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Study on the inclusion of eCall in the periodic roadworthiness testing of motor vehicles

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Final report

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Table of Contents

List of figures

List of tables

List of abbreviations – General

CBA	Cost-Benefits Analysis
EC	European Commission
eCall	Emergency Call
ECU	Electronic Control Unit
EeIP	European eCall Implementation Platform
EMC	Electromagnetic compatibility
ESC	Electronic Stability Control
ETSI	European Telecommunications Standards Institute
EU	European Union
FSD	Fahrzeugsystemdaten GmbH
VIN	Vehicle Identification Number
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
GSMA	Groupe Speciale Mobile Association
IVS	In-vehicle system
LCD	Liquid Crystal Displays
MSD	Minimum Set of Data
MTM	Methods-Time Measurement
NAD	Network Access Device
OBD	On-Board Diagnostics
PLMN	Public Land Mobile Network
PSAP	Public Safety Answering Point
PTI	Periodical Technical Inspection
SIM	Subscriber Identity Module
ST	(Electronic) Scan Tool
TF	Task Force
TS	Teleservice
UMTS	Universal Mobile Telecommunications System
WP	Working Package

List of abbreviations – Formulae

i	*Running index for the eCall components [i= 1,...10]*
j	*Running index for the test procedure [j= 0,...4]*
P_i^{def}	*Probability of the failure of the eCall component i in the PTI*
$P_{i,j}^{det}$	*Probability of the detection of an existing error in eCall component i when using the test procedure j*

List of abbreviations – Legislation

Directive 2014/45/EU	*DIRECTIVE 2014/45/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 3 April 2014 on periodic roadworthiness tests for motor vehicles and their trailers and repealing Directive 2009/40/EC*
Decision 585/2014	*DECISION No 585/2014/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 May 2014 on the deployment of the interoperable EU-wide eCall service*
Regulation 2017/758	*REGULATION (EU) 2015/758 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 29 April 2015 concerning type-approval requirements for the deployment of the eCall in-vehicle system based on the 112 service and amending Directive 2007/46/EC*
Regulation 2017/79	*COMMISSION DELEGATED REGULATION (EU) 2017/79 of 12 September 2016 establishing detailed technical requirements and test procedures for the EC type-approval of motor vehicles with respect to their 112-based eCall in-vehicles systems, of 112-based eCall in-vehicle separate technical units and components and supplementing and amending Regulation (EU) 2015/758 of the European Parliament and of the Council with regard to the exemptions and applicable standards*
Directive 2007/46/EC	*DIRECTIVE 2007/46/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 September 2007 establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles*
Regulation 2017/78	*COMMISSION IMPLEMENTING REGULATION (EU) 2017/78 of 15 July 2016 establishing administrative provisions for the EC type-approval of motor vehicles with respect to their 112-based eCall in-vehicle systems and uniform conditions for the implementation of Regulation (EU) 2015/758 of the European Parliament and of the Council with regard to the privacy and data protection of users of such systems*
Regulation 461/2010/EU	COMISSION REGULATION (EU) No 461/2010 of 27 May 2010 on the application of Article 101(3) of the Treaty on the Functioning of the European Union to categories of vertical agreements and concerted practices in the motor vehicle sector
Regulation 715/2007/EC	REGULATION (EC) No 715/2007 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 June 2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information

Abstract

This report assesses the inclusion of eCall – emergency call system in vehicle inspection schemes. eCall is mandatory since 2018 for M1 and N1 vehicles registered in the European Union. eCall generates an automatic emergency call in case of crash and can be also triggered manually.

Benefits consist in faster rescue time in case of crashes: reduction of injured severity and traffic congestion. The reduction of false emergency calls and detection of tampering are not included because of lack of data.

The costs contemplate the implementation of eCall within the frame of periodical vehicle inspection.

Stakeholders' inputs are considered via a questionnaire and a workshop.

The scenarios considered in the analysis are:

- Scenario 0: without case. Base case.
- Scenario I: testing via the warning indicator lamp. Benefit/cost ratio: 2.96.
- Scenario II: testing via the electronic interface. Level 2 (without function/performance). Benefit/cost ratio: 4.58.
- Scenario III: testing via the electronic interface. Level 3 (with function/performance). Benefit/cost ratio: 4.82.
- Scenario IV: testing via eCall. Benefit/cost ratio: 0.99.

The policy recommendation considers Scenario III. It only implies the modification of the Directive 2014/45/EU. Changes in the implementing act on the technical information for roadworthiness shall be assessed when published.

Executive Summary

This report has been made for the Directorate General for Mobility and Transport of the European Commission.

The eCall is the emergency call system mandatory for new passenger cars and light commercial vehicles in the European Union since 2018, with the aim of reducing the rescue time in case of crash. eCall automatically sends emergency services data on the position and direction of the vehicle in case of an accident.

Vehicles degrade over the time and may be subject to tampering, therefore it is advisable to analyse the suitability of incorporating the assessment of the proper functioning of eCall systems all along the life of the vehicle.

The aim of this study is to assess whether it is cost-effective to include eCall within the frame of the periodical inspection scheme of the European Union and, in the case of a positive answer, to recommend which is the most efficient procedure.

The opinion of stakeholders has been considered by means of a survey sent to 537 recipients and a workshop organized in Brussels on June 8th, 2018. The views of Member States and Observers were requested in the Roadworthiness Committee of the Directorate General for Mobility and Transport on September 20th, 2018.

This study analyses the legal framework, the technical definition of eCall, the possibilities of breakdowns and the options of inspections. The cost and benefit analysis used the results of the above and was used for the final policy recommendation.

Because of the lack of data, the cost and benefit analysis includes neither the benefit of the reduction of false alarms - wrong calls to the emergency services - nor the costs of tampering. Benefit – cost ratio must be higher if those concepts would be included.

These are the scenarios considered in the analysis, including the result of each cost and benefit analysis:

- Scenario 0: without case. This is the base case.
- Scenario I: testing via the warning indicator lamp. Benefit – cost ratio: 2.96.
- Scenario II: testing via the electronic vehicle interface. Level 2 (does not include function/performance). Benefit – cost ratio: 4.58.
- Scenario III: testing via the electronic vehicle interface. Level 3 (includes function/performance). Benefit – cost ratio: 4.82.
- Scenario IV: testing via eCall. Benefit – cost ratio: 0.99.

The policy recommendation has been made considering the Scenario III, testing via the electronic vehicle interface and it only implies the modification of the Annex 1 of Directive 2014/45/EU for its application. A possible modification of the implementing act on the technical information necessary for roadworthiness testing shall be assessed when published.

The consortium formed by CITA, FSD and VIAS, together with the IERC as subcontractor, are the authors of this report.

Résumé de l'étude

Ce rapport a été rédigé pour la Direction générale de la mobilité et des transports de la Commission européenne.

eCall est le système d'appel d'urgence obligatoire pour nouveaux modèles de voitures particulières et de véhicules utilitaires légers immatriculés dans l'Union européenne depuis 2018. Le but de ce système est de réduire le temps d'intervention des services de secours en cas d'accident. eCall envoie automatiquement aux services de secours des données concernant la position et la direction du véhicule en cas d'accident.

Les véhicules vieillissent et peuvent faire l'objet d'altérations ; il est donc recommandé d'analyser l'opportunité d'intégrer l'évaluation du bon fonctionnement des systèmes eCall tout au long de la vie du véhicule.

L'objectif de cette étude est d'évaluer s'il est rentable d'inclure eCall dans le cadre du système de contrôle technique de l'Union européenne et, en cas de réponse positive, de recommander la procédure la plus efficace.

L'avis des parties prenantes a été pris en compte au moyen d'un sondage envoyé à 537 destinataires et d'un atelier organisé à Bruxelles le 8 juin 2018. Le point de vue des États membres et des observateurs a été demandé au comité de contrôle technique de la direction générale de la mobilité et des transports le 20 septembre 2018.

Cette étude analyse le cadre juridique, la définition technique du système eCall, les possibilités de pannes et les options d'inspection. L'analyse coûts-bénéfices s'est appuyée sur ces résultats et a été utilisée pour les recommandations finales.

En raison du manque de données, l'analyse coûts-bénéfices ne tient compte ni des avantages de la réduction du nombre d'appels erronés aux services d'urgence, ni des coûts liés aux altérations des données transmises. Le rapport avantages-bénéfices est plus élevé si ces concepts sont inclus.

Il s'agit des scénarios considérés dans l'analyse, y compris le résultat de chaque analyse coûts-bénéfices :

- Scénario 0 : aucun test inclus. C'est le cas de base.
- Scénario 1 : test via le témoin lumineux d'avertissement. Rapport coûts-bénéfices: 2,96.
- Scénario 2 : test via l'interface électronique du véhicule. Niveau 2 (n'inclut pas la fonction/performance). Rapport coûts-bénéfices: 4,58.
- Scénario 3 : test via l'interface électronique du véhicule. Niveau 3 (comprend la fonction/performance). Rapport coûts-bénéfices: 4,82.
- Scénario 4 : test via eCall. Rapport avantages-bénéfices: 0,99.

La recommandation finale a été formulée en tenant compte du scénario 3, essais via l'interface électronique du véhicule, et elle implique uniquement la modification de l'annexe 1 de la Directive 2014/45/UE pour son application. Une éventuelle modification de l'acte d'exécution concernant les informations techniques nécessaires au contrôle technique doit être évaluée lors de sa publication.

Le consortium formé par CITA, FSD et VIAS, ainsi que le EIRC en tant que sous-traitant, sont les auteurs de ce rapport.

The project consortium and subcontractor

CITA, The International Motor Vehicle Inspection Committee, is the non-profit worldwide association of public and private organizations dealing with road vehicles' continuous compliance. It has more than 130 members come from 55 countries from Africa, America, Asia, Europe and Oceania. There is detailed information available in the website: www.citainsp.org

FSD Fahrzeugsystemdaten GmbH – Central Agency for PTI was founded in 2004 by the German vehicle inspection organizations as a non-profit entity. It plays the role of "Zentrale Stelle" (EN: Central Agency for PTI) according to the German Road Traffic Legislation. It is mandatory for all German PTI inspectors to use the PTI specifications and test methods coming from FSD.

The Belgian Road Safety Institute (www.ibsr.be), whose business name is **VIAS** Institute, is an official non-profit organisation, close to the Federal Public Service "Mobility and Transport". It is considered a Medium Enterprise with an average of 125 employees and an annual balance sheet of around 14 million EUR. The Institute's general aim is to improve road safety by means of information and education and of study and research. Our mission is to advice and support, to represent, co-ordinate and carry out the authority assignments in road safety matters.

The Institute for Economic Research and Consulting, **IERC** GmbH was founded in 2003 as a private research institute of Prof. Dr Wolfgang H. Schulz. Since then, the focus of research activities has been set on the fields of transport economics, traffic planning and consulting with special attention on electric mobility and intelligent transport systems.

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Disclaimer

The information and views set out in this study are those of the author(s) and do not necessarily reflect the official opinion of the Commission. The Commission does not guarantee the accuracy of the data included in this study. Neither the Commission nor any person acting on the Commission's behalf may be held responsible for the use which may be made of the information contained therein.

1 Scope and Background

This document is the final report corresponding to the project "Study on the inclusion of eCall in the periodic roadworthiness testing of motor vehicles" with the identification N° MOVE/C2/2017-282 – SI2.772101, contracted by the European Commission, Directorate General for Mobility and Transport to the consortium formed by CITA, FSD and VIAS, with the involvement of IERC.

According to Article 17 of Directive 2014/45/EU, the Commission shall be empowered to adopt delegated acts to adapt the list of controlled items, methods, following a positive assessment of the costs and benefits involved in the event of a modification of mandatory requirements relevant for type-approval in EU safety or environmental legislation.

The purpose of this study is twofold:

- Determine if eCall should be part of the periodic roadworthiness testing;
- If the answer to the above question is "Yes", define what needs to be tested and how the tests should be done.

This report is structured according to the requested tasks:

- Task 1: Data collection
- Task 2: Definition of scenarios
- Task 3: Cost and benefit analysis
- Task 4: Formulation of policy recommendations

2 Introduction to eCall

eCall is an automatic emergency call system for motor vehicles, intended to enable rescue measures to be initiated more quickly and in the most appropriate manner following an accident. The emergency call is transmitted by means of standardised transmission protocols. In normal vehicle use, the eCall system is in "stand-by mode", that means there is no network registration or data transmission. However, the need for the triggering of an eCall is continually monitored and scans for available networks are performed. The activation of the eCall system from "stand-by mode" in order to transmit an eCall can take place in two ways – automatically or manually.

The triggering of an eCall is automatically activated if an accident is registered by sensors of other safety systems, e.g. the crash sensors of an airbag system. So, the eCall functionality is depending on the functionality of the crash detection system in a similar way as the passive safety systems (airbags, pyrotechnic seatbelts, etc.). Furthermore manual triggering is also possible and is realized via a push button, e.g. for first responders in the case of an accident.

Only following the activation of the eCall system using one of these methods does the system register on the public land mobile network (PLMN) with best signal strength found during the most recent background scan. After registration, the minimum set of data, the (MSD) is transmitted and a voice connection is established between the vehicle and the responsible public service answering point (PSAP). Besides other data the MSD contains a certain set of basic data, including the following information (EN 15722)[1]:

Minimum set of data (MSD) - Static data:

- Vehicle identification number (VIN)
- Vehicle propulsion storage type (e.g. hydrogen storage present)
- Vehicle type (e.g. M1 or N1)

MSD - Dynamic data:

- Time stamp (i.e. trigger time)
- Vehicle location
- Vehicle direction

Further information is requested from the occupants via the additional voice connection in order to optimise rescue measures. If it is not possible to establish a voice connection, the PSAP will initiate the standard rescue measures in most cases.

For the eCall rescue system to work effectively all components of the eCall in-vehicle system need to function properly.

3 Data collection and context of the study

This chapter contains a summary of the data retrieved and analysed to undertake the definition and assessment of the scenarios related to the inclusion of eCall within the frame of vehicle inspection.

Annexes 2, 3, 4 and 5 contain additional data used for the development of this study.

3.1 Input from the stakeholders

The view of different stakeholders has been considered in the preparation of this report.

Annex 1 shows the survey sent to 537 recipients and the received answers, aiming to retrieve their opinions on relevant aspects about eCall, the suitability to introduce the control of eCall during PTI and, if so, which would be the most appropriate way.

Furthermore, on June 8th, 2018 a workshop took place in the facilities of the Directorate General Mobility and Transport of the European Commission to discuss the different options and approaches. The event was attended by more than 30 participants representing Member States, DG MOVE vehicle manufacturers, vehicle inspection operators, research centres, standardization bodies, road enforcement organizations, garage and inspection equipment manufacturers, automobile clubs, independent aftermarket distributors, communications associations, emergency management associations and vehicle leasing associations.

On September 20th, 2018 during the Roadworthiness Committee hosted by the Directorate General for Mobility and Transport, CITA made an additional request to the Member States and observers to supply any further relevant information.

[1] DIN EN 15722:2015-08, Intelligent transport systems – Esafety - ECall minimum set of data

3.2 State of the technical discussion on test scenarios

The EC eSafety European eCall Implementation Platform (EeIP) Task Force Periodic Technical Inspection published a "Study on the Periodic Technical Inspection requirements for eCall equipped vehicles"[2] in the year 2012. In this study different technical test scenarios were discussed. All test scenarios base on a "test call" and following were identified (see Annex 3):

- Use of TS12 emergency call set-up message to identify and route test eCall – Option A
- TS12 emergency call and additionally using the test indicator in the MSD – Option B
- Reservation of fixed numbers for test calls – Option C
- Capturing all calls coming from the vehicle and routing to a dedicated device for testing (e.g. by a Femtocell) – Option D
- Use of normal emergency call 112 to PSAP – Option E

However, the scenarios were not explained in detail and no cost-benefit analysis was performed. After publication of the report, the Task Force ceased its work and was reactivated in 2014. The Global System for Mobile Communications Association (GSMA) published a "position and proposal on Periodic Technical Inspection"[3] in November 2014. The GSMA raised general concerns to all proposed options:

"None of the options are optimal, they all arise the following problems:

- a clear statement of the purpose and scope of the PTI, what is the critical part
- Missing commercial and operational impact analysis of the proposed options
- The impact on the network load can be very high and compromise the normal traffic, such analysis is not present in the report
- Most of the options involved a high implementation and operational cost, not clear who will take the cost
- The proposed options are not testing the actual eCall service, but they are all testing the test eCall"

In 7th EeIP TF PTI Meeting in Brussels on November, 12th 2014 the group identified (GSMA 2014) two preferred scenarios:

- *"…one using diagnostic interface of vehicle only and the other establishing connection to a test PSAP via long number stored on the USIM for this purpose."*

The European Commission published the report "eCall Phase 2 - Technical requirements and test procedures for the type-approval of eCall in-vehicle systems"[4] in June 2015. The report gives a proposal for relevant provisions for periodic technical inspections in its chapter 7.4.5 (see Annex 4).

"*Whereas PTI purpose 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*

[2] EC eSafety European eCall Implementation Platform TF PTI 2012, Technical Report V1.0.0 - Study on the Periodic Technical Inspection requirements for eCall equipped vehicles

[3] GSMA 2014, GSMA position on Periodic Technical Inspection

[4] TRL 2015, eCall Phase 2 - Technical requirements and test procedures for the type - approval of eCall in-vehicle systems

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."*

Due to the missing legal basis the European Commission could not adopt the proposal within the Regulation 2017/79 as it has to be addressed within the roadworthiness framework. Nevertheless, the European Parliament and the Council advises to carry out periodic roadworthiness tests in accordance with Directive 2014/45/EU [see Regulation (EU) 2015/758 recital (18)].

3.3 Legal review

The improvement of the road safety is a continuous challenge for the European Union. The deployment of an eCall system is part of this challenge. Before analysing the specific legal framework for eCall, it's necessary to replace it in an overall context related to periodic roadworthiness tests.

3.3.1 Directive 2014/45/EU: an overall context

Directive 2014/45/EU establishes minimum requirements for a regime of periodic roadworthiness tests of vehicles used on public roads[5]. Roadworthiness testing is designed to ensure that vehicles are kept in a safe and environmentally acceptable condition during their use[6].

Recital (21) of the Directive adds that "*testing during the life cycle of a vehicle should be relatively simple, quick and inexpensive, while at the same time effective in achieving the objectives of this Directive".* Article 6 of the Directive specifies that *the "tests shall be carried out using techniques and equipment currently available without the use of tools to dismantle or remove any part of the vehicle".*

In the context of a study about the cost benefit analysis for the possible inclusion of eCall into the periodic technical inspection it's important to note that Annex III of the Directive sets out the "*minimum requirements concerning roadworthiness facilities and test equipment*". For example, paragraph (14) of point I "*Facilities and equipment*" requires "*a device to connect to the electronic vehicle interface, such as an OBD[7] scan tool".* Therefore, the scan tool will be available in the PTI network of the European Union regardless of how it is decided to ensure the operation of eCall during the lifetime of vehicles.

[5] Art. 1, Directive 2014/45/EU.

[6] Recital (3), idem

[7] OBD means On-Board Diagnostics. It's an automotive term referring to a vehicle's self-diagnostic and reporting capability https://en.wikipedia.org/wiki/On-board_diagnostics

3.3.2 Regulation 2015/758 (the "eCall Regulation"): a specific legal framework

Since 2003, a voluntary deployment approach has been developed for the implementation of the eCall system, but has not achieved sufficient progress[8]. In 2009, the Commission proposed new measures to deploy this system[9]. One of the suggested measures was to make the fitting of 112-based eCall in-vehicle systems in all new types of vehicles mandatory [10]. In 2014, Decision 585/2014 aimed namely to ensure the coordinated and coherent deployment of the interoperable EU-wide eCall service and to guarantee the full functionality, compatibility, interoperability, continuity and conformity of the service throughout Europe[11].

Regulation 2015/758 takes place in this context and the objective is the achievement of the internal market through the introduction of common technical requirements for new type-approved vehicles equipped with the 112-based eCall in-vehicle system[12]. To do it, the Regulation establishes the general requirements for the EC type-approval of vehicles in respect of the 112-based eCall in-vehicle systems, and of 112-based eCall in-vehicle systems, components and separate technical units[13] and it formulates the requirements that the eCall in-vehicle system is expected to comply with[14].

It should be noted that Regulation 2015/758 applies to vehicles of categories M1 and N1 as defined in points 1.1.1 and 1.2.1 of Part A of Annex II to Directive 2007/46/EC and to 112-based eCall in-vehicle systems, components and separate technical units designed and constructed for such vehicles.

The Regulation sets out general[15] and specific[16] obligations for the manufacturers. For example, Article 5.6 explains that manufacturers shall demonstrate 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. So, the article 5 enounces a set of obligations that the manufacturers have to demonstrate or have to ensure.

The data protection legal framework is also an important part of Regulation 2015/758 scope. Indeed, *it's necessary to guarantee that vehicles equipped with 112-based eCall in-vehicle systems, in their normal operational status related to 112 eCall, are not traceable and are not subject to any constant tracking and that the minimum set of data sent by the 112-based eCall in-vehicle system includes the minimum information required for the appropriate handling of emergency calls*.[15] [17] [18]

As an emergency system, the highest level of reliability has to be ensured, including the accuracy of the minimum set of data and of the voice transmission, and quality. Recital (18) expresses the need for the periodic roadworthiness testing of eCall in-vehicle system: *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*

[8] Recital (3), Regulation 2015/758.
[9] See the Commission Communication of 21 August 2009 entitled 'eCall: Time for Deployment'.
[10] Recital 4, Regulation (UE) 2015/758.
[11] Recital 14, Decision 585/2014.
[12] Recital 31, Regulation (UE) 2015/758.
[13] Art. 1, *idem.*
[14] Recital 18, *idem.*
[15] Art. 4, *idem.*
[16] Art. 5, *idem.*
[17] Recital 21, *idem.*
[18] https://ec.europa.eu/justice/article-29/documentation/opinion-recommendation/files/2006/wp125_en.pdf

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.

In addition to this Regulation, two others Regulations have been adopted. Regulation 2017/78 which is a Commission implementing act and Regulation 2017/79 that is a Commission delegated act[19]. Regulation 2017/79 establishes detailed technical requirements and test procedures for the EC type-approval of the vehicles. Regulation 2017/78 focuses on one hand on administrative provisions for the approval of new types of vehicles with respect to the 112-based eCall in-vehicle systems, as well as of 112-based eCall in-vehicle Separate Technical Units ('STUs') and 112-based eCall in-vehicle system components designed and constructed for such vehicles and on the other hand on the data protection legal framework[20].

3.3.3 Conclusion

Recital (18) of Regulation 2015/758 clearly acknowledges that a PTI is necessary for the eCall system as an emergency system and this periodic roadworthiness tests should be carried out regularly in accordance with Directive 2014/45/EU. Efficient PTI testing can be supported by ensuring for instance 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[21]. Certain PTI requirements were already defined in other type-approval related UNECE regulations on electronic safety systems, such as R13-H[22] or R79-H[23].

3.4 Key findings for the cost-benefits analysis (CBA)

In order to determine whether it is desirable to integrate eCall inspection into PTI, a CBA is required in line with Article 17 of Directive 2014/45/EU. During this process, a monetary value is assigned to each type of benefit that results from the measure. The sum of these monetary values is compared to the costs of the measure. If the benefits are higher than the costs, a measure is cost-effective.

The sections below present the key elements that need to be taken into account in a CBA.

The CBA is a method based on welfare-economics, to ensure efficient use of resources. Both the potential benefits and the potential costs of a measure/technology are estimated across a set of impacts and converted into monetary terms by multiplying impact units by prices per unit. The favourability of PTI-measures for eCall from a society's point of view can be illustrated by confronting the socio-economic benefits with the system costs (investment, operating and maintenance costs).

[19] To understand the difference between a Commission delegated and implementing acts, see https://ec.europa.eu/info/law/law-making-process/adopting-eu-law/implementing-and-delegated-acts_en

[20] Art. 1, Regulation 2017/78.

[21] eCall Phase 2 Technical requirements and test procedures for the type approval of eCall in vehicle system (2015), http://publications.europa.eu/resource/cellar/6ade51b5-82be-11e5-b8b7-01aa75ed71a1.0001.02/DOC_1, p. 91

[22] Regulation No 13-H of the Economic Commission for Europe of the United Nations (UN/ECE) — Uniform provisions concerning the approval of passenger cars with regard to braking. See paragraph 5.1.4. "Provisions for the periodic technical inspection of braking systems" and ANNEX 8 "Special requirements to be applied to the safety aspects of complex electronic vehicle control systems.

[23] Regulation No 79 of the Economic Commission for Europe of the United Nations (UN/ECE) — Uniform provisions concerning the approval of vehicles with regard to steering equipment

Introducing PTI for eCall offers two possible benefits:

- Economic benefit through the improvement of road safety.
- Economic benefit through the improvement of traffic efficiency.

Economic benefit through the improvement of road safety covers the reduction in the number of fatalities and the reduction in the number of severe and slight injuries. The economic benefit through the improvement of traffic efficiency includes the possible reduction of congestion by road accidents with fatalities and/or by road accidents with severe and slight injuries. Other possible benefits could be the avoidance of false calls, but those benefits cannot be calculated on a trustworthy basis because on the physical side, not enough empirical data is available. Furthermore, due to the heterogeneity of the national rescue systems in Europe, the resource losses by false calls cannot be calculated due to missing cost-unit rates. This means that the CBA covers the essential possible savings by PTI for eCall, but not the whole picture of reachable benefits.

Uncertainties for the benefit estimations exist also in the way that the possible failure rates and detection rates are not based on actual values because actual values can only be gained after the introduction of PTI for eCall. FSD made best guesses for these variables, based on their empirical experiences in this area. However, it might be useful to start the evaluation of the costs and benefits after the potential introduction of PTI for eCall to monitor the inspection process. On the cost side, various know factors, contributing to the cost of PTI and their respective cost-unit rates are used.

Benefit-cost ratios (BCR) of more than one indicate positive benefits for the public. In case of various PTI-measures, the BCR of each also allows a ranking based on economic efficiency. The literature (compare e.g. Prest & Turvey 1965[24], Schulz 1994[25]) offers the following graduations for the impact of the BCR:

BCR = 1:	“weak“
BCR between 1 and 3:	“acceptable“
BCR > 3:	“excellent“

Whereas a BCR below one is not acceptable.

4 Definition of scenarios

This work package considers as the “reference case” the scenario of not implementing any kind of activity to ensure the performances of the eCall systems during the vehicles' life.

For the scenarios definition, along with the current legal frame, technical constrains and market data, the result of the survey described in the section 3 and the input of the dedicated Workshop organized on June 8th, 2018 were taken in consideration.

The last public call for inputs was made by CITA during the Roadworthiness Committee on September 20th 2018.

[24] Prest, A. R., and R. Turvey (1965). “Cost-Benefit Analysis: A Survey.” The Economic Journal, vol. 75, no. 300, 1965, pp. 683–735. JSTOR, JSTOR, www.jstor.org/stable/2229670.

[25] Schulz, W. H. (1994). Rationalisierungspotentiale in der Verkehrs- und Telematikinfrastruktur - Methoden und empirische Ergebnisse von Nutzen-Kosten-Analysen. Köln.

4.1 Description of scenarios

The aim of the work package is to define different test scenarios, including their technical descriptions. Thus, the test scenarios known from the literature from WP 2 (data collection) will be incorporated and new test scenarios will be developed.

The definition of test scenarios is based on the functionality of the pan-European in-vehicle emergency call service (eCall), which is described in Regulation 2015/758. With the knowledge of the technical requirements of the eCall components and their functionality, it is possible to derive typical system faults, which can occur during the vehicle's life cycle.

The probability of a component failure is estimated. In addition, the reliability of the vehicle’s self-diagnosis should be evaluated when detecting a system failure or system degradation.

4.2 eCall - components and their defect rate

In order to gain a better understanding of the aspects involved in the cost-benefit analysis, the components of eCall and the defect rate are explained below.

eCall - overview components

The following figure illustrates the eCall components, which are necessary to establish the voice communication and to send the MSD in case of an automatically or manually triggered eCall.

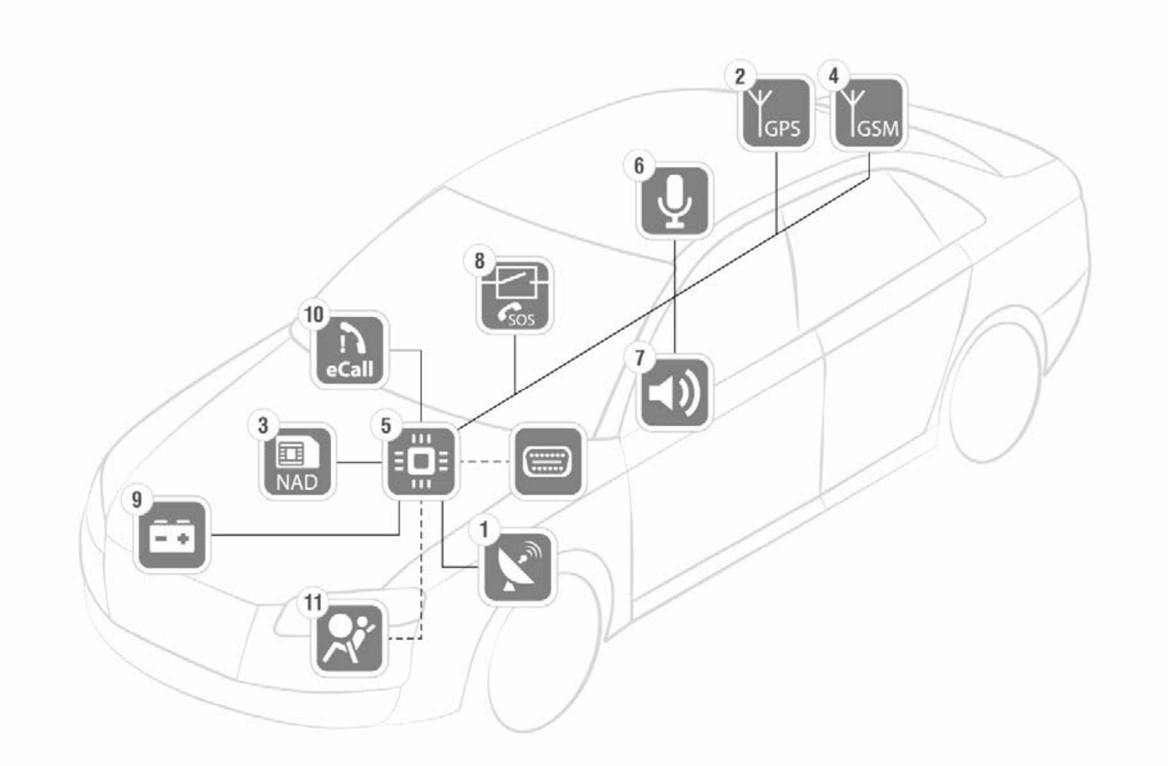

Figure 1: eCall components

1. GNSS receiver

The receiver for global navigation satellite systems (GNSS) enables the identification of the current geographical location of the vehicle and its direction of travel. In addition, the GNSS receiver also determines the current date and time. The most common example of a GNSS is the Global Positioning System (GPS). Additionally, the Galileo satellite navigation should be mentioned. This is the GNSS that is currently being deployed by the European Union.

2. GNSS antenna

The GNSS antenna is connected to the GNSS receiver and is responsible for receiving the signal related to the current geographic location.

3. NAD (including SIM)

The NAD enables the eCall system to dial into an available PLMN. The NAD transmits the MSD to the PSAP and also establishes the voice connection with the centre. In terms of design and function, the NAD acts like a mobile modem. A transmitter and a receiver unit, a SIM enable the wireless data transfer.

4. Mobile network antenna

The mobile network antenna is connected to the NAD and is responsible for receiving and transmitting the MSD and the voice connection signals.

5. ECU

The eCall ECU processes, prepares and initiates the transmission of the data for the realisation of the function of the eCall system. On the one hand, the dynamic data of the MSD is continuously determined in order that it can be made available in the event that an eCall is triggered (e.g. current vehicle location and direction). On the other hand, the static data of the MSD is permanently saved (e.g. VIN).

6. Microphone

In order to be able to establish the voice communication with the PSAP a microphone is part of the eCall system. The microphone is often near the driver's head, mounted on the vehicle's roof or A-pillar.

7. Loudspeaker/emergency speaker

In order to get a feedback from the PSAP at least one loudspeaker/emergency speaker is installed in the vehicle. Because of the crash requirements the loudspeaker/emergency speaker is normally separated from the rest of the audio system and located in the footwalls or beneath the driver's seat.

8. Manual push button

There is a manual option for the triggering of an eCall. The push button is installed centrally and clearly visible so that the push button is easily accessible to the vehicle occupants.

9. Battery & electrical power supply

The battery supplies all eCall components with electric power. For an eCall it is necessary that the state of charge does not reach a critical level. It must be possible after a crash to send the MSD and to make call with the PSAP. A call back from the PSAP shall be also possible even one hour after a crash.

10. Warning & indicator device

There is a warning or indicator device for displaying faults and defects. This can be designed as a tell-tale (not standardized) within the dashboard, in the form of an event-based notification (Check-Control notification) in the dashboard or on a screen on the vehicle's central console. However, no malfunction tell-tale is required which would be activated as a check of lamp function when the ignition locking system is turned to the "On" position (engine not running), or to the position between "On" and "Start".

11. Crash detection system

Following a crash detected by sensors, the crash detection system triggers an automatic emergency call. Usually the airbag system, including its crash sensors, is used to judge a critical crash. However, it is also possible that e.g. rollover detection system can be used to trigger the emergency call.

These crash detection systems are independent systems (with an electronic control unit, sensors and actuators) checked separately during the periodic technical inspection, therefore they won't be considered in the eCall test scenarios. In any case it should be mentioned that the flawless functioning of the crash detection systems gained further importance due to their role played in triggering an automatic emergency call.

eCall - defect rate components

As described in the previous section, an eCall system consists of several components. Each of these components fulfils a partial function, which cannot be fulfilled by another component. Each of these components is subject to stress, ageing and wear during the life cycle of the vehicle, which can lead from defects up to the complete failure of the eCall system. Other defects may result from faulty repair, improper maintenance or manipulation of a component.

There are no known statistics regarding the relevant defects. For this reason, defect rates were determined within the scope of an expert rating conducted by representatives of the components industry and FSD. In order to quantify the probability of a defect, a seven-step, equal-interval scale was selected.

A defect rate P_i^{def} always refers to the probability of a defect in the PTI. Here a highest possible defect rate of 1.5% was assumed:

- No defect likely: Defect rate = 0.00%
- Very low defect probability: Defect rate = 0.25%
- Low defect probability: Defect rate = 0.50%
- Fairly low defect probability: Defect rate = 0.75%
- Fairly high defect probability: Defect rate = 1.00%
- High defect probability: Defect rate = 1.25%
- Very high defect probability: Defect rate = 1.50%

The table below provides an overview of the possible defects in components of the eCall system i = 1, …, 10 and their average defect rates P_i^{def}:

eCall components $i = 1, \ldots, 10$	i	Possible defects	Defect rate P_i^{def}
GNSS receiver	1	Hardware defect in the GNSS receiver unit	0.25%
GNSS antenna	2	Damage/broken antenna (vandalism, improper maintenance) Manipulation by shielding the antenna ("jammer")	0.50%
Network access device (NAD)	3	Insufficient transmitter and/or receiver performance Internal hardware error SIM card defective/invalid/blocked	0.50%
NAD antenna	4	Damage/defect in the antenna (vandalism, improper maintenance) Manipulation by shielding the antenna ("jammer")	0.50%
Electronic control unit	5	Manipulation / deactivation by coding (scan-tool) Internal hardware error Fault in the vehicle's internal communication Replacement with not permitted device	1.50%
Microphone	6	Damage to the microphone Ageing due to heat or humidity Interference with regard to directionality (covering, incorrect alignment) Improper shielding of the wires (EMC)	1.25%
Loudspeaker/ Emergency speaker	7	Damage/defect to/in the loudspeaker Degradation (ageing of the suspension and membrane) Interference with regard to transmission (covering, alignment of the speaker) Unauthorised repair/replacement (incl. radio) Improper shielding of the wires (EMC)	1.00%
Manual push button	8	Push button mechanically defective or stuck	0.25%
Battery & electrical power supply	9	Line disconnection Short circuit to positive, to earth State of battery charge low Battery capacity low	0.25%
Warning and indicator device	10	Faulty bulb/LCD display Malfunction of the control device	0.25%

Table 1: Possible defects in the components of the eCall system and their average defect rates

The defects in the components are technically independent of one another, i.e. a defect in one of the components does not result in damage to the other components.

The eCall system adopts the principle of series connection with regard to its components, i.e. the overall system loses its function and efficacy if one of its components is defective. This does not apply to the "warning and indicator unit" component. If all other components are functioning flawlessly, a defective warning and indicator unit has no impact on the safety and benefit level of the eCall system, and therefore does not lead to a system-wide defect.

4.3 eCall - test scenarios

The purpose of the PTI of motor vehicles is to maintain the function and performance of the systems and components within the vehicle that are important for safety and the environment throughout its entire period of use.

Electronic systems and components are playing an increasingly significant role in modern motor vehicles. Their installation opens up new horizons, with regard to safety technology for example. This is also true for the eCall system which can be described as the first safety function that actively communicates from the vehicle.

The challenges for the future lie in even more effective and efficient inspection of electronic systems.

The eCall system, like every other electronic system and component, is subject to stress, ageing, wear and manipulation, the inspection and detection of faults is highly important. In the case of electronic systems and components in particular, a purely visual inspection is too limited to detect anomalies and faults.

In order to check electronic systems and components, the self-test function integrated in the systems and their internal assessment and display can also be used in PTI. However, this has its design-related limitations. Every vehicle manufacturer decides for itself, which system statuses are to be checked, stored and displayed, and with what frequency. In general, the extent of the mandatory self-test function is quite limited. In this context the definition of the warning and control device is given in Annex VII (In-vehicle system self-test) of Regulation 2017/79.

When developing test scenarios for PTI, it has to be ensured that the expenditure in terms of time and cost is reasonable in relation to the benefits of the inspection.

In accordance with Directive 2014/45/EU (see WP2), the tests in PTI may be supported via the electronic vehicle interface and by means of the use of a suitable scan tool. This enables effective and efficient test scenarios to be developed, in particular for the testing of electronically controlled systems and components within the scope of PTI. The only way to compensate for the increasing complexity of the safety and environment-related systems and components in the vehicle is to ensure that the increase in time expenditure for testing them as part of PTI remains moderate.

Test scenarios - test steps

In order to thoroughly examine a system, an assessment must be carried out according to the following scenarios. Each test scenario is designed in modular test steps which are based on existing test methods and PTI inspection criteria. In order to facilitate a clear, yet still comprehensive description of the test scenarios, these are described based on their modular construction. The various possible test steps are first described. These are then assigned to each test scenario as described in "Test scenarios – development".

Directive 2014/45/EU describes two standard test methods in Annex I:

- The test method **visual** means "in addition to looking at the items concerned, the inspector shall also, if appropriate, handle them, evaluate their noise or use any other appropriate means of inspection not involving the use of equipment."
- The test method using **electronic interface** addresses the possibility to check the correct fitment of a system or component, to read out failures or to trigger a functional check.

The scope of the inspection is represented by a three-level scale. This means that in order to fulfil the test scenario it is necessary to perform level 1 before performing level 2. Otherwise, the level to be achieved depends on the test scenario. These three levels are based on the following **inspection criteria**:

- Level1: fitment
- Level2: condition
- Level3: function/performance.

Level 1 – Inspection of fitment

During the inspection of fitment, the equipment in the vehicle with the respective system is tested as to whether:

- there is an existing eCall system in the vehicle,
- the existing installation complies with the manufacturer's specification.

The fitment of the system can be tested visually or using the electronic interface. The testing of the proper regulatory configuration of the system is only possible by using the electronic interface.

This results in the following possible test steps:

F1/V System identification (visual)

In the case of visual inspection, the identification of the eCall system, i.e. testing for its existence in the vehicle, is performed by using visible identifiers. Visible identifiers for the inspectors are, for example, the eCall push button, the emergency speaker, the antenna or the warning and control units. If these identifiers are present, then this test step has been successfully completed.

F1/E System identification (electronic)

The identification of the eCall system, i.e. testing for its existence in the vehicle, by electronic means takes place via the electronic vehicle interface and using a suitable scan tool (ST), whereby the existence of the eCall electronic control unit is identified. The scan tool sends a request to the eCall electronic control unit via the OBD interface. If the eCall electronic control unit sends a response to the scan tool, then this test step has been successfully completed.

F2/E Configuration testing (electronic)

The testing of the configuration of the eCall ECU follows the successful testing of the existence of the eCall system via the electronic vehicle interface. Here, the scan tool requests the hardware and software version and the current configuration of the software from the eCall ECU. The data sent back to the scan tool by the eCall ECUis compared with the respective reference data stored on the scan-tool. If these match, then this test step has been successfully completed.

Level 2 – Inspection of condition

If it is known that a vehicle is fitted with the eCall system (i.e. result of inspection of fitment is positive), then the condition of this system is tested. Condition testing checks its state, i.e. whether the current condition allows for its proper regulatory function. A definitive guarantee of the functional capability of the components cannot be provided by this. The testing of the condition of the system can likewise be performed visually or by using the electronic interface. This results in the following possible test steps:

C1/V Condition testing based on visual components (visual)

In the case of visual inspection, the condition of the eCall system based on visible components is tested by means of a visual inspection of the accessible and visible component parts of the eCall system. The external antennae, the internal eCall push button, the emergency speaker, the microphone and the warning and control unit can be visually checked. If no anomalies are evident, then this test step has been successfully completed.

C2/V Condition testing based on warning and control units (visual)

In the case of visual inspection, the condition of the eCall system on the basis of warning and control units is tested by means of the visual inspection of the display of the warning and control units. Their display is compared with the manufacturer's specifications. If no anomalies are evident, then this test step has been successfully completed.

C2/E Condition testing based on warning and control units (electronic)

The testing of the condition of the eCall system based on warning and control units by electronic means is performed via the electronic vehicle interface and with the help of a suitable scan tool. To this end, the current status of the components of the eCall system that would produce the display on warning and control units is electronically determined. The status transmitted to the scan tool is compared with the manufacturer's specifications. If no anomalies are evident, then this test step has been successfully completed.

C3/E Condition testing based on stored trouble codes (electronic)

The testing of the condition of the eCall system based on stored trouble codes by electronic means is performed via the electronic vehicle interface and with the help of a suitable scan tool. To this end, the existence of PTI-relevant entries stored by the vehicle's self-diagnosis, e.g. in the eCall electronic control unit, is checked. If there are no PTI-relevant entries, then this test step has been successfully completed.

Level 3 – Inspection of function / performance

The condition of the eCall system is directly linked with its functional availability, thus the proper function must also be tested accordingly. The function of the electronic system can only be tested electronically. For this reason, the test is performed via the electronic vehicle interface and using a suitable scan tool.

In general term, a functional test is the test whether, after the actuation of pedals, levers, switches or other operating devices, which trigger an operation, this process runs correctly in terms of time and function. On the other hand, a performance test describes a measuring technology based investigation - which also implies calculation processes - of a component or system for observing or reaching predetermined limits.

For the testing of the eCall system it should be noted that a complete function and performance test goes beyond the inspection of the vehicle. Here, a functioning mobile infrastructure is just as essential as functioning components within the vehicle.

This results in the following possible test steps:

FP1/E Checking the MSD (electronic)

In order to check the MSD [EN 15722][26] of the eCall system, an MSD is requested from the eCall electronic control unit. The entries of the MSD, such as VIN and propulsion storage type, are then compared with the vehicle data for PTI. A check will also be made of whether the stated vehicle position matches the location of the

[26] DIN EN 15722:2015-08: Intelligent transport systems – Esafety - eCall minimum set of data

vehicle test. If no anomalies are evident, then this test step has been successfully completed.

FP2/E Testing the voice functionality (electronic)

To test the voice functionality of the eCall system i.e. the voice quality, of the microphone and emergency speaker e.g. an echo-test mode is activated in the vehicle using the scan tool. After activating the echo-test mode, a test sentence, spoken aloud by the inspector for example, is recorded via the microphone and played back over the emergency speaker with a slight delay.

In case there is no echo-test mode provided by the eCall diagnosis functionality, the loudspeaker can be triggered and the signal level of the microphone can be queried using the scan tool in order to check the function. If no anomalies are evident, then this test step has been successfully completed.

FP3/E Testing the mobile communication components (electronic)

In order to test the function of the mobile communications components of the eCall system, the PLMNs available for the eCall system are requested in the NAD using the scan tool. This test is based on a periodic background scan for PLMNs, which is already provided in eCall systems, in conjunction with information about the fastest possible registration on a PLMN [EN 16062][27]. This test step does not involve registration on a mobile communications network. If no anomalies are evident, then this test step has been successfully completed.

FP4/E Triggering of a remote test call (electronic)

In order to test the function of the eCall system, in this step a test call is triggered via the scan tool. To ensure that the public safety answering point (PSAP) is not interfered with as a result of this test, the configuration of the eCall electronic control unit must be changed such that a long-dialling service number is selected for a test, rather than the international emergency number. The configuration of the eCall electronic control unit to a long-dialling number must be realised via the scan tool or should already be provided by the eCall system.

After triggering the test call by pressing the eCall push button, or via the scan tool, a test call is placed via the long-dialling number and a mobile connection to a server is established (PSAP simulation). The MSD is transmitted to this number. The received data are compared with the existing data from the vehicle and the location of the test. A test tone is sent to the vehicle from the server via the voice connection, which is played through the speaker and in turn picked up by the microphone and then sent back to the server. The quality of the transmitted test tone is automatically compared with the quality of the received test tone. The results of the comparisons will be provided to the inspector. If no anomalies are evident, then this test step has been successfully completed.

The technical implementation of the procedure requires the establishment of a test centre that is capable of processing all incoming test eCalls in parallel. Due to the large number of test eCalls that need to be processed in parallel a correspondingly large expansion stage is required for the full expansion as well as redundancy and availability.

The ETSI TS 129 010[28] standard merely allows the mobile network to receive a manual or automatic eCall signal in the case of a connection established via 112. Therefore, the standard would have to be amended to include the specification of a

[27] DIN EN 16062:2015-08, Intelligent transport systems - ESafety- eCall high level application requirements (HLAP) using GSM/UMTS circuit switched networks

[28] https://www.etsi.org/deliver/etsi_ts/129000_129099/129010/10.00.00_60/ts_129010v100000p.pdf

test eCall. If this standard is amended, ETSI TS 102 936-2[29] will likewise have to be amended by adding the corresponding test cases. Further adjustments are necessary for the EN 16072[30] standard; the description of the eCall flag must be amended to include the possibility of initiating a test eCall via the diagnostics interface, which may take several additional years.

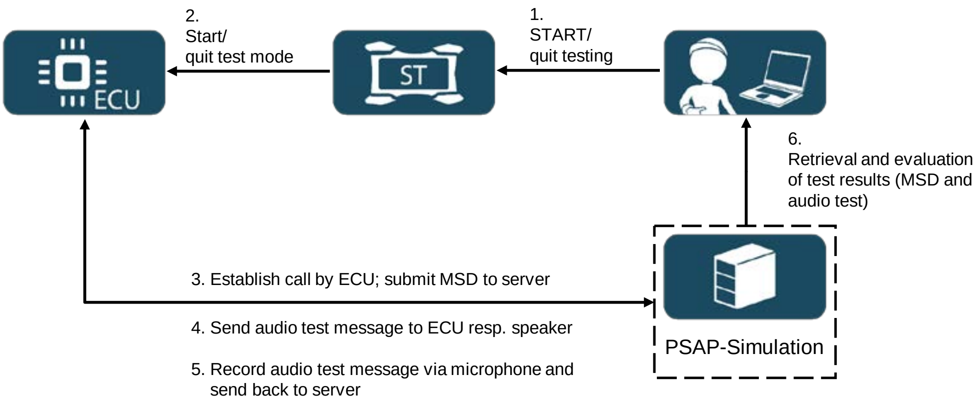

Figure 2: Test step FP4/E

4.4 Test scenarios - development

Based on the possible test steps outlined above, various test procedures can be derived that verify the proper regulatory fitment of the system in the vehicle, its condition and its function/ performance, to various extents and with varying levels of rigour.

In order to determine the time required for the realisation of each test procedure, empirically determined times from an internal MTM study and independent measurements are used. If this was not possible, then expert ratings were implemented. In particular, the electronically supported test steps of the test procedures result in an advantage in terms of the absolute execution time. This is justified in that the electronically supported test steps can for the main part be realised in parallel by the scan tool.

Below, the test procedures, steps, execution times and test statements are explained.

Scenario 0: Without-Case

The Without-Case describes the situation whereby the testing of the eCall system is not added to the harmonised minimum requirements for PTI on EU level. This means that defects in the system components may stay unnoticed. The Without-Case would lead to the continuous degradation of the eCall system without regular checks during a PTI identifying potential defects.

[29] https://www.etsi.org/deliver/etsi_ts/102900_102999/10293602/01.01.01_60/ts_10293602v010101p.pdf
[30] DIN EN 16072:2015-08, Intelligent transport systems - ESafety- Pan-European eCall operating requirements

Scenario I: Testing via warning and indicator lamp

Included test steps:

Code	Test step	Method	Time [s]
F1/V	System identification	visual	2
F1/E	System identification	electronic	2
F2/E	Configuration testing	electronic	0
C1/V	Condition testing on the basis of visual components	visual	4
C2/V	Condition testing on the basis of warning & control units	visual	3
C2/E	Condition testing on the basis of warning and control units	electronic	0
C3/E	Condition testing on the basis of stored trouble codes	electronic	1,4
FP1/E	Checking the minimum set of data	electronic	1,4
FP2/E	Testing the voice quality	electronic	4,7
FP3/E	Testing the mobile communications components	electronic	0
FP4/E	Execution of a remote test call	electronic	55,7
		sum	9

Table 2: Test steps – Scenario I – Testing via warning and indicator lamp

The execution time required for this test procedure was measured as 9 seconds (internal FSD and MTM study).

This test procedure only enables the testing of the proper regulatory fitment of the system and its condition on the basis of the vehicle's self-diagnosis. Electronic defects in the eCall system can be detected if the vehicle's stored trouble codes have not been actively deleted in preparation for PTI.

Scenario II: Testing via electronic vehicle interface – Level 2

Included test steps:

Code	Test step	Method	Execution time [s]
F1/V	System identification	visual	2
F1/E	System identification	electronic	2
F2/E	Configuration testing	electronic	0
C1/V	Condition testing on the basis of visual components	visual	4
C2/V	Condition testing on the basis of warning & control units	visual	0
C2/E	Condition testing on the basis of warning and control units	electronic	0
C3/E	Condition testing on the basis of stored trouble codes	electronic	1,4
FP1/E	Checking the minimum set of data	electronic	1,4
FP2/E	Testing the voice quality	electronic	4,7
FP3/E	Testing the mobile communications components	electronic	0
FP4/E	Execution of a remote test call	electronic	55,7
		sum	7,4

Table 3: Test steps – Scenario II – Testing via electronic Interface – Level 2

The execution time required for this test procedure was measured as 7.4 seconds (internal FSD and MTM study).

This test procedure only enables the testing of the proper regulatory fitment of the system and its condition based on the interaction of the scan tool with the electronic components of the eCall system. Only in this way, the configuration of the eCall system can be tested. Electronic defects in the eCall system can be detected if the vehicle's stored trouble codes have not been actively deleted in preparation for PTI.

Scenario III: Testing via electronic vehicle interface – Level 3

Included test steps:

Code	Test step	Method	Execution time [s]
F1/V	System identification	visual	2
F1/E	System identification	electronic	2
F2/E	Configuration testing	electronic	0
C1/V	Condition testing on the basis of visual components	visual	4
C2/V	Condition testing on the basis of warning & control units	visual	3
C2/E	Condition testing on the basis of warning and control units	electronic	0
C3/E	Condition testing on the basis of stored trouble codes	electronic	1,4
FP1/E	Checking the minimum set of data	electronic	1,4
FP2/E	Testing the voice quality	electronic	4,7
FP3/E	Testing the mobile communications components	electronic	0
FP4/E	Execution of a remote test call	electronic	55,7
		sum	13,5

Table 4: Test steps – Scenario III – Testing via electronic Interface – Level 3

The execution time required for this test procedure was measured as 13.5 seconds (internal FSD and MTM study).

This test procedure includes

- the testing of the proper regulatory fitment of the system,
- its condition, and
- its function/ performance

on the base of the interaction of the scan tool with the electronic components of the eCall system. This way Electronic defects, manipulations, the correctness of the MSD and functional limitations of the audio components can be detected.

Scenario IV: Testing via call

Included test steps:

Code	Test step	Method	Execution time [s]
F1/V	System identification	visual	2
F1/E	System identification	electronic	2
F2/E	Configuration testing	electronic	0
C1/V	Condition testing on the basis of visual components	visual	4
C2/V	Condition testing on the basis of warning & control units	visual	3
C2/E	Condition testing on the basis of warning and control units	electronic	0
C3/E	Condition testing on the basis of stored trouble codes	electronic	1,4
FP1/E	Checking the minimum set of data	electronic	1,4
FP2/E	Testing the voice quality	electronic	4,7
FP3/E	Testing the mobile communications components	electronic	0
FP4/E	Execution of a remote test call	electronic	55,7
		sum	64,5

Table 5: Test steps – Scenario IV – Testing via call

The execution time required for this test procedure was measured as 64.5 seconds (internal FSD and MTM study).

This test procedure includes

- the testing of the proper regulatory fitment of the system,
- its condition, and
- its function/ performance

on the base of the interaction of the scan tool with the electronic components of the eCall system and a test-call.

Thus, on the one hand, the correct configuration and the data in the MSD can be checked. On the other hand, the voice quality can be evaluated with the existing audio components. Furthermore, the establishment of a mobile communications connection should be analysed. Electronic defects in the eCall system, manipulations, the correctness of the MSD, functional limitations of the audio components and the connection to the PLMN can be evaluated this way.

The risk of this procedure is that it depends on the availability of a PLMN and the test result depends on circumstances which are outside the scope of the PTI and go beyond the vehicle and the test conditions.

4.5 Test scenarios - detection of defects

As described in section "eCall - defect rate components", a defect rate is assumed for each component part of the eCall system. The proposed test scenarios are, to varying extents, capable of detecting existing defects.

In order to check electronic systems and components, the self-test function (Scenario I) integrated in the eCall system and their internal assessment and display can also be used in PTI. However, this has its design-related limitations and is dedicated to inform the driver about the system status. Every vehicle manufacturer decides for itself, which system statuses are to be checked, stored and displayed, and with what frequency.

In general, the extent of the mandatory self-test function is quite limited. In this context, the parameterization of the warning and control device is defined on the basis of the Regulation 2017/79. In addition to the Regulation, it is be expected that the manufacturers fulfil ISO 26262 on functional safety and thus the warning and control device is able to provide information on the state of the connection to loudspeakers and microphone.

A self-test function of eCall system can cover a variety of electrical failures. However, not all possible failures of components are detectable with reasonable effort. The European Commission report "eCall Phase 2 - Technical requirements and test procedures for the type - approval of eCall in-vehicle systems"[31] provides a list of potential failure modes and mechanisms of eCall components, which are not feasible to cover it in a system self-test:

[31] TRL 2015, eCall Phase 2 - Technical requirements and test procedures for the type - approval of eCall in-vehicle systems

eCall components $i = 1, \ldots, 10$	i	Self-test limitations (failure modes)
GNSS receiver	1	
GNSS antenna	2	Reduced performance/failure due to unintended manipulation (e.g. non-approved replacement part, installation faults) or mechanical degradation (e.g. corrosion of contacts)
		Failure due to deliberate manipulation (shielding of antenna or jamming of signals), e.g. based on concerns the vehicle could be tracked
Network access device (NAD)	3	SIM invalid
NAD antenna	4	Reduced performance/failure due to unintended manipulation (e.g. non-approved replacement part, installation faults) or mechanical degradation (e.g. corrosion of contacts)
		Failure due to deliberate manipulation (shielding of antenna or jamming of signals), e.g. based on concerns that the vehicle could be tracked
Electronic control unit	5	
Microphone	6	Reduced performance/failure due to degradation (e.g. soiling, ageing, mechanical defects)
Battery & electrical power supply		Reduced performance/failure due to manipulation (e.g. non-approved replacement part, installation faults, covered by retrofit elements)
Loudspeaker/ Emergency speaker	7	Reduced performance/failure due to degradation (e.g. soiling, ageing, mechanical defects)
		Reduced performance/failure due to manipulation (e.g. non-approved replacement part, installation faults, covered by retrofit elements)
Manual push button	8	Mechanical failure (e.g. button stuck)
		Connection failure, short circuit
Battery & electrical power supply	9	Reduced state of capacity
Warning and indicator device	10	Connection failure, short circuit
		Failure due to deliberate manipulation
		LED failure

Table 6: Self-test limitations (failure modes)[32]

Regarding the eCall electronic control unit it is assumed that the entire system can be simply deactivated by a generic scan tool. The reasons are, for example, the need for privacy of the vehicle owner. This self-test limitation/s is/are not covered by the TRL-report. FSD verified this limitation on existing eCall third-party systems.

There are no publicly available statistics yet on the detectability of defects of the eCall system components. For this reason, detection rates were determined using expert judgement conducted by representatives of the test organisations. These detection rates express what proportion of the possible defects can be detected. The maximum

[32] TRL 2015, eCall Phase 2 - Technical requirements and test procedures for the type - approval of eCall in-vehicle systems

detectability of defects is taken as 95%. Due to context-related, technical and organisational influences, the 100% detection of all defects is not possible. For each of the proposed test procedures (section 5.4) the detectability of the possible defects in the component parts of the eCall system was estimated. In order to quantify the detection rates, a five-step, equal-interval scale was selected.

No detection of defects:	Detection rate = 0%	○
Defects are detected to a very limited extent:	Detection rate = 25%	●
Defects are occasionally detected:	Detection rate = 50%	●●
Defects are detected in the majority of cases:	Detection rate = 75%	●●●
Defects are detected at the best possible rate:	Detection rate = 95%	●●●●

The following table provides an overview of the considered component parts i= 1, … , 10 and the detection rates $P_{i,j}^{det}$ using the respective test procedures j = 1, … , 4.

		Detection rate $P_{i,j}^{det}$				
Scenario $j = 0, \dots, 4$		0	1	2	3	4
eCall Components $i = 1, \dots, 10$	i	**Without-Case**	**Testing via warning and indicator lamp**	**Testing via el. vehicle interface – Level 2**	**Testing via el. vehicle interface – Level 3**	**Testing via call**
GNSS receiver	1	o	●●	●●	●● ●●	●● ●●
GNSS antenna	2	o	●	●	●● ●●	●● ●●
Network access device (NAD)	3	o	●●	●●	●● ●	●● ●●
NAD antenna	4	o	●	●	●● ●	●● ●●
Electronic control unit	5	o	●	●● ●●	●● ●●	●● ●●
Microphone	6	o	●	●	●● ●●	●● ●●
Loudspeaker/ Emergency speaker	7	o	●	●	●● ●●	●● ●●
Manual push button	8	o	●●	●●	●●	●●
Battery & electrical power supply	9	o	●● ●	●● ●	●● ●●	●● ●●
Warning and indicator device	10	o	●	●● ●●	●● ●●	●● ●●

Table 7: Components of the eCall system and their defect detection rates

In the case of the testing via warning and indicator lamp, test procedure j = 1, the test tool used is the warning and control unit of the vehicle. A scenario is possible where the inspector does not detect a defective warning and control unit. This would have the direct consequence that defects in other components of the eCall system may also fail to be detected, as the control light is the only means of error detection in this case. As a means of simplification, it is assumed that the respective test tool used when applying each test scenario $j = 0, \ldots, 4$ is functional. A defect in the warning and control unit is thus not taken into consideration.

The detection of defects in components can then be considered as independent, i.e. the detection of a defect in one component does not mean that the detection of a defect in other components is more likely.

In PTI, the eCall function should be considered/declared as defective if at least one defect in one of the components $i = 1, \ldots, 10$ of the system has been detected as a result of the application of a test procedure during PTI. A defect in the component $i = 10$, does not result in a defect in the overall system and thus is of no significance to the classification of the overall system either.

5 Cost and Benefit Analysis

The objective of this study is to assess which of the four defined PTI test scenarios for the testing of the eCall system is the most efficient. In comparison, there will also be a scenario included, with no testing of eCall at all. In the following part, an extensive cost and benefit analysis will be conducted, to assess the different scenarios.

The selected approach for the economic assessment is the cost-benefit analysis (CBA). The CBA is often used to justify investment decisions, for instance in traffic projects. In many European countries, for example, it is a legal requirement that a CBA is carried out in the case of substantial public investments[33] The potential benefit and the potential costs of technology are estimated with this approach and monetarily assessed, considering a selection of effects. The benefits of a technology are multiplied by the cost of a unit and compared to the costs of the technology.

If the risk for the stakeholders is low and the risk for society is high, there is no general political willingness to introduce PTI test scenarios for an eCall system. Low risk for the stakeholders means that the price/cost difference per unit can always be expected to be positive. A high risk for society means that there is uncertainty as to whether a PTI of the eCall system results in the calculated safety effects (e.g., the avoidance of fatalities).

To overcome these social barriers, increased efforts are needed in the research and development of PTI test scenarios. The low financial risk to the stakeholders shows that the PTI test scenarios for testing the eCall system function well and that the system functions are stable. If the risk to society is low, but the risk to the stakeholders is high, the stakeholders will demonstrate the highest level of reservation about the introduction of a PTI test scenario for the eCall system. A low risk to society means that the social benefits are higher than the social costs. This would mean that testing eCall during the PTI does affect safety.

The goal now of the CBA is to determine all social net benefits or welfare effects that result from operations by decision makers. The CBA is an instrument that is used to compare alternative socio-economic statuses or courses due to a specific operation. Here, all the significant effects that are relevant to the area of efficacy are compared regarding their advantages and disadvantages. In so doing, it is essential that all

[33] Recital (25), idem.

welfare effects of a project be identified. All effects must be monetarily assessed in a standardized unit. This way, aggregated advantages can be compared with aggregated costs.

The result of a CBA is the **benefit-cost ratio** (BCR). To calculate a return on the investment, the costs (including capital and maintenance costs) and benefits (including time savings, reduction of accident severity and savings on operating costs) are discounted at an appropriate rate of discount back to the base year value. Alternatively, known market prices for the base year can be used for the forecast period. BCR's, which are determined in this way, have the advantage that they are not manipulated by hidden assumptions regarding projection prices, capital costs, and labour costs. This approach calculates without discounting capital. Uncertainties regarding future economic growth are excluded. In particular, the assessment of benefits has shown that the average annual benefit assuming the market prices for the study period is equal to the benefit annuity of discount models[34]. Therefore, on the benefit side, a discount on future benefits is not mathematically necessary.

The starting point for the CBA is the comparison of the scenarios 1 to 4, in which PTI tests are implemented, with the status quo, the scenario 0, where a PTI test scenario is not implemented. In the case without a test, the benefit is 0, and economic losses will occur, due to the lack of improvement in crash severity. The direct comparison of cost and benefit in conjunction with the implementation of a measure can only be realized if both are assessed in the same unit. Since the geographical scope of this study is the European Union, the unit for the monetary assessment is the euro [€].
Using the empirically derived defect rates from chapter 4.2 for the different components, and the likelihood that these defects will be detected and repaired, as described in chapter 4.5, maximum possible numbers for the mitigation of accident outcomes are derived and then monetized.
Overall it is estimated that due to the introduction of PTI for the eCall system, up to 8 fatalities per year and up to 130 seriously injured per year could be prevented in the most thorough scenario.
The steps that lead to these numbers and the monetarization as well as the ranking of the different scenarios according to their BCR are described in the following chapters.

5.1 Cost-Benefit Analysis methodology for eCall test scenarios

The introduction of a test scenario for the eCall safety function maintains the safety potential of the function at a consistently high level over the entire life of the vehicle and can detect signs of aging at an early stage, aiming to reduce errors to a minimum. The goal of this study is to identify primary and secondary benefits of the testing of safety functions and to demonstrate the effect of the application of various test scenarios on the discrepancy to be expected between scenario 0 with no checks in place and the different scenarios, described before.

The procedure for the investigation of the economic effects of the introduction of a test scenario for the preservation of the function of the eCall system over the life cycle of the vehicle incorporates seven steps and is based on the different scenarios described in WP 5.

[34] Recital (25), idem.

Steps for the CBA

Step 1: Discussion time frame and number of vehicles in consideration
The time frame for the PTI of eCall needs to be defined. When are the inspections starting, how often will they be and when will all vehicles have been tested at least once. Furthermore, it is estimated how the stock of vehicles with eCall is developing and how long it will take until 95% of the fleet have eCall incorporated.

Step 2: Identification of the valuation rates and assumptions
All assumptions necessary for the cost-benefit analysis are described in this step. To identify the use of periodic technical inspections, this step includes the rates for the defects and detection of failures as described in WP3. The detection rates differ for the different scenarios, depending on which tests are used, as described in WP3.

Step 3: Monetary assessment of the benefit
The benefit effects quantified in step 2 are given monetary values in step 3, such that they can subsequently be compared against the costs.

Step 4: Calculation of the benefit for each scenario
For each of the presented test scenarios, the overall benefit resulting from its introduction and application is calculated using the partial benefits with the monetary values described in step 3.

Step 5: Description of the costs
To realise the physical benefit effects, certain investments are required depending on the test scenario used, whereby the one-off and ongoing costs are described in this part.

Step 6: Calculation of the costs for each scenario
For each of the presented test scenarios, the costs for its introduction and application are calculated using the cost items described in step 5.

Step 7: Comparison of benefits and costs
This study produces scenario-related BCR's for all presented test scenarios which relate to the overall study period. To calculate them, the physical effects in monetary terms, as benefits, are compared with the investment costs. The variant with the best BCR can then be determined. Here, the preferred option is the variant that provides the most significant indirect economic yield (benefit) per euro invested.

5.2 Step 1: Discussion time frame and number of vehicles in consideration

In 2018, eCall systems became mandatory. In order to be able to estimate the long-term effects of the introduction of a test system for eCall– in particular during the phase following full market penetration – the end of the study period will be set at ten years following the achievement of full market penetration. According to the observations regarding market penetration, a study period of 23 years, beginning in 2018 and running up to and including the year 2040 would be reasonable. The following aspects have led to this decision:

In order to forecast the vehicle stock during the study period and to determine the study period, the empirical average of the development of the passenger car stock in Europe between 2011 and 2016 is used, unfortunately the data from Eurostat is missing some values and thus Denmark, Italy, Romania and the United Kingdom have to be excluded[35]. This yields an average growth rate of 1.26%. Another source reports for all countries but only until 2015, the reported rate there is from 2011 until 2015 and around 1.41%[36]. Newer data is unfortunately not yet available, but it can be concluded that an annual growth rate of the vehicle stock of around 1.33% on average is feasible.

In the year 2016, 259.7 million passenger cars were in use in the EU28; this serves as the base for projecting the stock development onwards[37].

The passenger car stock is projected with the average growth rate above until the year 2040. From Figure 3, it becomes visible that in 2031, 95% of inspected cars will have eCall included, the 95% are considered as full market penetration reached.

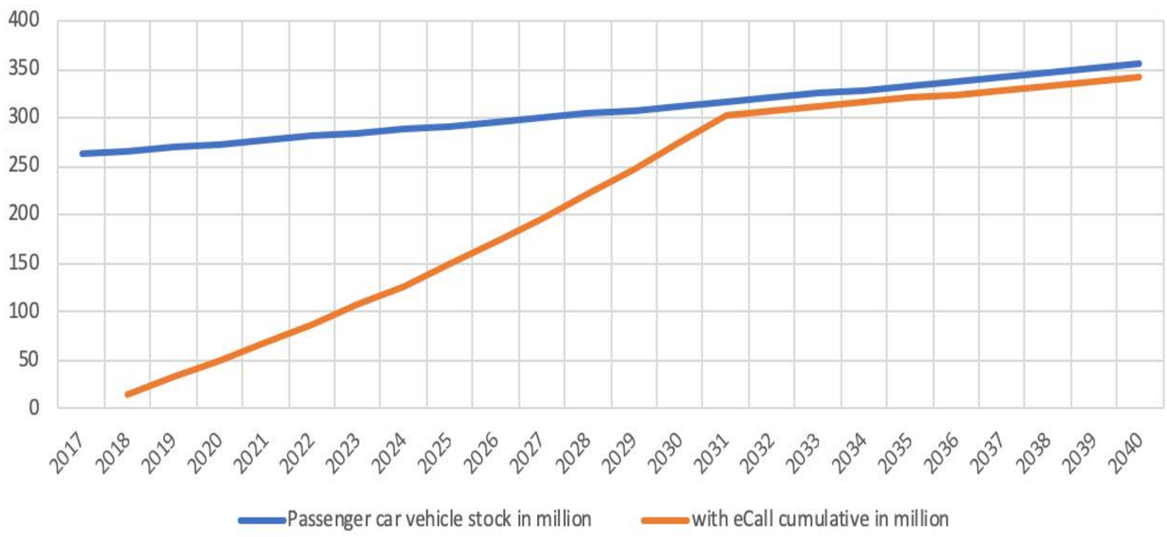

Figure 3: Passenger car stock projections

The following assumptions are made to be able to conclude this period. Before 2018, just a few vehicles within the vehicle stock in the European Union had a system for placing an electronic emergency call built in. Based on this fact, it can be assumed that the vehicle market will only have an appropriate amount of these systems from the year 2018, in which the eCall system became mandatory for all newly approved passenger cars. From this point on, the number of vehicles equipped with the eCall system will be the same as the number of newly approved vehicles, since all newly approved vehicles are obliged to have the system on board, and it will increase continually.

Based on the number for new registrations of around 15.138 million passenger cars in 2017[38] and based on the historic numbers for these new registrations[39], an average growth rate of 4.63% since 2013 and until 2017 can be derived. Cumulating the

[35] Eurostat (2018). Passenger cars, by age. Retrieved from http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=road_eqs_carage&lang=en

[36] OICA (2018). Vehicles in use. Retrieved from http://www.oica.net/category/vehicles-in-use/

[37] ACEA (2018). The Automobile Industry Pocket Guide 2018 / 2019. Brussels: European Automobile Manufacturers Association. Retrieved from https://www.acea.be/uploads/publications/ACEA_Pocket_Guide_2018-2019.pdf

[38] Recital (37), idem.

[39] ACEA (2018). Consolidated Registrations - By Country. Retrieved from https://www.acea.be/statistics/tag/category/by-country-registrations

numbers for the new registrations and assuming the fact that all new registrations will already feature eCall, 2031 is the year that is empirically derived when there will be around 95% of the vehicle stock being equipped with eCall.

Another key figure for this study is the number of vehicles put forward for the PTI. This number is dependent on the national regulations for the period within which vehicles are to be put forward for the PTI. Within the scope of the AUTOFORE study[40] it was determined that 30.5% of all cars approved within the EU be presented for the PTI each year.

This means that the number of vehicles within the vehicle stock tested in the year 2016 is 79.2 million passenger vehicles. Based on this, the number of vehicles inspected in a PTI in a given year is projected forward using the vehicle stock growth rate.

The projection data for the passenger car stock inspected and inspected with eCall are shown in Figure 4.

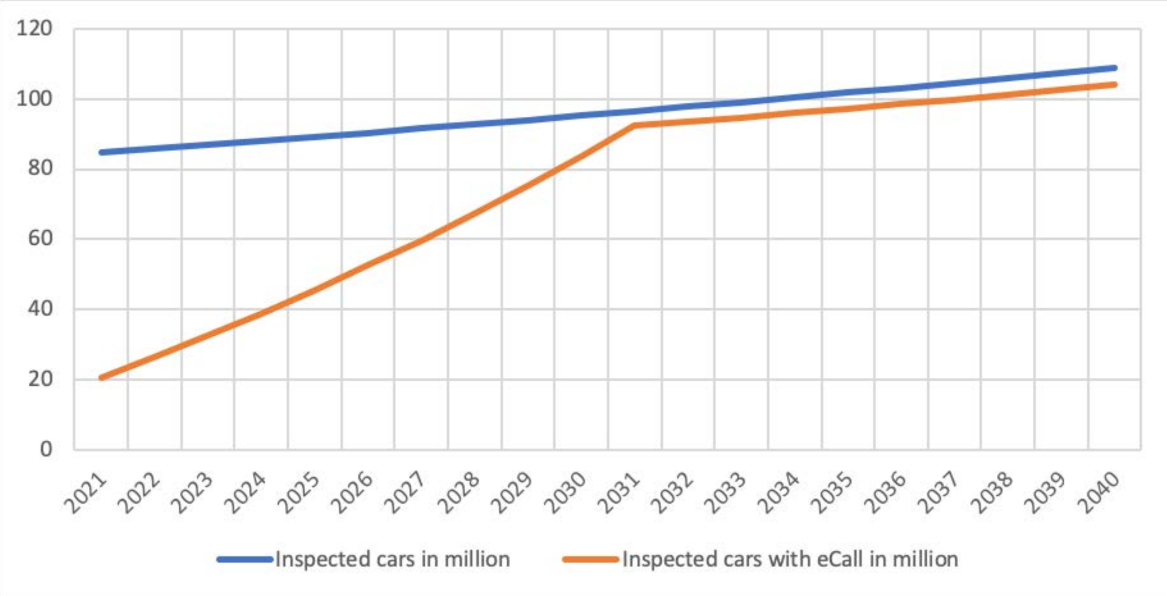

Figure 4: Projections inspected passenger cars and inspected passenger cars with eCall

Due to the heterogeneous individual regulations regarding the inspection periods within Europe, it is assumed that noteworthy quantities of vehicles with eCall will only be put forward for the PTI three years after its introduction, since on average it is three years in the EU that cars need to be rechecked after first being brought on the road.

In order to determine the impact of the eCall safety function, it is also necessary to quantify the number of fatalities on European roads. For this study, the applicable figures are taken from the PIN report with data running up until 2017[41] and using the European Union's Road Accidents Database - CARE. The annual number of people

[40] CITA (2007). AUTOFORE - Study on the Future Options for Roadworthiness Enforcement in the European Union. Retrieved from https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/projects_sources/autofore_final_report.pdf

[41] Adminaite, D., Calinescu, T., Jost, G., Stipdonk, H., & Ward, H. (2018). Ranking EU Progress on Road Safety - 12th Road Safety Performance Index Report. Retrieved from https://etsc.eu/wp-content/uploads/PIN_AR_2018_final.pdf and https://ec.europa.eu/transport/road_safety/specialist/statistics_en#

killed on European roads is then estimated from the year 2017 onwards with a geometrical forecast including a trend.

The forecast is based on the trendline for the observed data from 2001 until 2017 and then projected onwards with y = 6E +53e$^{-0,056x}$. The curve has thus an asymptotical characteristic. The development of the forecast can be seen in Figure 5. It shall be noted that this forecast is based and projected for accidents without the eCall system in place.

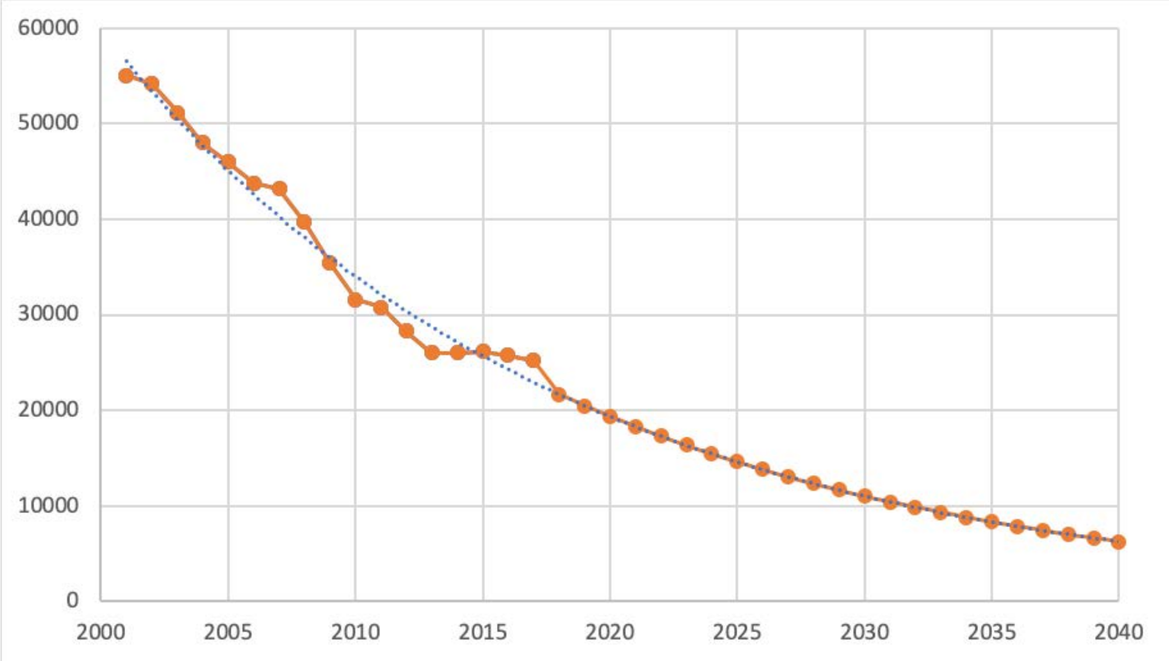

Figure 5: Assumed progression of fatality numbers in Europe

If the number of people killed on European roads is known, then the number of people suffering severe or minor injuries can be deduced from this. The Annual Accident Report 2018 of the European Road Safety Observatory has some information available regarding the ratio of the number of registered fatalities and injuries[42] :

- The ratio of registered fatalities to the number of severely injured persons is 1.8.
- The ratio of registered fatalities to the number of persons suffering minor injuries is 1:50[43].

The ratio for severely injured persons has been derived from the Road Safety Performance Index Report[44], taking the arithmetical average over the period from 2007 to 2017.

[42] ERSO (2018). Annual Accident Report 2018. Retrieved from https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/statistics/dacota/asr2018.pdf
[43] Gibson, G., Varma, A., Cox, V., Korzhenevych, A., Dehnen, N., Bröcker, J., . . . Meier, H. (2014). Ricardo-AEA - Update of the Handbook on External Costs of Transport - Final Report (Ricardo-AEA/R/ ED57769). Retrieved from https://ec.europa.eu/transport/sites/transport/files/themes/sustainable/studies/doc/2014-handbook-external-costs-transport.pdf
[44] Idem, Recital (41)

5.3 Step 2: Identification of the valuation rates and assumptions

In step 5.2 we had identified those passenger cars fitted with eCall among all passenger cars registered in Europe and described the changes in the stock. Furthermore, we had determined the proportion of vehicles presented for the PTI and the projection of accidents. In this step, the defect rates of the individual eCall components as described in WP3 are taken into consideration. The number of vehicles in which the eCall system is no longer functional can then be deduced.

If in the event of an accident, an eCall is initiated too late or the transmitted information is incomplete or not sent at all, there are far-reaching consequences. These affect the two impact areas of road safety and traffic efficiency.

The primary effect of the use of the eCall safety function affects the field of road safety and consists of the reduction in rescue times in the event of severe accidents involving personal injury. Provision of assistance to those affected more quickly can mean the difference between a fatal and a severe injury, or between a severe and a slighter injury.

Alongside these primary safety effects, a reduction in the length of traffic jams in cases of accidents involving personal injury can be described as a secondary effect. Here, the congestion effects are directly resultant from the level of severity of the accident and are incorporated into the overall economic cost accounting as economic losses. The eCall safety function thus contributes to the avoidance of congestion costs and thereby impacts the field of traffic efficiency.

To summarise, the impact of the inspection and the possible subsequent repair of defective eCall systems can be characterized as follows:

1. Economic benefit through the improvement of road safety through:

- Reduction in the number of fatalities
- Reduction in the number of severe injuries

2. Economic benefit through the improvement of traffic efficiency through

- Reduction in congestion in conjunction with fatalities
- Reduction in congestion in conjunction with severe injuries

Due to the missing of a detection mechanism for errors in the PTI system, the safety level of the function remains limited in scenario 0.

In the other scenarios, the eCall safety function is tested within the scope of the PTI. Depending on the test scenario used, defects in the individual components of the eCall system can be detected with a certain probability of detection, as described in WP3. Using these detection probabilities, the number of vehicles in which the eCall system is detected as no longer being functional is deduced. The detection of these non-functional eCall systems requires restoration of the functionality, thus preserving their safety function.

In order to calculate the benefit of each test scenario, the number of vehicles in which at least one defective eCall component can be identified during the test scenario is of interest. This defect detection results in the ability to correct the defect and to restore the original safety and benefit level of the existing eCall system.

To calculate the number of vehicles detected with faulty eCall systems during the test scenarios, both the defect rates of the individual eCall components and the detection rates for these defects are required.

According to the statements in section 3, the individual probabilities of the defects in the different components are to be considered as statistically independent of one another.

The detection probabilities for defects in individual eCall components also have to be viewed as statistically independent of one another, by Task 2 / WP3. Thus, depending on the specific detection rate for the test scenario, the probability for the detection of an existing defect in at least one eCall component can be determined.

As described above, the effects of the introduction of the test scenarios for eCall within the scope of the PTI affect two areas: road safety and traffic efficiency. The maximum achievable overall benefit is thus comprised of the sum of the partial benefit achievable within these two fields.

The maximum effect of introducing testing of the eCall system regarding improvement in road safety is limited by the number of fatalities and severe injuries that could theoretically be avoided by a properly functioning eCall system – assuming full market penetration of eCall. The theoretical benefit as a result of avoidable fatalities is estimated in the next steps. The theoretical benefit as a result of avoidable severe injuries can then be determined using the ratio of fatalities to severe injuries as stated above.

The real impact of the system is dependent on the current market penetration at the respective time. The real partial benefit regarding the avoidance of fatalities and the avoidance of severe injuries is thus calculated as a product of the respective theoretical partial benefit and the market penetration.

5.4 Step 3: Monetisation of the benefit

In this section, the maximum partial benefits achievable in each area of impact, as quantified in step 2, are given monetary values.

The economic benefit as the result of the improvement in road safety lies in the avoidance of costs that are incurred as the result of accidents. The following table lists the unit costs incurred as a result of fatalities, severe and minor injuries following accidents. The values shown in Table 8 are based on the Deliverable D6.5.1 of the Safespot Project[45] and are updated with inflation rates.

The consequence of the accident	Unit costs
Fatality	€1,370,993
Severe injury	€170,035
Minor injury	€22,288

Table 8: Cost-Unit Rates for Accident Effects updated with inflation rates (based on Safespot; own calculations)

The primary benefit of the function of the eCall system lies in the optimization of the rescue chain, so that appropriate rescue measures are put in place faster, reducing the severity of accident consequences. However, because the accident itself cannot be

[45] Safespot. Delieverable D6.5.1 (2010). Retrieved from http://www.safespot-eu.org/documents/SF_D6.5.1_Socio-economic_assessment_v12.pdf

prevented by the eCall system, it is not the unit costs that have to be considered as the benefit of the avoidance of the stated accident consequences, but rather the difference concerning the unit costs of the next lowest accident consequence category. Table 9 lists the benefits from the avoidance of the particular accident consequences, calculated from the information in Table 8.

Avoidance of the accident consequence	Value
Fatality	€1,200,958
Severe injury	€147,747

Table 9: Benefit resulting from the avoidance of a fatality or severe injury

The economic benefit as a result of the avoidance of fatalities through the application of the test scenario can now be calculated. To this end, the number of fatalities that can be avoided through the application of the test scenario is multiplied with the economic benefit of the avoidance of a fatality. The economic benefit as a result of the avoidance of severe injuries through the application of the test scenario is calculated according to the same principle.

The benefit for traffic efficiency as a result of the avoidance of congestion is calculated using the cost-unit rates for the congestion costs of the corresponding accident consequences[46].

The consequence of the accident	Congestion costs
Fatality	€19,263
Severe injury	€6,213
Minor injury	€6,213

Table 10: Cost-Unit Rates of the congestion costs depending on the accident consequences

As already explained, it is not the associated congestion costs that have to be taken into account as the benefit of the avoidance of the stated accident consequences, but rather the difference concerning the congestion costs of the next lowest accident consequence category. Table 11 below lists the benefits from the avoidance of the particular accident consequences, calculated from the information in Table 10.

Avoidance of the accident consequence	Value
Fatality	€13,050
Severe injury	€0

Table 11: Benefits of the avoidance of congestion depending on the accident consequences

The economic benefit as a result of the avoidance of congestion in conjunction with a fatality through the application of the test scenario can now be calculated. To this end, the number of fatalities that can be avoided through the application of the test

[46] Blincoe, L. J., Seay, A. G., Zaloshnja, E., Miller, T. R., Romano, E. O., Luchter, S., & Spicer, R. S. (2002). The Economic Impact of Motor Vehicle Crashes - 2000. Retrieved from https://rosap.ntl.bts.gov/view/dot/15504;
ICF Consulting (2003). Cost-benefit analysis of road safety improvements - Final Report. Retrieved from London;
Parry, I. W. H. (2004). Comparing alternative policies to reduce traffic accidents. Journal of Urban Economics, 56(2), 346-368. Retrieved from https://doi.org/10.1016/j.jue.2004.04.004

scenario is multiplied with the economic benefit of the avoidance of congestion in conjunction with a fatality.

The economic benefit as a result of the avoidance of congestion in conjunction with a severe injury through the application of the test scenario is calculated according to the same principle.

Because the congestion costs in the event of accidents with severe or minor injuries are set at the same level, the avoidance of congestion in conjunction with a severe injury does not result in an economic benefit.

5.5 Step 4: Calculation of the benefit for each scenario

In this section, the total benefit is calculated according to the findings presented in the previous sections.

The total economic benefit of the introduction of the test scenario during the study year is composed of the partial economic benefit

- of the avoidance of a fatality,
- of the avoidance of a severe injury,
- resulting from the avoidance of congestion in conjunction with a severe injury,
- resulting from the avoidance of congestion in conjunction with a fatality.

In the table below, the average partial benefits and the resulting overall benefits of the scenarios I to IV are presented. The monetised partial benefits are calculated from the annual average benefits of the particular test scenarios calculated over the study period from 2021 in this case, when the PTI for eCall begins to take effect, until 2040.

The partial benefit achievable through an improvement in road safety was characterised by the maximum number of fatalities or severe injuries that could have been avoided as a result of a functioning eCall system in the vehicles.

This benefit can therefore also be distributed across the total number of vehicles fitted with eCall within the vehicle stock. The proportion of fatalities that could be avoided through the application of a specific test scenario, therefore, corresponds to the proportion of vehicles fitted with eCall, whereby a defect can be detected through the application of this test scenario.

The benefit of the application of the test scenario for road safety as a result of the avoidance of severe injuries is calculated according to the same principle.

The following charts show the development of the number of avoided passenger cars with defects, detected via the four different scenarios, cumulative and in a million.

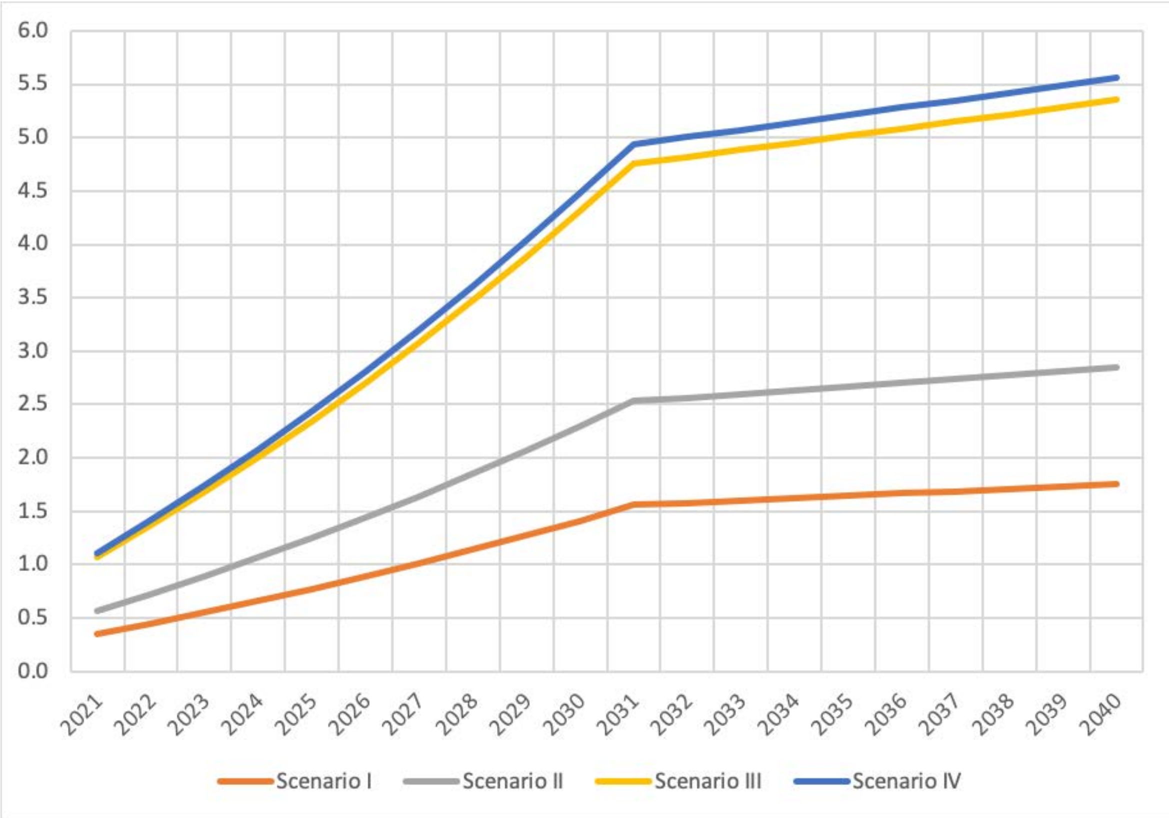

Figure 6: Avoided number of vehicles with defects in million cumulative

The following table shows the average benefit per year for the different scenarios during the study period.

Average Benefit in € per year					
Test Scenario	0	I	II	III	IV
Average partial benefit for the avoidance of	No testing	Testing via warning - indicator lamp	Testing via electrical interface of vehicle Lev. 2	Testing via electrical interface of vehicle Lev. 3	Testing via call
Fatalities	0 €	2,252,526 €	3,654,356 €	6,870,536 €	7,137,107 €
Severe injuries	0 €	4,433,836 €	7,193,178 €	13,523,857 €	14,048,571 €
Congestion (fatality)	0 €	36,130 €	58,616 €	110,203 €	114,479 €
Congestion (severe accident)	0 €	186,450 €	302,485 €	568,701 €	590,766 €
Overall average benefit	0 €	6,908,942 €	11,208,635 €	21,073,296 €	21,890,923 €

Table 12: Average partial and overall benefit of the test scenarios during the study period per year

It should be noted that scenario 0 yields a zero value in all cases since a PTI for eCall is not done and thus there are no costs but also no benefits. For all other values, the average benefit per year over the studio period for each outcome and each scenario is reported.

In Figure 7, the progression of the maximum achievable benefit during the study period for the benefits of avoided accidents per year for fatalities in the respective years is shown.

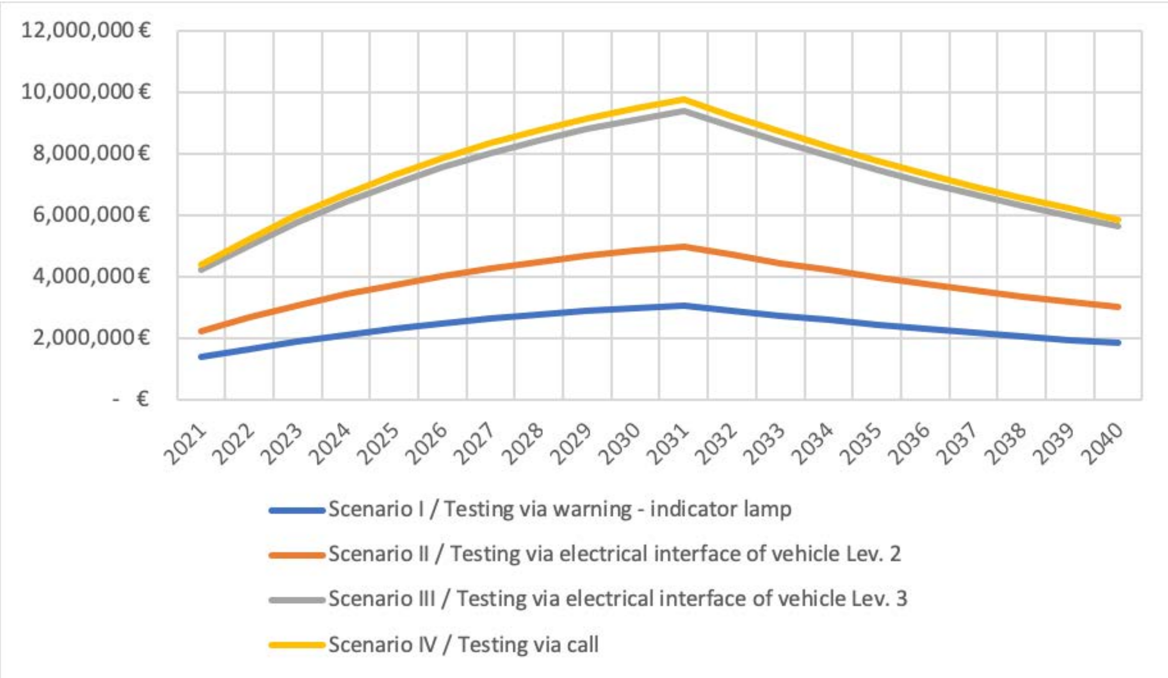

Figure 7: Benefits of avoided fatalities

The impact of the avoidance of severe injuries is calculated under the same conditions.

Figure 8 shows the progression of the maximum achievable benefit per year during the study period for severe accidents.

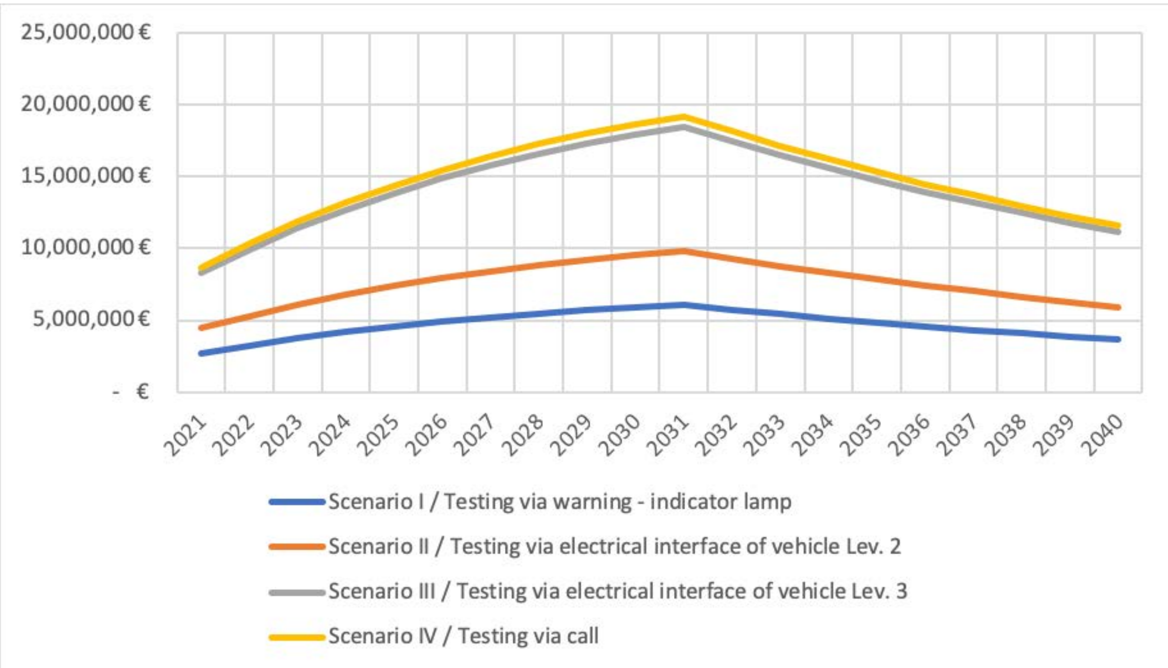

Figure 8: Benefits of avoided severe accidents

A considerable benefit, which is causally linked to the avoidance of numbers of fatalities and severe injuries, exists in the avoidance of congestion and the associated economic losses in the form of congestion costs. Here, the extent of congestion costs correlates directly with the consequences of the accident, such that the maximum partial benefit achievable there can be directly characterised through the avoidable fatalities and severe injuries[47]

5.6 Step 5: Description of the costs

The cost analysis for the introduction of a test scenario for testing the eCall system within the scope of the PTI considers the costs incurred in addition to the previous costs of the PTI for the development, provision, and application of the test scenario. Here, a distinction is made between one-off costs and ongoing costs.

Costs are incurred:

- in each Member State,
- to the automotive manufacturer,
- to the institutions developing the test scenarios,
- to the inspectors,
- testing centres, and
- as process costs for the PTI.

The following graphic shows the cost items described in the text below, as well as their classification.

[47] Recital (46), idem.

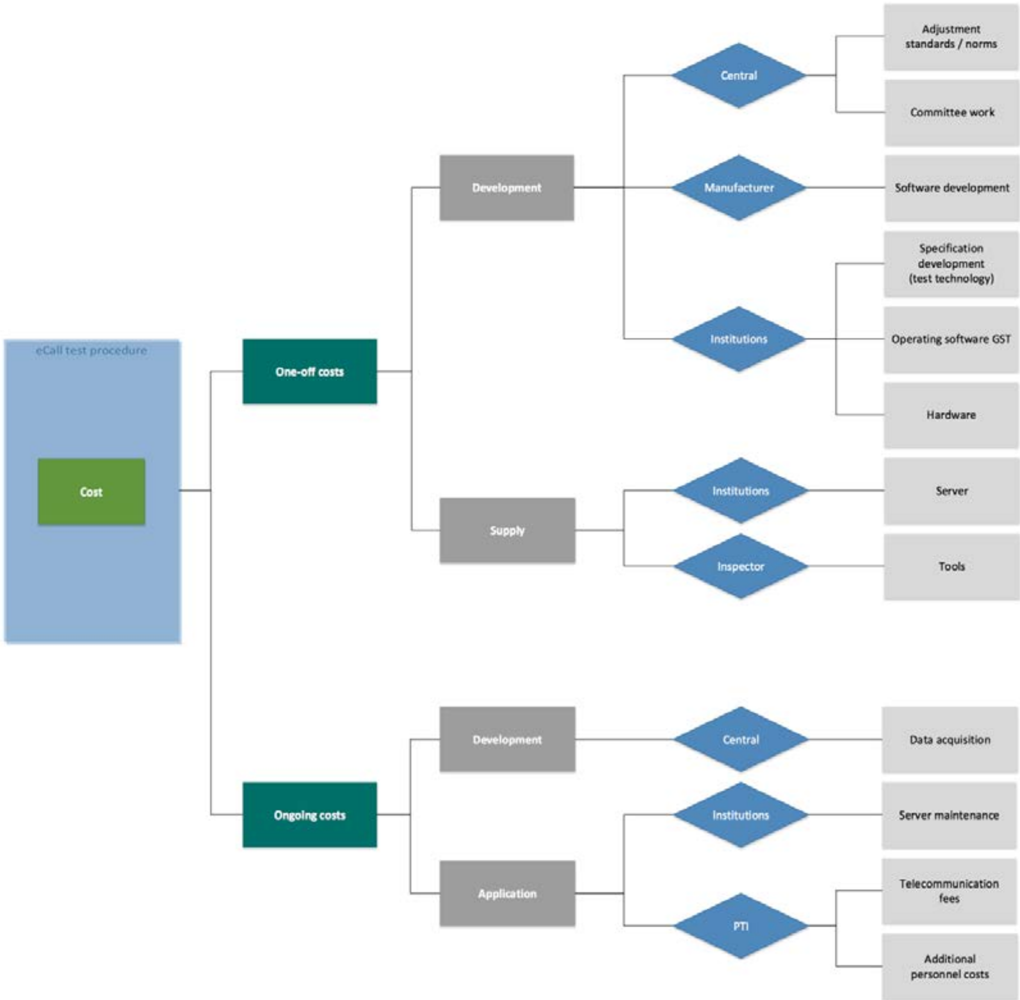

Figure 9: Classification of cost items

In the individual European member states, different pre-conditions currently exist for the introduction of the test scenarios under consideration, in particular with regard to

- organisational framework conditions,
- legal framework conditions,
- technical conditions,
- market-regulating factors, and
- language barriers.

On account of the subsidiarity principle that applies in Europe, it cannot be assumed that throughout Europe, all expenses for the introduction of the test scenarios considered will be met by a specific individual institution.
Thus, throughout this study, 28 institutions for the 28 member states are considered to develop and implement the measures in their respective countries.

5.6.1 One-off costs

The EU-wide one-off costs include all cost items that are incurred on a one-off basis during the development and provision of the particular test scenario under consideration. The total of the EU-wide one-off costs of a test scenario is referred to as

the rated value and is distributed in the form of annual rates of depreciation across the depreciation period, which is defined as ten years.
Following the expiration of this depreciation period, it is assumed that the capital goods will be newly procured. It is assumed that the replacement costs will correspond with the initial procurement costs. The annual rate of depreciation of the one-off costs for the introduction of the test scenario thus incorporates the annual rates of depreciation for all cost items, which are incurred on a one-off basis during the development and provision of the test scenario.

The mandatory equipment for all newly approved vehicle models in categories M1 and N1 from May 2018 requires that all infrastructure investments must have already been implemented in the year of introduction in order to be able to guarantee a vehicle inspection.

Adjustment of existing standards and norms
The amendment of existing standards and norms relates primarily to the adjustments required on the part of the European Committee for Standardization, for example in the area of telecommunications (ETSI).

Committee work
In order to ensure the smooth implementation of test scenarios, it must be possible to guarantee that standards are consistent across Europe. In addition to this, the processes and interfaces relating to the underlying technology must be agreed by all stakeholders within the appropriate committees. These definitions are of even greater practical benefit if they are deemed valid across all vehicle manufacturers and (at least) Europe-wide.

Here, the cost item committee work includes the minimum incurred personnel and travel expenses for such voting procedures, that manufacturers or PTI-providers might have.

Software development by the vehicle manufacturer
The software development costs to the vehicle manufacturer include the estimation of the costs for the drafting of requirement specifications, the additional adjustment of the software for the eCall electronic control unit and the test and safeguarding phases.

Specification development (test technology)
A test scenario includes several test steps. Various costs are incurred on the part of the developing institutions in relation to the definition and selection of the test technologies that form the basis for these test steps. It is assumed that the test scenarios are developed by the relevant institutions in the different Member States, the associated costs are thus for the 28 Member States taken into account and are a maximum value for those costs, since there might be groups of states that will develop test scenarios together.

Software development by the institutions developing test scenarios
The implementation of the test scenarios incurs costs that must be covered. These include, first and foremost, the development of the software for the scan tool which is mandatory from 2023 (see Directive 2014/45/EU), in order to be able to support the testing of the eCall system via the electronic vehicle interface. Furthermore, these also include the costs for the drafting of requirement specifications, the test phase, and safeguarding, and the development of suitable interfaces for the use of the scan tool, including the display of the electronically supported test steps and their result.

The operating software is developed by the institutions developing the test scenario, the associated costs thus is also assumed for the 28 Member States.

For some test scenarios, further technologies are required in addition to the prescribed scan tool; these technologies must then be taken into consideration by the institutions developing the test scenario when designing a suitable test infrastructure. Costs are incurred to the inspector for the realisation of the PTI.

Server
For the “Test Call” test scenario IV the setup and commissioning of at least one analysis server must be realised. Using this analysis server, the quality of the voice recording and playback determined during the PTI and the accuracy of the transmitted location information are assessed.

The operating software is provided by the institutions developing the test scenario; the associated costs thus depend linearly on the 28 institutions.

5.6.2 Ongoing costs

The EU-wide ongoing costs incurred in the study year for the introduction of the test scenarios include the costs of the cost items that are incurred during the development and application of the respective test scenario under consideration during the specific study year.

The cost items attributed to the ongoing costs are described below, these can be subdivided into development costs and application costs. The application costs incurred as PTI process costs are directly dependent on the market penetration with eCall.

In addition to the test technologies on which the test scenarios are based, manufacturer data is also required to perform the test scenario on the vehicle. The ongoing development costs incurred as a result of the continuous acquisition of this data by the institutions developing test scenarios are thus added to the one-off development costs.

Data acquisition
In accordance with so known Block Exemption Regulation[48] , vehicle data must be made available by the vehicle manufacturer for a non-discriminatory fee. The content framework, which is to be provided in addition to the previous scope of data provision, includes information on the installation and design of the components of the eCall system installed in the vehicle and the technical behaviour of the system’s warning and control units.

In the following observations, it is always assumed that data acquisition takes place centrally and that the data is then provided to all institutions developing test scenarios for use in the PTI.

When applying the test scenarios, maintenance costs are incurred on the part of the institutions developing test scenarios for the specifically provided server structure – regardless of the market penetration with eCall. Further application costs in the form of telecommunication fees and additional personnel costs are incurred as PTI process

[48] Commission Regulation (EU) No 461/2010 of 27 May 2010 on the application of Article 101(3) of the Treaty on the Functioning of the European Union to categories of vertical agreements and concerted practices in the motor vehicle sector.

costs. In contrast to the maintenance costs, these application costs are directly dependent on the market penetration with eCall.

Server maintenance
The required provision of an additional server structure for the "test call" test scenario IV incurs annual expenses for the maintenance of the devices, which are reflected in this cost item. An analysis server is maintained by the institutions developing the test scenario; the associated costs thus depend linearly on the number of these institutions.

Telecommunication fees
Due to the use of public regional telecommunications networks, usage fees must be paid in the case of each application of the "test call," test scenario IV. The amount of the telecommunication fee is thus directly dependent on the market penetration with eCall and is calculated as the product of

- the fees for data transfer during the application of the test scenario on an individual eCall system, and
- the number of vehicles with eCall put forward for the PTI.

In an expert rating, the fee for an individual data transfer is estimated by standard fees for telephone connections at €0.03.

Additional personnel costs
The application of the presented test scenarios involves additional time expenditure for the inspector. The amount of the additional personnel is directly dependent on the market penetration with eCall. The costs are calculated as the product

- of the additional personnel costs for the application of the test scenario on an individual eCall system
- the number of vehicles with eCall put forward for the PTI.

The values stated in the table below are taken as the costs for the additional personnel costs for the application of the test scenario on an individual eCall system:

Test scenario I…IV	Additional personnel costs for the application of the test scenario on an individual eCall system
Testing via warning - indicator lamp	€0.035
Testing via electrical interface of vehicle Lev. 2	€0.029
Testing via electrical interface of vehicle Lev. 3	€0.053
Testing via call	€0.251

Table 13: Additional personnel costs for the application of the test scenarios on an individual eCall system

These numbers are calculated by the additional time that is required in order to perform the testing of the eCall functionality. Assuming net labour costs of around 14€ per hour (here in the case for Germany), this translates to the above reported values.

5.7 Step 6: Calculation of the costs

When calculating the costs for the several test scenarios, all of the one-off costs and ongoing costs described before, for the development, provision, and application of the particular test scenario are taken into account. All expenses are recorded with their net present value. Table 14 contains an overview of the relevant cost items estimated by the FSD Fahrzeugsystemdaten GmbH for Germany for each of the test scenarios. Their approximate amounts correspond to the elements that are described in chapter 6.6.1 and 6.6.2 and can be used as representatives for a country with high costs.

The telecommunication costs depend on market penetration with eCall, as well as additional personnel costs and thus these are stated averaged across the study period.

	I	II	III	IV
	Testing via warning - indicator lamp	Testing via electrical interface of vehicle Lev. 2	Testing via electrical interface of vehicle Lev. 3	Testing via call
Annual depreciation amount of the one-off costs				
	86,500 €	510,500 €	920,500 €	3,192,000 €
Ongoing costs each year per institution				
	100,000 €	100,000 €	100,000 €	2,900,000 €
Extra cost of labour per PTI				
	0.035 €	0.029 €	0.053 €	0.251 €

Table 14: Overview of the cost items and their amounts

5.7.1 Total costs

The total costs of the development, provision, and application of the test scenarios during the study year are calculated as the sum of the one-off costs for the year distributed across the depreciation period and the ongoing costs of the test scenario incurred during the study year.

The application costs in the form of the cost items “telecommunications fees” and “additional personnel costs,” incurred as PTI process costs, are directly dependent on the market penetration with eCall.

In particular, additional personnel costs make a considerable contribution to the total costs. Accordingly, consistent increasing cost progressions are expected within the study period for all test scenarios dependent on market penetration. After achieving the market saturation criterion set out in Step 1, the development of the total costs from 2030 onwards runs parallel to the curve for the vehicle stock put forward for the PTI.

Figure 10 shows the development of the total costs for the test scenarios over the entire study period.

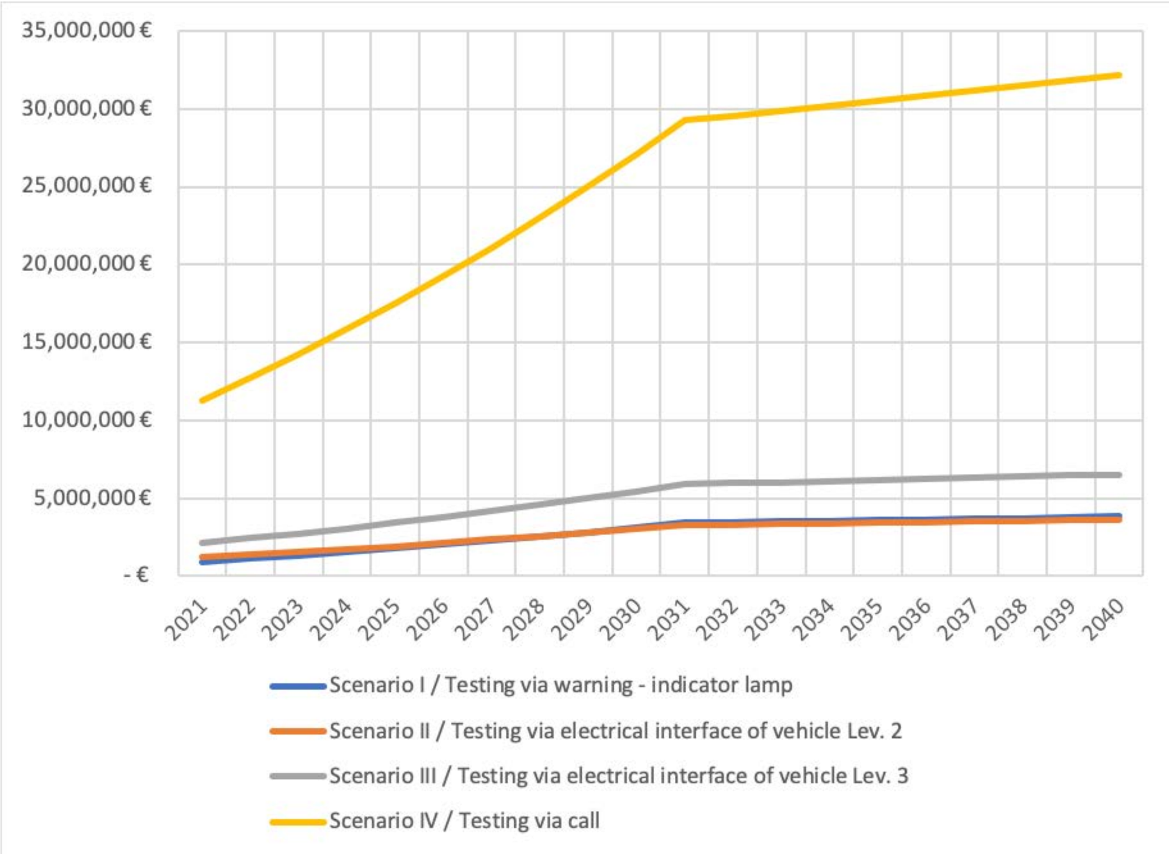

Figure 10: Development of total costs over the study period

5.8 Step 7: Comparison of benefits and costs

The goal of this study is the determination of a scenario-related BCR for each of the four presented test scenarios. This relates to the entire study period and serves for the subsequent determination of the variant with the best benefit-cost ratio. Here, the preferred option is the variant that provides the most significant indirect economic yield (benefit) per euro invested.

For this purpose, the annual BCR's are first of all calculated based on the monetised benefits and costs for the introduction of the test scenario in the respective study years.

Since it is assumed that noteworthy quantities of vehicles with eCall will only be put forward for the PTI in 2019, one year after eCall becomes mandatory, in 2018 the costs are not compensated by any benefit.

To assess the value of the test scenarios over the entire study period, the benefit-cost ratio is calculated as the arithmetical average of all benefit-cost ratios in the respective years during the study period. Table 15 gives the results for these.

	Fatalities	**Fatalities + severe accidents**	**Fatalities + severe accidents + congestion from accidents with fatality**	**Fatalities + severe accidents + congestion from accidents with fatality + congestion from severe accidents**
Scenario 0	-	-	-	-
Scenario I	0.96	2.86	2.90	2.96
Scenario II	1.49	4.43	4.56	4.58
Scenario III	1.57	4.77	4.80	4.82
Scenario IV	0.32	0.96	0.97	0,99

Table 15: Average partial and overall benefit of the test scenarios during the study period

Figure 11 shows the development of the benefit-cost ratio with regards to fatalities + severe accidents + congestion from accidents with fatalities + congestion from severe accidents for the four different test scenarios in the respective years from 2021 until 2040.

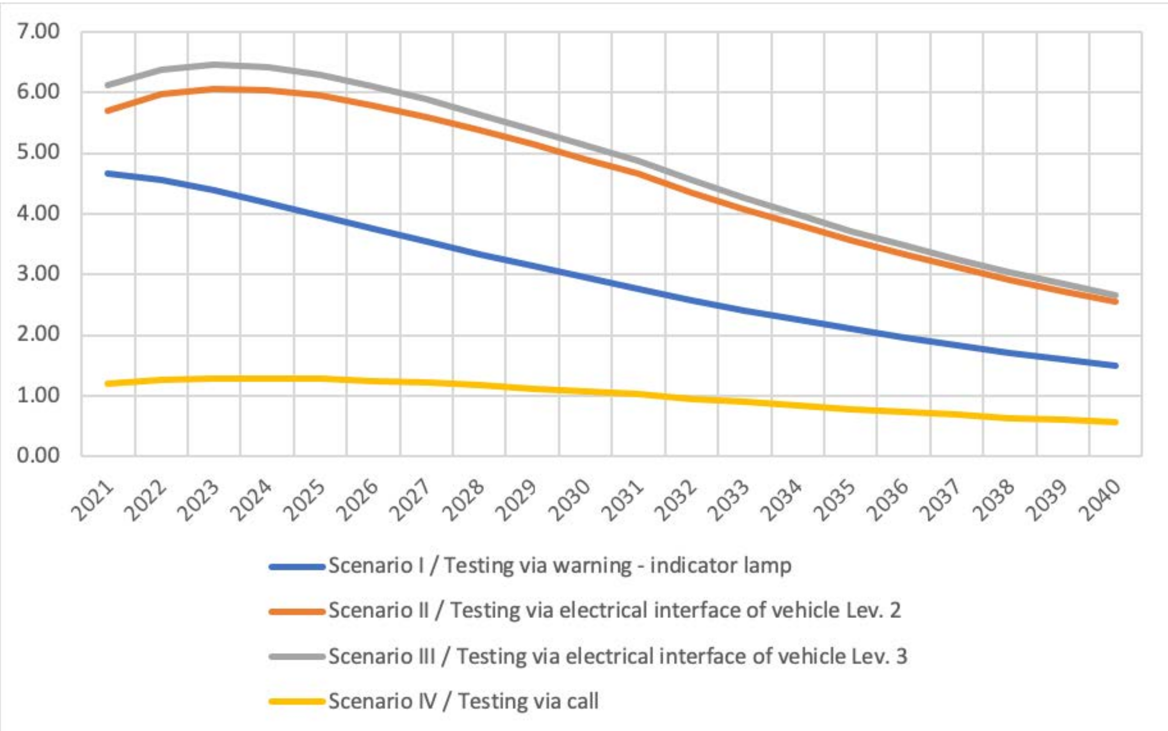

Figure 11: Development of benefit-cost ratio

5.9 Results of the cost-benefit analysis for the different eCall test scenarios

The results of the cost-benefit analysis are differentiated according to the scenarios and are shown for 28 institutions introducing the procedure.

For each of the five proposed test scenarios

- Test scenario I: Testing via warning - indicator lamp
- Test scenario II: Testing via electronic vehicle interface Level 2
- Test scenario III: Testing via electronic vehicle interface Level 3
- Test scenario IV: Testing via call

The benefit-cost ratios are summarised for all outcomes as an arithmetical average across the study period for the highest possible outcome, considering fatalities and severe accidents and also the congestion from accidents with fatality and the congestion from severe accidents. These can serve as a basis for decision-making.

	Benefit-Cost Ratio (BCR)
Scenario I	2.96
Scenario II	4.58
Scenario III	4.82
Scenario IV	0.99

Table 16: Benefit-cost ratio for all test scenario with 28 institutions introducing the procedures

Scenario III achieves the highest benefit-cost ratio. A benefit-cost ratio greater than one is achieved by scenarios I, II and III. This means that, for those test scenarios, the necessary investments are accompanied by more significant social and economic benefits.

The testing via a call (Scenario IV) with a benefit-cost ratio of 0.99 is below one and as such, the investment costs are greater than the accompanied benefits.

The testing via a warning/indicator lamp (Scenario I) with a benefit-cost ratio of 2.96 remains the test scenario with the lowest value. Test scenarios II and III are both much higher and close to each other with a benefit-cost ratio of 4.58 (testing via the electrical interface of the vehicle level 2) and 4.82 (testing via the electrical interface of the vehicle level 3), with Scenario III having the highest benefit-cost ratio with 4.82.

Overall, it can be stated that the effect of testing of the eCall system in periodic technical inspections would have an economic benefit for the whole society since the estimated benefit is larger than the estimated cost.

The case of false alarms has not been included in this analysis, and while one could argue that false alarms should be included, in the cost-benefit analysis, we deliberately chose not to include them. The audio components of the eCall safety system are necessary in the case of false calls to inform the PSAP that deployment of emergency services is not required. Detecting defects in the audio components can therefore prevent false deployments and thus contribute to an optimised rescue chain.

In order to issue the all-clear in the case of false calls, a functioning voice connection to the PSAP is essential. The proper function of the audio components of the eCall safety system ensures that this remains possible. If false calls are not issued the all-clear in due time, costs are incurred as the result of the triggering of an unnecessary rescue operation. The costs for these rescue operations are to a large extent dependent on the organisational structure of the emergency services within the individual European member states. While the false alarms are also related to human behaviour, the extent to which these will happen is not yet assessable. While the general PTI of the eCall system will lower defects in the passenger cars in question, this might also have a positive effect on false calls, meaning that the errors detected and fixed, will not lead to false calls either. However, there is no data yet available on how many false calls a defect would cause. Since any estimation would be very vague, the issue of false calls should be monitored and a separate study after a couple of years of the introduction of the eCall system should take place, evaluating the financial impact of false calls. Since each member state has a different health system and the cost-unit rates will differ substantially for the rescue operations. A general cost unit rate for the EU28 is not available and not universally applicable.

The results of the cost-benefit analysis will be taken into consideration in the next working package, containing the recommendations for political decisions.

6 Formulation of policy recommendation

This section deals with the implementation of the results of the cost-benefit analysis in the relevant Regulations, Directives and Standards.

The preferred test scenarios are first selected, then recommendations for their implementation are given.

This section also covers additional recommendations that could improve the cost–benefit factor of the selected test scenarios but are not strictly required for implementation.

6.1 Selection of test scenarios

Section 5 provided a cost–benefit analysis of the test scenarios developed in the Section 4.

The “Without case” test scenario involves neither costs nor benefits. This means that a periodic technical inspection would not find any fault with a non-functional eCall system, which would prevent the system from achieving its full potential in terms of reducing the number of road fatalities. The scenario capable of detecting the most potential faults as part of a PTI is the “Test call” scenario. However, its cost–benefit factor is below one due to the high costs. Neither of the two aforementioned test scenarios will be pursued further due to a lack of financial viability.

The three scenarios with a positive cost–benefit factor are suitable for introducing the evaluation of the eCall system as part of the PTI in Europe. The “Testing via electronic vehicle interface – Level 3” scenario has the best cost–benefit factor (4.78). The “Testing via electronic vehicle interface – Level 2” scenario has a cost–benefit factor of 4.55. The only difference between the “Level 2” variant and the “Level 3” variant is that the “Level 2” variant does not involve testing the MSD and the audio components. The “Testing via warning and indicator lamp” is the simplest variant, but is only capable of detecting a much smaller selection of the faults that can affect an eCall system. The self-test system has a lower detection rate because the technical complexity of monitoring the integrity of some components (e.g., speaker, microphone, control-module configuration) meant that they were omitted when the system was implemented in vehicles.

6.2 Recommendations for implementing the results

Under Article 17 of Directive 2014/45/EU, the Commission is empowered to adopt a delegated act in order to make additions to "the list of test items, methods, reasons for failure and assessment of deficiencies".

As shown in Section 4.4 the modular nature of each individual test scenario makes it possible to identify the necessary testing methods and how they detect specific faults. Recommendations for adding eCall to Annex I and Annex III of Directive 2014/45/EU are provided and justified below.

6.2.1 Directive 2014/45/EU Annex I – minimum requirements concerning the contents and recommended methods of testing

For the incorporation of the results of this study into Annex I of Directive 2014/45/EU, two variants were developed. The variants have the same technical content, and differ only in structure. The three test scenarios with positive cost–benefit factors are broken down into different sub-items based on the modules involved in each scenario.

Proposal Variant A:

Item	Method	Reason for failure	Assessment of deficiencies		
			Minor	Major	Dangerous
7.13 eCall					
7.13.1 Fitment	Visual inspection	(a) System or any component missing		X	
7.13.2 Configuration	Using electronic interface y reading out the software version and the configuration of the system	(a) Software version incorrect		X	
		(b) System coding incorrect		X	
		(c) Software tampering		X	
7.13.3 Condition	Visual inspection	(a) System or components damaged		X	
		(b) eCall MIL indicates any kind of failure of the system		X	
	Use of electronic interface by reading out all failure information	(a) eCall electronic control unit failure		X	
		(b) Mobile network communication device failure		X	
		(c) GPS signal failure		X	
		(d) Audio components not connected		X	
		(e) Power source not connected Power source insufficient charge		X X	
		(f) System indicates any other kind of failure not listed under (a)-(e) via the electronic vehicle interface		X	
7.13.4 Performance	Using electronic interface by reading out the minimum set of data and testing the audio-components (e.g. echo-test)	(a) Minimum set of data (MSD) incorrect		X	
		(b) Audio components not working in order		X	
		(c) Mobile communication jammed		X	

It has been considered that starting on May 21st, 2023, inspection centres shall have a device to connect to the electronic vehicle interface, such as an OBD scan tool.

Justification for Variant A:

The eCall system is a complex system comprising a large number of sensors and actuators (see Section 5.3 – eCall - components and their defect rate). Significantly more components play a role in the eCall system functioning properly compared to a normal electronic safety system (e.g. airbag). The entire eCall system can be rendered completely ineffective if a single component fails or is damaged.

Due to the variation between different evaluation methods, it makes sense to divide the item into various sub-items. Variant A provides a clear and concise overview of which testing methods can be used to identify a “reason for failure” and assign it to the relevant “deficiencies”. A similar format is used several times in Directive 2014/45/EU (e.g. item 4.1 “Headlamps”) and has been shown to be practicable.

The testing methods are restricted to the methods that already exist in Directive 2014/45/EU, i.e. “the visual inspection and the usage of the electronic interface”.

The description of the usage of the electronic interface is improved by specifying the electronic test step (e.g. “reading out all failure information”) so that it can be assigned to the actual “reason for failure”.

The “reasons for failure” are the results of the analysis of the identified faults from Section 4.2. For the sake of simplicity, the specific fault names were adapted to approximate how faults are normally referred to in Directive 2014/45/EU. Care was taken to reflect the fact that visual inspections are of limited use when attempting to detect failures in the system, even when using the MIL.

Due to the differences in how different countries have incorporated Directive 2014/45/EU into their legal systems, we recommend that the expansion of Directive 2014/45/EU gives member states the option to decide whether the use of the electronic interface should be mandatory when testing the eCall system. For this reason, the “Configuration”, “Condition” and “Performance” items would only be considered binding once the obligation to provide the test equipment for using the electronic interface (Annex III, 1. Facilities and equipment (14)) is imposed.

Proposal Variant B:

Item	Method	Reason for failure	Assessment of deficiencies		
			Minor	Major	Dangerous
7.13 eCall					
7.13.1 Fitment and configuration	Visual inspection and using electronic interface by reading out the software version and the configuration of the system	(a) System or any component missing		X	
		(b) Software version incorrect		X	
		(c) System coding incorrect		X	
		(d) Software tampered		X	
7.13.2 Condition	Visual inspection and using electronic interface by reading out all failure information	(a) System or components damaged		X	
		(b) eCall MIL indicates any kind of failure of the system		X	
		(c) eCall electronic control unit failure		X	
		(d) Mobile network communication device failure		X	
		(e) GPS signal failure		X	
		(f) Audio components not connected		X	
		(g) Power source not connected or insufficient charge		X	
		(h) System indicates failure via the electronic vehicle interface		X	
7.13.3 Performance	Visual inspection and use of electronic interface by reading out the minimum set of data and testing the audio components (e.g. echo-test)	(a) Minimum set of data (MSD) incorrect		X	
		(b) Audio components not working in order		X	
		(c) Mobile communication jammed		X	

It has been considered that starting on May 21st, 2023, inspection centres shall have a device to connect to the electronic vehicle interface, such as an OBD scan tool.

Justification for Variant B:

Variant B is in line with the current structural approach of Directive 2014/45/EU and can be recommended as an alternative to variant A without restriction.

6.2.2 Directive 2014/45/EU Annex III – minimum requirements concerning roadworthiness facilities and test equipment

The recommended additions to Annex I do not require any additional test equipment. The proposed methods would not necessitate any additional requirements for roadworthiness facilities in accordance with Annex III. This applies to both the visual inspection and the usage of the electronic interface. The necessary scan tool is already required in Directive 2014/45/EU, Annex III, I. Facilities and equipment (14): “A device to connect to the electronic vehicle interface, such as an OBD scan tool”.

6.3 Additional recommendations

The following recommendations relate to the relevant regulations and acts of the European Union, as well as the legal implementation of the eCall test method selected. These additional recommendations are not required in order to add eCall to Directive 2014/45/EU Annex I. The purpose of the following recommendations is merely to provide an overview of the relevant regulations, acts or standards that could be amended in future in order to increase the cost–benefit factor of the selected test method by further reducing the cost of implementing diagnostics and providing data. Some of the regulations addressed in this section are still being drafted and have yet to be published. This section also contains suggestions that could facilitate the international harmonization of eCall testing.

6.3.1 Amendment to Draft Commission implementing act on the technical information necessary for roadworthiness testing of the items to be tested, on the use of the recommended test methods, and establishing detailed rules concerning the data format and the procedures for accessing the relevant technical information

The information necessary for eCall testing as previously described has to be already provided as repair and maintenance information according to Article 3(14) of Regulation (EC) No 715/2007. No new requirements would be needed in this area.

However, if the Commission intends to make additions to the information that must be provided in accordance with Annex I of the Implementing Regulation, the following information should be added to the Annex:

- Information about the warning and control units
- Basic diagnostic information
- List of all failure information
- Fitment test information including the permitted hardware and software numbers
- Diagnostic sequences and diagnostic services necessary to access the failure-storage, to read the MSD, to trigger the audio-components and to read the hardware and software number.

6.3.2 Regulation 2017/79

It would not be necessary to expand Regulation 2017/79 in order to be able to carry out the recommended methods.

However, the PTI should be taken into consideration at an early stage of the vehicle development process. This is particularly important when it comes to implementing diagnostic functions. These functions must be available at a uniform quality level for every model of vehicle and every manufacturer. We therefore fully endorse the 2015 recommendation of the European Commission and TRL[49] for the "Provisions for the periodic technical inspection", in which the OBD diagnostic functions are included in PTI requirements at the type approval stage.

6.3.3 ISO/WD 20730 standardization

The ISO is currently working on ISO Standard 20730 "Road Vehicles – Vehicle roadworthiness interface for electronic Periodical Technical Inspection (ePTI)". We are currently unable to address the precise content of the standard as the draft is confidential and yet to be published.

However, we recommend that eCall be considered in the standard and that the relevant requirements for "diagnostic sequences" and "diagnostic services" to access the failure-storage, to read the MSD, to trigger the audio components and to read the hardware and software-number" be defined in the standard. Implementing these recommendations would have the advantage of significantly reducing the amount of data that needs to be provided, thereby reducing the cost of doing so. This would provide the relevant methods with an even better cost-benefit factor.

6.4 Summary

With the exception of the addition to Annex I of Directive 2014/45/EU Discussed in Section 6.2.1, no other changes to the current legislation are required. Any modification of the Commission implementing act on the technical information necessary for roadworthiness testing is to be assessed once published.

The following supplementary measures could bring about further improvements to the cost efficiency of testing eCall systems as part of the PTI:

- Adding requirements to Regulation 2017/79 to ensure that the eCall system can be later tested efficiently and effectively during the PTI
- Standardization of the functions of the electronic interfaces of vehicles required for the purpose of testing eCall systems as part of the PTI

[49] TRL 2015, eCall Phase 2 - Technical requirements and test procedures for the type - approval of eCall in-vehicle systems

Annex 1 - Survey

DG MOVE PROJECT - Study on the inclusion of eCall in the periodic roadworthiness testing of motor vehicles

The questionnaire includes a set of general questions to be answered by all participants and more specific questions per stakeholder groups (roadworthiness experts and policy makers). Participants can decide to answer all questions or questions specific to the group to which they belong. For most of the questions, you have the possibility to explain your answer. This information is valuable and we would appreciate to receive any information justifying your answers.

We expect to receive your answers before 31 May 2018. Thank you in advance for your cooperation!

If you have any doubts, please contact Mr J.-F. Gaillet at jean-francois.gaillet@vias.be

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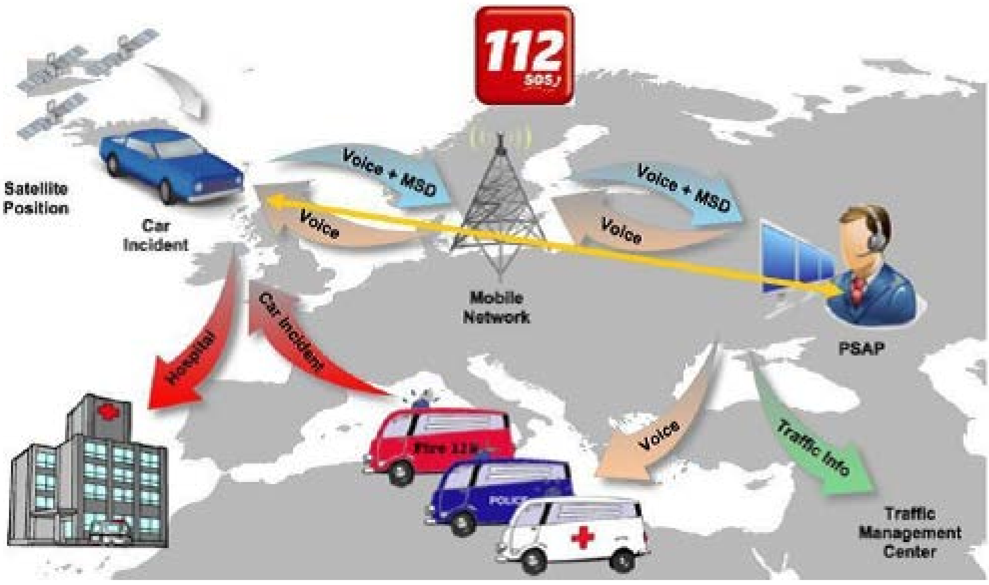
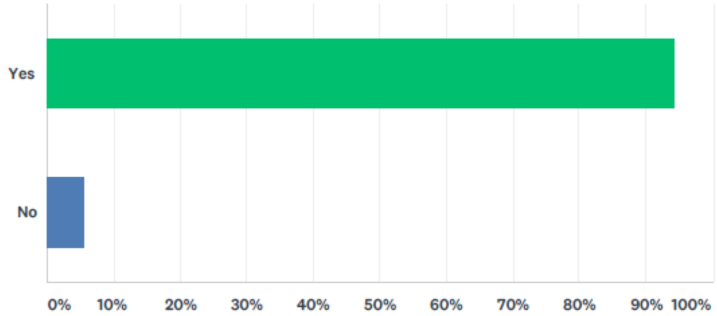
The process chain and functionality of eCall is shown in the list and the figure below:

- initialization of an eCall
- call set up via mobile network
- establishment of a call
- Transmission of the MSD (Minimum Set of Data) with the 3GPP modem (3GPP: 3rd Generation Partnership Project. In this context, it means that the modem is using standards for mobile communications (2G, 3G …))
- bi-directional voice communication
- disconnection of call



Q1 Are you familiar with the concept/principles of the public eCall system in general?

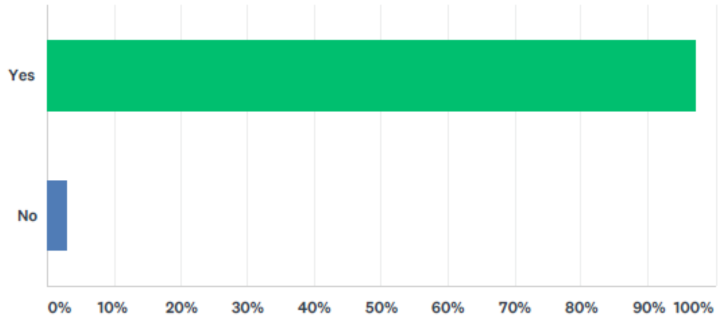
Answered: 35 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	94.29%	33
No	5.71%	2
TOTAL		35

Q2 Did you know that public eCall is using 112?

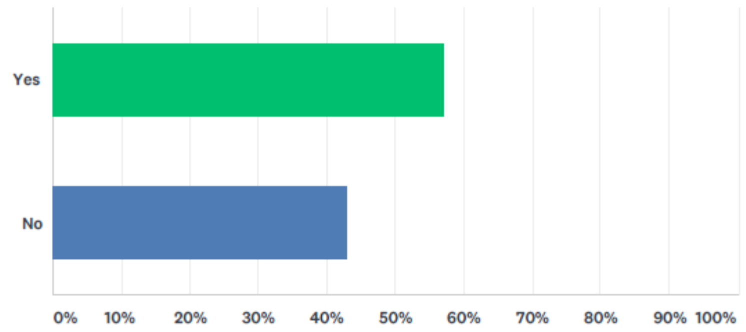
Answered: 35 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	97.14%	34
No	2.86%	1
TOTAL		35

Q3 Have you ever seen or tested a vehicle equipped with an eCall system (public eCall via 112 or Third Party Systems (TPS) eCall provided by a car maker)?

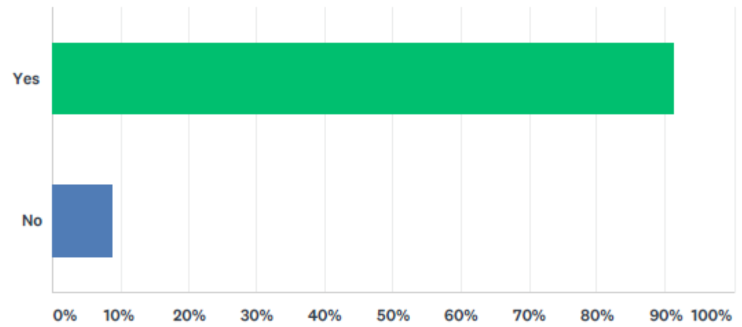
Answered: 35 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	57.14%	20
No	42.86%	15
TOTAL		35

Q4 Do you believe that the in-vehicle eCall system should be tested during the periodic roadworthiness test of the vehicle?

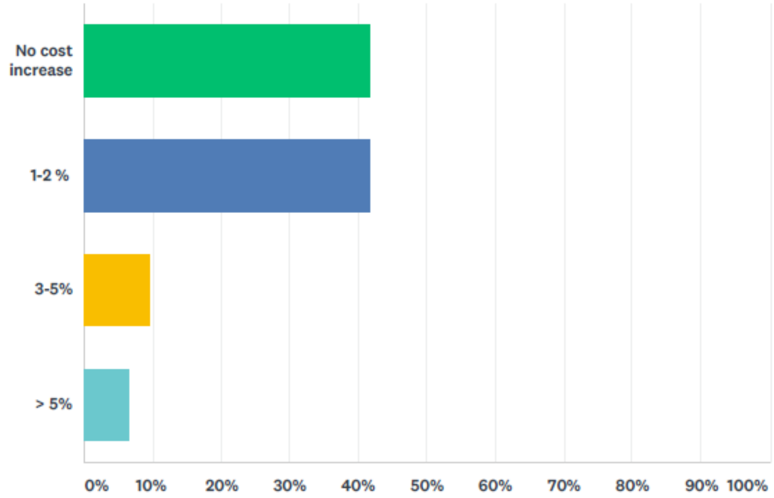
Answered: 34 Skipped: 1



ANSWER CHOICES	RESPONSES	
Yes	91.18%	31
No	8.82%	3
TOTAL		34

Q5 If you answered “Yes” to question 4, what would be an acceptable price increase to the cost of the test for the customer?

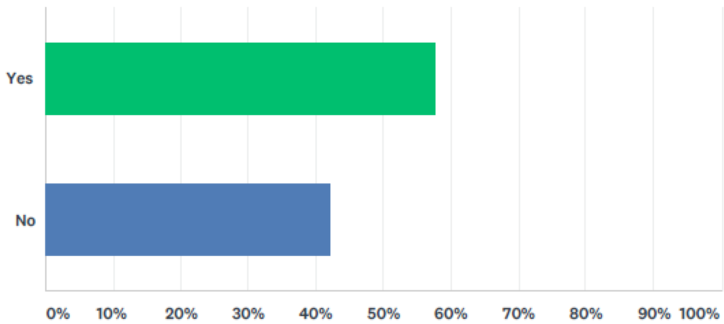
Answered: 31 Skipped: 4



ANSWER CHOICES	RESPONSES	
No cost increase	41.94%	13
1-2 %	41.94%	13
3-5%	9.68%	3
> 5%	6.45%	2
TOTAL		31

Q6 Would it be acceptable to invest in roadworthiness centres or to equip mobile inspectors (for example to purchase specific testing equipment) to test eCall systems?

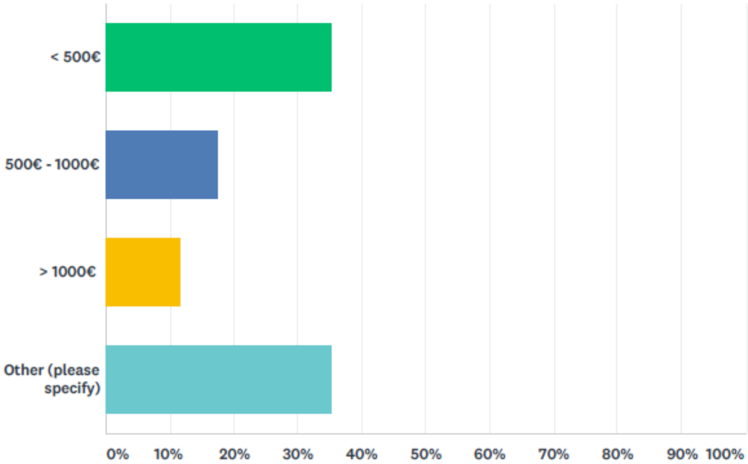
Answered: 26 Skipped: 9



ANSWER CHOICES	RESPONSES	
Yes	57.69%	15
No	42.31%	11
TOTAL		26

Q7 If you answered with 'yes', have you any thoughts on what might be the minimum level of investment acceptable per testing centre or to equip mobile inspectors?

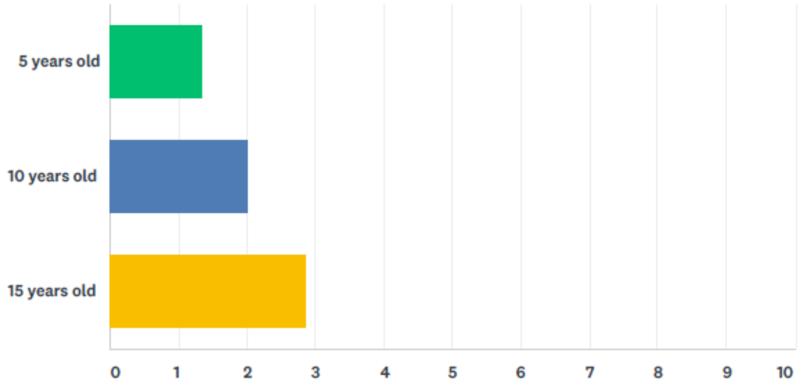
Answered: 17   Skipped: 18



ANSWER CHOICES	RESPONSES	
< 500€	35.29%	6
500€ - 1000€	17.65%	3
> 1000€	11.76%	2
Other (please specify)	35.29%	6
TOTAL		17

Q8 How high would you estimate the chance of (parts of) an in-vehicle eCall system (loudspeaker, SIM module, antennas, etc.) to show faulty behaviour if the car is:

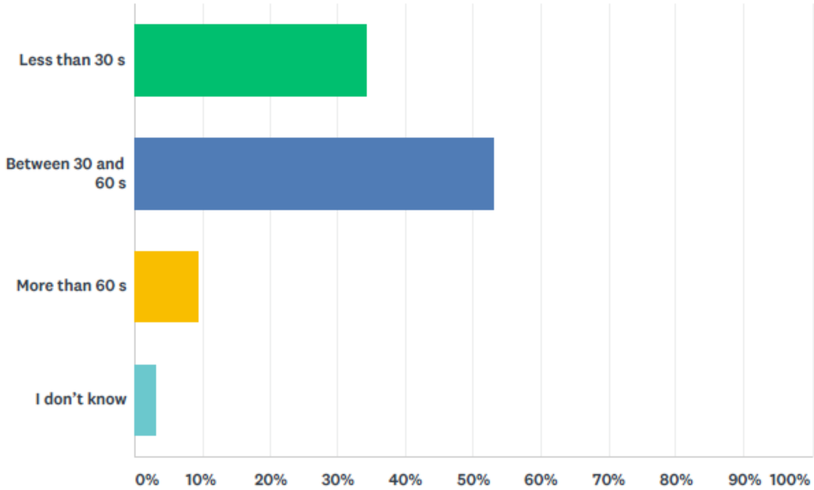
Answered: 29 Skipped: 6



	LOW (<2%)	MEDIUM (2-5%)	HIGH (5-10%)	VERY HIGH (>10%)	(NO LABEL)	TOTAL	WEIGHTED AVERAGE
5 years old	79.31% 23	13.79% 4	3.45% 1	0.00% 0	3.45% 1	29	1.34
10 years old	34.48% 10	41.38% 12	17.24% 5	3.45% 1	3.45% 1	29	2.00
15 years old	17.24% 5	17.24% 5	34.48% 10	24.14% 7	6.90% 2	29	2.86

Q9 What would be a reasonable execution time for an eCall test-procedure during the periodic roadworthiness test?

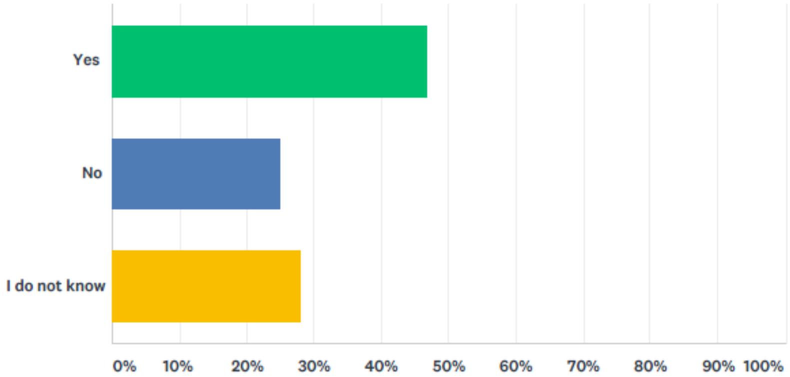
Answered: 32 Skipped: 3



ANSWER CHOICES	RESPONSES	
Less than 30 s	34.38%	11
Between 30 and 60 s	53.13%	17
More than 60 s	9.38%	3
I don't know	3.13%	1
TOTAL		32

Q10 Directive 2014/45/EU already recommends generic test methods and specific test methods for some items in Annex I. Would you find it suitable to introduce new test methods for testing eCall beyond what is in the directive (see also background information point a) above)?

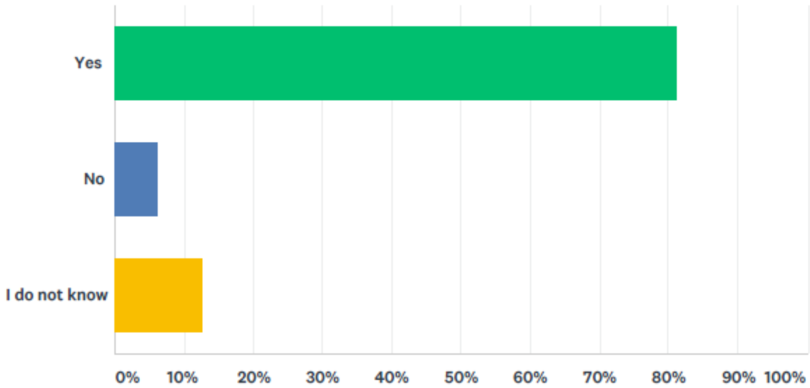
Answered: 32 Skipped: 3



ANSWER CHOICES	RESPONSES	
Yes	46.88%	15
No	25.00%	8
I do not know	28.13%	9
TOTAL		32

Q11 Should an eCall test method be aligned with the existing test method for other electronic safety systems which are listed in Annex I of Directive 2014/45/EU (e.g. Airbag, ESP, ABS, etc.)?

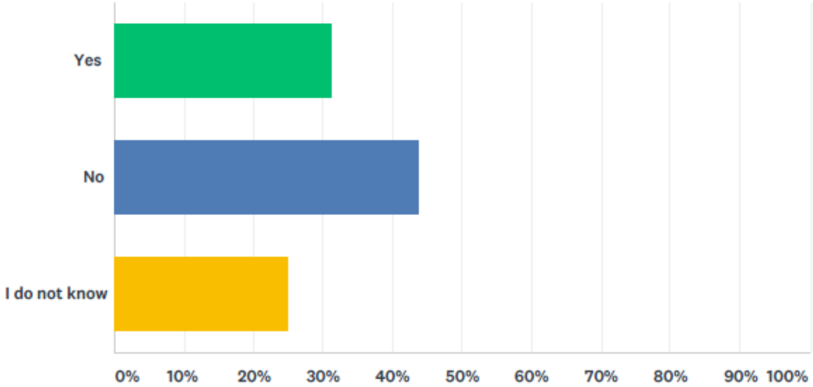
Answered: 32 Skipped: 3



ANSWER CHOICES	RESPONSES	
Yes	81.25%	26
No	6.25%	2
I do not know	12.50%	4
TOTAL		32

Q12 Do you think that the manufacturer specific self-diagnosis (see background information point e)) of eCall is reliable and trustworthy for use in the periodic roadworthiness test as a potential test method?

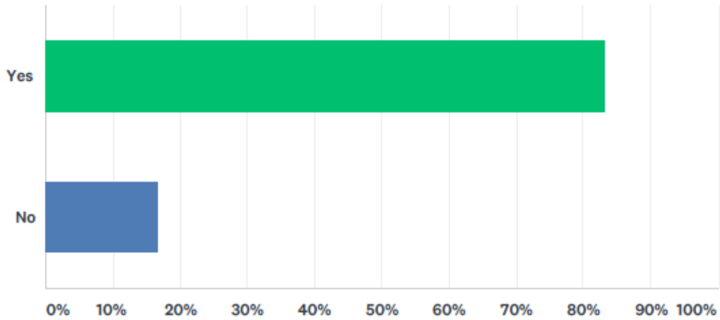
Answered: 32 Skipped: 3



ANSWER CHOICES	RESPONSES	
Yes	31.25%	10
No	43.75%	14
I do not know	25.00%	8
TOTAL		32

Q13 If “Yes”, should it be a part of the eCall test method?

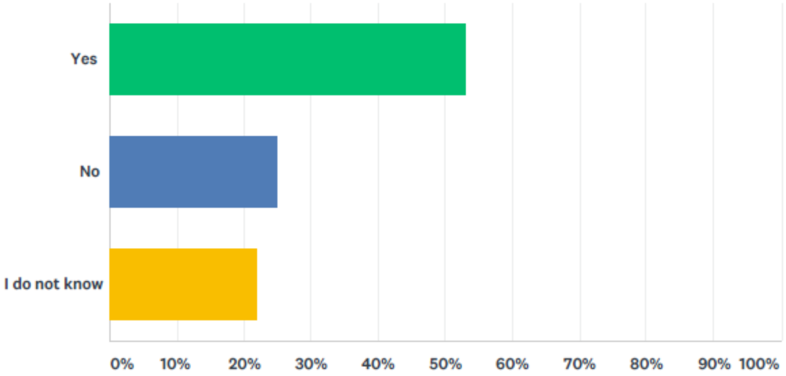
Answered: 18 Skipped: 17



ANSWER CHOICES	RESPONSES	
Yes	83.33%	15
No	16.67%	3
TOTAL		18

Q14 Do you think that the eCall test should include a check on the accuracy of the Minimum Set of Data (MSD – See background information above for details)?

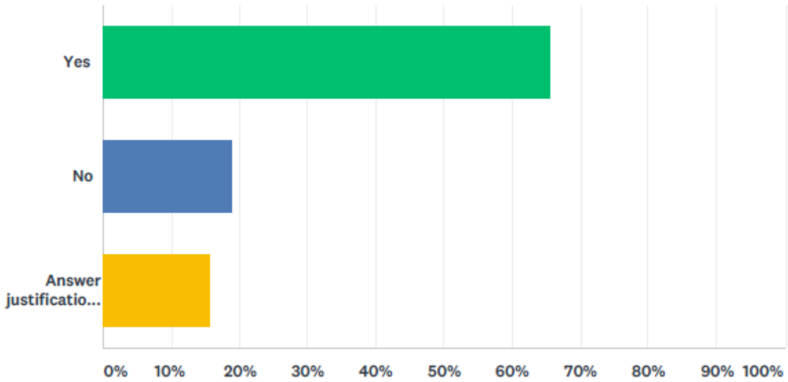
Answered: 32 Skipped: 3



ANSWER CHOICES	RESPONSES	
Yes	53.13%	17
No	25.00%	8
I do not know	21.88%	7
TOTAL		32

Q15 Do you think that the check of audio components should be part of the eCall test? This test should aim to check if the audio components are properly installed and functioning.

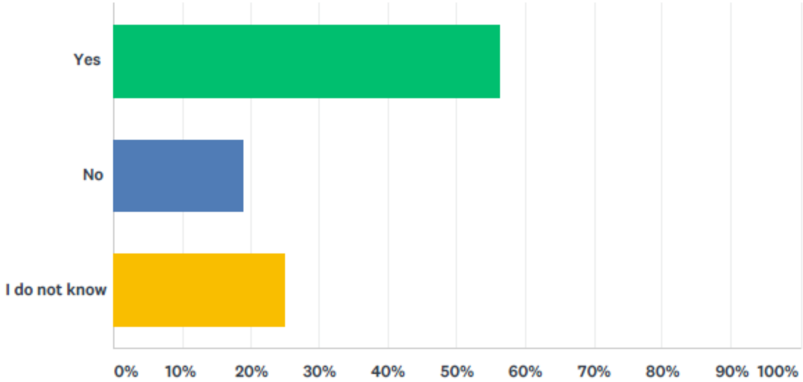
Answered: 32 Skipped: 3



ANSWER CHOICES	RESPONSES	
Yes	65.63%	21
No	18.75%	6
Answer justification / comment / additional information :	15.63%	5
TOTAL		32

Q16 Do you think that an integrity test of the software-version of the eCall system should be part of the test (this would ensure that the vehicle is using an approved eCall software version). See also background information above for further details.

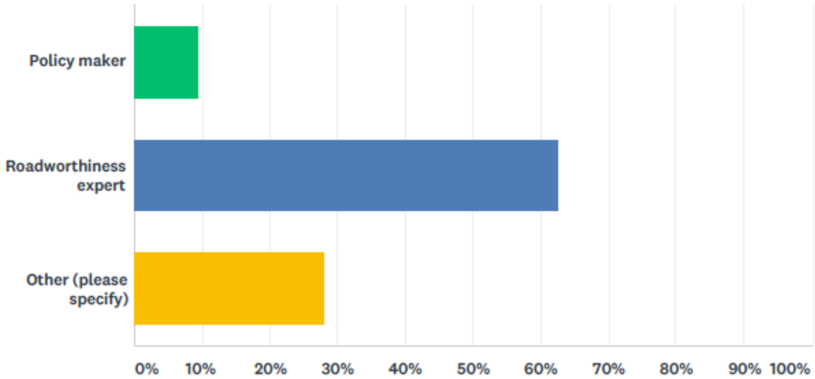
Answered: 32 Skipped: 3



ANSWER CHOICES	RESPONSES	
Yes	56.25%	18
No	18.75%	6
I do not know	25.00%	8
TOTAL		32

Q20 You are:

Answered: 32 Skipped: 3



ANSWER CHOICES	RESPONSES	
Policy maker	9.38%	3
Roadworthiness expert	62.50%	20
Other (please specify)	28.13%	9
TOTAL		32

NOTE: Questions 17-19 are related to personal data of respondents.

Annex 2 Estimation of the number of casualties that would be avoided with the introduction of eCall as well as cost savings related to fatalities, injuries and congestion savings

TABLE 2 - CALCULATIONS FOR BASELINE YEAR 2008

Country	Population	Accidents	Acc. x1M hab.	Fatalities	Fat.x 1M hab.	Injured	Injur.x 1M hab.	Seriously Injured	S.I.x 1M hab.	Cluster No	Fatalities Saving perc.	Number Fatalities Saved	Fatalities Cost Saving	Severity Reduct. Perc.	Severity Reduct. Savings	Injuries Costs Saving	Total Congestion Costs	Perc. Congest. reduction	Congestion Costs Saving	Total costs saving 2008
BELGIUM	10.666.866	42.115	3.948	944	88	55.643	5.216	6.013	564	5	5,00%	47,20	67.464.130	6,00%	541	115.850.311	1.601.590.736,66	17%	272.270.425,23	323.108.466,08
BULGARIA	7.640.238	8.045	1.053	1.061	139	9.952	1.303	2.930	383	6	6,00%	63,66	90.990.816	6,00%	264	56.451.258	321.580.537,12	17%	54.668.691,31	235.707.208,51
CZECH REP.	10.381.130	22.481	2.166	1.076	104	28.501	2.745	3.743	361	5	5,00%	53,80	76.897.674	7,50%	421	90.143.796	843.682.228,10	10%	84.368.222,81	272.032.984,20
DENMARK	5.475.791	5.020	917	406	74	5.923	1.082	2.831	517	5	5,00%	20,30	29.015.293	5,00%	212	45.453.217	182.513.288,86	10%	18.251.328,89	134.615.244,93
GERMANY	82.217.837	320.614	3.900	4.477	54	409.047	4.975	70.644	859	4	4,00%	179,08	255.963.483	5,00%	5.298	1.134.227.144	11.676.769.071,39	17%	1.985.050.742,14	2.721.996.616,66
ESTONIA	1.340.935	1.868	1.393	132	98	2.398	1.788	350	261	5	5,00%	6,60	9.433.544	5,00%	26	5.619.437	72.618.036,75	17%	12.345.066,25	26.051.570,50
IRELAND	4.401.335	6.736	1.530	280	64	9.747	2.215	835	190	5	6,00%	16,80	24.012.656	6,00%	75	16.087.645	285.065.021,57	10%	28.506.502,16	65.744.056,50
GREECE	11.213.785	15.083	1.345	1.553	138	19.010	1.695	1.872	167	6	6,00%	93,18	133.184.484	6,00%	168	36.067.152	595.621.603,38	17%	101.255.672,58	262.696.300,27
SPAIN	45.283.259	93.161	2.057	2.656	59	121.391	2.681	16.932	374	3	6,00%	159,36	227.777.198	6,00%	1.524	326.222.762	3.517.526.779,36	10%	351.752.677,94	942.373.555,11
FRANCE	64.004.333	74.487	1.164	4.275	67	93.798	1.465	34.965	546	4	4,00%	171,00	244.414.539	5,00%	2.622	561.381.746	2.805.488.886,59	10%	280.548.888,66	1.523.772.049,89
ITALY	59.619.290	218.963	3.673	4.731	79	310.739	5.212	43.350	727	4	4,00%	189,24	270.485.423	5,00%	3.251	696.007.399	8.922.809.467,74	17%	1.516.877.609,52	1.874.096.941,58
CYPRUS	789.269	1.392	1.764	82	104	1.963	2.487	280	355	5	5,00%	4,10	5.860.232	6,00%	25	5.394.659	58.419.122,66	17%	9.931.250,85	19.133.656,05
LATVIA	2.270.894	4.196	1.848	316	139	5.408	2.381	792	349	6	6,00%	18,96	27.099.998	6,00%	71	15.259.180	164.490.149,19	17%	27.963.325,36	67.924.957,48
LITHUANIA	3.366.357	4.897	1.455	499	148	5.940	1.765	875	260	6	6,00%	29,94	42.793.984	6,00%	79	16.858.311	186.653.124,29	17%	31.731.031,13	93.791.869,84
LUXEMBOURG	483.799	927	1.916	35	72	1.239	2.561	290	599	5	5,00%	1,75	2.501.318	4,00%	17	3.724.884	36.213.006,17	3%	1.086.390,18	12.257.622,27
HUNGARY	10.045.401	19.174	1.909	996	99	25.369	2.525	7.227	719	6	4,00%	39,84	56.944.300	6,00%	650	139.240.013	752.475.046,65	17%	127.920.757,93	350.236.047,57
MALTA	410.290	764	1.862	9	22	859	2.094	174	424	1	2,00%	0,18	257.278	2,00%	5	1.117.465	24.505.434,66	17%	4.165.923,89	4.544.793,63
NETHERLANDS	16.405.399	23.708	1.445	677	41	27.507	1.677	9.310	567	2	2,00%	13,54	19.353.058	1,00%	140	29.895.404	800.024.975,27	17%	136.004.245,80	222.776.971,93
AUSTRIA	8.318.592	39.173	4.709	679	82	50.521	6.073	12.035	1.447	5	5,00%	33,95	48.525.577	6,00%	1.083	231.874.022	1.447.149.693,92	10%	144.714.969,39	500.062.978,53
POLAND	38.115.641	49.054	1.287	5.437	143	62.097	1.629	16.042	421	6	6,00%	326,22	466.274.332	6,00%	1.444	309.075.452	1.959.958.885,30	17%	333.193.010,50	1.245.518.683,85
PORTUGAL	10.617.575	33.613	3.166	776	73	43.933	4.138	2.606	245	5	5,00%	38,80	55.457.802	7,50%	293	62.761.082	1.265.745.342,43	10%	126.574.534,24	197.313.169,15
ROMANIA	21.528.627	29.307	1.361	3.061	142	36.177	1.680	9.383	436	6	6,00%	183,66	262.509.790	6,00%	844	180.778.891	1.137.654.797,47	17%	193.401.315,57	713.571.951,08
SLOVENIA	2.010.269	9.165	4.559	214	106	12.472	6.204	1.100	547	5	5,00%	10,70	15.293.775	6,00%	99	21.193.305	359.080.517,88	10%	35.908.051,79	64.212.440,10
SLOVAK REP.	5.400.998	8.343	1.545	606	112	10.886	2.016	1.768	327	5	5,00%	30,30	43.308.541	7,50%	199	42.579.276	329.924.620,76	17%	56.087.185,53	138.801.257,22
FINLAND	5.300.484	6.881	1.298	344	65	8.513	1.606	2.200	415	3	6,00%	20,64	29.501.264	4,00%	132	28.257.740	252.890.717,00	10%	25.289.071,70	106.423.168,45
SWEDEN	9.182.927	18.462	2.010	397	43	26.248	2.858	3.657	398	3	3,50%	13,90	19.860.468	4,00%	219	46.972.070	753.602.787,71	10%	75.360.278,77	143.321.943,19
UK	61.191.951	170.591	2.788	2.538	41	228.367	3.732	26.034	425	2	2,00%	50,76	72.552.526	1,50%	586	125.396.932	6.520.544.974,57	3%	195.616.349,24	739.634.222,84
Total	**497.683.272**	**1.228.220**	**2.151**	**38.257**	**89**	**1.613.648**	**2.808**	**278.238**	**477**			**1.817,46**	**2.597.733.482**		**20.292**	**4.343.890.551**	**46.874.598.853,47**		**6.230.843.519,35**	**12.725.902.657,42**

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Annex 3 EeIP - European eCall implementation platform

Source: The EC eSafety European eCall implementation platform (EeIP - http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=2481)

The task force of EeIP on periodic technical inspection (TF-PTI) carried out a study on the periodic technical inspection requirements for eCall equipped vehicles. The work resulted in different solutions for testing call set up and routing. Those solutions are summarized below:

- A. Use of TS12 (TeleService 12) emergency call set-up message to identify and route test eCalls;
- B. TS12 emergency call and additionally using the test indicator in the MSD;
- C. Reservation of fixed numbers for test calls;
- D. Capturing all calls coming from the vehicle and routing to a dedicated device for testing (e.g. by a Femtocell)[50];
- E. Use of normal emergency call 112 to PSAP (solution not recommended).

The Task Force proposed different options for hosting test centres that would receive and manage the test eCalls:

- 1. eCall test centre hosted by PSAP;
- 2. eCall test centre hosted by governmental body;
- 3. eCall test centre hosted by vehicle manufacturer or national dealership;
- 4. eCall test server hosted locally by vehicle service centres.

The study did not perform a cost-benefit analysis of the different test and hosting options. The GSM Association (GSMA) reacted on those options on 12/11/2014 by indicating that none of the options are optimal. GSMA highlighted the following issues:

- a clear statement on the purpose and scope of the PTI is missing;
- a commercial and operational impact analysis of the proposed options is missing;
- The impact on the network load can be very high and compromise the normal traffic;
- Most of the options involved a high implementation and operational cost; it is not clear who will take the cost;
- The proposed options are not testing the actual eCall service, but they are all testing the test eCall.

GSMA made a counter proposal consisting of reducing the scope of testing eCall during PTI, by excluding eCall test call setup and by focusing on testing the communication between SIM and the modem locally in the car.

[50] In telecommunications, a femtocell is a small, low-power cellular-based network, typically designed for use in a home or small business offering a coverage of a few tens of meters.

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The TF-PTI finally recommended in September 2015 2 preferred scenarios for testing eCall:

1. Via the initiation of a test eCall from the on-board unit;
2. Via the eCall self-diagnostic tool.

A third scenario combining the 2 above scenarios was also proposed in their report. The pros and cons of those 2 scenarios are summarized below:

Initiation of a test eCall from the on-board unit	
Pros	*Cons*
• All components of the IVS and the entire chain of effect are tested; • PTI-Scan tool can be used without hardware changes; • No additional test equipment required; • Test is not bound to a location;	• Server infrastructure must be built; • Internet access required for test evaluation; • Problem of call-related costs is unresolved; • Changes to standards are necessary.
eCall self-diagnostic tool	
Pros	*Cons*
▪ PTI-Scan tool can be used without hardware changes; ▪ No changes to telecommunication standards; ▪ No additional hardware/costs.	▪ No functional test of the mobile communication; ▪ Limited functional test of the GPS unit.

Annex 4 Technical eCall system specifications with relevance to the PTI

Without prejudging the results of the final testing scenarios that will be produced by WP3, it is relevant for the test scenarios development to have a list of potential failures of an eCall in-vehicle system (IVS) and to know what is tested during the ecall system power-up. To this end, the following elements are of relevance.

1°) Source: Transport Research Laboratory (TRL) - eCall Phase 2: Technical requirements and test procedures for the type-approval of eCall in-vehicle systems:(https://circabc.europa.eu/webdav/CircaBC/GROW/automotive/Library/commission_expert/vehicles_working/128thmeetingon2July2015/TRLeCall20Phase20220-20Final20Report.pdf)

The eCall Regulation 2015/758 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". 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.

The following table extracted from the TRL document provides a high-level list of potential failures of an eCall unit. The colour-coding indicates for each failure whether it is technically feasible to cover it in a system self-test or not. 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.

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

Part	**Failure mode / mechanism**	**Comment**
		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,	Would require playback and recording of audio signal at vehicle start,

Part	Failure mode / mechanism	Comment
	installation faults, covered by retrofit elements)	(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

Table 1: 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)

2°) Source: Commission Delegated Regulation (EU) 2017/79

Annex VII of the regulation specifies a minimum list of technical items that need to be monitor by the self-test function at each system power-up. A warning in form of either a visual tell-tale or a warning message in a common space shall be provided in case a failure is detected by the self-test function. For the purpose of the test scenarios, we can assume that those elements are automatically checked and that a visual check during the PTI process will ensure that they are properly functioning if no warning is displayed.

Item
eCall ECU is in working order (e.g. no internal hardware failure, processor/memory is ready, logic function in expected default state)
External mobile network antenna is connected
Mobile network communication device is in working order (no internal hardware failure, responsive)
External GNSS antenna is connected
GNSS receiver is in working order (no internal hardware failure, output within expected range)
Crash control unit is connected
No communication failures (bus connection failures) of relevant components in this table
SIM is present (this item only applies if a removable SIM is used)
Power source is connected
Power source has sufficient charge (threshold at the discretion of the manufacturer)

Table 2: List of items checked during system power-up

Annex 5 - Data Material for CBA

A 5.1 Impact assessment of eCall

Source: IMPACT Socio-economic impact assessment of stand-alone and co-operative intelligent vehicle safety systems (IVSS) in Europe - 2008 (Author: TNO Built Environment and Geosciences - https://cordis.europa.eu/project/rcn/80586_en.html)

The perceived usefulness according to the Eurobarometer survey (Eurobarometer 2006) can be summarised as follows:

- eCall receives the biggest support among EU citizens. The highest number of people in each Member State (except Austria) perceives this safety system as useful and is willing to have this equipment in their new car. In every country the largest share of citizens does not regard the eCall safety system as inconvenient (45%). Those drivers who would like to have this system in their new cars rarely consider this system to be a real risk (8%). Those who would not want to have eCall consider this system to be a real risk more often (19%).

eCall is favourable from the perspective of the system users. The market price for eCall seems fair in that way that an average user will get a payback over the time he drives the vehicle. The assessment concluded that an early market introduction can be recommended.

Source: Impact assessment – Commission recommendation on support for an EU-wide eCall service in electronic communication networks for the transmission of in-vehicle emergency calls based on 112 – 2011 (Author: TRL - http://ec.europa.eu/smart-regulation/impact/ia_carried_out/docs/ia_2011/sec_2011_1019_en.pdf)

This impact assessment has been used for the consideration of the monetary value of road casualties and injuries.

Relevant elements include:
1°) With eCall, emergency services' response time would be reduced by 50% in rural areas and 40% in urban areas, leading to a reduction of fatalities estimated to be between 2% and 10%, and reduction of severity of injuries between 2% and 15%, depending on the country considered.

2°) Road accidents lead also to congestion. Due to a shorter rescue time, eCall will also reduce the congestion time, because on one side the faster arrival of rescue teams, police and towing firms enables the accident scene to be cleared more quickly, and on the other side, the quickest reporting of the incident to the traffic management centre. This would allow quicker information to other road users so that they can also take the necessary actions to avoid the incidents scene if possible. The study concluded in a possible reduction in congestion costs in case of accidents, depending on the country, in the range from 3% -UK, 10% -Finland, 17% -The Netherlands, Hungary.

3°) eCall would be more beneficial in remote areas and during night-time for the safety of road users, whereas in busy roads (during daytime) it would produce more benefits in terms of improving incident management and reducing road congestion and secondary accidents.

The table in Annex II gives an estimate of the number of casualties that would be avoided with the introduction of eCall as well as cost savings related to fatalities, injuries and congestion savings.

Source: European Commission statistics (2016 - road fatalities in the EU since 2001 (https://ec.europa.eu/transport/road_safety/road-safety-facts-figures-0_en)

The new EU road safety guidelines would aim to cut European road deaths by 50 % by 2020.

Other key figures:

- Road Safety is a major societal issue. In 2011, more than 30,000 people died on the roads of the European Union, i.e. the equivalent of a medium town.
- For every death on Europe's roads there are an estimated 4 permanently disabling injuries such as damage to the brain or spinal cord, 8 serious injuries and 50 minor injuries.

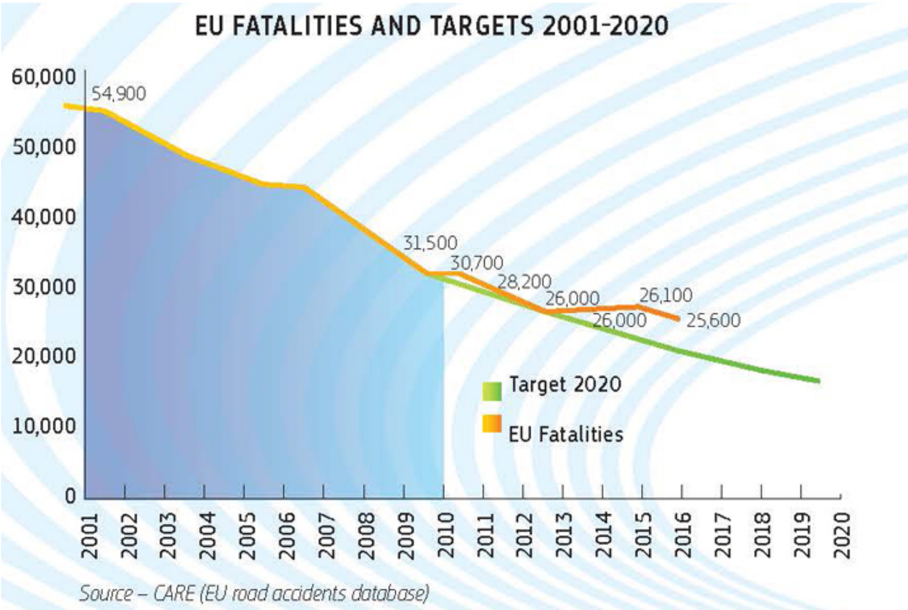

Figure 1: Evolution of EU fatalities

A 5.2 Expected number of eCalls

Source: Impact assessment – Commission recommendation on support for an EU-wide eCall service in electronic communication networks for the transmission of in-vehicle emergency calls based on 112 – 2011 (Author: TRL - http://ec.europa.eu/smart-regulation/impact/ia_carried_out/docs/ia_2011/sec_2011_1019_en.pdf)

The total number of eCalls, based on statistics from existing private systems (i.e., GM OnStar in USA and PSA in Europe) is estimated to be around 5,5 million of calls per year when fully deployed in the whole passenger cars' park. This would mean a 2%

increase in the total number of emergency calls in Europe, around 3 more calls per PSAP operator per day. This is not taking into account the substitution and accumulation effects:
1°) substitutions as the emergency calls will not be done using the mobile phones because the eCalls are initiated automatically;
2°) accumulation of eCalls by the PSAP operator, e.g., in case of accidents in the highway, where several "good Samaritans" may call for the same accident.

The table below is extracted from the TRL report and provides and provide estimates of the total eCalls per year and per day when fully deployed.

Country	Car Park (2008) Passenger Cars & LDV	Estimated Automatic eCalls per year when fully deployed	Estimated Manual eCalls per year when fully deployed	Estimated Total eCalls per year when fully deployed	Estimated eCalls per day when fully deployed
BELGIUM	5.817.452	11.635	110.532	122.166	335
BULGARIA	*2.699.348*	5.399	51.288	56.686	155
CZECH REPUBLIC	5.134.682	10.269	97.559	107.828	295
DENMARK	2.646.306	5.293	50.280	55.572	152
GERMANY	44.180.519	88.361	839.430	927.791	2.542
ESTONIA	639.472	1.279	12.150	13.429	37
IRELAND	2.278.189	4.556	43.286	47.842	131
GREECE	6.153.152	12.306	116.910	129.216	354
SPAIN	27.613.145	55.226	524.650	579.876	1.589
FRANCE	37.212.000	74.424	707.028	781.452	2.141
ITALY	40.894.491	81.789	776.995	858.784	2.353
CYPRUS	*506.556*	1.013	9.625	10.638	29
LATVIA	1.061.540	2.123	20.169	22.292	61
LITHUANIA	1.889.209	3.778	35.895	39.673	109
LUXEMBOURG	*375.353*	751	7.132	7.882	22
HUNGARY	*3.485.422*	6.971	66.223	73.194	201
MALTA	*261.264*	523	4.964	5.487	15
NETHERLANDS	8.882.000	17.764	168.758	186.522	511
AUSTRIA	4.673.347	9.347	88.794	98.140	269
POLAND	19.093.899	38.188	362.784	400.972	1.099
PORTUGAL	5.757.400	11.515	109.391	120.905	331
ROMANIA	*4.594.368*	9.189	87.293	96.482	264
SLOVENIA	*1.192.231*	2.384	22.652	25.037	69
SLOVAK REPUBLIC	1.699.800	3.400	32.296	35.696	98
FINLAND	3.118.964	6.238	59.260	65.498	179
SWEDEN	4.802.668	9.605	91.251	100.856	276
UNITED KINGDOM	34.457.011	68.914	654.683	723.597	1.982
Total	*271.119.788*	542.240	5.151.278	5.693.513	15.599

Table 3: Estimated number of annual emergency calls in the EU Member States

Remark: Recent (April – May 2018) discussions with PSAP operators indicated that around 5 to 10 % of current 112 calls (made today via mobile phones) are confirmed as incident report and transferred to emergency services. Some countries already report false eCalls caused by faulty mobile devices (around 10 per week). Those false eCalls refer to situations when mobile devices (phones) trigger eCall flag in the signalling and the call is handled by the mobile network operator as eCall; however, there are no MSD data included. Those false eCalls would also need to be considered in the CBA.

A 5.3 Defect rates of electronic systems in-vehicle system components

Source: Study on the Future Options for Roadworthiness Enforcement in European Union., 2007 (Author: AUTOFORE project – CITA: Comité international de l'inspection technique automobile - https://citainsp.org/studies/autofore-2007/)

Within the scope of the AUTOFORE study (CITA, 2007) it was determined that 30,5% of all cars registered in the EU are presented annually to PTI.

Source: Study on a new performance test for electronic safety components at roadworthiness tests – 2014 (Author: ECSS project – CITA: Comité international de l'inspection technique automobile - http://citainsp.org/studies/4267-2/)

There is currently no information about eCall system failure rate. Research undertaken by CITA and partly funded by the European Commission ***has shown that electronic systems on vehicles have failure rates comparable to mechanical systems*** that are considered important enough to be included in periodic inspections (Rompe 2002). The failure rates of electronic systems increase with both vehicle age and distance travelled. On-board electronic systems typically have built-in diagnostic capabilities that can recognize malfunctions; however, their capability is currently limited to the electronically controlled programme, the incoming signals from the sensors, and outgoing pulses.

The ECSS study used defect rates obtained from measured defect rates from year 2013. Detection rates were estimated using expert judgement based on the knowledge of what defects the current PTI is capable of detecting and what proportion these are of all possible defects. This was performed for each major safety system (i.e. brakes, steering and lighting) by building up from the sub-systems, e.g. brakes, pad/disc efficiency and electronic safety sub-systems ABS, ESC. For electronic sub-systems the current PTI only performs a visual inspection of components and checks the MIL (Malfunction Indicator Light). On this basis, the effectiveness of detection for the current PTI was estimated to be low at 50 %. With the new inspection method

Type of technical defect	Electronically Controlled Safety System (ECSS)	Base-line (Measured defect rate)	Estimated effectiveness of detection	Increased effectiveness of detection by new test method
BRAKE		20,57%	83%	11%
BRAKE DRUMS / BRAKE DISKS		3,70%	85%	10%
BRAKE HOSES		2,68%	85%	5%
BRAKE LINES		2,49%	85%	5%
BRAKE PADS		2,11%	85%	10%
SERVICE BRAKE		2,00%	85%	10%
PARKING BRAKING		1,98%	85%	10%
ABS-WARNING LIGHT		0,16%	100%	0%
ELECTRONIC SAFETY COMP.	Anti-lock Braking System (ABS) Electronic Stability Control (ESC) Brake Assist System (BAS) sometimes called Emergency Brake Assist (EBA) Electronic Braking System (EBS)	0,08%	50%	40%
OTHERS		5,37%		
STEERING		3,16%	78%	8%

information from the vehicle interface like status and values will be available, so an increase of 40 % in effectiveness of detection was estimated.

Type of technical defect	Electronically Controlled Safety System (ECSS)	Base-line (Measured defect rate)	Estimated effectiveness of detection	Increased effectiveness of detection by new test method
PUSH RODS / TRACK RODS	Electronic Power Steering (EPS)	1,98%	85%	0%
STEERING GEAR / STEERING SYSTEM – GAITER		0,43%	85%	0%
POWER STEERING / HYDRAULIC PIPES		0,36%	85%	0%
STEERING GEAR		0,15%	85%	0%
ELECTRONIC SAFETY COMP.		0,03%	50%	40%
OTHERS		0,21%		
LIGHTING		27,87%	86%	8%
LOW BEAM HEADLIGHT	Headlight Control Systems	8,61%	95%	0%
NUMBER PLATE LAMPS		4,56%	95%	0%
ADDITIONAL HEADLIGHTS (FOG-;		3,30%	95%	0%
SIDE LIGHTS / PARKING LAMPS / DAYTIME RUNNING LIGHTS		2,98%	95%	0%
ELECTRONIC SAFETY COMP.		0,03%	50%	40%
OTHERS		8,42%		
AXLES, TYRES		13,82%	77%	8%
AXLE – AXLE MOUNTING	Tyre Pressure Monitoring System (TPMS)	4,84%	90%	0%
AXLE – SUSPENSION / ANTI-ROLL-BAR		3,36%	90%	0%
AXLE – SHOCK ABSORBERS		1,12%	60%	0%
TYRES – SIZE / TYPE / LABEL		1,08%	95%	0%
ELECTRONIC SAFETY COMP.		0,01%	50%	40%
OTHERS		3,41%		
OTHER EQUIPMENT		2,38%	58%	22%
WARNING TRIANGLE / WARNING LAMPS / FIRST AID BOX	Supplementary Restraint System (SRS)	1,39%	95%	0%
SAFETY BELTS, SRS SYSTEMS		0,60%	60%	30%
SIGNAL HORN		0,22%	95%	0%
DRIVABILITY SYSTEMS WITH BRAKE/STEERING CONTROL		0,07%	20%	40%
ELECTRONIC SAFETY COMP.		0,02%	20%	40%

Table 4: Detection rate estimation

A 5.4 Statistics on vehicles

Source: Eurostat statistics database (http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do)

The CBA analysis will also be using estimates of the number of vehicles. The Eurostat statistics database will be used to this end.

eurostat

New registrations of passenger cars by type of motor energy

Last update: 19-04-2018

Table Customization show

TIME

Motor energy

Diesel

TIME / GEO	2013	2014	2015	2016
Belgium	319,863	303,953	305,838	285,653
Denmark	:	:	:	80,216
Germany (until 1990 former t	1,403,113	1,452,565	1,538,451	1,539,596
Estonia	7,345	7,726	6,949	6,393
Ireland	:	61,917	92,436	105,257
Spain	:	590,360 [d]	694,161 [d]	715,543
France	1,182,129	1,129,453	1,089,403	1,032,695
Croatia	31,046	50,861	56,807	74,421
Italy	707,641 [d]	:	:	:
Cyprus	2,998 [d]	5,782	6,667	10,344
Latvia	41,502	7,029	6,923	7,287
Lithuania	110,402	100,310	97,813	100,495
Hungary	72,343 [d]	91,757 [d]	103,928 [d]	110,271 [d]
Malta	5,267	5,768	5,312	5,451
Netherlands	103,557	105,014	129,773	72,356
Austria	181,061	172,574	180,510	189,139
Poland	468,097	470,967	481,006	530,548
Romania	136,673	:	181,809	:
Slovenia	28,016	29,763	31,031	32,589
Finland	38,697	41,404	38,844	39,556
Sweden	176,485	188,998	207,091	202,383
United Kingdom	:	:	1,257,152 [d]	1,264,307 [d]
Liechtenstein	858	800	937	985
Norway	97,464	87,738	89,499	56,095
Switzerland	116,600	113,300	129,000	125,600
Former Yugoslav Republic of	22,778	:	:	:
Turkey	383,904	364,242	462,191	460,829

Figure 2: New vehicle registration per country

Source: ACEA report, vehicles in use – Europe 2017 (www.acea.be)

Cars are on average 10,7 years old in the EU. Poland, Latvia and Lithuania have the oldest fleets, while the youngest cars can be found in Luxembourg and Belgium. From ACEA statistics below, 3 groups of countries can be identified:

1°) those for which age of fleet is on average below 10 years (e.g. Austria, Belgium, Denmark …): 10 countries
2°) those for which age is between 10 and 14 years: 7 countries
3°) those for which age is over 14 years: 8 countries

VEHICLES IN USE BY AGE

Passenger cars

Year of first registration	*2015*	*2014*	*2013*	*2012*	*2011*	*2010*	*2009*	*2008*	*2007*	*2006*	*>10 years*	*Total*	*Average age (in years)*
Austria	266,832	272,907	292,241	312,049	331,592	303,260	301,471	282,737	278,231	271,076	1,835,652	4,748,048	8.9
Belgium	454,633	430,812	425,491	415,722	451,907	406,086	344,033	355,728	325,124	304,374	1,673,505	5,587,415	7.7
Croatia	31,167	31,260	28,550	32,838	49,488	45,809	41,611	93,528	91,219	87,710	956,158	1,489,338	14.1
Czech Republic	198,052	157,852	142,113	162,273	178,039	184,593	192,827	204,627	208,967	210,088	3,275,885	5,115,316	14.5
Denmark	198,144	178,900	173,041	162,700	157,225	142,900	102,636	136,732	144,943	134,787	872,083	2,404,091	8.5
Estonia	19,137	19,969	19,562	20,986	20,182	14,545	13,814	32,095	40,568	34,013	441,721	676,592	15.1
Finland	105,106	105,255	103,250	112,256	129,938	116,844	97,625	148,341	136,975	154,634	1,402,698	2,612,922	12.7
France	1,876,942	1,754,279	1,729,233	1,814,912	2,118,135	2,112,231	2,140,288	1,911,962	1,888,570	1,777,378	12,791,563	31,915,493	9.0
Germany	2,910,740	2,836,192	2,789,857	2,765,288	2,813,408	2,543,586	3,333,835	2,541,445	2,442,804	2,608,028	17,486,026	45,071,209	8.9
Greece	75,806	70,533	58,112	57,864	116,906	152,092	220,841	263,789	279,940	271,500	3,537,525	5,104,908	13.5
Hungary	56,897	61,463	55,699	59,110	64,542	58,724	56,726	154,334	185,070	200,804	2,238,763	3,192,132	14.5
Ireland	113,053	90,612	75,791	91,245	110,789	115,765	83,911	178,481	174,106	166,309	785,069	1,985,130	9.0
Italy	1,641,259	1,410,711	1,322,430	1,385,528	1,713,038	1,919,630	2,101,118	2,044,993	2,360,118	2,158,460	19,293,948	37,351,233	10.7
Latvia	10,949	10,840	10,321	11,913	13,401	10,274	10,379	26,655	41,049	38,483	493,297	677,561	16.3
Lithuania	13,633	12,088	12,241	14,434	17,938	16,455	20,064	40,858	53,163	56,367	986,822	1,244,063	16.7
Luxembourg	43,248	45,103	38,701	37,286	32,111	28,665	24,578	21,940	18,861	15,772	74,840	381,105	6.2
Netherlands	451,827	410,494	444,629	526,370	560,634	481,334	374,816	449,391	447,335	472,954	3,716,630	8,336,414	9.5
Poland	271,677	319,344	284,819	318,453	368,342	360,656	386,179	573,080	654,765	647,163	16,538,945	20,723,423	17.2
Portugal	164,806	139,860	106,722	103,096	168,308	236,761	176,450	231,027	215,635	201,869	2,793,466	4,538,000	12.6
Romania	65,657	58,391	81,479	71,881	100,771	154,081	160,948	216,772	337,814	413,564	3,491,824	5,153,182	15.3
Slovakia	76,740	68,574	65,494	72,093	81,851	82,407	99,329	104,235	105,031	104,523	1,177,529	2,037,806	13.4
Slovenia	45,183	39,760	42,528	49,417	63,305	61,875	60,281	78,212	74,304	69,905	546,137	1,130,907	11.2
Spain	1,050,901	818,112	655,949	610,532	709,519	901,624	904,383	1,025,317	1,437,383	1,470,868	12,770,961	22,355,549	11.4
Sweden	262,462	291,155	254,142	248,257	289,970	277,821	183,724	228,827	278,403	252,817	2,101,485	4,669,063	9.6
United Kingdom	2,622,550	2,459,044	2,229,797	1,984,883	1,860,448	1,935,386	1,898,716	1,995,199	2,260,520	2,145,040	12,150,865	33,542,448	8.5
EUROPEAN UNION	***13,027,401***	***12,093,511***	***11,442,192***	***11,441,385***	***12,521,786***	***12,663,404***	***13,330,583***	***13,340,305***	***14,480,898***	***14,268,486***	***123,433,397***	***252,043,348***	***10.7***

Figure 3: Estimates of vehicle age per country

Source: ACEA (2017) consolidated registrations - by Country (http://www.acea.be/statistics/tag/category/by-country-registrations).

Each month, ACEA publishes two press releases reporting new passenger car (PC) and commercial vehicle (CV) registrations in Europe. These also contain an update of the previous year's results. The data published by ACEA for the current year is provisional and provided by national sources. ACEA also regularly publishes the consolidated data below. This information is compiled by the Association Auxilliaire de l'Automobile (AAA) and is occasionally refreshed in order to take account of variations in the way vehicle registrations were estimated or accounted for initially. This normally only applies for the current year or the year immediately preceding it.

Legend	
EU15	*Member States before the 2004 enlargement: Austria, Belgium, Denmark, Finland, France, Greece, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, the UK*
EU11	*Member States having joined the EU since 2004: Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia (data for Malta and Cyprus unavailable)*
EU	*EU15 + EU11*
EFTA	*Iceland, Norway, Switzerland*
Enlarged Europe	*EU + EFTA*
Western Europe	*EU15 + EFTA*

New registrations in European Union and EFTA

Country	Jan 16	Feb 16	Mrz 16	Apr 16	Mai 16	Jun 16	Jul 16	Aug 16	Sep 16	Okt 16	Nov 16	Dez 16	FY
PC-Passenger Car													
Austria	24.019	22.495	31.941	31.102	28.462	33.751	26.882	23.690	29.836	26.273	25.491	25.662	329.604
Belgium	44.326	49.707	56.423	55.022	48.856	55.272	34.373	38.655	41.748	41.969	39.645	33.285	539.281
Bulgaria	1.627	1.748	2.333	2.305	2.432	2.548	2.317	2.137	2.290	2.239	2.404	3.086	27.466
Croatia	2.427	2.583	4.119	4.924	6.090	6.244	3.578	2.365	2.586	2.889	2.826	3.475	44.106
Czech Republic	17.499	19.300	22.799	23.131	24.335	25.714	18.739	21.251	19.946	21.905	23.161	21.913	259.693
Denmark	16.412	16.611	19.142	19.853	21.121	23.641	15.697	17.424	18.452	17.076	18.058	19.408	222.895
Estonia	1.788	1.671	2.085	2.235	2.279	2.022	1.937	1.850	1.959	1.910	1.880	1.381	22.997
Finland	11.785	9.653	11.625	11.083	10.517	10.753	8.342	9.201	9.645	9.159	9.004	8.145	118.912
France	138.400	166.728	211.254	182.863	175.831	227.353	132.990	98.211	168.820	155.194	163.161	194.372	2.015.177
Germany	218.365	250.146	322.913	315.921	286.931	339.563	278.866	245.076	298.002	262.724	276.567	256.533	3.351.607
Greece	5.700	3.310	6.316	9.735	13.489	8.863	7.034	4.174	4.595	4.995	5.897	4.765	78.873
Hungary	5.568	6.627	7.502	8.063	8.517	9.696	8.064	7.177	8.225	7.951	9.415	9.750	96.555
Ireland	39.722	21.573	21.529	10.382	6.499	1.624	29.883	7.286	4.688	2.240	747	499	146.672
Italy	155.851	173.097	191.408	168.132	188.650	166.224	137.221	71.990	154.311	147.225	145.835	124.438	1.824.382
Latvia	1.090	1.246	1.548	1.462	1.415	1.937	1.257	1.168	1.530	1.288	1.275	1.141	16.357
Lithuania	1.561	1.407	1.625	2.036	2.160	1.899	1.651	1.552	1.703	1.740	1.536	1.414	20.284
Luxembourg	3.477	4.448	5.040	5.233	5.011	5.106	4.141	3.359	3.568	4.275	3.838	3.250	50.746
Netherlands	40.542	28.097	29.626	27.611	28.791	39.252	31.029	26.847	33.327	29.849	32.131	35.723	382.825
Poland	31.941	33.795	39.303	34.753	33.154	38.746	31.424	28.467	32.746	32.392	37.412	43.721	417.854
Portugal	13.940	18.029	26.459	15.978	20.851	23.369	15.632	10.708	13.960	14.933	16.483	17.003	207.345
Romania[1]	5.800	5.099	6.572	6.174	6.345	5.462	10.768	12.411	9.361	7.951	9.645	9.331	94.919
Slovakia	5.473	6.728	7.823	7.279	8.299	8.354	6.826	6.906	7.126	7.511	7.830	8.010	88.165
Slovenia	5.907	4.797	5.887	5.074	5.466	5.764	4.700	3.601	4.585	4.846	4.784	3.552	58.963
Spain	76.334	97.649	111.511	100.279	113.671	123.790	107.306	64.089	79.591	83.248	92.653	96.886	1.147.007
Sweden	21.648	26.869	34.712	33.580	34.475	36.307	24.197	27.316	32.292	31.840	31.801	37.281	372.318
United Kingdom	169.678	83.395	518.707	189.505	203.585	255.766	178.523	81.640	469.696	180.168	184.101	178.022	2.692.786
European Union (EU)	1.060.880	1.056.808	1.700.202	1.273.715	1.287.232	1.459.020	1.123.377	818.551	1.454.588	1.103.790	1.147.580	1.142.046	14.627.789
EU-15[2]	980.199	971.807	1.598.606	1.176.279	1.186.740	1.350.634	1.032.116	729.666	1.362.531	1.011.168	1.045.412	1.035.272	13.480.430
EU-11[3]	80.681	85.001	101.596	97.436	100.492	108.386	91.261	88.885	92.057	92.622	102.168	106.774	1.147.359
Iceland	1.213	1.044	1.333	2.260	3.392	2.855	1.611	1.181	1.027	897	954	706	18.473
Norway	10.991	12.222	13.875	14.116	12.864	13.681	11.040	13.232	13.854	11.932	13.194	13.602	154.603
Switzerland	20.371	22.564	29.022	28.498	25.852	31.104	25.897	21.734	25.989	23.205	25.918	35.325	315.479
EFTA	32.575	35.830	44.230	44.874	42.108	47.640	38.548	36.147	40.870	36.034	40.066	49.633	488.555
Total (EU + EFTA)	1.093.455	1.092.638	1.744.432	1.318.589	1.329.340	1.506.660	1.161.925	854.698	1.495.458	1.139.824	1.187.646	1.191.679	15.116.344
Total (EU15 + EFTA)	1.012.774	1.007.637	1.642.836	1.221.153	1.228.848	1.398.274	1.070.664	765.813	1.403.401	1.047.202	1.085.478	1.084.905	13.968.985

Source: Association Auxiliaire de l'Automobile

Figure 4: New passenger car registration

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