Interoperability of eCall and ERA-GLONASS in-vehicle emergency call systems

Risto Öörni1, Evgeni Meilikhov2, Timo Olavi Korhonen3

1VTT Technical Research Centre of Finland, P.O. Box 1000, FI-02044 VTT, Finland
2Non-for-profit Partnership for Development and Use of Navigation Technologies (Glonass Union), Office 1508, World Trade Center, 12 Krasnopresnenskaya nab., Moscow 127083, Russia
3Department of Social Research, Helsinki University, P.O. Box 54, FI-00014 Helsinki, Finland

✉ E-mail: risto.oorni@vtt.fi

Abstract: The objective of this study is to analyse the interoperability between pan-European eCall and Russian ERA-GLONASS in-vehicle emergency call systems. The analysis is based on a definition of interoperability from International Telecommunication Union and related system standards of eCall and ERA-GLONASS. The authors results indicate that the core functions of both systems – minimum set of data (MSD) transmission at the start of the call and establishing the related voice connection between vehicle occupants and a public safety answering point – will be available in the interworking scenarios analysed in this study. However, not all features of both systems will be available in use cases with interworking between the systems, such as SMS-based MSD retransmission. The study indicates that further empirical tests are required to obtain more information on practical interoperability between the systems.

1 Introduction

1.1 eCall and ERA-GLONASS

eCall [1–4] is a pan-European in-vehicle emergency call system that is expected to be mandatory in new vehicle models type-approved in the EU after October 2015 [5]. In the future, deployment of a public safety answering point (PSAP) infrastructure capable of receiving and processing eCalls will become mandatory for EU member states [6, 7]. An overview of the standards of eCall is given in Fig. 1.

Meanwhile, Russia is developing the ERA-GLONASS system, which also provides in-vehicle emergency call functionality [9–12]. This will be made mandatory in new vehicle types of categories M and N after 1 January 2015 by the Amendment to the Technical Regulation of the Customs Union adopted by the Eurasian Economic Commission on 30 January 2013 [13]. Highlights of the regulation are given elsewhere [14]. Both systems provide an in-vehicle emergency call function, and their deployment has been scheduled to take place almost simultaneously. An overview of the core standards of ERA-GLONASS is given in Fig. 2.

Both systems provide very similar functionalities, and there is a clear need to analyse the interoperability between them. Interoperability would improve access of travellers to emergency services both in the EU and in countries that have decided to implement the ERA-GLONASS system. Notably, it would be important to provide an interoperable in-vehicle emergency call service for users of eCall in Russia and users of ERA-GLONASS in Finland. The ability to make an in-vehicle emergency call is a safety feature that in some cases could be vitally important. It should be available during all types of trips independently of the user’s physical location, as with emergency call services based on a general emergency number (112 in the EU). Interoperability of eCall and ERA-GLONASS is especially important for users travelling abroad because of language difficulties and challenges in expressing one’s location accurately in unfamiliar environments.

1.2 Interoperability

There are several definitions for interoperability in the context of data communications [17] and computing [18]. International Telecommunication Union (ITU) recommendation Y.101 [19] defines interoperability as: ‘The ability of two or more systems or applications to exchange information and to mutually use the information that has been exchanged.’ The European Telecommunications Standards Institute (ETSI) white paper on interoperability [17] presents three alternate definitions for interoperability. One of them that we apply in this paper is used by the 3rd Generation Partnership Project. It is essentially similar to the ITU definition and refers to ‘the ability of two or more systems or components to exchange data and use information’. In the case of pan-European eCall realisation and ERA-GLONASS, important questions of interoperability relate to the quality of the joint service.

The ETSI white paper on interoperability [17] describes briefly the different levels of interoperability: technical, syntactical, semantic and organisational (Fig. 3).

Technical interoperability allows the transmission of bits from one communicating entity to another, and is usually related to software and hardware components and to communication protocols [17]. Syntactical interoperability is associated with data formats and encoding of information, whereas semantic interoperability covers the meaning of the content being transmitted [17]. Organisational interoperability is ‘the ability of organisations to effectively communicate and transfer (meaningful) data (information) ...’ [17]. In case of in-vehicle emergency call services such as eCall or ERA-GLONASS, technical interoperability covers aspects such as call establishment, transmission and retransmission of data, call teardown and opening of a call from PSAP to in-vehicle system (IVS) (call-back). Syntactical interoperability covers the coding and decoding of the minimum set of data (MSD). Semantic interoperability is mostly related to human interpretation of information received as MSD or via voice connection. Organisational interoperability can be understood as the capability of vehicle occupants and the PSAP to communicate efficiently and in a coordinated manner, and will include aspects such as call handling practices of PSAPs and user behaviour. The primary focus of this paper is on technical interoperability, and aspects related to syntactical interoperability are discussed as they are closely related to technical interoperability. The other layers are related mainly to human factors and organisational aspects of the service, and are therefore outside the scope of this paper with its main focus on technology.
1.3 State machines, state diagrams and sequence diagrams

Communication protocols can be seen as mechanisms that transfer information and propagate the system state between communicating entities. It would have been possible to describe eCall and ERA-GLONASS elements of the interworking use cases as finite state machines such as Mealy machines. For example, a modelling of eCall with state diagrams can be found in CEN technical specification (TS) 16454 [20], which describes conformance test points for eCall. State machines described with state diagrams are most suitable for describing the internal states and state transitions of the communicating entities, but they are less practical for visualising messages or data flows exchanged between systems. Systematic description of eCall and ERA-GLONASS as finite state machines would require describing a large number of states. This is seen in CEN TS 16454, where the conformance test points for pan-European eCall are described as transitions between the states possible for the system. Any attempt to accurately describe both systems and their states with state machines could therefore lead to overspecification. If two entities communicate using the same communication protocol, it may be possible to present the operation of both entities with the same state machine diagram. However, this is not the case when the systems have different specifications.

Connection state diagrams such as those in RFC793 [21] have been used to describe the operation of communication protocols.

---

**Fig. 1** Overview of standards of pan-European eCall [8] (PLMN: public land mobile network, TPS-eCall: third party services supported eCall)

**Fig. 2** Overview of core standards of ERA-GLONASS (adapted from [15, 16])

**Fig. 3** Levels of interoperability [17]
Many of the limitations of state machines apply also to connection state diagrams: they are impractical for visualising data flows and messages exchanged between systems. Sequence diagrams can be used to present data flows and messages exchanged between systems. Sequence diagrams have means to present system states, but they are not primarily intended for describing or modelling system states or state transitions. This means that sufficient explanatory text has to be provided when system states are concerned and relevant for interoperability between systems.

Tools such as specification and description language (SDL) and unified modelling language (UML) can be used to describe communication protocols and other distributed systems as state machines. SDL has been developed for description and analysis of communication protocols, but it can be used for other kinds of distributed systems [22]. SDL allows modelling of the interactions between entities as sequence diagrams and the statuses of the communicating entities as state machines. UML is mainly intended for analysis, design and implementation of software-based systems, and it can also be used for modelling of business and other similar processes [23]. UML includes a variety of tools such as use cases, sequence diagrams and state machines. A comparison of SDL-2000 and UML 1.3 when applied in a case study is provided elsewhere [24].

1.4 Structure of this study

The introduction provides an overall description of pan-European eCall and Russian ERA-GLONASS in-vehicle emergency call systems analysed in this study, and is followed by the main objectives of this study. The methods section describes the analysis of interoperability between the systems. The section ‘Core functions of the systems’ discusses the functionalities of eCall and ERA-GLONASS emergency call services. The results of this study are presented as use cases involving interworking between the systems. This study closes with a discussion of the results, conclusions and recommendations for further research.

2 Objectives

The objective of this paper is to analyse the interoperability between pan-European eCall and the Russian road accident emergency response system, ERA-GLONASS. The main question is what kind of mutual interoperability can be expected and where potential problems may reside.

The focus of the analysis is on typical use cases involving interworking of the two systems: (a) where an eCall IVS (in-vehicle system) interacts with ERA-GLONASS PSAP and (b) where ERA-GLONASS IVS interacts with a PSAP supporting pan-European eCall. Detailed analysis of scenarios involving non-standard implementations of the IVS or PSAP or failures in network registration or call setup are not included here, because of a current lack of respective equipment and in order to focus on standardisation related interoperability issues. The general framework for the analysis is the one presented in the ETSI white paper on interoperability [17].

The main focus of this paper is on telecommunications related technical interoperability between the two systems. We have discussed the interoperability issues relevant to this paper in a paper describing the results of eCall and ERA-GLONASS interoperability tests performed in spring 2012 in Finland [25]. This provided some early results on the interoperability between the two systems. However, many important standardised features of pan-European eCall and ERA-GLONASS such as MSD retransmission requested by a PSAP needed more focus, which we provide here.

3 Methods

The analysis of interoperability between the two systems is performed mainly from information available in their core standards (Fig. 1 and 2). This approach was chosen for three reasons. First, the results of theoretical analysis support the planning of empirical pilot tests, where the interoperability of the two systems can be verified and unclear points clarified. Second, full implementations of both systems were not available for empirical testing at the time of writing. Third, it is reasonable to assume that both systems will be implemented according to their own standards.

The analysis is based on the framework presented in the ETSI white paper on interoperability [17] and the definition of interoperability as defined in ITU Y.101 [19]. Interoperability between the systems is analysed by referring to the respective protocol stack and sequence diagrams, which are commonly used tools in communications engineering in the design of communication protocols. The analysis is carried out for typical use cases involving interworking between the two systems: an eCall IVS interacting with an ERA-GLONASS PSAP and an ERA-GLONASS IVS interacting with a PSAP supporting pan-European eCall. The results are presented as figures and text indicating what features of both systems are available in each of the cases. Before analysing the interoperability, the core functionalities of both systems are summarised as tables.

Several factors had to be taken into account when selecting the analysis approach and the methods for presenting the results. First, interworking use cases of eCall and ERA-GLONASS include several interacting telecommunication network layers of the International Organisation for Standardisation (ISO) open systems interconnection model (ISO-OSI model) and are therefore complex. This requires an appropriate level of detail in the analysis, while applying both the analysis and the presentation methods consistently. Second, the results must be presented concisely yet be easily understood by the reader. Third, we wished to focus on the interface between the two interworking systems, and to consider the internal states of the systems only as far as they are relevant to interoperability. For the reasons explained above, the approach based on sequence diagrams was considered most suitable for this paper.

4 Core functions of the systems

4.1 Pan-European eCall

The objectives of conformance tests for a PSAP operating according to the standards of pan-European eCall are defined in EN16062. These objectives can be used also in the assessment of interoperability between eCall and ERA-GLONASS. The core functionalities of pan-European eCall have been summarised based on the objectives for conformance tests specified in EN16062 and the related conformance testing points. The main functionalities analysed here are summarised in Table 1.

Functionality 2 refers to routing of the call to the most appropriate PSAP. The organisation of PSAPs is different in different EU member states. There are also differences in the way eCalls are handled by PSAPs. Therefore the most appropriate PSAP to receive and process eCalls in a given geographical area is defined at member state level.

4.2 ERA-GLONASS

The core functionalities of ERA-GLONASS can be summarised on the basis of GOST R 54721 (base service description) and GOST R 54620 (general technical requirements). The core functionalities of ERA-GLONASS are summarised in Table 2.

The messages exchanged between the ERA-GLONASS IVS and the ERA-GLONASS back-office system are summarised in Table 7 of GOST R 54620.

5 Use cases involving interworking between the systems

5.1 Pan-European eCall IVS initiating a call to PSAP based on ERA-GLONASS

Fig. 4 is a use case sequence diagram in which an IVS complying with the standards of pan-European eCall is activated either
automatically or manually and the respective interaction is accomplished with a mobile network supporting ERA-GLONASS and the ERA-GLONASS back-office system.

The figure is based on the text of GOST R 54721 (Chapter 5.4) and standards related to pan-European eCall [1–3]. The current version of the eCall MSD as defined in EN15722 will be replaced with a new version (version 2) [26]. However, the existing standards of ERA-GLONASS describe the current version (version 1) of MSD defined in EN15722:2011 (GOST R 54620-2011, Appendix B). Updating ERA-GLONASS standards is expected to be initiated once EN15722 for MSD version 2 is approved. Owing to the reverse compatibility, a possible interim period should not critically affect interoperability, as long as both MSD versions are supported by the PSAP software. This applies also in the use case in which an ERA-GLONASS IVS initiates a call to a PSAP supporting pan-European eCall. A SIM card is mandatory for an eCall IVS. Therefore the IVS will be able to initiate a TS12 emergency call (Teleservice 12, Emergency Calls [27]) even in cases where emergency calls are not allowed without a SIM card.

One should also note that the value of the setting application layer acknowledgement (AL-ACK) period (‘ALACKPERIOD’) in Table A.1 of GOST R 54620-2011 is 2 s. The value of the corresponding timer for eCall, T6 (IVS wait for AL-ACK period), defined in Annex A of EN16062, is 5 s. This is an interoperability issue, but is not likely to lead to catastrophic consequences. The fact that the ERA-GLONASS back-office system stops transmitting AL-ACKs after 2 s may reduce the probability that the eCall IVS successfully detects an AL-ACK. In practice, an eCall IVS sending an MSD to the ERA-GLONASS back-office system will simply open the voice channel 3 s later than an ERA-GLONASS IVS in cases where a link layer acknowledgment (LL-ACK), but no AL-ACK has been received by the IVS.

5.2 ERA-GLONASS IVS initiating a call to eCall PSAP

The use case in which an ERA-GLONASS IVS initiates a call to a PSAP supporting pan-European eCall is illustrated in Fig. 5. An ERA-GLONASS IVS is required to have a SIM card installed and can therefore legally make a TS12 emergency call also in countries that do not allow emergency calls without a SIM card. In the case of pan-European eCall, this has been solved with a requirement that the IVS must have a SIM card installed. The exact SIM profile structure is not relevant to this capability. The need for international roaming is under discussion. A TS12 emergency call can be made even without full roaming capabilities, but the call-back feature will not be available in cases without a roaming agreement. This is a limitation to interoperability, although seldom a critical one. Given the issue with ALACKPERIOD and T6 mentioned above, an
ERA-GLONASS IVS sending an MSD to a PSAP conforming to the standards of eCall will simply quit listening for AL-ACK and transfer to voice mode too early. This can result in unreliable or even no detection of AL-ACK at all in situations, in which the IVS has already detected the LL-ACK. Whether an AL-ACK will eventually be detected depends on the configuration of the PSAP, in other words, how many LL-ACKs and AL-ACKs are sent, and the successes and failures of transmissions of individual acknowledgments.

5.3 Call-back from PSAP based on ERA-GLONASS to eCall IVS

Sometimes, the PSAP may attempt to obtain further information about the incident after the eCall has already been closed by it, or the call has been disconnected for some other reason, but the IVS has not made a redial attempt as specified by the standards of eCall. Information about the location of the incident may be ambiguous, for example, if the call has been initiated by a passer-by (Good Samaritan calls and calls related to animals or obstacles on the road). In these situations, the PSAP may open a call to the IVS that initiated the emergency call. The requirement that the PSAP should be able to call-back the IVS is part of the functionality of both eCall and ERA-GLONASS. For this reason, the call-back functionality has to be described together with the main use cases analysed in this paper.

Operation of the call-back feature in an interworking scenario involving an eCall IVS and ERA-GLONASS back-office system is outlined in Fig. 6.

The possibility to make the call-back from an ERA-GLONASS back-office system to an eCall IVS will depend on the existence of a roaming agreement between the mobile network operator that provided the SIM card used in the IVS (mobile network operator (MNO)1) and the mobile network operator serving the IVS in the area where the emergency call was made (MNO2).

Let us first focus on the scenario in which there is a roaming agreement between MNO1 and MNO2. When the IVS is powered up, (global system for mobile communications) GSM mobility management is activated and the IVS enters the state ‘PLMN SEARCH’. After performing a PLMN search, it enters the state ‘ECALL INACTIVE’ as defined in chapter 4.2.1.1 of [28], and no location updates are made. The IVS may leave the ‘ECALL INACTIVE’ state by attempting to establish an emergency call, at which point the GSM mobility management layer moves to the state ‘MM-IDLE’, and a location update is attempted (chapter 4.4.7 of [29]). As part of the procedure, the home location register (HLR) of MNO1 and visitor location register of MNO2 are updated with the current location of the IVS. A roaming agreement between MNO1 and MNO2 is required for a successful location update.
After performing the location update, a circuit-switched emergency call is established with the standard mobility management and connection management procedures of GSM and third generation (3G) networks [28] and related protocols in public switched telephone network [30]. The PSAP receives the mobile subscriber integrated services digital network number (MSISDN number) of the IVS from the mobile switching centre (MSC) as part of the normal call setup procedure as the calling line identification (CLI). CLI presentation (CLIP) is available in second generation (2G) and 3G networks as a supplementary service [31, 32]. The services for which CLIP is applicable in 2G and 3G are defined in Table A.1 of ETSI TS 122 004 [29, 33]. It should be noted that CLIP has not been marked in ETSI TS 122 004 as applicable to emergency calls (TS12, [27]), although it may in fact be supported in real-life implementations of the standards. The interworking of CLIP provided by 2G and 3G networks with fixed-line networks is discussed briefly [31, 32] as follows: ‘According to national network specific rules, the CLIP supplementary services need not be applicable, if at least one of the two parties is not an integrated services digital network (ISDN) or PLMN subscriber.’ The transmission of CLI in fixed-line networks between the MSC of MNO2 and the PSAP takes place as a normal call setup procedure as defined in ITU Q.731.3 [34] and Q.764 [30].

When the operator of the ERA-GLONASS back-office system attempts to call-back the IVS, it initiates a normal call setup procedure using the ISDN user part protocol [30] to the MSISDN number of the IVS. The call is first connected to the gateway MSC of MNO1. The MSC of MNO1 then performs a lookup in the HLR of MNO1. If the location update performed by the IVS

![Diagram of interworking of ERA-GLONASS IVS and eCall back-office system](image)

Fig. 5 Interworking of ERA-GLONASS IVS and eCall back-office system
was successful, a voice call between the IVS and the PSAP is established correctly. The situation is completely different if MNO1 (the MNO which provided the SIM card) and MNO2 (the Russian MNO serving the IVS) have no roaming agreement. In this case, there will be no location update from MNO2 to the HLR of MNO1, and the MSC of MNO1 has no means to route the call from the PSAP to MNO2 serving the IVS. The unavailability of call-back in case the location update is not successful is confirmed in a specific note in chapter 4.4.7 of [28]: ‘If an eCall device has not successfully completed a location update procedure, PSAP call-back will not be possible because of its calling line identity being unavailable at the PSAP.’

5.4 Call-back from eCall PSAP to ERA-GLONASS IVS

The issue with roaming is essentially similar to that in the use case with eCall IVS interacting with an ERA-GLONASS back-office system. In other words, if the Russian MNO providing the SIM card for the ERA-GLONASS IVS has no roaming agreement with the MNO serving the IVS, calling back from the PSAP to the IVS will not be possible.

6 Discussion

The approach used here is based on analysis of information available in the standards of both systems. However, it does not take into account items that are not specified in the standards, but may still have an impact on interoperability, such as choices of particular system parameters (e.g. non-linear signal processing performed by mobile and fixed-line networks along the call path). These may have been set or recommended by the equipment manufacturer or network operator. There are also factors that can be expected to have effects in practical implementations, but are not presented in theoretical analyses, such as features that have been standardised, but not implemented correctly or at all. For example, call clear-down by AL-ACK instead of hanging up or MSD retransmission during call-back from PSAP to IVS were not implemented by all eCall IVS prototypes at the start of eCall tests carried out as part of Harmonized eCall European Pilot. Therefore extensive pilot tests are required to obtain further information on interoperability between the two systems.

Our analysis approach has been balanced to obtain some practical level of detail when describing the interworking protocols. This is important for two reasons. First, the objective of this paper is to provide new information on interoperability issues between the two systems, in general. The way the use cases were depicted had to allow both identification of their main components and a description of the related interactions. Increasing the level of detail would not necessarily have improved the accuracy of this paper, but would have increased the length of this paper substantially.

7 Concluding remarks and future work

The results suggest that the core functionalities of both emergency call systems (MSD transmission from IVS to PSAP and voice communication between vehicle occupants and the PSAP) are generally readily available in the analysed use cases involving interworking between the systems. The identified limitations of these functionalities relate to the transmission of AL-ACK, which may be unreliable or impossible in interworking scenarios (Figs. 3 and 4) with certain parameter values (numbers of LL-ACKs and AL-ACKs sent by the PSAP). However, this does not prevent the transmission of MSD from IVS to PSAP, and the respective impact on the interoperability between the two systems will

---

**Fig. 6** High-level description of the operation of call-back functionality in an interworking scenario involving an eCall IVS and ERA-GLONASS back-office system.
therefore be limited. The inconsistency with timer values ("ALACK" period in GOST R 54620-2011 and T6 in EN16062:2011) should be considered when developing the next version of GOST R 54620. Our analysis indicates that all features of both systems are readily available in interworking systems. First, MSD retransmission based on SMS (as defined for ERA-GLONASS in GOST R 54620) is not available in either of the use cases (Figs. 4 and 5); the pan-European eCall supports only MSD retransmission and a retransmission request made using the in-band modem. This is unlikely to become a barrier to interoperability, as the ERA-GLONASS PSAP may use the in-band modem to request an MSD retransmission. Second, call clear-down using the AL-ACK signal of the eCall in-band modem (as defined in EN16062) is not supported by the ERA-GLONASS IVS or the ERA-GLONASS back-office system. Therefore it is not available in use cases involving interworking between the two systems. In conclusion, the only possible way for eCall PSAP or ERA-GLONASS back-office systems to end the call is to hang up. Therefore the eCall PSAPs should preferably clear down the call by hanging up if there is a possibility that the IVS is an ERA-GLONASS IVS. This is not expected to have a major impact on interoperability, since most PSAPs compliant with the standards of pan-European eCall will likely support call clear-down by hanging up as in the case of any 112 emergency call (EN16062, 7.9). Availability of the call-back function is dependent on the existence of mutual roaming agreements between the mobile network operator that provided the SIM card in the IVS and the mobile network operator serving the IVS. It should also be noted that the availability of the call-back function or calls is subject to national or regional regulations. The results presented here should be taken into account when preparing guidelines for implementation and operation of eCall and ERA-GLONASS and in developing their standards further. Analysis of the standards of the two systems provides an answer to the question of which functionalities will likely be available in the analysed interworking scenarios. However, this is not enough as such to guarantee interoperability between the two systems in real-life situations. First, real-life systems do not always fully conform to the standards. In other words, some important features of the systems may have been implemented wrongly or not at all. For example, the first prototype implementations of eCall IVS and eCall PSAP did not have all the features defined in EN16062. This is consistent with the fact that software development work is frequently carried out incrementally by not implementing all the features of the product at once. Second, there may be parameters that affect the interoperability between systems, but have been poorly documented in standards, and therefore have not been anticipated to affect interoperability. Third, it is also difficult to rule out the possibility of unexpected feature interactions. In telecommunications, feature interaction is understood as a situation in which ‘new features may interact in unexpected or adverse ways with existing features’ [35], for the original description see [36]. In conclusion, further empirical tests will be required in addition to analysing the standards to obtain information on the real-life interoperability between eCall and ERA-GLONASS.

The interoperability tests to be carried out should cover all the relevant features of both systems required for solid interoperability. For eCall, a starting point for defining the scope of the tests could be the use cases presented here (Figs. 4 and 5) and the functionalities and conformance requirements identified in EN16062 and CEN TS 16454. For ERA-GLONASS, the starting point could be the same use cases described (Figs. 4 and 5) and the functionalities described in GOST R 54620 and GOST R 54721. In addition to the typical use cases, also abnormal ones such as a redial attempt after a failed call setup should be covered in pilot tests to ensure overall system performance and reliability.

Finally, the results of this analysis are based on standard versions available in December 2013. When new standard versions are published, the analysis and related conclusions should be updated accordingly. Careful attention should also be paid to maintaining interoperability when new standard versions are developed for both systems.

8 Acknowledgments

We thank Dr. Timo Larikko for his valuable comments, the Ministry of Transport and Communications (Finland) and the Finnish Transport Safety Agency for supporting the analysis of interoperability and Mrs. Adelaide Lönnberg for editing the English.

9 References

1 EN16062: ‘eCall high level application requirements (HLAP)’, 2011
2 EN16072: ‘Pan-European eCall operating requirements’, 2011
3 EN15722: ‘eCall minimum set of data (MSD)’, 2011
9 GOST R 54620: ‘Global navigation satellite system. Road accident emergency response system. In-vehicle emergency call system. General technical requirements’
10 GOST R 54721: ‘Global navigation satellite system. Road accident response system: Service description’
11 GOST R 54188-2011: ‘Global navigation satellite system. Road accident emergency response system. Compliance test methods for electromagnetic compatibility, environmental and mechanical resistance requirements of In-Vehicle Emergency Call System’
15 Ööni, R.: ‘Interoperability of pan-European eCall and ERA-GLONASS’. Presentation at eCall Days Germany, Berlin, Germany, 26 – 27 September 2013
20 CENTES 16454: ‘eCall end to end conformance testing’, 2013
24 Leblanc, P., Ober, I.: ‘Comparative Case Study in SDL and UML’. Proc. 33rd Int. Conf. on Technology of Object-Oriented Languages, Mont-Saint-Michel, France, 5–8 June 2000

This is an open access article published by the IET under the Creative Commons Attribution-NoDerivs License (http://creativecommons.org/licenses/by-nd/3.0/)
27 ETSI TS 122 003 (10/2012): ‘Digital cellular telecommunications system (Phase 2 +); Universal Mobile Telecommunications System (UMTS); LTE; Circuit TeleServices supported by a Public Land Mobile Network (PLMN) (3GPP TS 22.003 version 11.0.0 Release 11)’. Available at http://www.etsi.org/deliver/etsi_ts/122000_122099/122003/11.00.00_60/ts_122003v110000p.pdf, accessed 6th August 2014
28 ETSI TS 124 008 (03/2014): ‘Digital cellular telecommunications system (Phase 2 +); Universal Mobile Telecommunications System (UMTS); LTE; Mobile radio interface Layer 3 specification; Core network protocols; Stage 3 (3GPP TS 24.008 version 11.10.0 Release 11)’. Available at http://www.etsi.org/deliver/etsi_ts/124000_124099/124008/11.10.00_60/ts_124008v110000p.pdf, accessed 6th August 2014
29 ETSI TS 122 004 (01/2000): ‘Digital cellular telecommunications system (Phase 2 +); Universal Mobile Telecommunications System (UMTS); General on supplementary services (3G TS 22.004 version 3.1.0 Release 1999)’. Available at http://www.etsi.org/deliver/etsi_ts/122000_122099/122004/03.01.00_60/ts_122004v030100p.pdf, accessed 7th August 2014
31 ETSI TS 122 081 (11/2012): ‘Digital cellular telecommunications system (Phase 2 +); Universal Mobile Telecommunications System (UMTS); Line Identification supplementary services; Stage 1 (3GPP TS 22.081, version 11.1.0 Release 11)’. Available at http://www.etsi.org/deliver/etsi_ts/122080_122099/122081/11.01.00_60/ts_122081v110100p.pdf, accessed 7th August 2014
32 ETSI TS 122 081 (06/2000): ‘Digital cellular telecommunications system (Phase 2 +) (GSM); Universal Mobile Telecommunications System (UMTS); Line Identification Supplementary Services; Stage 1 (3G TS 22.081 version 3.2.0 Release 1999)’. Available at http://www.etsi.org/deliver/etsi_ts/122080_122099/122081/03.02.00_60/ts_122081v030200p.pdf, accessed 7th August 2014
33 ETSI TS 122 004 (11/2012): ‘Digital cellular telecommunications system (Phase 2 +); Universal Mobile Telecommunications System (UMTS); LTE; General on supplementary services (3GPP TS 22.004 version 11.0.0 Release 11)’. Available at http://www.etsi.org/deliver/etsi_ts/122000_122099/122004/11.00.00_60/ts_122004v110000p.pdf, accessed 7th August 2014
34 ITU-T Q.731.3 (03/1993): ‘Stage 3 description for number identification supplementary services using Signalling System No. 7: Calling line identification presentation (CLIP)’. Available at http://www.handle.itu.int/11.1002/1000/2199, accessed 4th July 2014