3.2. The test conditions defined in UN Regulation No. 94 or UN Regulation No. 95 shall apply.*

- 2.3.3. Before performing the impact tests, ensure that:*

(a) the in-vehicle power source, if installed for the test, is charged sufficiently at the beginning of the test to allow performing the subsequent verification tests;

(b) the automatic eCall is enabled and armed and that the vehicle ignition or master control switch is activated;

(c) one of the connection procedures defined in Paragraph [Connection procedures], as agreed between the technical service and the manufacturer, will be applied for any test call;

(d) the dedicated PSAP test point, configured in normal mode (non-robust mode), is available to receive an eCall emitted by the 112-based system;

(e) a false eCall to a genuine PSAP cannot be made over the live network; and

(f) if applicable, the TPS system is deactivated or will automatically switch to the 112-based system.

2.4. Verification procedure

- 2.4.1. *The performance requirements shall be verified by performing two test calls from the vehicle after the impact using the 112-based eCall in-vehicle system: An automatically triggered eCall following the impact test and a subsequent manually triggered eCall.*
- 2.4.2. *Perform a test call (push mode) by applying an automatic trigger (impact event) or a manual trigger (in-vehicle HMI), as applicable.*
- 2.4.3. *Verify each of the following items in at least one of the test calls:*
- (a) Verify that an eCall was triggered automatically by the full-scale impact event. This shall be verified by a record of the PSAP test point showing that it received an eCall initiation signal following the impact event and that the MSD control indicator was set to 'automatically initiated eCall'.*
 - (b) Verify that an eCall was triggered manually. This shall be verified by a record of the PSAP test point showing that it received an eCall initiation signal following the manual trigger application and that the MSD control indicator was set to 'manually initiated eCall'.*
 - (c) Verify that the eCall status indicator indicated an eCall sequence following the automatic or manual trigger. This shall be verified by a record of a test engineer showing that an indication sequence was performed on all sensory channels specified in the manufacturer's documentation (visual and/or audible).*
 - (d) Verify that an MSD was received by the PSAP test point. This shall be verified by a record of the PSAP test point showing that an MSD emitted from the vehicle following the automatic or manual trigger was received and successfully decoded. Automatic re-transmissions at higher redundancy levels are permitted if necessary to successfully transmit the MSD.*
 - (e) Verify that the MSD contained accurate vehicle-specific data. This shall be verified by a record of the PSAP test point showing that the information transmitted in the fields regarding vehicle type, vehicle identification number (VIN) and vehicle propulsion storage type does not deviate from the information specified in the type-approval application.*
 - (f) Verify that the MSD contained an accurate, up-to-date location. This shall be verified in accordance with the Vehicle Location Test Procedure as defined in Paragraph [Positioning Test Procedure] by a test record showing that the deviation between IVS location and true location, d_{IVS} , is less than 150 metres and the confidence bit transmitted to the PSAP test point indicates 'position can be trusted'. If no GNSS signals are available at the impact test location, the vehicle can be moved to an appropriate location before performing the test call.*
- 2.4.4. *Clear down the test call using the appropriate PSAP test point command (e.g. hang up).*
- 2.4.5. *If the automatic test call could not be performed successfully due to vehicle-external factors, it shall be permissible to verify the automatic trigger following the impact via the internal record transaction function of the in-vehicle system. This register shall be capable to store received trigger signals in non-volatile memory. The test engineer shall have access to the data*

stored in the in-vehicle system and shall verify that no record of automatic trigger signal is stored before the impact event and that a record of an automatic trigger signal is stored after the impact event.

- 2.4.6. *If the test call was performed with the vehicle connected to an off-vehicle power supply (in cases where the impact test was carried out with the standard vehicle power supply not installed), verify that the on-board electrical system feeding the eCall in-vehicle system remained intact. This shall be verified by a record of a test engineer confirming a successful check of the integrity of the on-board electrical system including the dummy in-vehicle power source (visual inspection for mechanical damage to either the battery mounting bracket or battery structure) and the connections via its terminals.*

2.5. *Positioning test procedure*

[The proposal for the positioning test procedure is identical to the procedure as defined for Task 1 in Section 2.3 of this report.]

2.6. *Antenna test procedure*

- 2.6.1. *[The proposal for the antenna test procedure is identical to the procedure as defined for Task 1 in Section 2.3 of this report.]*

- 2.6.2. *Verify additionally that no wire breakage or short-circuit of the antenna feed line occurred by checking the electrical resistance between the end points of the wire and between the wire and vehicle ground.*

2.7. *Connection procedures*

[The proposal for connection procedures is identical to the procedures as defined for Task 1 in Section xx of this report.]

3.4 Justification

3.4.1 Purpose of the full-scale impact test procedure

The purpose of the full-scale impact test procedure is to ensure that the vehicle to be type-approved is constructed in a way that the eCall system survives a frontal and side collision in its original mounting situation and configuration and to verify the automatic triggering function. To minimise costs associated with testing, the eCall full-scale assessment shall be performed within the full-scale impact tests already carried out under UN R94 and UN R95.

This draft proposal shall not prompt vehicles to undergo additional full-scale crash testing: Vehicles that are currently not in scope of either UN R94 or UN R95, or are exempt from these regulations, shall still not be required to undergo these procedures; vehicles which are currently in scope of only one, UN R94 or UN R95, shall still undergo only this one procedure. Equally, no additional testing, for example a low severity test, has been proposed currently.

This is also relevant with regard to vehicle converters, such as the wheelchair-accessible vehicle industry: These converters usually modify the structure of cars or

multi-purpose vehicles (MPVs), for example by replacing the floor, and sometimes disable individual airbags. Due to these modifications, the vehicles will behave structurally different from the base vehicles. The usual routes for type-approval include individual vehicle approvals, national small series type-approvals and EC whole vehicle type-approval (usually as special purpose vehicles under Annex XI of 2007/46/EC). Also in these cases, the type-approval of eCall shall not require performing additional full-scale impact tests, from which the vehicles are otherwise exempt.

The core functionality of an eCall system is to notify the PSAP that an incident has happened and where the vehicle is by transmitting an MSD, and establishing a voice connection with the vehicle occupants. Six performance requirements (1.1.2. to 1.1.7.), to be demonstrated post-impact, were defined to ensure the comprehensive functionality of an eCall IVS after an impact. This list was defined based on the 'specific obligations of manufacturers' according to Regulation (EU) 2015/758, Article 5, Paragraph 2 (Sentences 1 and 2) and Paragraph 5. Note that the procedure for verification of the crash resistance of audio equipment is described separately in Section 4.

3.4.2 General test principle

Two principal options were considered closely for the demonstration of automatic triggering and sustained functionality of the IVS after a crash test: A procedure based on the demonstration of successful test eCalls or a procedure based solely on inspections or functional tests of individual IVS components post-crash. The proposed draft annexes for the AECS UN Regulation can be considered a mix of these approaches (see Section 3.2). These draft annexes have been proposed by OICA and RUS, respectively, but have not yet been discussed in detail by the AECS working group. The proposals were acknowledged and elements of both were used in developing the present proposal for a European procedure.

Preference was given to a test procedure that involves the demonstration of successful test eCalls, because this procedure is:

- Not reliant on the self-diagnosis of the system under test;
- Not design-restrictive or design-specific; and
- A close simulation of the real-world conditions, which allows a direct assessment of the whole-system functionality.

The proposed procedure involves two subsequent test calls to assess both the automatic and manual eCall function. Each of the requirements shall be demonstrated in at least one of these test calls. Note that, according to EN standards, as long as an eCall is in progress, a new trigger shall not disconnect the current eCall. This means, that it is necessary to clear down the automatic test call to allow performing a subsequent manual test call.

The automatic triggering requirement needs to be demonstrated using the automatic test call and the manual triggering using the manual test call. If connection attempts of the automatic test call fail, for example due to mobile network circumstances, the IVS will re-attempt connecting and transmitting. However, a situation should be avoided where a full-scale impact test needs to be repeated because the automatically triggered eCall could not be completed because of vehicle-external problems. If this was the case it shall be permissible to demonstrate that an automatic trigger signal

was received via IVS-internal transaction records.

Depending on the test setup, some elements might preferably be verified during the manual test call. For instance, it might not be feasible or convenient to perform the status indication assessment immediately after the impact test because the vehicle might not be in a condition that allows entering it comfortably and the test room might not immediately be accessible (some test houses have procedures in place that do not allow entering the room for a few minutes because of airbag gases). It might also not be feasible to assess positioning after the automatic test call if no GNSS simulation is available inside the test laboratories. It might therefore be required to move the vehicle to an outdoor location before performing the manual test call.

Table 3 summarizes the options for verifying each of the specific requirements, either during the automatic test call, the manual test call or alternative component tests. Note that a setup with an over-the-air network (simulated or genuine) and GNSS coverage (simulated or genuine) allows straightforward verification of all requirements bar the manual triggering.

Table 3: Options for verification of specific requirements during test calls; each requirement to be demonstrated by at least one of the options indicated by 'x'

Requirement	To be demonstrated using:			Comments
	Auto. test call	Manual test call	Component test	
Automatic triggering	x		(x)	If automatic call fails because of external factors, verification by IVS-internal transaction records.
Manual triggering		x		
Call status indication	x	x		
MSD emission and encoding	x	x		
Vehicle-specific data determination	x	x		
Position determination	x	x		
Mobile network access	x	x	(x)	Implicitly verified by over-the-air test call or, in case of wired connection procedure, explicitly by antenna test procedure and feed wire inspection.
Power supply	x	x	(x)	Implicitly verified by test call or, in case the vehicle was connected to external power supply during the test call, inspection of the on-board electrical system.

3.4.3 Automatic triggering verification

Automatic triggering in a potentially injurious collision is one of the basic functional premises of eCall and shall therefore be demonstrated during the type-approval testing.

Regulation (EU) 2015/758, Article 5, Paragraph 2.:

"Manufacturers shall demonstrate that all new types of vehicles are constructed in such a way as to ensure that, in the event of a severe accident, detected by activation of one or more sensors or processors within the vehicle, which occurs in the territory of the Union, an eCall to the single European emergency number 112 is triggered automatically."

EN 16072 further stipulates that UN R94 and UN R95 crash tests shall trigger an eCall.

EN 16072, Section 7.5:

"The in-vehicle eCall system shall transmit the MSD message [...] in all crash tests which are required by regulation for the European type-approval:"

NOTE At the time of developing this European Standard, the relevant frontal crash tests are defined in Directive 96/79, amended by Directive 1999/98 (or equivalent ECE R94-01); and lateral crash tests are defined in: Directive 96/27 (or equivalent ECE R95-02)."

The proposed procedure verifies that an eCall was triggered following the impact test by monitoring the connection behaviour via test equipment independent of the IVS (dedicated PSAP test point). The procedure ensures that the eCall was triggered automatically by verifying the corresponding indicator ('automatically initiated eCall') in the MSD.

Note: If the test call is performed using public mobile network procedure, the IVS SIM will be specifically set up to perform a TS11 call (to the phone number of the dedicated PSAP test point) rather than a TS12 call (to the emergency number 112). The requirement of the IVS to conform to the relevant eCall EN standards will ensure that the IVS transmission logic performs a TS12 call in cases where this modification has not been performed.

The alternative procedure, for cases where the automatic test call failed due to vehicle-external reasons, relies on the verification of IVS-internal transaction records. EN 16072 requires that every IVS shall keep a register of recent eCalls:

EN 16072, Section 7.17.4:

"Record transaction

The IVS responsible for eCall shall register recent eCalls in non-volatile memory. The method and means by which this is done, and number of records stored is not specified in this European Standard. The storage of data shall respect European data protection regulations."

However, the verification test case (CTP 1.1.16.3) of this requirement in EN 16454, Section 9.4.41 requires only a register of a successful eCall (after AL-ACK was received). Measures exceeding this requirement might need to be implemented in the IVS design to document cases where a trigger was received but the eCall failed.

3.4.4 Manual triggering verification

The eCall regulation requires that an eCall can also be triggered manually.

Regulation (EU) 2015/758, Article 5, Paragraph 2.:

"Manufacturers shall demonstrate that new types of vehicles are constructed in such a way as to ensure that an eCall to the single European emergency number 112 can also be triggered manually."

The sustained functionality of the manual triggering device (eCall button) after a collision enables vehicle occupants to initiate an eCall in collision types that were not detected by in-vehicle sensors (such as rollovers) and to initiate a repeated call to the PSAP after an automatic eCall was terminated. While damages to the manual triggering device due to vehicle deformation in other collision types than frontal and lateral collisions cannot be assessed within the scope of UN R94 and UN R95, the feasibility of repeated calls can be ensured by performing a manual test call post-crash.

The proposed manual test call procedure involves the manual application of a trigger by a test engineer using the in-vehicle HMI and monitoring the connection behaviour via test equipment independent of the IVS (dedicated PSAP test point). The procedure

ensures that the eCall was triggered manually by verifying the corresponding indicator ('manually initiated eCall') in the MSD.

When working inside the crashed vehicle, safety risks for test engineers could arise from undeployed airbags, sharp edges or shattered glass inside the vehicle, which is why a risk assessment should be performed before performing this task.

3.4.5 Call status indication verification

eCall IVS are equipped with a visual and/or audible status indicator as per the stipulation in EN 16072.

EN 16072, Section 7.9.1 stipulates:

"The eCall in-vehicle system shall provide clear visual and/or audible information regarding the status of the connection (IVS-MNO-PSAP) when the eCall system is automatically or manually activated.

The general provisions of the updated 'European Statement of Principles on Human Machine Interface' shall apply. [...]

The human machine interface of the eCall in-vehicle system shall inform the driver if the eCall system on board is not functioning properly."

EN 16072, Section 7.9.4:

"Alerting of initiated eCall (automatically or manually triggered)

Subsequent to the triggering of the event, whether initiated automatically or manually, the eCall in-Vehicle System shall wherever practicable alert the vehicle occupants that an eCall message has been sent and that the system shall attempt to make a direct voice connection with the PSAP. The means by which this alert is made, and the nature of the alerts, shall be a function of product design and it is not defined in this European Standard."

The post-crash functionality of this call status indication is an important aspect of the eCall system to provide assurance to the occupants that an eCall is being performed and a voice connection with the PSAP will be established. In cases where an eCall cannot be established successfully, it is also important to make people aware of this circumstance in order to allow them to explore and use other options of calling the emergency services.

The post-crash check is intended to verify sustained functionality, not performance. Correct post-crash status indication during a successful, manually activated test call provides sufficient assurance of sustained functionality of the relevant components of the status indicator. A separate check of the status indication during a failed call is not required because the indication logic and protocol are not expected to be adversely affected by a crash.

When working inside the crashed vehicle, safety risks for test engineers could arise from undeployed airbags, sharp edges or shattered glass inside the vehicle, which is why a risk assessment should be performed before performing this task.

The details of how the status shall be indicated to the occupants are not in scope of this study and are not currently defined in European legislation or technical standards. The status indicator sequence is therefore only compared to the manufacturer's specification with regard to the sensory channels used (visual and/or audible).

3.4.6 *MSD emission and encoding verification*

An MSD that was successfully transmitted to a PSAP test point under the control of the technical service provides system- and design-independent assurance that the eCall IVS under test is still able to construct an MSD and emit it via the mobile communication module. This behaviour can be verified during the automatic or manual post-crash test call.

3.4.7 *Vehicle-specific data determination verification*

An MSD, decoded by a PSAP test point under the control of the technical service, which contains the correct data content in the mandatory vehicle-specific fields, demonstrates that the IVS is still able to gather this information successfully. This behaviour can be verified during the automatic or manual post-crash test call.

3.4.8 *Positioning test procedure*

The proposal for the positioning test procedure is identical to the procedure described in Task 1. See Section 2.4.3.2 for the general justification.

With regard to the full-scale impact test, the conditions at the test laboratory are of particular relevance: Most full-scale impact tests are performed inside special buildings or test laboratory facilities, which will block genuine GNSS signals to varying extents. If this is the case, the post-crash functionality of the position system can be verified during the manual test call (after the vehicle has been moved outside under open sky to ensure appropriate signal conditions). If moving the crashed vehicle outside must be avoided, then appropriate signal strength at the test location must be ensured by GNSS signal simulation.

3.4.9 *Antenna test procedure*

The proposal for the antenna test procedure is identical to the procedure described in Task 1. See Section 2.4.3.3 for the general justification.

Depending on the routing of the antenna feed lines, there is a potential for wire breakage or short-circuit due to deformation of the vehicle body. This can be ruled-out by simple electrical resistance measurements. Note that this is only relevant if the wired transmission procedure was used for both test calls (mobile network antenna wire) or if simulated GNSS signals via a wired connection were used for the positioning test procedure (GNSS antenna wire). By their very nature, the wired transmission procedures do not allow an assessment of the antenna connectors because they are not plugged in during the impact test. This is considered acceptable because higher inertial loads, which might unplug the antenna connector, are evaluated during the sled test.

3.4.10 *Power supply integrity check*

The power source is an important aspect of the post-crash functionality because a failure of the power source would lead to a complete failure of the eCall.

Note: For TPS systems (which are not in scope of type-approval), EN 16102 stipulates certain requirements regarding the systems power supply:

EN 16102, Section 8.9:

"8.9 Energy supply

The installed TPS-IVS shall demonstrate an adequate energy supply to conform to the post crash performance requirements in 8.8. [i.e. "Ideally, it should be possible to maintain a voice communication for at least 8 min."]

If necessary, or to provide a solution which is less dependent on a particular vehicle installation, this requirement may be achieved by the use of an appropriate vehicle-independent power supply."

For 112-based systems, the European legislative requirements and technical standards do not set out a minimum capacity of the power supply or a minimum duration of operation in certain modes. The corresponding requirements in EN 16072 cover only the software logic, but not the aspect of power supply. The question whether or not it would be advisable to require an IVS power supply that operates autonomously from the main vehicle power supply system was not in scope of this project and therefore no specific requirements are included in this test.

If the full-scale impact test is performed with the normal vehicle power sources installed, a successful test call to a PSAP test point provides sufficient confirmation that the IVS is powered post-crash (irrespective of whether the power is supplied from the main vehicle power source or an dedicated power source).

However, in some cases the main vehicle power source may be removed from the vehicle for UN R94 frontal impact tests for safety reasons. In some test houses this is common practice to avoid the risk of battery explosions. In these cases a dummy battery (e.g. filled with water instead of acid) is used during the test and the vehicle is connected to an off-vehicle power source to supply the on-board systems during the impact test.

In these cases it is necessary to demonstrate that the IVS would be powered post-crash by at least one of the in-vehicle power sources (main vehicle power source or dedicated power source). If the IVS is equipped with a dedicated power source this can be demonstrated by disconnecting the off-vehicle power supply before performing the manual test call. If the IVS is not equipped with a dedicated power source this shall be verified by a test engineer checking that the on-board energy distribution system feeding the IVS remained intact (electrical check) and remained connected to the terminals of the dummy battery, and that the dummy battery did not sustain damage during the impact (visual inspection for mechanical damage to either the battery mounting bracket or battery structure).

3.4.11 Test call setup

The permissible connection procedures (simulated mobile network procedure, public mobile network procedure, and wired transmission procedure) are identical for all test calls to be performed during the type-approval test programme (i.e. after the deceleration test, after the full-scale impact test and during the course of the TPS co-existence test). Please refer to Section 2.4.4 for the general justification.

4 CRASH RESISTANCE OF AUDIO EQUIPMENT

4.1 Background

The eCall Regulation stipulates that an eCall shall be performed *"in the event of a severe accident"*. To ensure the system's ability to perform an eCall after the vehicle has been damaged in a collision, the survivability of the IVS components is assessed in conjunction with the full-scale front and side impact tests, namely UN Regulations No. 94 and No. 95 (see Section 3).

The core functionality of an eCall system is not only to notify the PSAP of an incident by transmitting the MSD, but also to establish a voice connection between occupants and PSAP operator. This voice channel is a vital part of an eCall to provide the PSAP with information regarding, for example, the accident severity and details and a description of any casualties and their characteristics, such as age and state of health. This section covers specifically the crash resistance of audio equipment to ensure that the components required for a voice channel are protected from damage during a collision.

An inspection procedure to be carried out after the full-scale impact tests (UN R94 and UN R95) has been developed to verify the sustained functionality of the eCall audio equipment. The procedure applies to vehicles with eCall in-vehicle systems installed.

4.2 Legislative source material

4.2.1 Draft AECS UN Regulation

Two proposals for post-crash assessments, prepared by the Russian Federation and OICA respectively, are discussed in more detail in Section 3. These also contain an assessment of the voice communication capability. Note that both proposals have not yet been discussed within the UN informal working group on Automatic Emergency Call Systems (UN IWG AECS).

Draft UN Regulation (AECS-07-02), Annex 6:

"3. Hands-free voice communication assessment (subjective test) shall include verification of the following:

3.1. Voice originating inside the vehicle can be clearly heard by the remote listener with satisfactory intelligibility, and

3.2. Speech of the remote speaker can be clearly heard in the vehicle with satisfactory intelligibility

4. Hands-free voice communication assessment can be performed either

4.1. By establishing voice communication to a simulator, or

4.2. By establishing voice communication via real PLMN"

Draft UN Regulation (AECS-07-03), Annex 8:

"Appendix 1 (separated functional check, objective audio test procedure):

<i>Microphone</i>	<i>Possibility of voice communication</i>	<i>Keep initial prescribed performance</i>	- <i>Output sound pressure measurement by the standard input</i> - <i>Confirm by hearing the output of speaker with input (voice) to microphone (using function confirming software)</i>
<i>Speaker</i>	<i>The possibility of voice communication</i>	<i>Keep initial prescribed performance</i>	- <i>Output voltage measurement by the standard input sound</i> - <i>Confirm by hearing the output of speaker with input(voice) to microphone (using function confirming software)</i>

Appendix 2 (functional transmission test, subjective audio test procedure):

<i>Microphone</i>	<i>Possibility of voice communication</i>	<i>Voice message from vehicle can be confirmed at PSAP simulator.</i>	<i>Confirm voice condition during talking test with wire procedure.</i> <i>One inspector of the technical service makes telephone call to another inspector of PSAP simulator side through PSAP simulator.</i>
<i>Speaker</i>	<i>Possibility of voice communication</i>	<i>Voice message from PSAP simulator can be confirmed at vehicle side.</i>	<i>One inspector of the technical service makes telephone call to another inspector of PSAP simulator side through PSAP simulator."</i>

4.2.2 ITU-T Recommendation P.emergency

The International Telecommunication Union (ITU) is in the process of finalising a proposal for speech communication requirements for emergency calls originating from vehicles (Draft Recommendation P.emergency). This procedure was designed to assess the performance of the audio equipment in an un-crashed vehicle (pre-crash), as stated in the scope: "*specific tests after a car crash are not in the scope of this Recommendation*"

A draft was published and presented to the UN IWG AECS (document: AECS-08-03⁴). The use cases, requirements and test methods defined in P.emergency are designed to ensure sufficient intelligibility and communication quality in hands-free communications from all locations in the vehicle. Specifics of a post-crash situation are taken into account with regard to the acoustic environment after a crash (background noise) but, as already noted, the tests are carried out on un-crashed vehicles.

The P.emergency procedure is based on a head and torso simulator (HATS; a manikin with built-in ear and mouth simulators intended to provide a realistic reproduction of the acoustic properties of an average adult human head and torso) positioned in the AECS-equipped vehicle. Measurements of key parameters are taken both in the

⁴ <https://www2.unece.org/wiki/download/attachments/25266009/AECS-08-03e.pdf?api=v2>

sending and receiving directions under simulated background noise generated by additional loudspeakers:

- Sending, i.e. testing IVS microphone(s): A speech-like audio signal is emitted by the artificial mouth of the HATS; recorded by the IVS microphone(s); transmitted via simulated mobile network to the PSAP simulator; and transmitted via wired connection to the test system where the signal is analysed.
- Receiving, i.e. testing the IVS loudspeaker(s): A speech-like audio signal is generated by the test system; transmitted via wired connection to the PSAP simulator; transmitted via simulated mobile network to the IVS and played back by the IVS loudspeaker(s); recorded by the artificial ears of the HATS and transmitted via wired connection to the test system where the signal is analysed.

The parameters assessed in P.emergency are:

- Delay
- Loudness ratings
- Variation of loudness (Receive Loudness Rating, RLR) in presence of background noise
- Sensitivity frequency responses
- Speech quality during single talk
- Idle channel noise
- Echo performance without background noise
- Switching characteristics
- Double talk performance
- Background noise transmission

4.2.3 ITU-T Recommendation P.1100

ITU-T P.1100 describes performance requirements and test methods for narrowband hands-free communication in vehicles. Section 14 of this recommendation includes guidance on subjective testing and references to ITU-T P.800. The recommendations are aimed at performance evaluations, rather than mere functionality tests, which somewhat limits their applicability, but some relevant general aspects of this guidance were taken into consideration for the proposal:

- Native language should be used.
- Since conversational tests are rather time consuming, most hands-free tests are conducted as single talk and double talk tests following a clear given structure.
- Some mobile networks have an influence on the hands-free performance (e.g., echo, automatic gain control, noise reduction, etc.). These networks should not be chosen for the tests, if possible.

4.2.4 ITU-T Recommendation P.800

ITU-T P.800 defines methods and procedures for conducting subjective evaluations of

the transmission quality of transmission systems and components for telephony. While these methods are designed to closely assess the quality of a transmission system, rather than just an assessment of the sustained functionality after an incident, certain aspects of these recommendations are relevant for the procedure to be developed. The test methods require a number of different test subjects from the general public (not experts in the field of audio testing) and test rooms with controlled sound qualities. The overall quality scores are based on a statistical analysis of the subjective quality assessments of individuals.

Various opinion scales are recommended for different kinds of assessments. The five-point listening effort scale can be applied for the listening test (in contrast to conversation tests). The task eCall evaluations requires a simpler binary scale representing a pass/fail for type-approval, but a description regarding the 'effort required to understand the meaning of sentences' is likely to constitute the relevant criterion for this.

ITU-T P.800, Annex B, Section B.4.5 :

"B.4.5 Opinion scales recommended by the ITU-T

[...]

b) Listening-effort scale

The heading of the listening-effort opinion scale is particularly important. Without it, the other descriptions are liable to be seriously misunderstood.

<i>Effort required to understand the meanings of sentences</i>	<i>Score</i>
<i>Complete relaxation possible; no effort required</i>	<i>5</i>
<i>Attention necessary; no appreciable effort required</i>	<i>4</i>
<i>Moderate effort required</i>	<i>3</i>
<i>Considerable effort required</i>	<i>2</i>
<i>No meaning understood with any feasible effort</i>	<i>1</i>

The quantity evaluated from the scores (mean listening-effort opinion score) is represented by the symbol MOS_{LE} but where suffix notation is not available, the symbol MOS_{le} is used."

The difficulty scale is an opinion scale that can be applied for conversation tests. It is relevant for the eCall assessment because it is a binary scale, requiring a 'yes or no' answer from each subject. The answers are combined statistically to obtain an overall score.

ITU-T P.800, Annex A, Section A.4.2.2:

"A.4.2.2 Difficulty scale

This is a binary response obtained from each subject at the end of each conversation.

Did you or your partner have any difficulty in talking or hearing over the

connection?

Yes

No

The experimenter allocates the following values to the scores:

Yes = 1 No = 0

The quantity evaluated (percentage of "yes" responses) is called percentage Difficulty or per cent "Difficult", and is denoted by the symbol %D. The corresponding simple proportion is denoted by the symbol d; in other words, %D = 100d."

4.2.5 ITU-T Recommendation P.501

ITU-T P.501 defines test signals (including speech signals) for use in telephony. This includes a selection of phonetically balanced test sentences in different languages. These sentences are provided as recordings for repeatable measurement procedures but can also be used as example sentences to be read by testers for the proposed type-approval procedure. The test sentences in European languages are reproduced in full in the proposal (see Section 0).

4.3 Draft proposal

1. Requirements

1.1. Performance requirements

- 1.1.1.** *The assessment of the crash resistance of the eCall audio equipment of vehicles with eCall in-vehicle systems installed, carried out in accordance with Paragraph [Audio equipment crash resistance test procedure], shall be considered satisfactory if the following requirements are demonstrated post-impact.*
- 1.1.2.** *Reconnection of audio equipment: The eCall system shall reconnect the loudspeaker(s) and microphone(s) after being disconnected during an eCall for MSD transmission.*
- 1.1.3.** *Voice communication: The eCall system shall allow hands-free voice communication (send and receive direction) of sufficient intelligibility between vehicle occupants and an operator.*

2. Test procedure

2.1. Purpose of the audio equipment crash resistance test procedure

The purpose of this test is to verify that loudspeaker(s) and microphone(s) are successfully reconnected after being disconnected for MSD transmission and that the audio equipment remained functional after the vehicle has been subjected to a frontal impact or side impact.

- 2.2.** *The following verification test shall be performed on a vehicle with eCall in-vehicle systems installed that has been subjected to a full-scale impact according to Regulation No. 94, Annex 3 for frontal impact or UN Regulation*

No. 95, Annex 4 for side impact.

2.3. Overview of test procedure

- 2.3.1. The sustained functionality of the audio equipment shall be verified by performing a manually triggered test call after the impact test and using the voice communication channel between the vehicle and the PSAP test point.*
- 2.3.2. Two test engineers, positioned in the vehicle (near-end tester) and at the PSAP test point (far-end tester) respectively, successively transmit (read and listen) pre-defined, phonetically balanced sentences in single talk mode.*
- 2.3.3. The testers are required to assess whether they were able to understand the meaning of the transmission in the send and receive directions.*

2.4. Arrangement of testers

- 2.4.1. The test shall be performed in a quiet environment, with a background noise level of not more than 50 dB(A) and that is free from any noise sources that might otherwise disrupt the tests.*
- 2.4.2. The near-end tester shall be positioned so that their head is close to a normal seating position on the driver's seat of the impacted vehicle. The tester shall use the in-vehicle audio equipment in the original arrangement.*
- 2.4.3. The far-end tester shall be positioned away from the vehicle with sufficient separation so that speech in normal loudness from one tester cannot be understood without any aids by the other tester.*

2.5. Test setup

- 2.5.1. Before performing the test call, ensure that:*
 - (a) one of the connection procedures defined in Paragraph [Connection procedures], as agreed between technical service and manufacturer, will be applied for any test call;*
 - (b) the dedicated PSAP test point is available to receive an eCall emitted by the 112-based system;*
 - (c) a false eCall to a genuine PSAP cannot be made over the live network;*
 - (d) if applicable, the TPS system is deactivated or will automatically switch to the 112-based system; and*
 - (e) the vehicle ignition or master control switch is activated.*
- 2.5.2. Where it is possible to adapt the volume setting, the maximum volume control setting in send and receive direction at the near-end and at the far-end shall be chosen. The volume control settings at the far-end may be decreased during the test if required for better intelligibility.*
- 2.5.3. If possible, no mobile networks that have an influence on the hands-free performance (e.g. echo, AGC, noise reduction, etc.) should be chosen for the connection. For simulated networks, if possible, DTX shall be switched off, the full rate codec shall be used (for GSM standard) and the highest bit rate of*

12.2 kbit/s shall be used (for AMR codecs).

2.6. Test call

2.6.1. *Perform a test call (push mode) by applying a manual trigger via the in-vehicle HMI and wait until the loudspeaker(s) and microphone(s) are reconnected for voice communication after completed MSD transmission.*

2.6.2. Exchange of test messages

2.6.2.1. Receive direction

2.6.2.1.1. *The far-end tester shall select and read one sentence pair of the list provided in Appendix [Test sentences]. The tester shall read the sentences in a normal volume as used in phone calls.*

2.6.2.1.2. *The near-end tester shall assess whether the voice transmission in the receive direction was intelligible: The test in receive direction is passed if the near-end tester, resting in their original seating position, was able, with any feasible effort and to the satisfaction of the type-approval authority, to understand the full meaning of the transmission.*

2.6.2.1.3. *If required for the assessment, the near-end tester can request from the far-end tester to transmit additional sentence pairs.*

2.6.2.2. Send direction

2.6.2.2.1. *The near-end tester shall select and, resting in their original seating position, read one sentence pair of the list provided in Appendix [Test sentences]. The tester shall read the sentences in a normal volume as used in phone calls.*

2.6.2.2.2. *The far-end tester shall assess whether the voice transmission in the send direction was intelligible: The test in send direction is passed if the far-end tester was able, with any feasible effort and to the satisfaction of the type-approval authority, to understand the full meaning of the transmission.*

2.6.2.2.3. *If required for the assessment, the far-end tester can request from the near-end tester to transmit additional sentence pairs.*

2.6.3. *Clear down the test call using the appropriate PSAP test point command (e.g. hang up).*

2.6.4. *If the requirements cannot be fulfilled due to impairments introduced by the PSAP test point or the transmission medium, the test call may be repeated, if required in an adapted test setup.*

2.7. Connection procedures

2.7.1. *[The proposal for connection procedures is identical to the procedures as defined for Task 1 in Section 2.3 of this report.]*

Appendix 1: Test sentences

1. *The following test sentence pairs, as defined in ITU-T P.501, Annex B, shall be used for the exchange of test messages in the send and receive directions.*

2. *Test sentence pairs in the language most commonly spoken by the testers shall be selected from the list below. If the testers are not familiar with any of the languages, alternative sentences in a familiar language, preferably phonetically balanced, shall be used.*
3. *Test sentence pairs*
 - 3.1. *Dutch*
 - (a) *Dit produkt kent nauwelijks concurrentie.*
Hij kende zijn grens niet.
 - (b) *Ik zal iets van mijn carrière vertellen.*
Zijn auto was alweer kapot.
 - (c) *Zij kunnen de besluiten nemen.*
De meeste mensen hadden het wel door.
 - (d) *Ik zou liever gaan lopen.*
Willem gaat telkens naar buiten.
 - 3.2. *English*
 - (a) *These days a chicken leg is a rare dish.*
The hogs were fed with chopped corn and garbage.
 - (b) *Rice is often served in round bowls.*
A large size in stockings is hard to sell.
 - (c) *The juice of lemons makes fine punch.*
Four hours of steady work faced us.
 - (d) *The birch canoe slid on smooth planks.*
Glue the sheet to the dark blue background.
 - 3.3. *Finnish*
 - (a) *Ole ääneti tai sano sellaista, joka on parempaa kuin vaikeneminen.*
Suuret sydämet ovat kuin valtameret, ne eivät koskaan jäädy.
 - (b) *Jos olet vasara, lyö kovaa. Jos olet naula pidä pääsi pystyssä.*
Onni tulee eläen, ei ostaen.
 - (c) *Rakkaus ei omista mitään, eikä kukaan voi sitä omistaa.*
Naisen mieli on puhtaampi, hän vaihtaa sitä useammin.
 - (d) *Sydämellä on syynsä, joita järki ei tunne.*
On opittava kärsimään voidakseen elää.

3.4. French

- (a) *On entend les gazouillis d'un oiseau dans le jardin.*

La barque du pêcheur a été emportée par une tempête.

- (b) *Le client s'attend à ce que vous fassiez une réduction.*

Chaque fois que je me lève ma plaie me tire.

- (c) *Vous avez du plaisir à jouer avec ceux qui ont un bon caractère.*

Le chevrier a corné pour rassembler ses moutons.

- (d) *Ma mère et moi faisons de courtes promenades.*

La poupée fait la joie de cette très jeune fille.

3.5. German

- (a) *Zarter Blumenduft erfüllt den Saal.*

Wisch den Tisch doch später ab.

- (b) *Sekunden entscheiden über Leben.*

Flieder lockt nicht nur die Bienen.

- (c) *Gegen Dummheit ist kein Kraut gewachsen.*

Alles wurde wieder abgesagt.

- (d) *Überquere die Strasse vorsichtig.*

Die drei Männer sind begeistert.

3.6. Italian

- (a) *Non bisogna credere che sia vero tutto quello che dice la gente. Tu non conosci ancora gli uomini, non conosci il mondo.*

Dopo tanto tempo non ricordo più dove ho messo quella bella foto, ma se aspetti un po' la cerco e te la prendo.

- (b) *Questo tormento durerà ancora qualche ora. Forse un giorno poi tutto finirà e tu potrai tornare a casa nella tua terra.*

Lucio era certo che sarebbe diventato una persona importante, un uomo politico o magari un ministro. Aveva a cuore il bene della società.

- (c) *Non bisogna credere che sia vero tutto quello che dice la gente tu non conosci ancora gli uomini, non conosci il mondo.*

Dopo tanto tempo non ricordo più dove ho messo quella bella foto ma se aspetti un po' la cerco e te la prendo.

- (d) *Questo tormento durerà ancora qualche ora. Forse un giorno poi tutto finirà e tu potrai tornare a casa nella tua terra.*

Lucio era certo che sarebbe diventato una persona importante, un uomo politico o magari un ministro, aveva a cuore il bene della società.

3.7. *Polish*

(a) *Pielęgniarki były cierpliwe.*

Przebiegał szybko przez ulicę.

(b) *Ona była jego sekretarką od lat.*

Dzieci często płaczą kiedy są głodne.

(c) *On był czarującą osobą.*

Lato wreszcie nadeszło.

(d) *Większość dróg było niezmiernie zatłoczonych.*

Mamy bardzo entuzjastyczny zespół.

3.8. *Spanish*

(a) *No arroje basura a la calle.*

Ellos quieren dos manzanas rojas.

(b) *No cocinaban tan bien.*

Mi afeitadora afeitó al ras.

(c) *Vé y siéntate en la cama.*

El libro trata sobre trampas.

(d) *El trapeador se puso amarillo.*

El fuego consumió el papel.

4.4 Justification

4.4.1 Purpose of the audio equipment crash resistance test procedure

The performance requirements (1.1.2. and 1.1.3.) were defined based on the 'specific obligations of manufacturers' according to Regulation (EU) 2015/758, Article 5, Paragraphs 2 and 5, in particular the obligation to perform an eCall in the event of a severe accident. To ensure that the type-approved eCall systems are able to perform an eCall after the vehicle has been damaged in a collision, the survivability of the audio equipment components needs to be verified in an impact test procedure.

The full-scale impact test procedures in accordance with UN R94 and UN R95 offer a cost-effective opportunity to perform this assessment in a frontal and side impact. Note that the survivability of other, non-audio-related parts of the IVS is also tested in higher deceleration accidents, which are simulated using a deceleration sled test (see Section 2). The voice connection functionality was exempted from this procedure following concerns raised by the AECS working group about the ability to design audio equipment (loudspeaker and microphone) that is crash-proof at the required level within the current design cycle of systems to be type-approved. Refer to Section 2.4.1 for further details.

The MSD of an eCall is transmitted via the voice channel using an in-band data modem. For this purpose, microphone and loudspeaker are disconnected from the line

before the transmission; hence, no voice communication is possible during MSD transfer. EN 16062, Section 6 states: *"On completion of the MSD transfer the in-vehicle audio system is reconnected to the line and a voice communication is established between the vehicle occupants and a PSAP operator."*

To rule out the possibility of a catastrophic failure of the audio equipment after an impact, the steps necessary for a successful voice connection shall be verified in this type-approval test procedure: The audio equipment must be connected to the line and it must have sustained its functionality after the collision, i.e. not have failed completely and not suffer from loudness reduction or distortions that make voice communication impossible. Note that an assessment of the performance or quality of the audio equipment is not part of this functionality check procedure. ITU-T recommended a procedure to be performed pre-crash for this purpose (see Section 4.2.2).

4.4.2 General test principle

Two principal options were considered for the audio assessment: A procedure based on the assessment of human testers transmitting voice messages or a procedure involving measurements of performance parameters of the audio equipment.

Different grades of complexity would be conceivable between these options: A basic assessment by test engineers of the test house; a comprehensive subjective performance assessment by a representative set of test listeners; measurement of the difference of certain performance parameters between pre- and post-crash conditions; or a full performance assessment based on ITU-T P.emergency.

No full-scale impact testing has been performed for this work programme, but some deceleration sled experiments have been carried out with individual loudspeakers involving deliberate destruction of the samples (see Section 8). The experience gained during these tests suggests that the loudspeakers of current voluntary emergency call systems are designed to perform sufficiently well after a severe deceleration event. The tests demonstrated that unless the damage to the speaker was catastrophic and resulted in complete or near-complete failure, for example by full dissection of electrical wires/connections or complete destruction by vehicle deformation; the speakers were likely to perform to satisfactory standards.

A basic assessment by test engineers exchanging test messages will cost-effectively check for complete or near complete failures and is therefore considered the most suitable of the discussed testing options, because of its simplicity, promptness and limited test equipment and test room requirements. This is under the assumption that the pre-crash performance of the audio equipment is sufficient for intelligible voice communication.

A post-crash performance measurement procedure would incur additional testing costs because of the required investment in test equipment by the test house (e.g. HATS) and extended duration of the tests. Considerations of what a measurement procedure would involve can be found in Section 4.4.4. While this would, without doubt, be feasible to perform, it would need to be justified by offering added benefit. However, without further research this benefit is not known, but it would have to be sufficiently large to surpass the additional investment required to facilitate it.

4.4.3 Test procedure

The proposed procedure relies on a test call that can be performed using the same test setup as used for the other type-approval test calls. The PSAP test point requirements for this procedure are extended in that it needs to allow the establishment of voice communication with the vehicle. A standard commercial- or higher-grade audio headset (headphones and microphone) connected to the PSAP simulator will also be required by the far-end tester.

The positioning of the near-end tester on the driver's seat of the vehicle after it has been impacted might not be practical in all cases. Depending on the structural performance of the tested vehicle in frontal and side impacts, the driver's side door might not open or intrusion might prohibit sitting comfortably and safely on the driver's seat. Some of these obstacles can certainly be overcome with reasonable effort. For the remaining cases it shall be permissible for the near-end tester to remain outside the vehicle and just reach their head into the vehicle close to the required position. Safety risks for test engineers could arise from undeployed airbags, sharp edges or shattered glass inside the vehicle, which is why a risk assessment must be performed before undertaking this task.

Various methods exist for speech intelligibility testing, such as the diagnostic rhyme test, the modified rhyme test or the phonetically balanced word list test. However, as discussed in the preceding section, the simple functionality test to be defined needs to be suited for a type-approval setting. This means it should, if possible, not rely on a large number of test subjects and specific test environments (such as sound-proof cabins) that might be available at specialised laboratories, but cannot necessarily be expected at test houses for vehicle approval.

The proposed procedure takes account of this by requiring only a quiet, and not necessarily sound-proof, environment for testing and only requiring two test engineers (one in the vehicle and one at the PSAP test point) to perform the test. The repeatability and reproducibility of this procedure have not been assessed for this study. Compared to a performance measurement procedure or a subjective quality assessment involving many test subjects or expert listeners, female and male speakers, quiet and loud talkers, and transmission in different languages with different sound profiles, repeatability and reproducibility could be compromised. However, the testers are not required to perform a graded assessment of performance criteria, but provide a yes/no assessment of whether an intelligible communication was possible. Even considering inter-individual differences in perception and capabilities, individual human testers will generally be capable of reliably detecting the complete or near-complete failure of the audio equipment (i.e. no functionality, considerably reduced loudness or distortion to an extent that makes voice communication impossible). A representative of the type-approval authority might witness the exchange of test sentences to gain sufficient assurance of intelligibility.

An alternative test setup that requires only one test engineer would generally be conceivable by making use of an audio loopback function of the PSAP simulator. The tester would speak a message inside the vehicle, which would be recorded by the vehicle's microphone and played back via its speakers after a certain time delay. An advantage would be that the vehicle and PSAP simulator would not need to be physically separated (to prevent sound transfer over the air). However, this option lacks the additional assurance provided by the scenario where the near-end and far-end testers do not know which sentence pairs are selected; which allows a more reliable assessment as to whether the message was intelligible compared to a

situation where a message of known content is received.

In the case that the subjective post-crash audio test is not successful (fails), there is an option to offer the opportunity to demonstrate sustained performance by a post-crash application of the ITU performance measurement procedure P.emergency. However, this option depends on whether and how P.emergency will be applied in the EU.

The proposed test sentences are phonetically balanced sentences in eight European languages taken over from ITU-T P.501, Annex B. Familiarity with the language is considered more important than phonetic balance for this simple assessment, which is why alternative sentences can be used if the list does not cover the required language.

4.4.4 Test call setup

The permissible connection procedures (simulated mobile network procedure, public mobile network procedure, and wired transmission procedure) are identical for all test calls to be performed during the type-approval test programme (i.e. after the deceleration test, after the full-scale impact test and during the course of the TPS co-existence test). Please refer to Section 2.4.4 for the general justification.

4.5 Considerations regarding post-crash performance measurement procedures

If future large-scale, real-world experience or additional research warrants a full performance or quality assessment of the audio equipment post-crash, the following considerations for application of the ITU-T P.emergency procedures post-crash or a differential performance measurement might be taken into account.

4.5.1 Full vehicle assessment based on ITU-T P.emergency

4.5.1.1 Test parameters

In order to verify that the audio equipment is still operable after a full-scale crash test a reduced subset of the tests performed in P.emergency could be repeated in the crashed car. The background noise simulation could be omitted for the sake of simplicity and reducing the test equipment required.

To ensure that the performance characteristics of loudspeaker and microphone have not deteriorated to an extent that would impact negatively on emergency calls, two main parameters can be used:

- Loudness ratings (send and receive)
- Sensitivity frequency responses (send and receive)

These parameters allow conclusions about the sustained hardware integrity and the impact of potential mechanical damage to the loudspeaker or microphone on the audio performance, such as distortion, and hence the intelligibility of a voice call.

In addition to the loudspeaker and microphone components, (partial) breakage of their cable connections after a collision might be a concern. This could be checked and ruled out by performing a check of the:

- Idle channel noise (send and receive)

The audio signal processing might be affected negatively by mechanical damage to

speaker or microphone and changes in their performance. The echo cancelling might not be working with distorted audio signals and the double talk performance might be reduced if the echo path is not sufficiently linear. These two aspects could therefore also be checked post-crash:

- Echo performance without background noise
- Double talk performance

The remaining parameters defined in P.emergency are not expected to be influenced by an impact event and are therefore not required for this post-crash assessment.

4.5.1.2 Pass/fail criteria

During full-scale crash tests according to UN R94 and UN R95 the occupant compartment and the roof structure of the vehicle (i.e. the areas where audio equipment for eCalls will most likely be fitted) do not typically sustain considerable deformations. Hence, the performance levels required post-crash, i.e. pass/fail criteria, can be set at a similar level as for the pre-crash performance assessments. Experts from ITU indicated that the limits proposed for P.emergency can be considered sufficiently relaxed so as to be applied also to post-crash situations.

4.5.1.3 Test equipment

Specific test equipment is required for the procedures defined in P.emergency: An artificial head, i.e. a head and torso simulator (HATS), conforming to [ITU-T P.58] is required to perform the measurements. Additionally, using a simulated mobile network (wired or over-the-air) is required because, according to ITU experts, the potential fluctuations in performance and signal strength (over time and at different locations) between public mobile networks are prohibitive of their use.

4.5.2 Component assessment based on differential performance measurements

4.5.2.1 Motivation

For component-based test procedures, such as the deceleration sled test, the audio components are not installed in a vehicle. The ITU P.emergency procedure is designed to be performed in a vehicle and the surrounding vehicle presents a major impact factor on the frequency response characteristics of the audio equipment. Hence, it is not possible to simply mirror requirements for a component-based assessment.

4.5.2.2 Test parameters

A suitable solution could be to assess the 'differential performance' of loudspeaker and microphone, that is to compare component-based measurements of key parameters pre- and post-sled test to ensure that there is no unacceptable reduction in performance.

The two main parameters that would allow an assessment of the differential performance of loudspeaker and microphone are:

- Loudness ratings (send and receive)
- Sensitivity frequency responses (send and receive)

The measurement procedures could be based on the corresponding sections in

P.emergency and could be performed either on a full IVS (via connection to a PSAP test point) or on an individual loudspeaker and microphone. In the latter case, the tests need to be performed on individual components (for example a single microphone as opposed to an array of microphones) because no signal processing would occur.

The test setup would need to be adapted because the components are not installed in a vehicle. For example, the arrangement and distances between system under test and test equipment would need to be defined. Furthermore, it might be warranted to relax the requirements for test equipment because no absolute performance assessment is performed.

5 CO-EXISTENCE OF THIRD PARTY SERVICES (TPS)

5.1 Background

The eCall Regulation allows the use of TPS systems, however it requires that *"all vehicles should be equipped with the public 112-based eCall service, regardless of whether or not a vehicle buyer opts for a TPS eCall service."* Due care needs to be given to make sure that type-approval can facilitate a system which switches between TPS service and 112-based service. Please also see (Carroll, Seidl, Cuerden, & Stevens, 2014)⁵, Section 3.18 for further background.

As 112-based eCall functions will be mandatory, their function is within the scope of type-approval. In contrast the TPS system itself will not be assessed, apart from its interaction with the 112-based system, as per the stipulations in Article 5 that a switch to the 112-based system happens *"in the event that the TPS eCall in-vehicle call system does not function"* and that *"manufacturers shall ensure that there is only one system active at a time"*.

A procedure has been developed to verify during type-approval that a TPS system switches to the 112-based eCall IVS ('fallback') if it does not function and that both systems are not active at the same time. This also ensures that a TPS system can be interrupted sufficiently to perform all of the necessary functional tests on the 112-based IVS for other aspects of eCall type-approval. The procedure applies to eCall in-vehicle systems, components and separate technical units that shall be used in conjunction with a TPS eCall in-vehicle system.

5.2 Legislative source material

UN R79 (steering equipment), Annex 6, and the identical UN R13-H (braking), Annex 8, describe documentation requirements with regard to the safety aspects of complex electronic vehicle control systems for type-approval. These requirements were designed for steering and braking systems, which are complex dynamic systems to ensure the safe operations of vehicles. , After a careful assessment it was concluded that these requirements are likely to be too onerous to be applied in full for assessing the fallback of static TPS eCall systems. However, the general concept applied in these regulations can be used for verifying the fallback procedure, by:

- Requiring documentation that explains the design provisions taken for safe operation and details of the system behaviour under fault conditions; and
- Verifying the system behaviour by applying one or more failures (at the discretion of the type-approval authority) and assessing the outcome against the documentation.

UN Regulation No. 79, Annex 6:

"3.4. SAFETY CONCEPT OF THE MANUFACTURER

3.4.1. The manufacturer shall provide a statement which affirms that the strategy chosen to achieve "The System" objectives will not, under non-fault conditions, prejudice the safe operation of systems which are subject to the prescriptions of this Regulation.

⁵ <http://ec.europa.eu/DocsRoom/documents/5601/attachments/1/translations/en/renditions/native>

3.4.2. In respect of software employed in "The System", the outline architecture shall be explained and the design methods and tools used shall be identified. The manufacturer shall be prepared, if required, to show some evidence of the means by which they determined the realisation of the system logic, during the design and development process.

3.4.3. The Manufacturer shall provide the technical authorities with an explanation of the design provisions built into "The System" so as to generate safe operation under fault conditions. Possible design provisions for failure in "The System" are for example:

(a) Fall-back to operation using a partial system.

(b) Change-over to a separate back-up system.

(c) Removal of the high level function.

In case of a failure, the driver shall be warned for example by warning signal or message display. When the system is not deactivated by the driver, e.g. by turning the ignition (run) switch to "off", or by switching off that particular function if a special switch is provided for that purpose, the warning shall be present as long as the fault condition persists.

3.4.3.1. If the chosen provision selects a partial performance mode of operation under certain fault conditions, then these conditions shall be stated and the resulting limits of effectiveness defined.

3.4.3.2. If the chosen provision selects a second (back-up) means to realise the vehicle control system objective, the principles of the change-over mechanism, the logic and level of redundancy and any built in back-up checking features shall be explained and the resulting limits of back-up effectiveness defined.

3.4.3.3. If the chosen provision selects the removal of the Higher Level Function, all the corresponding output control signals associated with this function shall be inhibited, and in such a manner as to limit the transition disturbance.

3.4.4. The documentation shall be supported, by an analysis which shows, in overall terms, how the system will behave on the occurrence of any one of those specified faults which will have a bearing on vehicle control performance or safety.

This may be based on a Failure Mode and Effect Analysis (FMEA), a Fault Tree Analysis (FTA) or any similar process appropriate to system safety considerations.

The chosen analytical approach(es) shall be established and maintained by the Manufacturer and shall be made open for inspection by the technical service at the time of the type approval.

3.4.4.1. This documentation shall itemize the parameters being monitored and shall set out, for each fault condition of the type defined in paragraph 3.4.4. of this annex, the warning signal to be given to the driver and/or to service/technical inspection personnel.

4. VERIFICATION AND TEST

4.1. The functional operation of "The System", as laid out in the documents

required in paragraph 3., shall be tested as follows:

4.1.1. Verification of the function of "The System"

As the means of establishing the normal operational levels, verification of the performance of the vehicle system under non-fault conditions shall be conducted against the manufacturer's basic benchmark specification unless this is subject to a specified performance test as part of the approval procedure of this or another Regulation.

4.1.2. Verification of the safety concept of paragraph 3.4.

The reaction of "The System" shall, at the discretion of the type approval authority, be checked under the influence of a failure in any individual unit by applying corresponding output signals to electrical units or mechanical elements in order to simulate the effects of internal faults within the unit.

4.1.2.1. The verification results shall correspond with the documented summary of the failure analysis, to a level of overall effect such that the safety concept and execution are confirmed as being adequate."

5.3 Draft proposal

1. Requirements

1.1. *The following requirements apply to eCall in-vehicle systems, components and separate technical units that shall be used in conjunction with a TPS eCall in-vehicle system.*

1.2. Performance requirements

1.2.1. *The 112-based system shall be deactivated as long as the TPS system is active and does function.*

1.2.2. *The 112-based system shall be automatically triggered in the event that the TPS system is triggered but does not function.*

1.3. Documentation requirements

1.3.1. *The manufacturer shall provide the technical authorities with an explanation of the design provisions built into the TPS system to ensure automatic triggering of the 112-based system ('fallback procedure') in the event that the TPS system does not function. This documentation shall describe the principles of the changeover mechanism.*

1.3.2. *The documentation shall be supported by an analysis which shows, in overall terms, any hardware or software failure conditions that would result in an inability of the TPS system to perform a successful call and how the TPS system will behave on the occurrence of these.*

This may be based on a Failure Mode and Effect Analysis (FMEA), a Fault Tree Analysis (FTA) or any appropriate similar process as agreed between the technical service and the manufacturer.

The chosen analytical approach(es) shall be established and maintained by the manufacturer and shall be made open for inspection by the technical

service at the time of the type-approval.

2. *Test procedure*

2.1. *Purpose of the TPS co-existence test procedure*

The purpose of this test procedure is to verify for eCall in-vehicle systems, components and separate technical units that shall be used in conjunction with a TPS eCall in-vehicle system, that there is only one system active at a time and that the 112-based system is triggered automatically in the event that the TPS system does not function.

2.2. *The following tests shall be performed either on a vehicle with an eCall in-vehicle system installed or on a representative arrangement of parts, for the approval of vehicles, components or separate technical units.*

2.3. *The deactivation of the 112-based system while the TPS system is active shall be verified by performing a manually triggered test call.*

2.3.1. *Before performing the test call, ensure:*

(a) that one of the connection procedures defined in Paragraph [Connection procedures], as agreed between the technical service and the manufacturer, will be applied for any test call;

(b) that the dedicated PSAP test point is available to receive an eCall emitted by the 112-based system;

(c) that the TPSP test point is available to receive a call emitted by the TPS system;

(d) that a false eCall to a genuine PSAP cannot be made over the live network; and

(e) that the vehicle ignition or master control switch is activated.

2.3.2. *Perform a test call by applying a manual trigger of the TPS system (push mode).*

2.3.3. *Verify:*

(a) that a call was established with the TPSP test point by a record of the TPSP test point showing that it did receive a call initiation signal or by a successful voice connection to the TPSP test point; and

(b) that no eCall was attempted or established with the PSAP test point by a record of the PSAP test point showing that it did not receive an eCall initiation signal.

2.3.4. *Clear down the test call using the appropriate PSAP test point command (e.g. hang up).*

2.3.5. *If the call attempt of the TPS system fails during the test, the test procedure may be repeated.*

- 2.4. *The fallback procedure shall be verified by performing a manually triggered test call to a dedicated PSAP test point in a condition where the TPS system does not function.*
- 2.4.1. *Modify the TPS system to simulate a failure, selected at the discretion of the technical service, that shall result in a fallback procedure based on the documentation provided by the manufacturer.*
- 2.4.2. *Before performing the test call, ensure:*
- (a) that one of the connection procedures defined in Paragraph [Connection procedures], as agreed between the technical service and the manufacturer, will be applied for any test call;*
 - (b) that the dedicated PSAP test point, configured in normal mode (non-robust mode), is available to receive an eCall emitted by the 112-based system;*
 - (c) that a false eCall to a genuine PSAP cannot be made over the live network; and*
 - (d) that the vehicle ignition or master control switch is activated.*
- 2.4.3. *Perform a test call by applying a manual trigger of the TPS system (push mode).*
- 2.4.4. *Verify that an eCall was established by the 112-based system by a record of the PSAP test point showing that it did receive an eCall initiation signal.*
- 2.4.5. *Clear down the test call using the appropriate PSAP test point command (e.g. hang up).*
- 2.5. *Connection procedures*
- [The proposal for connection procedures is identical to the procedures as defined for Task 1 in Section 2.3 of this report.]*

5.4 Justification

5.4.1 Purpose of the procedure

As briefly outlined in the introduction, the purpose of the proposed procedure is twofold:

- Verify the stipulations in Regulation (EU) 2015/758, Article 5, Paragraph 3. (b) regarding fallback and mutually exclusive activation of the systems; and
- Ensure that the TPS system can be interrupted sufficiently during testing to perform the type-approval tests, in particular the post-full-scale impact verification tests via test calls, on the 112-based IVS.

Regulation (EU) 2015/758, Article 5, Paragraph 3. (b):

"(b) manufacturers shall ensure that there is only one system active at a time and that the 112-based eCall in-vehicle system is triggered automatically in the event that the TPS eCall in-vehicle system does not function;"

Note that the European eCall standards also contain a stipulation regarding this topic:

EN 16102 (Version: 2011), Section 8.5:

"In the event that the TPS-IVS cannot establish the voice connection with the TPS-eCall responder, and is also unable to send the 'IVS dataset' to the TPS-eCall responder, the TPS-IVS shall attempt to establish a voice connection between the vehicle occupants and a PSAP using the 112 service."

This is verified in Test Case CTP 1.2.5.3 of the eCall conformance testing in accordance with EN 16454. However, the explicit stipulation in the eCall Regulation should be assessed individually during type-approval using the system as installed in a vehicle. The test case as defined in CTP 1.2.5.3 cannot be used immediately because it requires an MNO test point and does not assess the aspect of mutually exclusive activation. The procedure proposed for assessing the fallback is however closely linked, if not identical, to CTP 1.2.5.3.

5.4.2 General principle

There is a number of potential failures that can lead to a situation where the TPS system does not function: SIM issues, software errors, manipulation of the system, or unavailability of the TPSP or its inability to receive the transmission; in addition to that, in cases where the TPS system is realised in separate hardware, internal hardware failures or power supply failures (battery discharged) can prevent the TPS system from working. These are dependent on the specific system layout (components), the software design and external factors (TPSP, mobile network).

Two principal approaches to covering this topic during type-approval, with solutions of varying degrees of stringency in between, were considered:

- Testing every potential failure case during the type-approval process and verifying the fallback function for each of these;
- Requesting the applicant to disclose information regarding the design provisions applied to ensure the fallback function without verification in the form of physical testing.

Both of these extreme ends of potential solutions were considered inadequate for eCall type-approval: Testing each failure would impose a disproportionately high testing effort on the manufacturers and might, altogether, even be technically infeasible in many cases. There is precedent in Regulations where individual aspects of a system can be verified by documentation only, such as the European regulation on automatic emergency braking systems (AEBS).

Commission Regulation (EU) No 347/2012, Annex II, Paragraph 2.5.4.:

"The emergency braking phase shall not start before a TTC equal to or less than 3,0 seconds."

Compliance shall be verified by either actual measurement during the test or using documentation provided by the vehicle manufacturer, as agreed between the Technical Service and the vehicle manufacturer."

However, the TPS fallback function might include numerous potential failures and interrelated aspects so that a procedure relying exclusively on documentation (without verifying the system conformance in a physical test) might create a large variation in how this rule is applied by different type-approval authorities. A solution applied in other regulations, such as UN R13-H and UN R79, is to cover the variety of cases by documentation and verify selected cases in physical tests:

- Require documentation that explains the design provisions taken for safe operation and details the system behaviour under fault conditions; and
- Verify the system behaviour by applying one or more failures (at the discretion of the type-approval authority) and assessing the outcome against the documentation.

This general approach is considered suitable to also be applied to the issue at hand.

5.4.3 *Documentation requirements*

The proposal requires additional documentation only for the verification of the fallback procedure, not for verifying mutually exclusive activation, because the latter can be sufficiently addressed by performing one test case in the state where the TPS system is functioning.

The proposed documentation requirements for the fallback procedure are reduced compared to UN R13-H and UN R79. This is considered appropriate because:

- Only the fallback function of the TPS system in the failure case shall be assessed and not the general performance of the system; and
- The complexity of the system fallback function is limited compared to complex electronic vehicle control systems for braking or steering.

The documentation according to Paragraph 1 requires the manufacturer to explain the principles of the changeover mechanism, i.e. to provide technical details of how the changeover between the TPS system and the 112-based system is implemented and technically realised.

The documentation according to Paragraph 2 shall include details of under what failure conditions a changeover is intended to happen. The provision of this information shall prompt TPS suppliers and vehicle manufacturers to consider all relevant scenarios that might result in an inability to perform a successful TPS eCall during system development and ensure the type-approval authority that all such fallback cases are appropriately addressed. Also, it enables the technical service to decide on the failure to be simulated during the verification test procedure and also allows deactivation of the TPS system for the full-scale crash test procedure.

In accordance with the provisions in UN R13-H and UN R79 the documentation according to Paragraph 2 shall be retained by the manufacturer, but made open for inspection at the time of type-approval.

5.4.4 *TPS co-existence test procedure*

The test procedures for verification of the mutually exclusive activation and the fallback are limited to only one exemplary test case, respectively. This is considered appropriate because the complexity of these functions is limited compared to complex electronic vehicle control systems for braking or steering.

The test procedures are based on manually triggered test calls in an un-crashed vehicle or using an arrangement of the IVS components in the case of approval of components or separate technical units. It is not expected that an assessment of these requirements during the course of the full-scale crash tests would deliver different results compared to the un-crashed vehicle (because the requirements are mainly related to the implementation of the functionality and not to the crash-resistance of any hardware components) but would add additional complexity to the

full-scale procedures. If a vehicle is used it can be the same vehicle as used for the full-scale impact tests (pre-crash) or a different vehicle.

To perform the fallback procedure test, the TPS system or the simulated environment (i.e. the TPSP simulator and/or the simulated mobile network) shall be modified to result in a condition where the TPS system does not function. The simulated failure shall be at the discretion of the technical service to introduce a random element in the verification test and to allow the accommodation of different test setups in different test houses. Ways to force a fallback scenario could, for example, be: Programming the TPS to dial an unreachable number, preventing the simulated mobile network from accepting the call from the TPS system, removing or invalidating the TPS SIM, disabling the TPS mobile network equipment, or disabling the TPS power supply.

5.4.5 Test call setup

The permissible connection procedures (simulated mobile network procedure, public mobile network procedure, and wired transmission procedure) are identical for all test calls to be performed during the type-approval test programme (i.e. after the deceleration test, after the full-scale impact test and during the course of the TPS co-existence test). Please refer to Section 2.4.4 for the general justification.

The TPS co-existence test is the only procedure that requires simulation of a TPSP answering point to receive a call emitted by the TPS system, because the TPS system is not part of the other test procedures. The TPSP answering point is represented by a TPSP test point in all connection procedures. This can be a dedicated piece of test equipment under the control of the test house simulating the behaviour of the TPSP answering point (similar to a PSAP simulator) or a genuine TPSP answering point.

According to EN 16062, *"the detail of how TPSP operator communicates to/from the vehicle is service provider specific"*, which means that a full TPSP simulator needs to be specific to the TPS under test. The only requirement for the TPS co-existence test is, however, that the TPSP simulator is able to verify that a call from the TPS system was established and to clear down that call to prevent a fallback to a TS12 voice connection. This option requires test-specific encoding of TPS system by the manufacturer or supplier to perform a TS11 call to the specified number of the TPSP test point at the test house. The alternative of using a genuine TPSP answering point via the public mobile network does not require additional test equipment or test-specific encoding, but requires previous agreement of using the TPSP answering point for test purposes. Note that a test call via an over-the-air or wired simulated network can be forwarded to a genuine TPSP answering point.

6 AUTOMATIC TRIGGERING MECHANISM

6.1 Background

In the event of a collision where there is a risk of serious or life threatening injury, automatic triggering of the eCall must occur, and where practicable, a connection to the PSAP must be made. The eCall Regulation stipulates that a "*severe accident, detected by activation of one or more sensors or processors within the vehicle*" should trigger an automatic eCall. This stipulation needs translation into a specific procedure for demonstrating this link to the type-approval authority.

The automatic triggering is physically tested in conjunction with the full-scale impact tests according to UN R94 and UN R95. However, it was shown and discussed in detail by Seidl et al. (2015)⁶ and in AECS-04-09 that automatic eCall triggering only in accident conditions similar to, and at least as severe as, these impact tests would not be appropriate to protect a satisfactory proportion of vehicle occupant casualties. Also see Carroll et al. (2014)⁷, Section 3.4 for further background.

The triggering threshold to be demonstrated during type-approval should therefore be lower than the full-scale impact test configurations and this should be verified during type-approval in addition to the physical triggering tests in UN R94 and UN R95. As stipulated in EN 16072, Section 7.10.1, "*the nature of [the automatic triggering] device and its operational process shall be at the discretion of the vehicle manufacturer/equipment supplier*", i.e. the exact triggering algorithm shall not be prescribed, but only a certain minimum triggering condition established.

A documentation procedure has been defined to demonstrate an appropriate triggering threshold during type-approval. The procedure applies to vehicles with eCall in-vehicle systems installed.

6.2 Legislative source material

UN R79 (steering equipment), Annex 6, and the identical UN R13-H (braking), Annex 8, describe documentation requirements with regard to the safety aspects of complex electronic vehicle control systems for type-approval. These requirements were designed for steering and braking systems, which are complex dynamic systems to ensure the safe operations of vehicles. After a careful assessment it was concluded that these requirements are likely to be too onerous to be applied in full for assessing the triggering strategy of static eCall systems, which do not involve the same inherent dynamic safety functionality. Rather it is suggested that eCall systems shall remain at the discretion of the manufacturer, as long as a certain minimum condition is achieved. However, the general principle of requiring an affirmative statement and suitable documentation is useful for the present task.

UN Regulation No. 79, Annex 6:

"3.4. SAFETY CONCEPT OF THE MANUFACTURER"

⁶ Seidl, M, Carroll, J, Cuerden, R (2015). eCall – Defining Accident Conditions for Mandatory Triggering of Automatic Emergency Calls, Proceedings of the 24th International Technical Conference on the Enhanced Safety of Vehicles (ESV), Paper 15-0137

⁷ <http://ec.europa.eu/DocsRoom/documents/5601/attachments/1/translations/en/renditions/native>

3.4.1. The manufacturer shall provide a statement which affirms that the strategy chosen to achieve "The System" objectives will not, under non-fault conditions, prejudice the safe operation of systems which are subject to the prescriptions of this Regulation.

[...]

3.4.4. The documentation shall be supported, by an analysis which shows, in overall terms, how the system will behave on the occurrence of any one of those specified faults which will have a bearing on vehicle control performance or safety.

This may be based on a Failure Mode and Effect Analysis (FMEA), a Fault Tree Analysis (FTA) or any similar process appropriate to system safety considerations.

The chosen analytical approach(es) shall be established and maintained by the Manufacturer and shall be made open for inspection by the technical service at the time of the type approval."

6.3 Draft proposal

1. Requirements

1.1. The following requirements apply to vehicles with eCall in-vehicle systems installed.

1.2. Documentation requirements

1.2.1. The manufacturer shall provide a statement which affirms that the strategy chosen to trigger an automatic eCall ensures triggering also in accident configurations dissimilar from and of a lower severity than the collisions simulated in the applicable full-scale crash tests in UN Regulation No. 94 and UN Regulation No. 95.

1.2.2. The manufacturer shall choose the collision typology and severity and will demonstrate that it is significantly different than the full-scale crash tests.

1.2.3. The manufacturer shall provide the type-approval authority with an explanation and technical documentation which shows, in overall terms, how this is achieved.

1.1.1.1. Documentation that shows, to the satisfaction of the type-approval authority, that the activation of supplemental restraint systems, at the severity level chosen at the discretion of the manufacturer, also induces an automatic eCall shall be considered satisfactory.

1.1.1.2. Airbag control unit specification drawings, specification data notes, sensitivity drawings, relevant circuit diagrams or similar documents considered equivalent by the type-approval authority would be suitable means to demonstrate this connection.

6.4 Justification

6.4.1 Low-severity crash testing

It was shown in research, that a triggering severity level that included only accident

conditions similar to, and at least as severe as, the impact tests of UN Regulations No. 94 and No. 95 would not be appropriate to protect a satisfactory proportion of vehicle occupant casualties (Seidl et al. (2015)⁸, Carroll et al. (2014)⁹, AECS-04-09). Triggering of an eCall in lower severity collisions would greatly improve the potential benefit offered by the technology. However, it is generally accepted that the creation of an eCall Regulation does not warrant the implementation of a new crash test. Therefore, there is a need to demonstrate that eCall would be triggered during lower severity crashes, but without a full-scale test which can be used to show that triggering empirically. Until such time as a suitable crash test becomes available for this purpose (whether that be through adoption for another purpose or by specific development and application) alternative measures are sought to help demonstrate both that eCall is available to a wider range of casualties than those involved in collisions of at least the severity of Regulation No. 94 or Regulation No. 95.

6.4.2 Purpose of the procedure

Regulation (EU) 2015/758, Article 5, Paragraph 2. stipulates that a “*severe accident, detected by activation of one or more sensors or processors within the vehicle*” should trigger an automatic eCall. The purpose of the proposed procedure is to complement the physical automatic triggering tests in conjunction with the UN R94 and UN R95 full-scale impact tests. It shall ensure that automatic eCalls are not only triggered in accident conditions similar to these impact tests.

EN 16072 stipulates that “*the eCall shall be generated to reflect as many different crash types as possible (e.g. front, rear, side crashes).*” It is an established consensus that the exact triggering strategy should be left to the vehicle manufacturer’s discretion to prevent undue restriction of design freedom. This is also due to the fact that only vehicle manufacturers have advanced knowledge of the vehicle models and should therefore be enabled to tune the eCall triggering to the properties and sensors of the specific model.

It shall therefore be required to demonstrate a sensible low-severity triggering level during type-approval in a way that does not restrict manufacturers in applying their expertise to provide eCall functional cover for a large proportion of casualties. The procedure applies to vehicles with eCall in-vehicle systems installed, but not to components or separate technical units, because the triggering is initiated by vehicle sensors and the thresholds are vehicle-dependent.

6.4.3 Documentation requirements

In the absence of a low-severity crash test, and given the reluctance to introduce a new crash test in an effort to keep type-approval testing costs low, the existing full-scale crash tests shall be accompanied with a dossier of information regarding low-severity triggering. The documentation that is most suitable to demonstrate the low-severity triggering can vary depending on the vehicle, its equipment and the design processes used by the manufacturer.

⁸ Seidl, M, Carroll, J, Cuerden, R (2015). eCall – Defining Accident Conditions for Mandatory Triggering of Automatic Emergency Calls, Proceedings of the 24th International Technical Conference on the Enhanced Safety of Vehicles (ESV), Paper 15-0137

⁹ <http://ec.europa.eu/DocsRoom/documents/5601/attachments/1/translations/en/renditions/native>

An acceptable way would, for example, be to assure the type-approval authority that there is a positive link between airbag deployment and eCall triggering, i.e. if any airbag deploys an eCall is also triggered. As was shown by Seidl et al. (2015), this would be sufficient assurance while not restricting design freedom, because the algorithm for airbag triggering is defined by the manufacturer. Also, this would not be restrictive because eCalls could still be triggered under different accident conditions where no airbag was deployed to also cover the proportion of casualties in non-airbag deployment collisions.

This is in line with the relevant stipulations in EN 16072.

EN 16072, Section 7.10.1

"EXAMPLE a signal generated by the airbag control module and/or a combination of other sensor data. (e.g. gyro, radar, axle load, speed), or other crash information status (a severe accident has happened), e.g. created in the airbag control module without deployment of an airbag (e.g. rear crash).

[...]

the eCall shall be generated to reflect as many different crash types as possible (e.g. front, rear, side crashes). The automatic eCall trigger shall be safe, robust, reliable, and designed so as to maximise the number of valid eCalls whilst minimizing the number of false eCalls, generated by the eCall generator."

It is expected that in most vehicles, the same control unit will manage restraint deployment and eCall triggering. In this case specification drawings or data notes of the airbag control unit showing the link between deployment and eCall triggering could be sufficient documentation. If different control units are used additional circuit diagrams could be provided if required.

Documentation which shows the triggering strategy of the restraints themselves, or the trigger or no-trigger data outcome of the airbag control unit in several tested crash scenarios (e.g. airbag control unit sensitivity drawing) would also be a feasible means of demonstration. However, if the above link is demonstrated, it would not be necessary to disclose the restraint triggering strategy.

Other ways of demonstrating that the eCall triggering approach covers various accident configurations and a lower severity than UN R94 or UN R95 are conceivable and would be acceptable if they are considered sufficient assurance by the type-approval authority.

7 IN-VEHICLE SYSTEM SELF-TEST

7.1 Background

The eCall Regulation requires that a warning shall be given to the occupants of a vehicle *“in the event of a critical system failure which would result in an inability to execute a 112-based eCall”*. This requirement needs to be verified for type-approval. The background to this stipulation is that the eCall function is only used in very rare occasions, which means that the vehicle user would not have the opportunity to pick up malfunctions of the system without a self-test and malfunction indicator associated with the IVS.

Furthermore, the recitals of the eCall Regulation stipulate with regard to periodic technical inspections (PTI) that the *“accuracy of the minimum set of data and of the voice transmission and quality should be ensured, and a uniform testing regime should be developed to ensure the longevity and durability of the 112-based eCall in-vehicle system”*. Whereas PTI *per se* is beyond the scope of this study, the self-test requirements might facilitate future PTI testing.

A procedure has been developed that allows the technical service to verify the self-test and malfunction indication requirements based on a physical test and supporting documentation. The procedure applies to eCall in-vehicle systems, components and separate technical units.

7.2 Legislative source material

7.2.1 Draft AECS UN Regulation

The current draft of the AECS UN Regulation contains different requirements regarding the self-test and malfunction indication for AECD and AECS, which have not been agreed or harmonised yet by the working group.

Draft AECS UN Regulation (AECS-02-02-r4), Paragraph 6.5.2.:

“A warning signal shall be provided in case of AECD internal malfunction. Visual indication of the AECD malfunction shall be displayed while the failure is present. It may be cancelled temporarily, but shall be repeated whenever the device which starts and stops the engine is switched on and off.”

Draft AECS UN Regulation (AECS-02-02-r4), Paragraph 15.3.3.:

“A warning signal shall be provided when the onboard AECS is not functioning properly. Visual indication of the AECD malfunction shall be displayed at all times while ignition is turned on or the vehicle master control switch is activated (whatever applicable).”

As per the proposal by the Russian Federation, the current draft of the AECS UN Regulation also requires a post-crash assessment of the malfunction indication, which indirectly includes elements that need to be covered by the self-test.

Draft AECS UN Regulation (AECS-07-02), Annex 6, Paragraph 5.:

"5. HMI operation assessment shall include the following

[...]

5.3. Malfunction indication is working properly. This is verified by checking malfunction indication in at least one of the following conditions:

5.3.1. Communication module antenna is disconnected, or

5.3.2. GNSS receiver antenna is disconnected, or

5.3.3. Microphone(s) is (are) disconnected, or

5.3.4. Loudspeaker(s) is (are) disconnected, or

5.3.5. AECD control module is disconnected from the HMI module"

7.2.2 GOST R 54620

The Russian standard GOST R 54620 defines the self-test requirements for ERA-GLONASS systems. The requirements are restricted to apply "*whenever technically feasible*"; it is not currently known how this stipulation is interpreted in practice by the Russian technical service. The requirements are:

GOST R 54620, Section 6.17.6:

"*Whenever technically feasible, the following checks during IVS self-tests shall be carried out:*

- *integrity of software image;*
- *operational condition of GSM/UMTS communication module interface;*
- *operational condition of GNSS receiver;*
- *integrity (dependability) of navigation and timing parameters of GNSS receiver (RAIM function);*
- *sufficient battery charge level;*
- *operational condition (correct connection) of external GNSS antenna (if installed);*
- *operational condition (correct connection) of external GSM/UMTS antenna (if installed);*
- *operational condition of automatic RTA [road traffic accident] detector (for vehicles of Categories M1 and N1 only);*
- *operational condition of UIM [the manual call button];*
- *proper connection of microphone;*
- *operational condition of microphone;*
- *operational condition of loudspeaker (loudspeakers)."*

7.2.3 UN Regulation No. 13-H

UN R13-H (braking) defines self-test requirements for anti-lock braking systems (ABS) and electronic stability control systems (ESC).

UN Regulation No. 13-H, Annex 6 (ABS), Paragraph 4.1.:

"Any electrical failure or sensor anomaly that affects the system with respect to the functional and performance requirements in this annex, including those in the supply of electricity, the external wiring to the controller(s), the controller(s) and the modulator(s) shall be signalled to the driver by a specific optical warning signal."

UN Regulation No. 13-H, Annex 9 (ESC), Paragraph 3.4.:

"3.4. ESC MALFUNCTION DETECTION

The vehicle shall be equipped with a tell-tale that provides a warning to the driver of the occurrence of any malfunction that affects the generation or transmission of control or response signals in the vehicle's electronic stability control system."

UN R13-H also defines certain characteristics of the malfunction indicator. While these might not be applicable, in full, to eCall systems, because ESC is a primary safety system, they give an indication of what is defined in other regulations.

UN Regulation 13-H, Annex 9 (ESC), Paragraph 3.4.:

"3.4.1. The ESC malfunction tell-tale:

3.4.1.1. *Shall be displayed in direct and clear view of the driver, while in the driver's designated seating position with the driver's seat belt fastened;*

3.4.1.2. *Shall appear perceptually upright to the driver while driving;*

3.4.1.3. *Shall be identified by the symbol shown for "ESC Malfunction Tell-tale" below or the text "ESC":*



3.4.1.4. *Shall be yellow or amber in colour;*

3.4.1.5. *When illuminated shall be sufficiently bright to be visible to the driver under both daylight and night-time driving conditions, when the driver has adapted to the ambient roadway light conditions;*

3.4.1.6. *Except as provided in paragraph 3.4.1.7., the ESC malfunction tell-tale shall illuminate when a malfunction exists and shall remain continuously illuminated under the conditions specified in paragraph 3.4. for as long as the malfunction exists, whenever the ignition locking system is in the "On" ("Run") position;*

3.4.1.7. *Except as provided in paragraph 3.4.2., each ESC malfunction tell-tale shall be activated as a check of lamp function either when the ignition locking system is turned to the "On" ("Run") position when the engine is not running, or when the ignition locking system is in a position between "On" ("Run") and "Start" that is designated by the manufacturer as a check position;*

3.4.1.8. Shall extinguish at the next ignition cycle after the malfunction has been corrected in accordance with paragraph 5.10.4.;

3.4.1.9. May also be used to indicate the malfunction of related systems/functions, including traction control, trailer stability assist, corner brake control, and other similar functions that use throttle and/or individual torque control to operate and share common components with ESC.

3.4.2. The ESC malfunction tell-tale need not be activated when a starter interlock is in operation.

3.4.3. The requirement of paragraph 3.4.1.7. does not apply to tell-tales shown in a common space. [...] "

For ESC malfunctions UN R13-H defines a physical test to be carried out that allows the technical service to verify the self-test function. This simulates at least one malfunction by disconnecting the power source to a relevant component and verifies that the malfunction under defined subsequent driving manoeuvres is as expected:

UN Regulation No. 13-H, Annex 9 (ESC), Paragraph 5.10.:

"ESC MALFUNCTION DETECTION

5.10.1. Simulate one or more ESC malfunction(s) by disconnecting the power source to any ESC component, or disconnecting any electrical connection between ESC components (with the vehicle power off). When simulating an ESC malfunction, the electrical connections for the tell-tale lamp(s) and/or optional ESC system control(s) are not to be disconnected.

5.10.2. With the vehicle initially stationary and the ignition locking system in the "Lock" or "Off" position, switch the ignition locking system to the "Start" position and start the engine. Drive the vehicle forward to obtain a vehicle speed of 48 ± 8 km/h. 30 seconds, at the latest, after the engine has been started and within the next two minutes at this speed, conduct at least one left and one right smooth turning manoeuvre without losing directional stability and one brake application. Verify that the ESC malfunction indicator illuminates in accordance with paragraph 3.4. by the end of these manoeuvres.

5.10.3. Stop the vehicle, switch the ignition locking system to the "Off" or "Lock" position. After a five-minute period, switch the vehicle's ignition locking system to the "Start" position and start the engine. Verify that the ESC malfunction indicator again illuminates to signal a malfunction and remains illuminated as long as the engine is running or until the fault is corrected.

5.10.4. Switch the ignition locking system to the "Off" or "Lock" position. Restore the ESC system to normal operation, switch the ignition system to the "Start" position and start the engine. Re-perform the manoeuvre described in paragraph 5.10.2. and verify that the tell-tale has extinguished within this time or immediately afterwards."

In order to facilitate PTI of complex electronic systems with regard to braking, UN R13-H sets out the following requirements.

UN Regulation No. 13-H, Paragraph 5.1.4.:

"5.1.4. Provisions for the periodic technical inspection of braking systems

[...]

5.1.4.2. It shall be possible to verify, in a frequent and simple way, the correct operational status of those complex electronic systems which have control over braking. If special information is needed, this shall be made freely available.

5.1.4.2.1. Where the operational status is indicated to the driver by warning signals, as specified in this Regulation, it shall be possible at a periodic technical inspection to confirm the correct operational status by visual observation of the warning signals following a power-on.

5.1.4.2.2. At the time of type approval, the means implemented to protect against simple unauthorized modification of the operation to the verification means chosen by the manufacturer (e.g. warning signal) shall be confidentially outlined. Alternatively, this protection requirement is fulfilled when a secondary means of checking the correct operational status is available. [...]"

7.2.4 UN Regulation No. 48

UN R48 (lighting installation) requires an indicator (tell-tale) for lighting malfunctions under certain conditions and allows the signal to be switched off temporarily.

UN Regulation No. 48, Paragraph 6.2.8.1.:

"[The visual tell-tale] shall remain activated while the failure is present. It may be cancelled temporarily, but shall be repeated whenever the device, which starts and stops the engine, is switched on and off."

7.2.5 UN Regulation No. 79

UN R79 (steering equipment), Annex 6, and the identical UN R13-H (braking), Annex 8, describe documentation requirements with regard to the safety aspects of complex electronic vehicle control systems for type-approval. These requirements were designed for steering and braking equipment, which are complex dynamic systems, vital for the safe operation of vehicles. After careful consideration, it is concluded that such an approach is likely to be too onerous to be applied in full for assessing the self-test function of eCall systems. However, the general principle of requiring suitable documentation and verifying it by a physical test is useful for the present task.

UN Regulation No. 79, Annex 6:

"3.4. SAFETY CONCEPT OF THE MANUFACTURER

[...]

3.4.4. The documentation shall be supported, by an analysis which shows, in overall terms, how the system will behave on the occurrence of any one of those specified faults which will have a bearing on vehicle control performance or safety.

This may be based on a Failure Mode and Effect Analysis (FMEA), a Fault Tree

Analysis (FTA) or any similar process appropriate to system safety considerations.

The chosen analytical approach(es) shall be established and maintained by the Manufacturer and shall be made open for inspection by the technical service at the time of the type approval.

3.4.4.1. This documentation shall itemize the parameters being monitored and shall set out, for each fault condition of the type defined in paragraph 3.4.4. of this annex, the warning signal to be given to the driver and/or to service/technical inspection personnel.

4. VERIFICATION AND TEST

4.1. The functional operation of "The System", as laid out in the documents required in paragraph 3., shall be tested as follows:

[...]

4.1.2. Verification of the safety concept of paragraph 3.4.

The reaction of "The System" shall, at the discretion of the type approval authority, be checked under the influence of a failure in any individual unit by applying corresponding output signals to electrical units or mechanical elements in order to simulate the effects of internal faults within the unit.

4.1.2.1. The verification results shall correspond with the documented summary of the failure analysis, to a level of overall effect such that the safety concept and execution are confirmed as being adequate."

7.3 Draft proposal

1. Requirements

1.1. The following requirements apply to eCall in-vehicle systems, components and separate technical units.

1.2. Performance requirements

1.1.1. The eCall system shall carry out a self-test at each system power-up.

1.1.2. Where technically feasible with the chosen system design and architecture, the self-test function shall monitor at least the technical items listed in Table 1.

1.1.3. A warning in form of a visual tell-tale shall be provided in case a failure is detected by the self-test function.

1.1.3.1. It shall remain activated while the failure is present.

1.1.3.2. It may be cancelled temporarily by the driver, but shall be repeated whenever the ignition or vehicle master control switch is being activated.

1.2. Documentation requirements

1.2.1. The manufacturer shall provide the technical authorities with documentation in accordance with Table 1, which shall contain the following information.

(a) Which of the items listed are being monitored by the self-test function.

(b) For each item that is being monitored: The technical principle applied to monitor the item.

(c) For each item that is not being monitored: A technical reason, to the satisfaction of the type-approval authority, why it is not feasible to monitor the item with the chosen system design or architecture.

Table 1: Template of information for self-test function

<i>Item</i>	<i>Monitored by self-test function?</i>	<i>If yes: Technical principle applied for monitoring</i>	<i>If no: Technical reason prohibitive of monitoring</i>
<i>eCall ECU is in working order (e.g. no internal hardware failure, processor/memory is ready, logic function in expected default state)</i>	<i>yes/no</i>		
<i>External mobile network antenna is connected</i>	<i>yes/no</i>		
<i>Mobile network communication device is in working order (no internal hardware failure, responsive)</i>	<i>yes/no</i>		
<i>External GNSS antenna is connected</i>	<i>yes/no</i>		
<i>GNSS receiver is in working order (no internal hardware failure, output within expected range)</i>	<i>yes/no</i>		
<i>Crash control unit is in working order (e.g. no internal hardware failure, processor is ready, logic function in expected default state)</i>	<i>yes/no</i>		
<i>No communication failures (bus connection failures) of relevant components</i>	<i>yes/no</i>		
<i>SIM is present</i>	<i>yes/no</i>		
<i>Software image integrity</i>	<i>yes/no</i>		
<i>Dedicated battery is connected</i>	<i>yes/no</i>		
<i>State of health of dedicated battery</i>	<i>yes/no</i>		

<i>Microphone(s) are connected</i>	<i>yes/no</i>		
<i>Loudspeaker(s) are connected</i>	<i>yes/no</i>		
<i>Manual call button is connected</i>	<i>yes/no</i>		
<i>Status indicator is connected</i>	<i>yes/no</i>		

2. Test procedure

2.1. Self-test function verification test

- 2.1.1. *The following test shall be performed on a vehicle with an eCall in-vehicle system installed or on a representative arrangement of components for the approval of vehicles, components or separate technical units.*
- 2.1.2. *Simulate a malfunction of the eCall system by introducing a critical failure in one or more of the items monitored by the self-test function according to the technical documentation provided by the manufacturer. The item(s) shall be selected at the discretion of the technical service.*
- 2.1.3. *Power the eCall system up (e.g. by switching the ignition 'on' or activating the vehicle's master control switch, as applicable) and verify that the malfunction indicator illuminates shortly afterwards.*
- 2.1.4. *Power the eCall system down (e.g. by switching the ignition 'off' or deactivating the vehicle's master control switch, as applicable) and restore it to normal operation.*
- 2.1.5. *Power the eCall system up and verify that the malfunction indicator does not illuminate or extinguishes shortly after illuminating initially.*

7.4 Justification

7.4.1 Purpose of the procedure

The purpose of the proposed procedure is to verify the stipulation in the eCall Regulation regarding warning of the occupants in case of system failures.

Regulation (EU) 2015/758, Article 5, Paragraph 6.:

"Manufacturers shall demonstrate that, in the event of a critical system failure which would result in an inability to execute a 112-based eCall, a warning will be given to the occupants of the vehicle."

Note that the European eCall standards also articulate the requirement to perform an IVS self-test and specify that this should be performed on power-up. They do not describe further which elements or specific failures should be covered.

EN 16062, Section 7.1.5:

"7.1.5 Self-test

On power up, the IVS responsible for the eCall system shall normally perform a self-test without attempting to connect to the network. In the event of a critical

system failure, which would result in an inability to execute an eCall as described in this European Standard detected during or following the self-test, a warning shall be given to the occupants of the vehicle. The nature of such warning is a feature of product design and is not standardized in this European Standard. It is then the responsibility of the driver/occupant(s) of the vehicle to consider whether the warning is to be followed up. Correct eCall functionality cannot be ensured as long as such a critical system failure is present."

7.4.2 Technical items to be covered by the self-test function

It will be shown in the following sub-sections that it is not technically feasible for a system self-test to detect all possible failures that would result in an inability to execute an eCall. Hence, the far-reaching stipulation in the eCall Regulation that a malfunction indication should be given "*in the event of a critical system failure which would result in an inability to execute a 112-based eCall*" needs to be further specified and simplified to be suitable for verification during type-approval.

A sensible definition of the technical items to be covered by the self-test ensures that the range of expectations is uniform between different technical services and type-approval authorities and therefore ensures a level playing field for manufacturers and a comparable level of self-test capabilities across the range of vehicles and systems. The remaining potential failure cases, which cannot be detected by a system self-test, should be covered during PTI.

7.4.2.1 Self-test capabilities of current TPS system designs

The self-test capabilities of the TPS system designs of three premium segment vehicle manufacturers (A, B and C) are listed below. This can give an indication of what is currently done on a voluntary basis. The driver is not informed of all the failures below via a malfunction indicator (some failures are just stored as fault codes). Components that will not be required for a 112-based eCall IVS, such as a Bluetooth antenna, were omitted for these lists.

The self-test of vehicle Manufacturer A covers:

- Microphone: Connection failure
- Speakers: Failure (based on electrical signal)
- Manual call button: Failure
- State indicator LED: Failure
- Internal backup battery: Connection failure (non-rechargeable)
- Crash sensor: Failure
- Communication Module Interface: Failure
- GNSS receiver: Failure
- GNSS antenna: Failure

From communication with Manufacturer A it was inferred that:

- Only external antennas are monitored and not internal backup antennas (because the likelihood of faulty diagnostics would be similar to the likelihood of antenna failure).

The self-test of vehicle Manufacturer B covers at least the following items:

- Microphones: Short circuit; ground or plus pole
- Microphones: Connection failure
- Speakers: Short circuit; ground or plus pole
- Speakers: Connection failure
- GPS antenna: Short circuit; ground
- GPS antenna: Connection failure
- Manual call button: Connection failure
- Buttons: Buttons stuck
- Control unit: Fan malfunction
- Control unit: Internal hardware malfunction (detected by 'watchdog' function)
- Control unit: Software error
- Control unit: Bus communication failure
- Control unit: Communication failure on direct connections
- Control unit: Voltage level; high or low
- Power supply: Voltage level; high or low
- Wake-up cable: Short circuit; ground or plus pole
- Radio antennas: Short circuit; ground or plus pole
- Radio antennas: Connection failure

The self-test of vehicle Manufacturer C covers at least the following items:

- Speakers: Short circuit; ground or plus pole
- Speakers: Connection failure
- Microphone: Connection failure
- Control unit: Power supply failure
- Control unit: Communication failure
- State indicator LED: Failure
- Mobile network antenna: Connection failure
- Backup mobile network antenna: Connection failure

A comparison of the items on the above lists reveals that there is a certain variety in the likely extent of what failures manufacturers might cover with the self-test function. In a separate communication received, ACEA indicated that the extent varies depending, for example, on the abilities of the vehicle's CAN bus (advanced, limited CAN bus or no CAN bus link of the application) and that the control unit (ECU) was the only part commonly monitored across different manufacturers.

7.4.2.2 Possible failure modes and mechanisms

A self-test function of eCall IVS can cover a variety of electrical failures; however, not all possible failures of IVS components can be detected with reasonable effort. Also, the technical capabilities vary between manufacturers and vehicles depending on aspects of eCall system and CAN bus design. This needs to be reflected in the proposal in order to not unduly restrict the system design.

Table 4 provides a high-level list of potential failure modes and mechanisms of eCall IVS components. The colour-coding indicates for each failure whether it is technically feasible to cover it in a system self-test or not. The consideration of technical feasibility is based on the responses comprising Section 7.4.2.1, general technical considerations and additional stakeholder input. The green elements of the list formed the basis for the required items to be monitored as a default. It is considered to be likely that the red elements cannot be monitored by a self-test function in a typical system design.

Table 4: Potential failure modes and mechanisms of eCall IVS parts; colour-coding indicates feasibility to check via IVS self-test (green: generally feasible; yellow: feasible in some instances; red: generally not feasible)

Part	Failure mode/mechanism	Comment
eCall control unit, network access device, GNSS receiver	Power supply failure (connection failure, short circuit, voltage high/low)	
	Communication failure (bus connection failure)	
	Internal hardware failure	e.g. via monitoring signal from NAD and GNSS receiver
	Software error	e.g. software image integrity via checksum
	SIM failure/not present	
	SIM invalid	Not feasible to test without network communication (dormant mode SIM)
Dedicated battery	Connection failure, short circuit	e.g. via voltage monitoring
	Output voltage high/low	Generally feasible; challenging in high/low temperature conditions
	Reduced state of capacity	Generally feasible for rechargeable batteries; challenging for primary batteries to be performed at every vehicle start (gradually discharging battery)
	Reduced state of charge	When applicable to rechargeable batteries only

Mobile network antenna (GSM/UMTS)	Connection failure, short circuit	
	Reduced performance/failure due to unintended manipulation (e.g. non-approved replacement part, installation faults) or mechanical degradation (e.g. corrosion of contacts)	Not feasible to test because similar to weak signal situation and dormant mode SIM
	Failure due to deliberate manipulation (shielding of antenna or jamming of signals), e.g. based on concerns the vehicle could be tracked	Not feasible to test because identical to no-signal situation and dormant mode SIM
GNSS antenna	Connection failure, short circuit	
	Reduced performance/failure due to unintended manipulation (e.g. non-approved replacement part, installation faults) or mechanical degradation (e.g. corrosion of contacts)	Not feasible to test because similar to weak signal situation
	Failure due to deliberate manipulation (shielding of antenna or jamming of signals), e.g. based on concerns the vehicle could be tracked	Not feasible to test because identical to no-signal situation
Microphone(s)	Connection failure, short circuit	
	Reduced performance/failure due to degradation (e.g. soiling, ageing, mechanical defects)	Would require playback and recording of audio signal at vehicle start (unreliable in noisy conditions, nuisance for occupants)
	Reduced performance/failure due to manipulation (e.g. non-approved replacement part, installation faults, covered by retrofit elements)	Would require playback and recording of audio signal at vehicle start (unreliable in noisy conditions, nuisance for occupants)
Loudspeaker(s)	Connection failure, short circuit	
	Reduced performance/failure due to degradation (e.g. soiling, ageing, mechanical defects)	Would require playback and recording of audio signal at vehicle start, (unreliable in noisy conditions, nuisance for occupants)
	Reduced performance/failure due to manipulation (e.g. non-approved replacement part, installation faults, covered by retrofit elements)	Would require playback and recording of audio signal at vehicle start, (unreliable in noisy conditions, nuisance for occupants)
Crash control unit	Power supply failure (connection failure, short circuit, voltage high/low)	Potentially separate self-test that is fed back to the eCall ECU

	Communication failure (bus connection failure)	
	Internal hardware failure	Potentially separate self-test that is fed back to the eCall ECU
Manual call button	Connection failure, short circuit	Depends on button design (open circuit design would not allow resistance check)
	Mechanical failure (e.g. button stuck)	
Status indicator	Connection failure, short circuit	Detection feasible, but only possible to indicate if status indicator is separate from malfunction indicator
	LED failure	Detection feasible, but only possible to indicate if status indicator is separate from malfunction indicator
	Failure due to deliberate manipulation	Detection feasible, but only possible to indicate if status indicator is separate from malfunction indicator
Malfunction indicator	Connection failure, short circuit	Detection feasible, but indication to driver not possible
	Failure due to deliberate manipulation	
	LED failure	Detection feasible, but indication to driver not possible

7.4.3 Documentation and verification procedure

As outlined above, there are a large number of potential failures that can lead to an inability of the IVS to execute an eCall and which can be detected by the self-test function. Testing each of these failures would impose a disproportionately high testing effort on the manufacturers and might, altogether, not even be technically feasible in many cases; relying exclusively on documentation (without verifying the system conformance in a physical test) may result in a large variation in how this rule is applied by different type-approval authorities. The general principle applied in these UN regulations, such as UN R13-H and UN R79, is to cover the variety of cases by documentation and verify selected cases in physical tests:

- Require documentation that explains the design provisions taken; and
- Verify the system behaviour by applying one or more failures (at the discretion of the type-approval authority) and assessing the outcome against the documentation.

This general approach is considered suitable also to be applied to the issue at hand.

The provision of documentation in accordance with Table 1 shall prompt system suppliers and vehicle manufacturers to implement a wide range of self-test functions.

Emphasis has been given to pragmatic self-testing, which should be possible without having to significantly change the system design or architecture, which is governed by the vehicle's communication and information sharing protocols. This has been referred to as "*technically feasible*" testing within the draft proposal. If it is not feasible to monitor a certain item with reasonable effort, the manufacturer can provide a technical reason to opt out of monitoring this item (e.g. open-circuit design of manual call button does not allow electrical resistance check; or, no communication monitoring because application not linked to CAN bus).

Note that feedback received from ACEA indicated that the definition of a list of specific items to be monitored was considered problematic in particular for the transition phase, because this could require wiring harness modifications of new vehicles design specifications that were already fixed for the year 2018. Particular concerns were raised regarding mandatory monitoring of loudspeaker connection status, because these components were typically part of the vehicle's infotainment system. Therefore, monitoring might require changes to the vehicle system architecture in some cases. The intention is for this to be addressed by the definition "*where technically feasible with the chosen system design and architecture*". It was nevertheless suggested to omit these items from the list based on the fact that MSD transmission would still be possible without loudspeakers, which would be sufficient to dispatch emergency services.

The documentation allows the technical service to verify that all required items are being monitored by suitable means unless there are technical reasons inherent to the current system design or architecture that prohibit monitoring of the specific item. It also enables the technical service to select a test case for the physical verification test.

The physical verification test is limited to only one exemplary test case (unless the technical service has reason to believe more test cases are necessary, for example if the specifications in Table 1 are not fully adequate). This limited approach to physical verification is considered appropriate because the complexity of the static eCall IVS is limited compared to complex electronic vehicle control systems for dynamic functions such as braking or steering.

The simulated malfunction shall be at the discretion of the technical service to introduce a random element in the verification test. Ways of introducing a critical failure could, for example, be: Disconnecting the power supply or bus connection of a monitored active component, disconnecting direct connection of a monitored component (e.g. loudspeaker, microphone or antenna), manipulation of the power supply or removing the SIM.

7.4.4 Malfunction indicator provisions

The physical appearance of the malfunction indicator was not in the scope of the current study. The requirements of the draft proposal are therefore kept to the minimum aspects that are necessary for the physical verification procedure, i.e. that a visual malfunction tell-tale is available and that it is activated whenever a failure is present, unless it is temporarily cancelled by the driver. Note that a temporary lack of mobile network coverage is not considered a failure that should be indicated to the driver using the malfunction indicator.

These requirements are based on UN R48, with the added limitation that the cancellation of the tell-tale has to be performed by the driver; this was added to avoid automatic cancellation after a defined period of time, which could lead to false

assumptions that the system has returned to working order. This shall not prohibit system designs that initially display a comprehensive message about a failure and then reduce the tell-tale to a simple failure indicator symbol.

It is expected that aspects such as colour, location and the symbol for the visual tell-tale will be specified elsewhere, if considered necessary.

7.4.5 Provisions relevant for periodic technical inspections

As discussed above, some failures that might result in the inability of the IVS to perform an eCall cannot be detected by a self-test function. The red elements in Table 4 are examples of such failures. Some of these failure mechanisms appear particularly relevant when considering the performance of an eCall IVS over the full lifespan of a vehicle, for example degradation, mechanical defects as well as deliberate or unintended manipulation. Therefore, simple visual observation of the warning signal would not be adequate for a PTI. Instead, additional diagnostic interrogation is proposed; thereby allowing the PTI to detect these faults.

Existing UN regulations, such as UN R13-H (braking) and UN R79 (steering equipment), cover relevant prescriptions to facilitate PTI tests. The need to cover eCall during PTI is confirmed in the eCall Regulation.

Regulation (EU) 2015/758, Recital (18):

"(18) The 112-based eCall in-vehicle system, as an emergency system, requires the highest possible level of reliability. The accuracy of the minimum set of data and of the voice transmission, and quality, should be ensured, and a uniform testing regime should be developed to ensure the longevity and durability of the 112-based eCall in-vehicle system. Periodic roadworthiness tests should therefore be carried out regularly in accordance with Directive 2014/45/EU of the European Parliament and of the Council"

Whereas PTI *per se* is beyond the scope of this study, the self-test requirements could facilitate future PTI testing because performing a test call during PTI tests might not be feasible. Efficient PTI testing can be supported by ensuring that a universal scan tool can access relevant diagnostic information via the standard OBD connector and that the necessary information to do so is made available by the manufacturer. The following prescriptions could be included in the type-approval acts for this purpose:

1. *Provisions for the periodic technical inspection*
 - 1.1. *It shall be possible to verify the integrity of the eCall in-vehicle system via the serial interface of the standard on-board diagnostic connector (OBD). According to this it shall at least be possible to test the accuracy of the Minimum Set of Data, the availability of Public Land Mobile Network(s) and the functionality of the voice communication by audible means (e. g. short echo test).*
 - 1.2. *All necessary information for the proper conduct of the test shall be made freely available.*

Note that concerns were raised by ACEA regarding this item at the current stage, stressing that it might have a strong influence on eCall system design and would require considerable further legislative work: For example, the current OBD2 message set did not include the relevant messages for these prescriptions, which is why further work would be needed on the relevant specifications to enable these prescriptions.

8 PRIVACY AND DATA PROTECTION

As mentioned in the Introduction, TRL was commissioned to provide an overview of the privacy and data protection aspects contained within the eCall regulation. In particular, to provide an initial exploration of the potential technical requirements, test procedures and practical arrangements which could be used in delegated and implementing acts associated with Article 6 of the regulation. This section of the report provides this initial review and some draft concepts which could be adapted and used in future acts.

The mandatory fitment of vehicles with devices that allow the vehicle to determine its location and transmit it via a mobile network requires consideration of privacy and data protection aspects. The eCall regulation sets out privacy and data protection safeguards related to eCall in-vehicle systems that shall be verified during type-approval. For instance, these require vehicle manufacturers to:

- Ensure that the in-vehicle system (IVS) only processes the minimum set of data (MSD)
- Adopt safeguards to prevent surveillance and misuse of data

Specifically, the safeguards are translated into some of the articles of the regulation. These articles are reproduced below.

Within Regulation (EU) 2015/758, Article 6 "Rules on privacy and data protection" states that:

"12. The Commission shall be empowered to adopt delegated acts in accordance with Article 8 in order to establish:

(a) the detailed technical requirements and test procedures for the application of the rules on personal data processing referred to in paragraphs 2 and 3;

(b) the detailed technical requirements and test procedures for ensuring that there is no exchange of personal data between the 112-based eCall in-vehicle system and third party systems as referred to in paragraph 11."

Paragraphs 2, 3 and 11 state:

"2. The personal data processed pursuant to this Regulation shall only be used for the purpose of handling the emergency situations referred to in the first subparagraph of Article 5(2).

3. The personal data processed pursuant to this Regulation shall not be retained longer than necessary for the purpose of handling the emergency situations referred to in the first subparagraph of Article 5(2). Those data shall be fully deleted as soon as they are no longer necessary for that purpose.

11. Manufacturers shall ensure that the 112-based eCall in-vehicle system and any additional system providing TPS eCall or an added-value service are designed in such a way that no exchange of personal data between them is possible. The non-use of a system providing TPS eCall or an added-value service or the refusal of the data subject to give

consent to the processing of his or her personal data for a TPS eCall service or an added value service shall not create any adverse effects on the use of the 112-based eCall in-vehicle system."

There is also the provision that:

"13. The Commission shall, by means of implementing acts, lay down:

- (a) the practical arrangements for assessing the absence of traceability and tracking referred to in paragraphs 4, 5 and 6;*
- (b) the template for the user information referred to in paragraph 9."*

Paragraphs 4, 5, 6 and 9 state:

"4. Manufacturers shall ensure that the 112-based eCall in-vehicle system is not traceable and is not subject to any constant tracking.

5. Manufacturers shall ensure that, in the internal memory of the 112-based eCall in-vehicle system, data are automatically and continuously removed. Only the retention of the last three locations of the vehicle shall be permitted in so far as it is strictly necessary to specify the current location and the direction of travel at the time of the event.

6. Those data shall not be available outside the 112-based eCall in-vehicle system to any entities before the eCall is triggered.

9. Manufacturers shall provide clear and comprehensive information in the owner's manual about the processing of data carried out through the 112-based eCall in-vehicle system. That information shall consist of:

- (a) the reference to the legal basis for the processing;*
- (b) the fact that the 112-based eCall in-vehicle system is activated by default;*
- (c) the arrangements for data processing that the 112-based eCall in-vehicle system performs;*
- (d) the specific purpose of the eCall processing, which shall be limited to the emergency situations referred to in the first subparagraph of Article 5(2);*
- (e) the types of data collected and processed and the recipients of that data;*
- (f) the time limit for the retention of data in the 112-based eCall in-vehicle system;*
- (g) the fact that there is no constant tracking of the vehicle;*
- (h) the arrangements for exercising data subjects' rights as*

well as the contact service responsible for handling access requests;

- (i) *any necessary additional information regarding traceability, tracking and processing of personal data in relation to the provision of a TPS eCall and/or other added value services, which shall be subject to explicit consent by the owner and in compliance with Directive 95/46/EC. Particular account shall be taken of the fact that differences may exist between the data processing carried out through the 112-based eCall in-vehicle system and the TPS eCall in-vehicle systems or other added value services."*

In the following sections consideration is given to how these requirements can be incorporated into appropriate stipulations within delegated and implementing acts.

8.1 Article 6(2):

"The personal data processed pursuant to this Regulation shall only be used for the purpose of handling the emergency situations referred to in the first subparagraph of Article 5(2)."

8.1.1 Context

The emergency situations referred to in the first subparagraph of Article 5(2) are,

"a severe accident, detected by activation of one or more sensors or processors within the vehicle, which occurs in the territory of the Union, {upon which} an eCall to the single European emergency number 112 is triggered automatically."

Personal data is not defined within the regulation. However, considering the MSD to be transmitted during the eCall, then an indication is available as to what 'personal data' needs to be considered. The contents of the MSD are defined in EN 15722. The core components of this are reproduced in Tables 5 and 6 showing the mandatory and optional data fields (EN 15722).

Table 5: Mandatory contents of the MSD data – based on EN 15722

Name	Description
MSD version	MSD format version
Message identifier	Message identifier, starting with 1 for each new eCall transaction and to be incremented with every application layer MSD retransmission following a new 'Send MSD' request after the incident event.
Automatic activation	True = Automatic False = Manual Precise vehicle type encoding (M1/M2/M3/N1/N2/N3/L1e/L2e/L3e/L4e/L5e/L6e/L7e)
Test call	True = Test call False = Emergency

Position can be trusted	True = Position can be trusted False = Low confidence in position
Vehicle type	The supported vehicle types are as follows: • passenger vehicle (Class M1) • buses and coaches (Class M2) • buses and coaches (Class M3) • light commercial vehicles (Class N1) • heavy duty vehicles (Class N2) • heavy duty vehicles (Class N3) • motorcycles (Class L1e) • motorcycles (Class L2e) • motorcycles (Class L3e) • motorcycles (Class L4e) • motorcycles (Class L5e) • motorcycles (Class L6e) • motorcycles (Class L7e)
Vehicle identification	VIN number according to ISO 3779
Vehicle propulsion storage type	These parameters identify the type of vehicle energy storage(s) present. For each storage type the following coding applies: false = indicates a type of storage not present true = indicates type of storage which is present The following storage types are supported: • Gasoline tank • Diesel tank • Compressed natural gas (CNG) • Liquid propane gas (LPG) • Electric energy storage (with more than 42 v and 100 Ah) • Hydrogen storage
Time stamp	Timestamp of the initial data message generation within the current eCall incident event. The timestamp is represented in seconds elapsed since midnight January 1st, 1970 UTC.
Vehicle location	Position latitude (WGS84) maximum value: 90°00'00.000" = 324000000 minimum value: -90°00'00.000" = -324000000 Position longitude (WGS84) maximum value: 180°00'00.000" = 648 000 000 minimum value: -180°00'00.000" = -648 000 000
Vehicle direction	The vehicle's last known real direction of travel (expressed in 2°- degrees steps from magnetic north (0– 358, clockwise) determined at the latest moment possible before message generation.

Table 6: Optional contents of the MSD data – based on EN 15722

Name	Description
Recent vehicle location n-1	Latitude Delta (+ for North and – for South; WGS84) with respect to Vehicle location maximum value: 511 = 0°0'51.100" (±1580 m) minimum value: -512 = -0°0'51.200" (± -1583 m) Longitude Delta (+ for East and – for West; WGS84) with respect to Vehicle location
Recent vehicle location n-2	Latitude Delta (+ for North and – for South; WGS84) with respect to Recent vehicle location n-1 Longitude Delta (+ for East and – for West; WGS84) with respect to Recent vehicle location n-1
Number of passengers	Number of occupants in the vehicle according to available information.
Optional additional data	Further bytes of data available for encoding

EN 15722, Section 6.1.5 defines that the,

"Optional additional data shall not include any data concerning or identifying a person (personal data) unless the transfer of such data has been explicitly and expressly prior instructed and authorized by the person who is identified by the data and its provision shall in any event only be provided only in accordance with European Union and National privacy regulations pertaining at the time of the transfer of any such personal data."

Therefore, the likely components of 'personal data' are going to be the:

- VIN – from which the registered owner of the vehicle can be identified assuming the interpreter has sufficient access to a national database of registered keepers.
- Vehicle location – which allows the vehicle movement to be determined at a moment in time. With repeated sampling, a pattern of movement could be determined.
- Optional, recent vehicle locations – showing the immediate history of travel.
- Instance that an eCall has been placed, potentially indicating the involvement in a collision of a vehicle.

By design, eCall functions will provide this information to the Public Service Answering Point (PSAP). This point, or collection of people, will have been approved by the nation to treat such information with due regard for data protection and will routinely handle such data. The treatment of data at the PSAP is also beyond the scope of the vehicle type-approval regulation.

Therefore, Article 6(2) seemingly relates to two concerns:

- 1) The leakage of data from the eCall IVS to other uses within the vehicle
- 2) Storage of data beyond any necessary use in conjunction with the immediate emergency event

The second of these is dealt with more explicitly by Article 6(3) and considered in the next section below. The first warrants further consideration.

Returning to the 'personal' components of the MSD, then the VIN is programmed into the vehicle or, for example, the powertrain control module. Also, the vehicle location could be used for a satellite navigation system. Therefore, both of these items are already used elsewhere within the vehicle. Primarily then, this article relates to the availability of a log noting that an eCall was placed.

In EN 16072, Section 7.17.4, it states that,

"The IVS responsible for eCall shall register recent eCalls in non volatile memory. The method and means by which this is done, and number of records stored is not specified in this European Standard. The storage of data shall respect European data protection regulations."

This places a requirement on the eCall IVS to log recent eCalls. To protect the data contained within these logs (the acknowledgement of an automatically initiated eCall and the timestamp associated with that event), it is proposed that this should not be transferred from that memory to any other system within the vehicle. It should also not be kept beyond the necessary minimum time for use in association with the current emergency event (as stipulated in Article 6(3)).

8.1.2 Technical requirements and test procedures

There is a technical requirement associated with this article that any record of eCall activation stored within the IVS is secure and not available to a third party without special provisions from the vehicle or device manufacturer. This does not readily lend itself to a test procedure which could be used to confirm such a requirement. Instead it may be more appropriate that the delegated act specifies anticipated security measures, such as encryption of the memory within the IVS, if log files are stored there.

8.2 Article 6(3):

"The personal data processed pursuant to this Regulation shall not be retained longer than necessary for the purpose of handling the emergency situations referred to in the first subparagraph of Article 5(2). Those data shall be fully deleted as soon as they are no longer necessary for that purpose."

8.2.1 Context

An interpretation regarding exactly what information should be considered as 'personal data' and the reference for the emergency situation from the first paragraph of Article 5(2) are given in the Context Section of the previous sub chapter. However, to understand this article, it is necessary to analyse what is meant in association with the time 'necessary for the handling of the emergency situation'.

Within EN 16072, Section 7.17.3, it specifies that,

“Once the IVS responsible for the eCall system is registered on the network, it shall remain registered for a minimum period of one hour after the eCall is terminated or until available power is exhausted, in case the PSAP wishes to reconnect to the vehicle.

If an eCall has been successfully terminated by the PSAP, then the IVS responsible for the eCall system shall allow a call-back into the vehicle.”

EN 16062 then sets the maximum time that the IVS responsible for the eCall system shall stay registered on the network before an intended network de registration or a loss of power shall have the effect to cause deregistration. This maximum time is 12 hours from the point at which the call was ‘cleared down’ (T10 – IVS NAD network ‘Deregistration Fallback Timer’ DFT). Additionally, there may have been one hour elapsed between the IVS starting with the call setup and that call being cleared down (T2 – IVS Call Cleardown Fallback Timer (CCFT)). In which extreme case, the total time anticipated to be relevant for a single event is at most 13 hours. If an emergency call from the IVS follows this period then it would be assigned a new event identification number.

Following this timing provided by the relevant EN standards on eCall suggests that 13 hours is the maximum period following an eCall event that could reasonably be expected to be considered as the same emergency event. Therefore, if personal data from an event is only kept for the minimum length of time necessary, a requirement could be set that it should not be kept for longer than 13 hours.

Section 9.4.41 of EN 16454 specifies Conformance Test Procedure 1.1.16.3 which is intended to ‘Verify that IVS registers recent eCalls, stores the fact of the AL ACK receipt and its timestamp’. To facilitate this verification it is required that the ‘Tester has access to where the data is stored in the IVS’. It seems reasonable that a similar provision could be given for type-approval where the technical service has the same access (it should be noted here that this may be easier to confirm with a representative arrangement of parts from the eCall IVS, rather than the complete vehicle). However, in this instance the access is used to verify that personal data is removed from the eCall IVS after a given time-period.

Note that there could be potential uses for the data beyond the handling of the emergency situation. Examples of uses for log files, which could be of benefit to the owner of the vehicle or similar vehicles, are:

- To resolve issues over liability in the possible event that an eCall is not transmitted successfully. The vehicle data could be used to demonstrate initiation of the eCall. This could be needed retrospectively beyond the immediate emergency need to attend the scene.
- When investigating a crime. The manual eCall function can be used to alert the emergency services to any emergency event (not just a motor vehicle crash). If criminal proceedings are followed, then access to the eCall log could be important for setting the event timeline. This may take a much longer period to implement than the immediate event requires for emergency response.
- To improve future service provision if an eCall doesn’t successfully lead to location of an injured person. If the crashed vehicle remains unfound for longer than 13 hours, it could still be useful to find out exactly when the eCall was logged.

The benefits of retaining some data are understood, but the eCall Regulation stipulates that the data shall not be retained longer than necessary for handling the emergency

situation, and this must be verified during type-approval.

8.2.2 *Technical requirements and test procedures*

If a test is required for assessing the length of time an eCall log file is stored by the IVS, then it could be formulated in a way similar to that following:

1. *Purpose*
 - 1.1. *This test procedure shall apply to the requirement set out in Article 6(3) of Regulation (EU) 2015/758.*
 - 1.2. *This is to demonstrate that the personal data shall not be retained by the eCall in-vehicle system longer than necessary for the purpose of handling the emergency situation. Those data shall be fully deleted as soon as they are no longer necessary for that purpose. This is to be judged by proving that eCall log files are not kept beyond {X} hours from the point of initiating an eCall.*
2. *Requirements*
 - 2.1. *When interrogated, the eCall in-vehicle system shall not maintain any record of an eCall in its memory beyond {X} hours from the point of initiating an eCall.*
3. *Test conditions*
 - 3.1. *The technical service shall be facilitated to have access to the part of the system where the eCall log files are stored in the IVS*
 - 3.2. *The following test shall be performed on a representative arrangement of parts for the approval of vehicles, components or separate technical units.*
4. *Test Method*
 - 4.1. *The tests as described in Sections {X – relating to the sled-based testing, for instance} shall be carried out. They require that a test call is placed in order for functionality checks to be made.*
 - 4.2. *{X} hours after a test call has been placed, the technical service tester shall be facilitated with access to where the eCall log files are stored in the IVS. This will involve the potential to download from the IVS any log files so that they can be viewed by the tester.*
5. *Assessment*
 - 5.1. *The requirement is determined to have been passed if no log files are present in the eCall in-vehicle system memory.*
 - 5.2. *The presence of a log file pertaining to an eCall that has occurred more than {X} hours ago constitutes a failure.*

8.3 *Article 6(11):*

"Manufacturers shall ensure that the 112-based eCall in-vehicle system and any additional system providing TPS eCall or an added-value service are designed in such a way that no exchange of personal data between them is possible. The non-use of a system providing TPS eCall or an added-value service or the refusal of the data subject to give consent to the processing of his or her personal data for a TPS eCall service or an

added value service shall not create any adverse effects on the use of the 112-based eCall in-vehicle system.”

There appear to be two main features of this article.

- 1) That the design of the eCall systems does not allow any exchange of personal data between the 112-based eCall in-vehicle system (IVS) and the TPS eCall
- 2) That without the TPS system, the 112-based eCall is not adversely affected

Conformance of the second part will be assured through the testing regime described in the technical proposals presented in Section 5 of this report. Those should give confidence that the 112-based eCall IVS will operate adequately without reliance on the TPS.

With regard to the exchange of information between two systems, this is more difficult to inspect. The personal data of the vehicle position must be available to both the 112-based system and the TPS system. Equally, the VIN is likely to be available via the vehicle's controller area network and so readily called upon for eCall activities. As such, there is no direct need for communication between the 112 and TPS in-vehicle systems for them to have the same information. This means an assessment to show separation of information is difficult to define.

However, there are cases where it is conceivable that the TPS system has additional information stored in its memory than the 112-based system. If a consumer then elected to discontinue the TPS or added-value service, it would be important to ensure that the additional, perhaps personal, information was not available to the 112-based system. It may not be adequate to only deactivate the network access component of the TPS system. Under such circumstances it is important to ensure that the contents of the TPS system memory are not available for inclusion within the 112-based system.

One potential item which is unique to either the 112-based system or the TPS would be the log of activity. A test procedure could be based around this to show that there is no exchange of information from one system to the other. For instance, with the TPS disabled, a manual call could be made. This would connect via the 112-based system. On completion of the call, the TPS in-vehicle system memory could be interrogated to confirm that it has no log of the call.

On the other hand, documentation could be used to show that there is no direct wiring, shared memory or data exchange pathway between the 112-based and the TPS in-vehicle components. Perhaps appropriate cryptography is necessary to ensure adequate data separation.

8.3.1 *Technical requirements and test procedures*

As mentioned, two options are proposed for consideration in response to this article. These are represented by the following two sets of requirements. One or the other could be used in conjunction with the requirements imposed by Article 6(11).

Option 1:

1. *Purpose*
 - 1.1. *This test procedure shall apply to the requirement set out in Article 6(11) of Regulation (EU) 2015/758.*

- 1.2. *This is to ensure that the 112-based eCall in-vehicle system and any additional system providing TPS eCall or an added-value service are designed in such a way that no exchange of personal data between them is possible.*
2. *Requirements*
 - 2.1. *The following requirements apply to eCall in-vehicle systems, components and separate technical units that shall be used in conjunction with a TPS eCall in-vehicle system.*
 - 2.2. *Performance requirements*
 - 2.2.1. *There is no exchange of personal data between the 112-based eCall in-vehicle system and any additional system providing TPS eCall or an added-value service.*
 - 2.2.2. *Following an eCall made via the 112-based eCall in-vehicle system, no log of this eCall shall be recorded in the memory of the TPS eCall or added-value service system.*
3. *Test procedure*
 - 3.1. *The following tests shall be performed either on a vehicle with an eCall in-vehicle system installed or on a representative arrangement of parts, for the approval of vehicles, components or separate technical units.*
 - 3.2. *The TPS system shall be disabled for the duration of the test call.*
 - 3.2.1. *Before performing the test call, ensure:*
 - (a) *that one of the connection procedures defined in Paragraph [Connection procedures], as agreed between the technical service and the manufacturer, will be applied for any test call;*
 - (b) *that the dedicated PSAP test point is available to receive an eCall emitted by the 112-based system;*
 - (c) *that a false eCall to a genuine PSAP cannot be made over the live network; and*
 - (d) *that the vehicle ignition or master control switch is activated.*
 - 3.2.2. *Perform a test call by applying a manual trigger of the system (push mode) with the TPS disabled.*
 - 3.2.3. *Verify:*
 - (a) *that a call was established with the PSAP test point by a record of the PSAP test point showing that it received a call initiation signal or by a successful voice connection to the PSAP test point; and*
 - 3.2.4. *Clear down the test call using the appropriate PSAP test point command (e.g. hang up).*
 - 3.2.5. *If the call attempt of the 112-based system fails during the test, the test procedure may be repeated.*
 - 3.3. *The lack of a log file in the TPS system shall be verified via access to the part of the system where eCall log files are stored.*
 - 3.3.1. *The technical service tester shall be facilitated with access to where the eCall log files are stored in the IVS. This will involve the potential to download from the IVS any log files so that they can be viewed by the tester.*

- 3.3.2. *The requirement is determined to have been passed if no log files are present in the TPS system in-vehicle system memory.*
- 3.3.3. *The presence of a log file TPS system pertaining to an eCall that has occurred via the 112-based system constitutes a failure.*
- 3.4. *Connection procedures*
[The proposal for connection procedures is identical to the procedures as defined for Task 1 in Section 2.3 of this report.]

Option 2:

- 1. *Purpose*
 - 1.1. *This test procedure shall apply to the requirement set out in Article 6(11) of Regulation (EU) 2015/758.*
 - 1.2. *This is to ensure that the 112-based eCall in-vehicle system and any additional system providing TPS eCall or an added-value service are designed in such a way that no exchange of personal data between them is possible.*
- 2. *Requirements*
 - 2.1. *The following requirements apply to vehicles with 112-based and TPS or added-value eCall in-vehicle systems installed.*
 - 2.2. *Documentation requirements*
 - 2.2.1. *The manufacturer shall provide a statement which affirms that that the 112-based eCall in-vehicle system and any additional system providing TPS eCall or an added value service are designed in such a way that no exchange of personal data between them is possible.*
 - 2.2.2. *The manufacturer shall provide the type-approval authority with an explanation and technical documentation which shows, in overall terms, how this is achieved. For example:*
 - 2.2.2.1. *Documentation that shows, to the satisfaction of the type-approval authority, that there is no direct wiring or memory shared between the 112-based eCall in-vehicle system and any additional system providing TPS eCall or an added value service system.*
 - 2.2.2.2. *Documentation that shows, to the satisfaction of the type-approval authority, that there is no data pathway existing in the vehicle, without an adequate firewall or separation by encryption, that allows an exchange of information between the 112-based eCall in-vehicle system and any additional system providing TPS eCall or an added value service system.*

8.4 Article 6(4):

"Manufacturers shall ensure that the 112-based eCall in-vehicle system is not traceable and is not subject to any constant tracking."

8.4.1 Context

In EN 16072, Section 6.2.3, it states that,

"The eCall service shall only operate from the point of service demand (automatic or manual) triggering of the eCall. eCall shall therefore be a

'sleeping' application and shall not be used to monitor the movement of vehicles other than at the point of eCall message triggering as defined in the appropriate high level application protocol standard. (In the case of GSM/UMTS circuit switched networks, EN 16062). For detail of network registration in the case of GSM/UMTS circuit switched networks, see ETSI/TS 122 101."

The concept of this stipulation is that whilst the eCall in-vehicle system is in an idle mode waiting to place a call, it is sleeping or dormant and therefore not registered on the network. This implies that the 112-based system would indeed not be traceable assuming:

- Registration on the network is required for tracking
- That the eCall device is designed in compliance with the EN standards
- That in the dormant state, the eCall IVS is not transmitting in a way that allows the device to be traced

It is understood that the implementation in eCall in-vehicle systems is likely to involve a dormant state which allows background scanning of the available networks. This provides an important function in reducing the time to connect when an eCall is required.

EN16062, Section 7.1.6, sets the provision that:

"An IVS responsible for the eCall system configured for "eCall only" shall periodically scan and maintain a list of available PLMNs, whilst in inactive state, so as to reduce the network selection and registration time in accordance with ETSI/TS 122 011 when the IVS responsible for the eCall system needs to initiate an eCall."

The consequence of this function is that the dormant state involves an active SIM which is maintaining the image of available mobile networks. As such, it is conceivable that the device could be traced. However, this can be achieved with a passive, listening, action so should not require traceable activity of the SIM.

Furthermore, tracing such a system is unlikely to reveal personal data as the identifiers associated with a SIM would be retained until formal communications with the mobile network operator begin during connection and registration. This assumes that there is no collective register of the SIM associated with each vehicle in service. Without this it would not be until an emergency call that the caller line identification and caller location are released. This cannot occur until the eCall system initiates the emergency call. It cannot be 'pulled' without prior communication with the device.

e.g. EN 16072, Section 6.1.5 states that,

"The MNO system shall treat the eCall as any other emergency call (in the case of GSM/UMTS circuit switched networks circuit switched networks, a 'TS12' call), and shall include caller line identification and caller location information."

NOTE 1 This caller line identification and caller location information is obtained from the network and is in addition to the vehicle calculation of location that is included in the MSD."

8.4.2 *Technical requirements and test procedures*

The technical requirement that is presented by this article is that, in its idle or dormant state (with the ignition on but before placing a eCall), the eCall IVS is not registered on the network.

This can be tested by connecting the eCall in-vehicle system to a network simulator and demonstrating that it is not registered in its idle state. Confirmation would also be necessary to show that it is detectable and registered for the purposes of placing a call. Therefore, the following requirements should be added to the existing manually activated eCall assessments. For example when associated with the sled test assessment of the resistance of eCall IVS to severe crashes.

1. *Purpose*
 - 1.1. *This test procedure shall apply to the requirement set out in Article 6(4) of Regulation (EU) 2015/758.*
 - 1.2. *This is to ensure that the 112-based eCall in-vehicle system is not traceable.*
2. *Requirements*
 - 2.1. *The 112-based eCall in-vehicle system is not available for communication with the PSAP if the PSAP test point initiates the communication.*
 - 2.2. *Failure to establish the connection can be attributed to the 112-based eCall in-vehicle system not being registered on the network.*
3. *Test procedure*
 - 3.1. *The following tests shall be performed on a representative arrangement of parts (without a vehicle body) for the approval of vehicles, components or separate technical units.*
 - 3.2. *This test shall be performed after successful connection of the eCall IVS with the network and registration of the device so as to facilitate transmission of the MSD.*
 - 3.2.1. *The initial emergency call must have been 'cleared down' prior to this test, otherwise the PSAP test point will be enabled to connect.*
 - 3.2.2. *Before performing the test, ensure that:*
 - (a) *one of the connection procedures defined in Paragraph [Connection procedures], as agreed between the technical service and the manufacturer, will be applied for any test call;*
 - (b) *the dedicated PSAP test point, configured in normal mode (non-robust mode), is available to receive an eCall emitted by the 112-based system;*
 - (c) *that the vehicle ignition or master control switch is activated;*
 - (d) *that any TPS or added-value service system is disabled.*
 - 3.2.3. *Leave the 112-based eCall IVS powered.*
 - 3.2.4. *Via the PSAP test point, attempt to connect to the 112-based eCall IVS.*

8.5 *Article 6(5):*

"Manufacturers shall ensure that, in the internal memory of the 112

based eCall in-vehicle system, data are automatically and continuously removed. Only the retention of the last three locations of the vehicle shall be permitted in so far as it is strictly necessary to specify the current location and the direction of travel at the time of the event."

8.5.1 Context

Within the Minimum Set of Data there is the requirement to include the most recent vehicle location and two previous locations. This means that the three most recent locations of the vehicle must be available for transmitting. However, to preserve excess personal data from being available beyond the immediate need, no further data are to be stored in memory. This means that the available locations will be constantly refreshed within the in-vehicle system memory.

8.5.2 Technical requirements and test procedures

In consideration of Article 6(3) it was suggested how the in-vehicle system memory could be interrogated to show how eCall logs are no longer present. The Article 6(5) requirements could be monitored in a similar manner. When prompted for the last known locations of the vehicle, the requirement would be met if no more than three locations are returned.

1. *Purpose*
 - 1.1. *This test procedure shall apply to the requirement set out in Article 6(5) of Regulation (EU) 2015/758.*
 - 1.2. *This is to demonstrate that in the internal memory of the 112 based eCall in-vehicle system, only the last three locations of the vehicle shall be retained.*
2. *Requirements*
 - 2.1. *When interrogated, the eCall in-vehicle system shall not maintain more than three recent locations of the vehicle.*
3. *Test conditions*
 - 3.1. *The technical service shall be facilitated to have access to the part of the system where the vehicle location data are stored in the IVS internal memory.*
 - 3.2. *The following test shall be performed on a representative arrangement of parts for the approval of components or separate technical units.*
4. *Test Method*
 - 4.1. *The technical service tester shall be facilitated with access to where the vehicle location data are stored in the IVS internal memory. This will involve the potential to download from the IVS any stored locations so that they can be viewed by the tester.*
5. *Assessment*
 - 5.1. *The requirement is determined to have been passed if no more than three locations are present in the eCall in-vehicle system memory.*
 - 5.2. *The presence of more than three locations constitutes a failure.*

8.6 Article 6(6):

"Those data shall not be available outside the 112-based eCall in-vehicle system to any entities before the eCall is triggered."

8.6.1 Context

As this article follows on from Article 6(5), 'those data' are assumed to be data in the internal memory of the 112-based eCall in-vehicle system; and in particular, location data and other personal data.

It is expected that by confirming that the 112-based eCall IVS is not registered on the network in its idle or dormant state, then it is assured that the data contained within the IVS are not available externally (see Article 6(4)). Furthermore, it could be possible to obtain data from the TPS if there was a link to the 112-based system. The absence of a link is assured via Article 6(11). Therefore confirmation of the requirements of these other articles should guarantee conformance with the requirement of this article.

A potential confounding factor in the restriction of availability to data in the 112-based eCall system would be through diagnostics channels. It is likely that the status of the 112-based system can be determined via a diagnostic port. Therefore, the possibility remains that data are available via this port. It is therefore important to provide advice to the vehicle owner that their data may not be secure once access has been granted to plug in diagnostic equipment via the designated manufacturer's access point. They should consider this when allowing a garage or dealer network to perform actions requiring such access.

8.6.2 Technical requirements and test procedures

No specific additional measures seem necessary to confirm compliance with this article, assuming that the conditions of Articles 6 (4) and (11) are met.

However, it may be important to note to the vehicle owner that security of personal data could be compromised if access is granted to use the diagnostic port within the vehicle.

9 DECELERATION SLED TESTING

9.1 Introduction

A programme of deceleration sled tests and operability verification tests was carried out as part of Task 1 (Resistance of eCall IVS to severe crashes). The test programme was organised in three testing phases, the succession of which was determined by the project requirements and the availability of samples and test equipment.

- Phase 1: Deceleration testing of in-vehicle telematics units using various deceleration pulses (20g to 100g, different corridor shapes)
- Phase 2: Deceleration testing of eCall IVS samples using the proposed regulatory deceleration pulse (65g, simplified shape)
- Phase 3: Deceleration testing of in-vehicle loudspeaker samples using the proposed regulatory deceleration pulse (65g, simplified shape)

The tests were carried out on TRL's in-house high-energy test sled, the Impact Sled Facility. The TRL rig is a rail-guided deceleration sled using a bungee propulsion system to achieve the impact speed. The deceleration pulse is shaped by friction induced by polyurethane tubes or buckling of crash tubes or a combination of both. Lighting and cameras are available for the recording of high speed video footage.

9.2 Phase 1: In-vehicle telematics units

9.2.1 Context

In-vehicle telematics units were used as a substitute for eCall IVS control modules (ECU), because samples of eCall IVS units could not be made available by stakeholders in time. Samples of four different unit designs were tested (three samples of each). Note that these units were not specifically crash-hardened because they were designed for anti-theft and telematics services rather than automatic emergency calling. The samples for Phase 1 were designed, produced and provided to TRL by Stadium United Wireless.

The purpose of Testing Phase 1 was to verify that the telematics units do not sustain mechanical damage when they are subjected to inertial loads of different severities up to a severe vehicle crash.

9.2.2 Tests

The components included in the test were limited to the telematics control module (ECU), containing the printed circuit board with GSM and GNSS modules, SIM card holder and SIM card, capacitors and other electronic components. Two of the four designs contained internal batteries (primary button cells and rechargeable battery, respectively). Further parts of a complete in-vehicle system, such as external antennas or cable connectors, were not available for testing.

The samples were fixed to the sled via Perspex interface plates and bolts between the sample and the horizontal body of the test sled and between the sample and a vertical metal bracket (Figure 2, Figure 3). This connection is considered a rigid test setup and no noticeable relative displacement between the test sled and the ECUs was recorded on the high-speed footage. A rigid mounting represents the worst case and was chosen because no vehicle-specific fixtures for the samples existed.

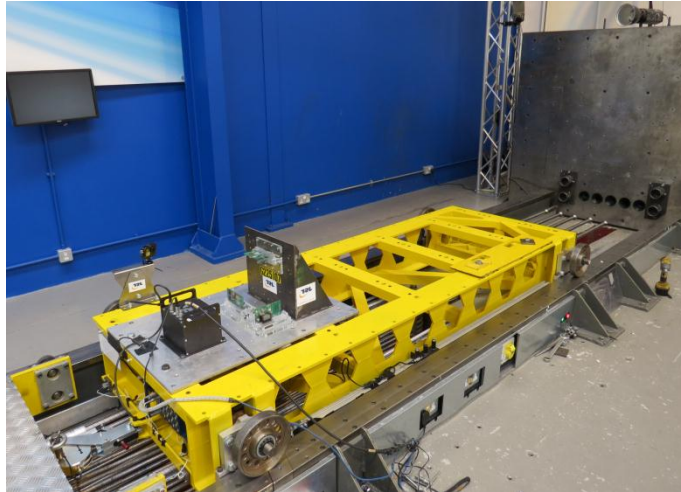


Figure 2: Test setup, overview of deceleration sled with mounting bracket and battery for data logging power supply



Figure 3: Test setup, detail of horizontal mounting plate and vertical mounting bracket

For this exploratory testing phase, three deceleration pulse corridors of different severity were examined. The samples were successively subjected to the following pulses, beginning with the lowest severity:

- Pulse Corridor 1: Peak deceleration: 20-28g, duration: 80-120 ms (used in UN Regulation No. 17 and 44)
- Pulse Corridor 2: Peak deceleration: 65-77g, duration: 36-60 ms (TRL's proposed regulatory deceleration pulse)
- Pulse Corridor 3: Peak deceleration: 85-100g, duration: 36-60 ms (deceleration pulse including safety factor)

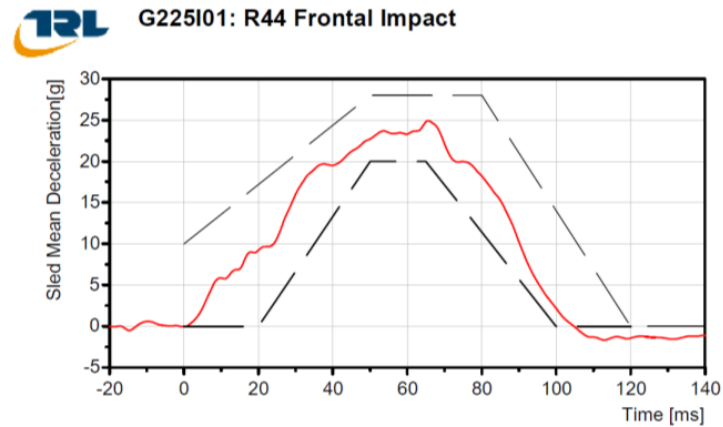


Figure 4: Pulse Corridor 1 and exemplary test pulse, test number: G225I01

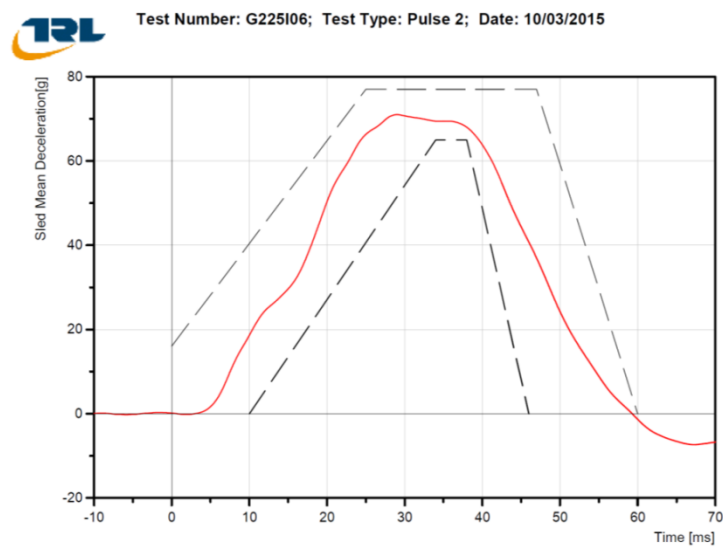


Figure 5: Pulse Corridor 2 and exemplary test pulse

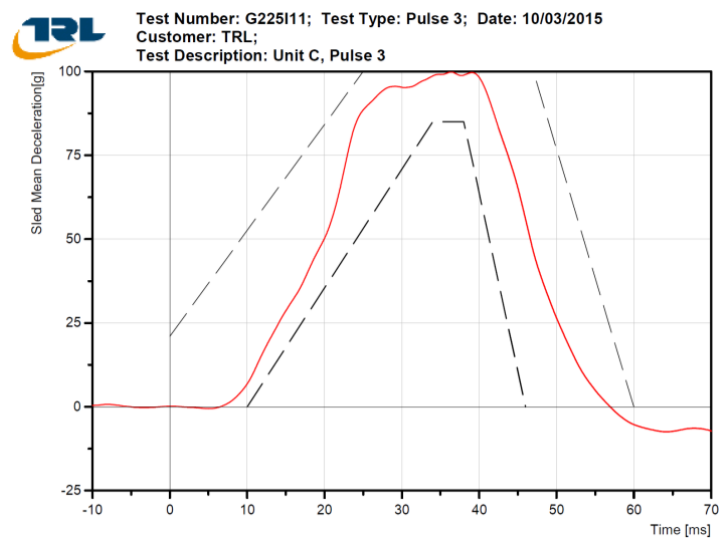


Figure 6: Pulse Corridor 3 and exemplary test pulse

To simulate different directions of the inertial loading, all three samples of each design were mounted simultaneously to the test sled in directions perpendicular to each other (Figure 7). A fourth direction was tested for each design by mounting one sample to the back of the vertical bracket.

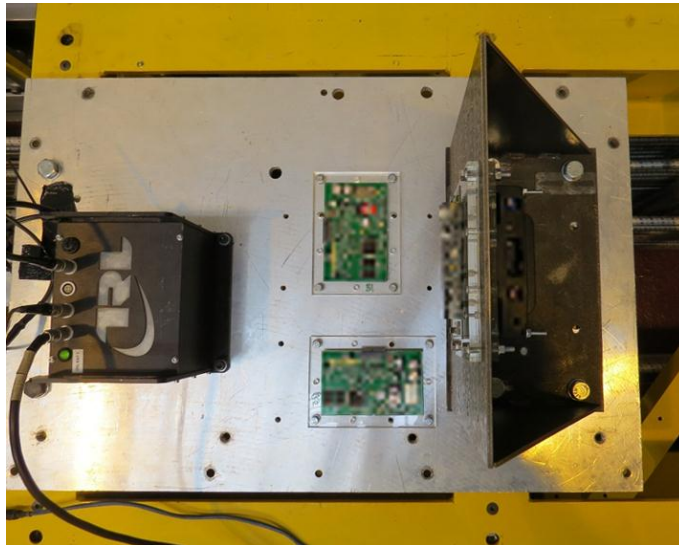


Figure 7: Test setup with three samples of identical design mounted in three perpendicular orientations allowing a reduction of the number of deceleration test runs

9.2.3 Results

A visual inspection of the samples for bent, displaced or lifted-off components was carried out after each deceleration event (in between tests). These inspections did not reveal damage in any of the tested samples. An electronic inspection, via current consumption and GPS/GSM functionality, was carried out by Stadium United Wireless at the end of the tests. This inspection also concluded that all 12 samples remained undamaged, even after being subjected to a deceleration of about 100g (98g to 104g throughout Test Phase 1).

The successful completion of the deceleration testing demonstrated that the peak deceleration levels required for all three pulse corridors could be achieved easily on the existing deceleration facility; a maximum deceleration of 104 g was performed during this test phase. All pulse corridors proved wide enough to achieve a valid deceleration pulse with limited effort for pulse-tuning.

The inspection results of the telematics ECUs showed that all system designs under test, although not specifically crash-hardened, survived even the highest-severity deceleration event. This demonstrates that the required level of deceleration-resistance for an ECU (including a dedicated battery) can be achieved by applying good and diligent system design practice, without applying overly burdensome or unconventional crash-hardening measures. Other components, such as external antennas, cable connectors, loudspeakers or microphones were not tested during Phase 1.

9.3 Phase 2: eCall IVS development units

9.3.1 Deceleration tests

The purpose of Testing Phase 2 was to trial the proposed test procedure, including the deceleration test and verification procedure, and to confirm its viability.

Two sets of eCall IVS samples in the development stage were made available to TRL for testing: They were developed and provided to TRL by Fujitsu Ten and a vehicle manufacturer (anonymous, 'Manufacturer D'), respectively.

The Fujitsu Ten samples consisted of ECUs (without power source) only (Figure 8). Each ECU was fixed to the horizontal body and to the vertical metal bracket of the test sled through their two intended mounting points (metal-reinforced through-holes in plastic latches of the ECU housing) using standard bolts (Figure 9). This connection is considered a rigid test setup and no noticeable relative displacement between the test sled and the ECUs was recorded on the high-speed footage.



Figure 8: Fujitsu Ten sample of eCall IVS development unit (ECU only),



Figure 9: Fujitsu Ten samples mounted on the test sled for horizontal testing

The Manufacturer D samples contained the ECU, mobile network and GNSS antennas (including connectors and cables), loudspeaker and an in-vehicle mounting bracket (Figure 10).

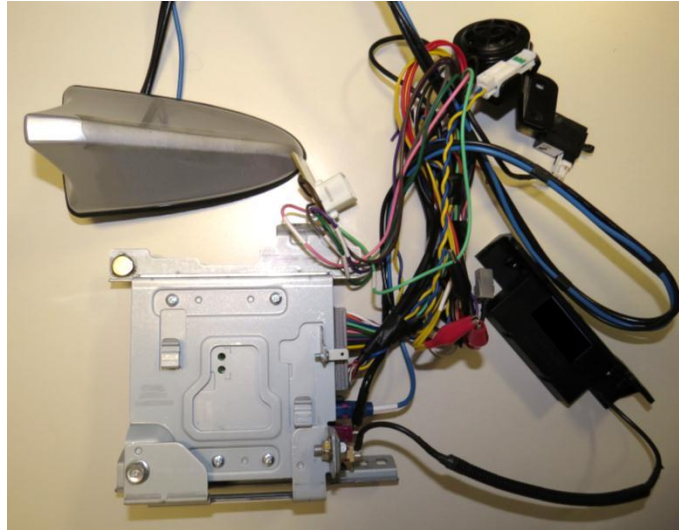


Figure 10: Manufacturer D sample of eCall IVS development unit (clockwise from bottom left: ECU, GNSS antenna, loudspeaker, mobile network antenna),

The ECUs were fixed to the horizontal body and to the vertical metal bracket of the test sled through its in-vehicle metal mounting bracket, which was bolted to sheet metal interface angles at the three intended mounting points (Figure 11). It was not examined in detail for this test whether the stiffness of this connection was high enough so that it did not affect the outcome of the tests: The high-speed footage of the tests shows some vibration and relative displacement between the ECUs and the test sled. The majority of this displacement appears to be induced by the in-vehicle mounting brackets, which is a design effect that is intentionally reproduced in the test procedure. For type-approval testing, the remaining displacement and vibration should be prevented by applying stiffer interface elements between the mounting bracket and the sled.

The loudspeaker was fixed by a single bolt and a stiff metal bracket ensuring a rigid connection. Due to their irregular geometry, the antennas were tethered down by cable ties which could not be considered a rigid connection for a type-approval test. However, the parts were of comparatively low weight and the high speed footage shows only limited relative movement between them and the sled.

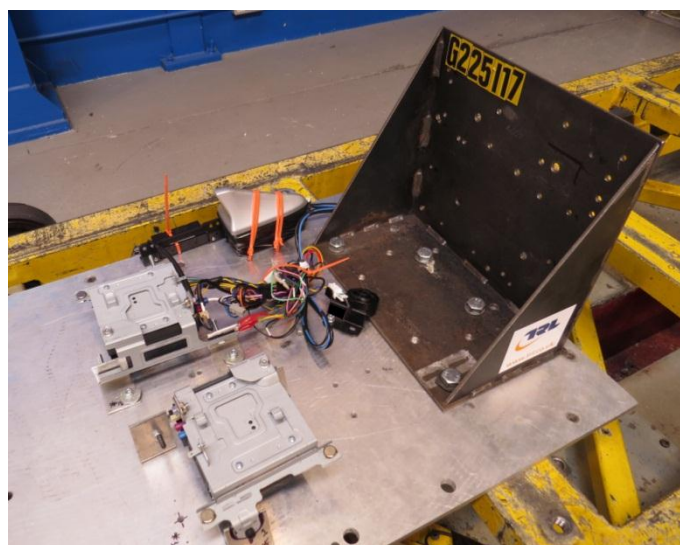


Figure 11: Manufacturer D samples mounted on the test sled for horizontal testing

The ECU designs from Fujitsu Ten and Manufacturer D were tested in a total of six orientations. Without being able to examine the internal layout of the printed circuit board, the perpendicular edges of the ECU housing were considered likely to be parallel to any main axes of the component design. Therefore, the samples were arranged on the sled so that the inertial force acted along three perpendicular edges (each in positive and negative direction). To test six orientations, each of the two samples of each design was subjected to three deceleration events.

The antennas and the loudspeaker of the Manufacturer D samples were tested only in one orientation representative of a frontal impact in the assumed installation direction in the vehicle. Note that according to the proposed test procedure this would restrict the allowable installation direction of these components in the vehicle to the tested direction.

The pulse corridor applied for all six test runs was TRL's proposed regulatory deceleration pulse, i.e. peak deceleration: 65-77g; duration: 36-60 ms. Figure 12 shows an exemplary test pulse recorded during Test Phase 2. Note that the pulse in this exemplary case exceeded the maximum curve of the corridor from about 59 milliseconds onwards. The test results were positive and should therefore nevertheless be considered valid (as defined in the proposed description of the test procedure).

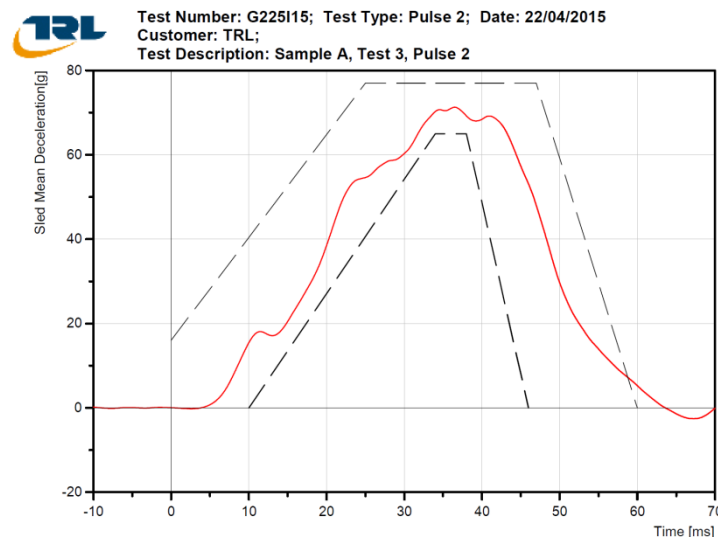


Figure 12: Exemplary test pulse of Test Phase 2

9.3.2 Verification tests

The sustained functionality of the Fujitsu Ten samples was assessed by performing manual test calls at TRL's facilities after each deceleration event. The Manufacturer D samples could not be verified at TRL because the IVS encoding of the development samples did not allow access with the simulated network or dialling the long number of TRL's dedicated PSAP simulator via the public mobile network. The samples were therefore verified by the manufacturer via manual test calls. Cable connections were not verified because samples of the ECU main connectors were not available.

9.3.2.1 *Test Call Setup*

Different test call setups were arranged at TRL's facilities: A Rohde & Schwarz CMW500 radio communication tester (network simulator) with audio boards was available for over-the-air or wired mobile network simulation. A public mobile network signal was available (signal strength not measured).

A Rohde & Schwarz SMBV100A signal generator was available for wired GNSS simulation. Real GNSS signals were available at a known outdoors, open-sky location at the TRL facilities.

Three PSAP simulators were available:

- Rohde & Schwarz CMW-KA094 PSAP simulation software running on a laptop (connected to simulated mobile network)
- TTworkbench Express software running on a TestingTechnologies eCall Simulator (connected to the public phone network via an ISDN line)
- VTT eCall Testbed software running on a Windows laptop (connected to the public phone network via an ISDN line)

The connection procedure applied for the Fujitsu Ten samples was the wired transmission procedure, i.e. connecting to the Rohde & Schwarz PSAP simulator using the simulated network via a wired connection between the network antenna connectors and the Rohde & Schwarz network simulator. A Rohde & Schwarz test SIM card ensured that the simulated network could be accessed and a TS12 call was emitted.

It was not possible to trial other combinations of IVS samples and PSAP simulators because the encoding of Fujitsu Ten units did not allow dialling a long number via the public mobile network.

9.3.2.2 *Manual Test Calls*

To perform the test call the Fujitsu Ten ECU samples were connected to a standard 12V power supply. For type-approval testing according to the proposed procedure, the IVS power supply has to be deceleration tested on the sled, which was not possible in this case, because it was not included in the samples.

The positioning verification tests were performed with genuine GNSS signals at a known open-sky location: The samples were equipped with an external GNSS antenna, moved to an outdoors location, and powered up in order to achieve a GNSS position fix under open sky conditions. The samples were then moved back inside the test laboratory in a powered state and connected to the network simulator for the test call. Note that due to the limited available cable length for the mobile network simulation, it was not possible to perform the test call with the IVS remaining outdoors. For a type-approval verification of the positioning system, either a test call under open sky conditions or simulated GNSS signals inside the test laboratory will be required.

Manual test calls were triggered via the control provided with the ECU samples and the interactions with the PSAP test point were recorded via log files and screenshots of the PSAP simulator outputs.

9.3.2.3 *Results*

For the Fujitsu Ten samples it was verified, based on the records from the PSAP

simulator (Figure 13), that:

- an MSD was received (Output: "Decoded MSD successful");
- the MSD contained an up-to-date timestamp (Exemplary output: "Timestamp = 1429699236 [Seconds since midnight 01.01.1970 UTC]", which was within 60 seconds of trigger application); and
- the MSD contained an accurate, up-to-date location (Exemplary output: "Latitude = 184977475 [mili-arc-seconds]; Longitude = -2820261 [mili-arc-seconds]", which was within 150 metres of the true location).

The Fujitsu Ten samples successfully passed the verification test calls. No mobile network antenna was provided, which is why no antenna test was performed, although the wired connection procedure was used.

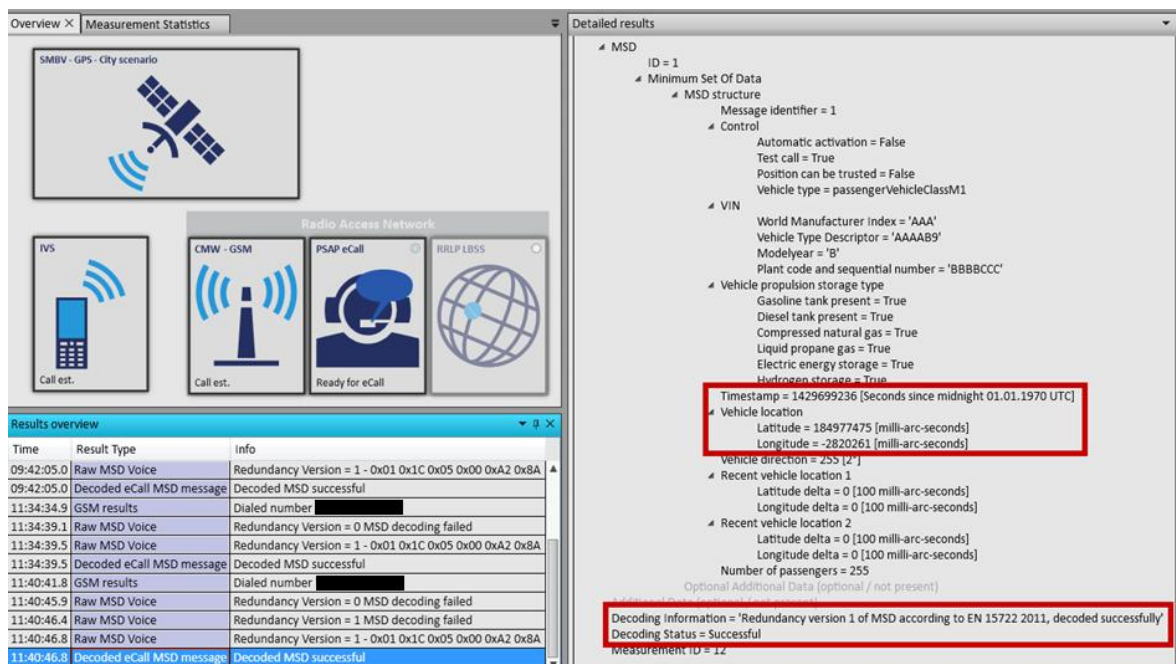


Figure 13: Exemplary test record from Rohde & Schwarz CMW-KA094 PSAP simulator. The record "Position can be trusted = False" is due to the indoors test setup, not due to component failure.

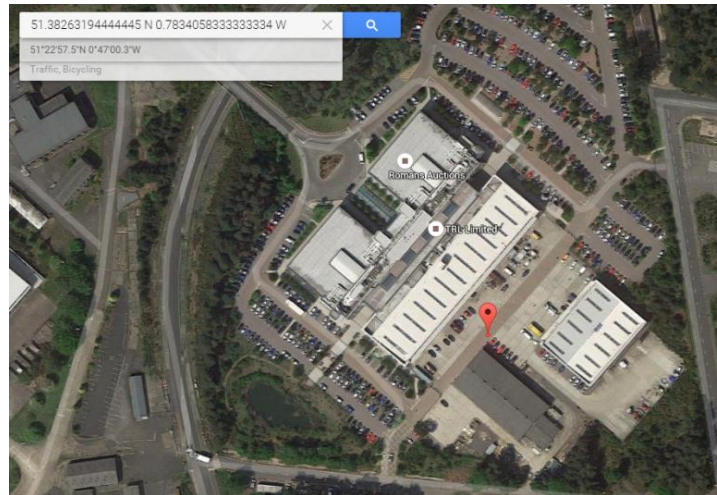


Figure 14: Exemplary reported MSD location, showing the known open-sky location on TRL ground. The units of latitude and longitude were converted from milliarcsecond to degree.

As indicated above, the samples from Manufacturer D were verification tested via manual test calls at the manufacturer's facilities. The records of the PSAP simulator output show that an MSD was received; that it contained an up-to-date timestamp; and that it contained an accurate, up-to-date location. An inspection of the mobile network antenna was not performed. In conclusion, the samples of Manufacturer D fulfil the main verification criteria and are therefore expected to pass the regulatory verification test.

Although the number of different models was limited and not all parts were included in the samples, the positive test results of both eCall IVS units indicate that the required level of deceleration-resistance can be met by designs of eCall systems currently under development at suppliers and manufacturers.

The successful completion of the verification tests with the Fujitsu Ten samples demonstrates that the proposed test procedure is fit-for-purpose in the trialled configuration and that each of the verification steps can be addressed.

9.4 Phase 3: Loudspeakers

9.4.1 Context

As *per* a decision of the UN AECS working group, the eCall audio equipment was exempted from the post-sled test functionality assessment. This was based on concerns raised by manufacturers about the ability to design audio equipment (loudspeaker and microphone) that is crash-proof at the required level within the current design cycle of systems to be type-approved (see minutes from 8th AECS meeting, currently unpublished). This exemption should be re-considered after a certain period of time; in the UN AECS working group an agreement was made to re-evaluate the exemption for the first series of amendments to the AECS UN Regulation.

The concern raised was with regard to the design of both, loudspeakers and microphones, but the main focus was on the design of loudspeakers. However, no evidence was available from any of the working group delegations to support or refute these concerns. The purpose of Testing Phase 3 was to contribute initial evidence of the level of resilience of in-vehicle audio equipment to inertial forces.

9.4.2 Tests

9.4.2.1 Deceleration tests

Three different loudspeaker models, designed for voluntary automatic emergency call system and hands-free devices, from production vehicles of three major manufacturers were available for testing (Figure 15, Figure 16, Figure 17). All samples were purchased through dealerships. It was intended to also test hands-free microphones, but it proved to be not feasible to use/assess the components without the in-vehicle data processing units.



Figure 15: Loudspeaker model A (front and back view), mass: 124 grams, cone diameter: 66 millimetres, in-vehicle location: dashboard



Figure 16: Loudspeaker model B (front and back view), mass: 53 grams, cone diameter: 52 millimetres, in-vehicle location: dashboard

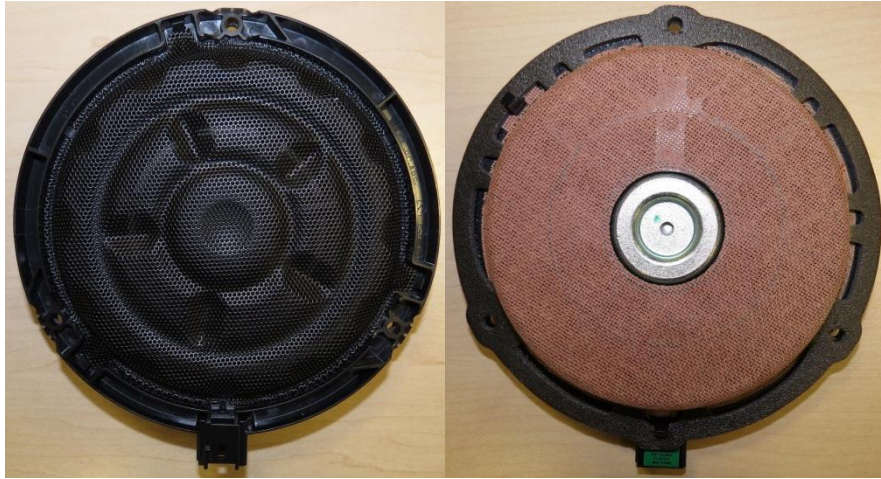


Figure 17: Loudspeaker model C (front and back view), mass: 266 grams, cone diameter: 125 millimetres, in-vehicle location: door

The deceleration tests were carried out along various directions of the samples: Along the oscillatory axis of the loudspeaker cone (this was considered a main axis of the component design) and along two axes perpendicular to this and to each other. The tests along the oscillatory axis were carried out in positive and negative direction.

The samples were fixed to the deceleration sled via a rigid connection by bolts or metal interface plates (Figure 18).

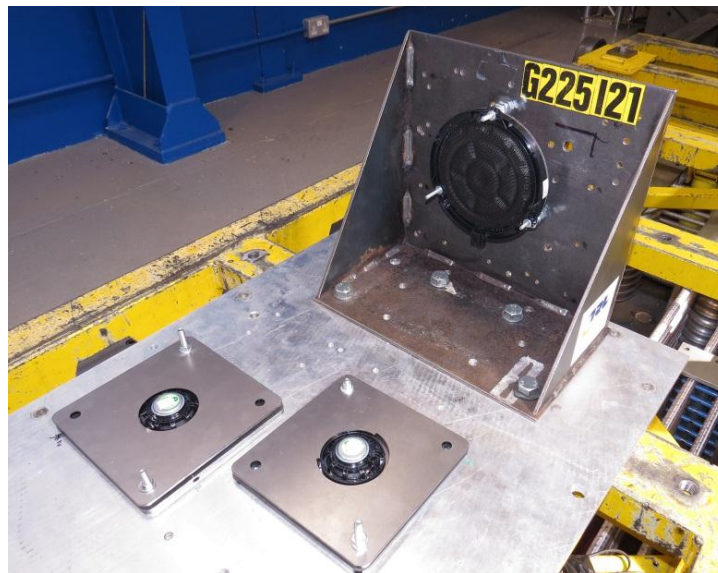


Figure 18: Loudspeaker models B and C mounted on test sled for deceleration testing

The pulse corridor applied for all test runs was TRL's proposed deceleration pulse for IVS testing, i.e. peak deceleration: 65-77g; duration: 36-60 ms. Figure 19 shows an exemplary test pulse recorded during Test Phase 3.

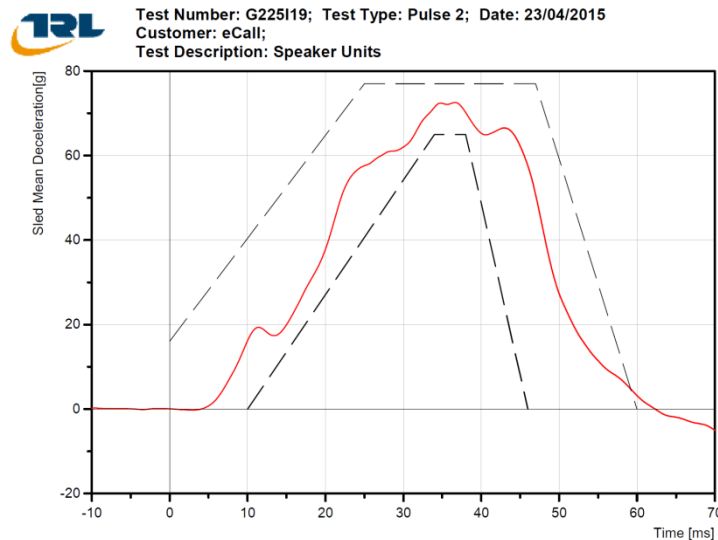


Figure 19: Exemplary test pulse of Test Phase 3

9.4.2.2 *Functionality checks*

Various failure modes of loudspeakers during collisions are conceivable. These might be induced by inertial loads or deformation by intruding parts:

- Failure of feed or flexible wires
- Failure of voice coil attachments
- Mechanical failure of the cone structure
- Mechanical failure of the magnet structure
- Failure due to over-excursion of the cone
- Distortion of the frame

Some of these, such as breakage of wires, are likely to lead to a complete failure of the loudspeaker. Others, such as distortion of the frame, may cause degradation and might impair the intelligibility of a voice communication by introducing distortion or reducing the loudness of the transmission.

Therefore, after each deceleration event, a three step functionality check of the samples was performed by: A visual inspection, a measurement of the loudness level and a subjective assessment of the audio quality.

The visual inspection was carried out with the unaided eye, checking for anomalies, such as distortions or cracks of the frame, or ruptures of cone or suspension.

The loudness measurements were carried out using a Norsonic Sound Analyser NOR140 sound level meter; the audio input was delivered by a signal generator. The loudness was measured before and after the deceleration event at frequencies of 900 Hz, 1,000 Hz and 1,100 Hz (close to the frequencies of human voice); 1 metre horizontal distance; 10 seconds average loudness. The measured pre- and post-levels were compared for potential reductions in loudness. The measurements were impaired by the fact that they were not performed in an entirely sound-proof room.

The subjective assessments were carried out by a test engineer in a quiet but not sound-proof environment:

- Performing a frequency sweep from 100 Hz to 1,500 Hz using a signal generator and checking for anomalies;
- Playing back voice recordings (of a male and female voice) and assessing their

intelligibility;

- Playing back recordings of familiar music and assessing the sound quality.

The subjective results were produced on a two point scale: Was there any anomaly; were the voice recordings intelligible (i.e. was it possible to understand the meaning of what is being said); were there differences in the music sound quality between pre- and post-tests (e.g. distortions of certain sounds)?

9.4.3 Results

All samples remained undamaged after the deceleration events:

- The visual inspection did not reveal any mechanical damage. The plastic frames were strong enough to withstand the loads and the magnets (the heaviest part of the speaker) were fixed strongly enough to withstand the inertial forces; the cones and suspension system did not sustain ruptures or cracks.
- The differential loudness measurements did not reveal a reduction in loudness. There were differences recorded between pre- and post-test measurements of up to 5 dB, but these fluctuated in negative as well as positive direction (i.e. the loudspeaker was measured as being louder post-test between samples and between frequencies examined. This indicates that the differences recorded were likely to be due to random fluctuations between individual measurements due to the limitations of the test setup.
- The subjective assessments of frequency sweeps, voice and music recordings did not reveal degradation in intelligibility or music quality.

Subsequently, mechanical damage was deliberately inflicted upon some samples in order to probe what effect size could be expected with a severely damaged units. Even a loudspeaker with about 25% of the outer suspension slit open, a punctured central dust cap, a cut and deformed plastic frame (Figure 20) still reproduced voice recordings of an intelligible quality. The frequency sweep showed anomalies at frequencies below ca. 270 Hz, but not at the typical human voice frequencies of around 1,000 Hz.



Figure 20: Sample of loudspeaker model A, deliberately damaged by slitting the outer suspension, puncturing the dust cap and cutting open the frame

A loudspeaker that was deliberately damaged by mechanically crushing the cone along its oscillatory axis (Figure 21) showed a considerable decrease in loudness from ca. 70 dB to ca. 50 dB at 1,000 Hz. This reduction in loudness was also noticeable in the subjective tests; however, the voice recordings were still intelligible.



Figure 21: Sample of loudspeaker model B, deliberately damaged by crushing the cone

These results show that it is possible, and currently already achieved, to design loudspeakers that survive the required deceleration levels without failure or a noticeable degradation in quality. It is not known to TRL what (or if any) specific measures have been taken in the design of the tested loudspeakers in order to make them resilient to inertial forces. As indicated above, the models examined were designed for voluntary automatic emergency call system and hands-free devices.

GLOSSARY OF TERMS

Term	Definition
ACEA	European Automobile Manufacturers' Association
AEBS	Automatic emergency braking systems
AECD/AECS	Automatic emergency call device/system
AGC	Automatic gain control
DTX	Discontinuous transmission
EC	European Commission
ECU	Electronic control unit
ETSI	European Telecommunications Standards Institute
FMEA	Failure mode and effect analysis
FTA	Fault tree analysis
GNSS	Global navigation satellite system
GSA	European Global Navigation Satellite Systems Agency
GSM	Global System for Mobile Communications
HATS	Head and torso simulator
HMI	Human-machine interface
ITU	International Telecommunication Union
IVS	eCall in-vehicle system
MSD	Minimum set of data in accordance with EN 15722
MY	Model year
NHTSA	National Highway Traffic Safety Administration
OICA	Organisation Internationale des Constructeurs d'Automobiles
PLMN	Public land mobile network
PSAP	Public safety answering point
PTI	Periodic technical inspection (roadworthiness testing)
REESS	Rechargeable electric energy storage systems
SIM	Subscriber identity module
TPS	Third party service
TPSP	Third party service provider
TS11, TS 12	Teleservice 11, Teleservice 12
UMTS	Universal Mobile Telecommunications System
UTC	Coordinated Universal Time
VSWR	Voltage standing wave ratio

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