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AN OBJECT-ORIENTED MODEL FOR EXPANSION OF THE MINIMUM SET OF DATA TRANSMITTED DURING eCALL SESSIONS

ABSTRACT

The focus of this paper goes beyond the horizon of the current status of the implementation of Europe's unique emergency distress platform for road traffic accidents called eCall (Emergency Call). In the near future, the eCall system will provide end-to-end communication service that will be used for transmission of an accident related information between the vehicles in distress and nearest Public Safety Answering Point (PSAP). Currently, different pilot projects strive to test the transmissions of the Minimum Set of Data (MSD) upon the accident occurrence, containing the information such as the location of the accident and a vehicle type. The received MSD is used by the PSAP operators for incident management purposes. In this study, we propose an Object-Oriented Model (OOM) for expansion of the MSD to include more information needed for efficient coordination of the emergency services at the scene of the accident as well as for more accurate investigation and analysis of the accidents.

KEY WORDS

eCall; communication system; architecture; model; minimum set of data; UML

1. INTRODUCTION

In recent years, significant effort has been invested worldwide into reducing the number of injuries and fatalities caused by road accidents (see, for instance, [1-2]). Vehicle manufacturers, infrastructure operators, scientific, research and educational institutions, civil organizations, national/international regulatory bodies and other stakeholders are continuously (co)working on the improvement of road safety by developing and implementing a wide range of Intelligent Transport System (ITS) solutions. Hence, nowadays we are witnessing the implementation and operationalization of various systems, for instance, active and passive in-vehicle safety systems, adaptive navigation systems capable of dynamic vehicle routing, new and improved information systems, intelligent lighting systems, and (semi-) autonomous vehicles. One of the most promising systems, with the ability to notably reduce the negative impacts of traffic accidents, is the Emergency Call or eCall system, currently developed and tested as a part of HERO (Harmonized eCall European Pilot) project [3].

The eCall system is a communication platform capable of collecting and distributing vital traffic accident related information to all parties involved in the process of accident management and clearance (i.e. incident management). In the core of the system sits the communication network; both fixed and wireless telecommunication networks are interconnected. The network connects drivers and vehicles with the infrastructure, i.e. Public Safety Answering Point (PSAP) responsible for handling the accidents [4]. This includes also the connection with emergency services as well as other organizations.

The communication system, therefore, connects mobile users (vehicles, i.e. drivers) with the PSAP responsible for the certain area of the road network (usually one or more regions).

Upon the accident occurrence, the vehicle automatically sends the information about the event to the PSAP or, in another use case, the driver of the vehicle initiates the eCall session manually [5]. Next, the onboard vehicle system transmits the Minimum Set of Data (MSD) to the PSAP, indicating e.g. vehicle type and geographical location of the vehicle [6-7]. A voice channel between the vehicle and the operator in PSAP is established as well; thus, the operator can acquire additional information from the driver and/or the passenger(s) if they are conscious. The received information helps PSAP operators to efficiently dispatch required emergency services to the location of the accident and to dynamically route the emergency vehicles to/from the location. Hence, the system directly increases the probability of transporting the victims of the accident to the medical facilities within the "golden" hour, ergo, reducing the fatality rates of the accidents.

Note that the eCall system is based on the 112 SOS platform, i.e. it upgrades the functionalities of the Europe's joined emergency response system. Furthermore, the eCall system requires appropriate communication capabilities of the vehicles. It is planned that all new-produced vehicles will be equipped with the eCall technology from April 2018 onwards (as indicated in [8]), while different solutions are currently being developed for older vehicles (e.g. see the work presented in [9-10]).

In this paper, we argue for the expansion of the MSD transmitted during the eCall sessions to the PSAP and propose an Object-Oriented Model (OOM) of the upgraded system that would be capable of accommodating the proposed functionalities. The main motivation for this work stems from the fact that modern vehicles are collecting a wide range of data from the on-board sensors, while Next Generation Mobile Networks (NGMN), namely Long Term Evolution (LTE) and future 5G networks, are capable of fast and reliable data transfers. By expanding the MSD, the PSAP operators would have a complete traffic accident related information at their disposal which can improve the process of incident management as well as the accuracy of traffic accident investigations. Note that some possibilities for the expansion of the MSD are previously discussed in [11-12].

The remainder of the paper is structured as follows. Section 2 provides a brief overview of the current architecture of the eCall system, setting up a baseline for our proposed expansion of the system. In section 3 we present the OOM of the new and upgraded system, while in Section 4 we draw conclusions.

2. SYSTEM ARCHITECTURE

Based on the results of the HERO project [3], in this section, a brief overview of the eCall system architecture will be presented. The system consists of three integral subsystems as depicted in *Figure 1*. Namely, the eCall platform connects the mobile users (i.e. In-Vehicle System or IVS) with PSAP operators via a telecommunication network, enabling the MSD transmissions and voice communication.

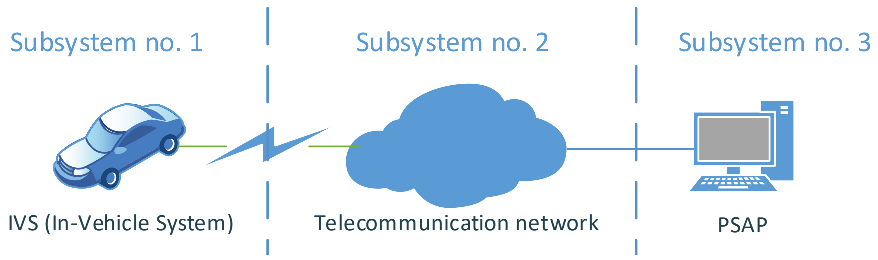

Figure 1 – Three subsystems of the eCall system
Source [3]

2.1 In-Vehicle System (IVS)

To become fully operational, the eCall system requires that the vehicles can participate in the network communication and data exchange [13]. The equipment used to collect and transmit the data is depicted in *Figure 2*. The key component is the MSD generator that collects the on-board data (e.g. geographical location of the vehicle and airbag status) and transmits them to the PSAP via network access device and the antenna. Note that the size of the MSD is 140 Bytes and it contains six different types of information, tabulated in *Table 1*.

The IVS consisted of these components (*Figure 2*) has to meet the following functional demands: (a) network access device, such as GSM or 3G module, has to be installed onboard and IVS has to detect when the eCall has been initiated; (b) in case of an accident, IVS has to be able to autonomously decide whether to initiate the call or not, but it has to enable manual initiation of the eCall session as well; (c) upon the initiation of the eCall, IVS has to transmit MSD to any local mobile network service provider; (d) voice communication has to be enabled between the vehicle and PSAP (therefore, the integral part of the IVS is a microphone and a speaker, as indicated in *Figure 2*); and (e) the IVS communication equipment has to be robust and durable so that it is immune to the damage caused by the accidents as well as the elements.

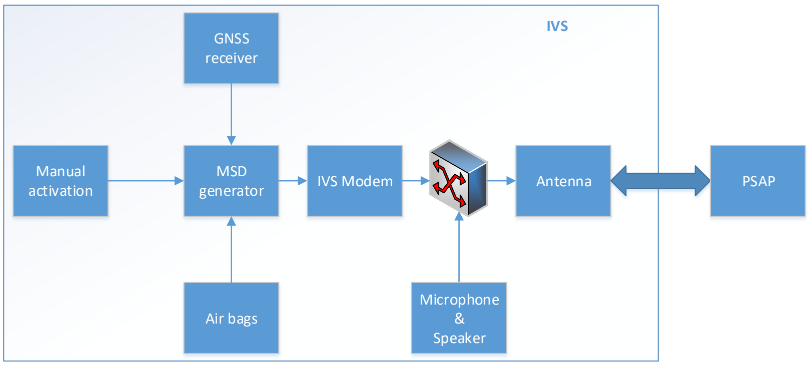

Figure 2 – IVS components
Source [3]

Table 1 – The Minimum Set of Data transmitted during eCall session

Control	Size in Bytes = 1	• Type: Integer • Validation: No • Description: Bit 7: Automatic activation | Bit 6: Manual activation | Bit 5: Test call | Bit 4: No confidence in position | Bit 3 - Bit 0: Reserved
Vehicle identification	Size in Bytes = 20	• Type: String • Validation: 17 characters, excluding the letters I, O or Q • Description: Vehicle Identification Number according to ISO 3779
Time stamp	Size in Bytes = 4	• Type: Integer • Validation: ≥0 • Description: UTC seconds
Location	Size in Bytes = 9	• Type: Integer (latitude and longitude) and Byte (direction in degrees) • Validation: [-324.000.000, 324.000.000] for latitude; [-618.000.000, 618.000.000] for longitude; [0, 255] for direction in degrees
Service provider	Size in Bytes = 4	• Type: Byte • Validation: IPv4 format or blank field • Description: Service provider IP address or blank field
Optional data	Size in Bytes: 102	• Type: String • Validation: No • Description: Additional data or blank field

Source [14]

As seen from *Table 1*, there are 102 free Bytes for transmission of additional (optional) data from IVS to PSAP. In this study, we propose to use that free space to transmit other onboard data that is frequently collected by the vehicle systems (e.g. the accelerator/brake pedal status, vehicle speed etc.). This will be further discussed in section 3.

2.2 Telecommunication network

One of the key eCall stakeholders are the mobile service providers. Similarly to IVS, the telecommunication network (i.e. the providers) also needs to meet different case specific demands. Namely, the eCall service must be available across Europe regardless of the state borders, without any charges. The vehicles, representing the User Equipment (UE), must gain access to the network through BTS (Base Transceiver Station) and BSC (Base Station Controller). eCall UE must be recognized by the MSC (Mobile Switching Centre) and the initiated eCalls must be prioritized within the network. Each eCall must be treated by the network as an emergency call, meaning, the network must flag the call with *eCall flag* and acquire the location and ID of the UE. The eCall is routed to the nearest PSAP over Transcoder and Rate Adaptation Unit (TRAU), Media GateWays (MGW) and Wireline Switching Centres (WSC) when the MSC receives the call with the abovementioned eCall flag (*Figure 3*).

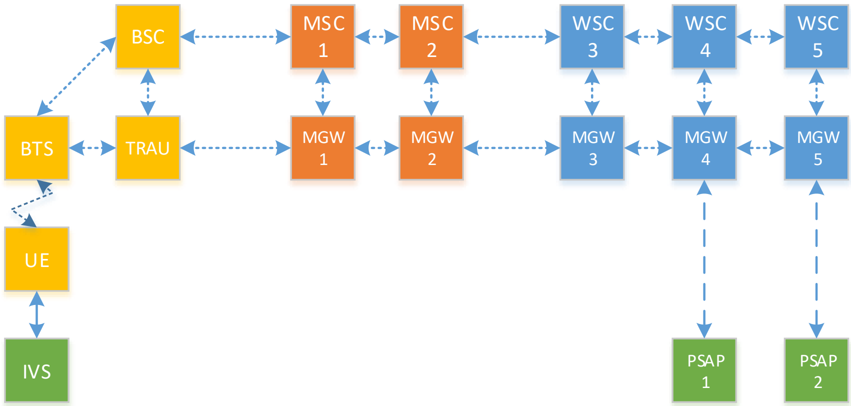

Figure 3 – Network components of the eCall system
Source [15]

The network also must be able to differentiate between the eCall and the standard 112 emergency calls. The eCall must be routed only to those PSAP complying with the eCall requirements (e.g. PSAP must be capable of receiving the MSD), while the standard emergency calls can be routed to any PSAP in the area. If a PSAP can receive both the eCall and the standard calls, then the network must route the eCall to appropriate interface of that PSAP. Based on the location of the UE, the service providers must provide a mobile cell ID, i.e. the cell location from where the eCall is routed.

2.3 PSAP

One of the proposed solutions for the PSAP architecture is presented in *Figure 4*. To this day, the eCall system is not fully operational [16], thus the PSAP architecture is still evolving; however, it is clear that some key functionalities have to be enabled by the architecture. Naturally, the PSAP must be connected to the mobile and fixed telecommunication networks, i.e. the PLMN (Public Land Mobile Network) and PSTN (Public Switched Telephone Network), respectively. The ingress components of the PSAP are the Eones (eCall identification equipment) and the eCall modem responsible for extracting the MSD from the eCall.

Based on the type of information that receives (voice or data), the Multiprotocol Switched Services (MSS) device conducts the routing within the PSAP. The voice communication is forwarded to the PBX (Private Branch Exchange), Voice over Internet Protocol (VoIP) server, as well as to the Data Base/Application server. The MSD is forwarded to the MSD decoder that decodes the received data set and joins them with the additional data sources such as VIN DB (Vehicle Identification Number DataBase), TPS (Third Party Service provider) or EUCARIS (European CAR and driving license Information System). In addition, local emergency station(s) are also provided with the eCall information via IP connection.

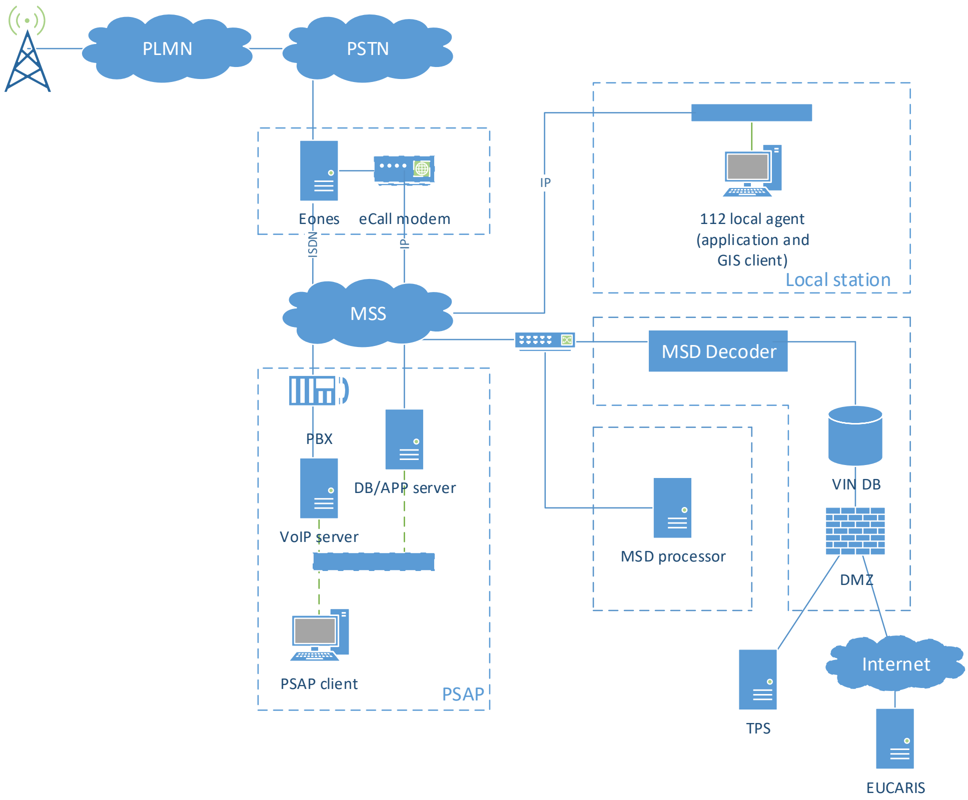

Figure 4 – The PSAP architecture
Source [3]

3. OOM OF THE PROPOSED EXPANDED SYSTEM

3.1. Upgraded IVS

The primary incentive for development and implementation of the eCall system is to decrease the time needed for emergency response to the scene of the accident; thus, reducing the negative impacts of the accidents. The current blueprints of the system, i.e. the system architecture discussed in the previous section, will enable that since the call is initiated immediately upon the accident (automatically or manually) and the location of the accident is sent to the PSAP. Hence, some sources, for instance [8], state that the time needed for an emergency response can be decreased with the eCall system by 50 and 60% in urban and rural areas, respectively. However, the potential of the system goes beyond the transfer of MSD, given the fact that modern vehicles are mobile sensors capable of collecting a wide range of traffic and vehicle status data. Apart from the incident management, these data could also be used for accident scene investigation.

In this study we propose to use in-vehicle EDR (Event Data Recorder) device as another data source and to collect and transmit the data, such as, vehicle speed (ranging from 0 to 250 km/h) and position of the accelerator pedal (0-100% of the pressure), number of Revolutions Per Minute of the engine (0-12.800 RPM), status of the brake pedals (pressed or not), position of the gear shifter (R/N/P/D/5/4/3/2/LO/B/Seq), position of the steering wheel (in degrees ±375°) and status of the cruise control (on or off). Furthermore, onboard Inertial Measurement Unit (IMU) can also be used as another data collector. The proposed new components of the IVS are depicted in *Figure 5*.

This new data would take up to 20 additional Bytes of those 102 Bytes reserved for additional (optional) data (*Table 1*). The Extended MSD (EMSD) would provide information not only about the location of the accident, vehicle type etc.; the EMSD provides the insight into driver behavior as well.

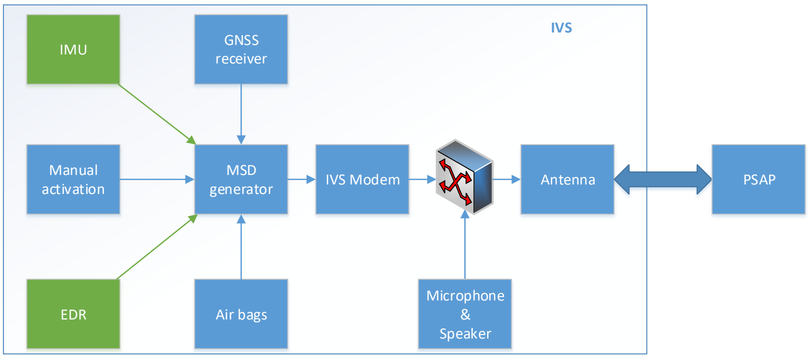

Figure 5 – Additional IVS components

Note, that the data send with EMSD can contain different timestamps so, for instance, vehicle speed can have two timestamps: one indicating the speed at the exact time of the accident (i.e. before the impact), and another record indicating the speed, e.g., 10 seconds before the accident. This would consume only 1 additional Byte of transmitted information but could produce a profound impact on the accuracy of the accident scene investigation.

3.2. Proposed PSAP architecture

Apart from the expansion of IVS functionalities, the proposed model includes the introduction of the connection between the PSAP and local/regional/national Traffic Management Centre (TMC) via Internet network, as indicated in *Figure 6*. This new system would be able to integrate different sets of data that are now dispersed over various data providers. For instance, Road Weather Information System (RWIS) can provide important information to the PSAP operator when he or she tries to dispatch the emergency services at the scene of the accident and prevent secondary incidents from happening. In fact, the proposed connection is beneficial also for the TMC, since the PSAP operator can inform the center about the occurrence of the accident; thus, the center detects and confirms the event with more accuracy. This, in turn, improves the efficiency of the incident and traffic management around the scene of the event [17] and as well as the accuracy of travel information.

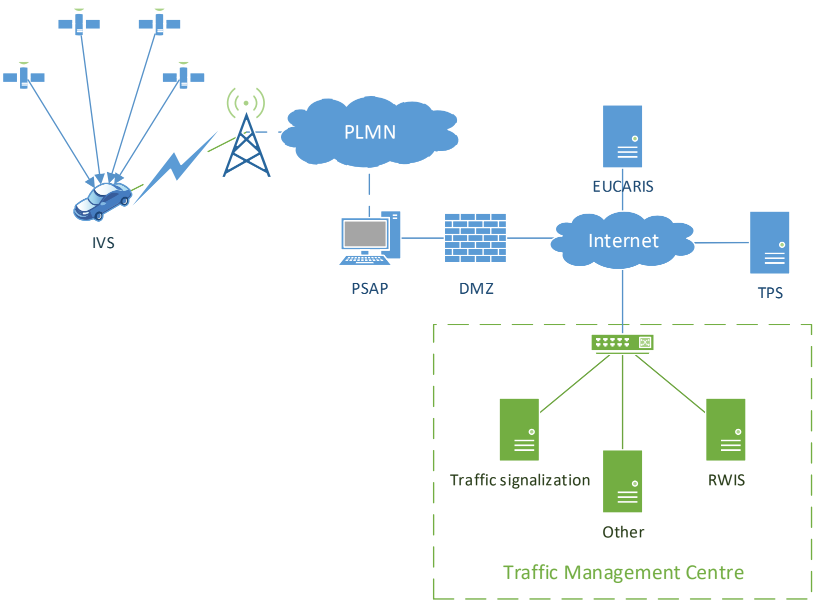

Figure 6 – Interaction of the PSAP and other systems

Another important benefit of this extension is the data collected from the Traffic signalization component of the TMS. Consider the following case presented on the sequence diagram depicted in *Figure 7*. The accident occurs at a signalized intersection. The exact time of the accident is recorded by the IVS and transmitted to the PSAP through the eCall system. After receiving and decoding the MSD, PSAP operator acquires the signaling plan for that intersection from local TMC and determines the exact signaling phase at the time of the accident. Thus, the accuracy of the accident investigation improves.

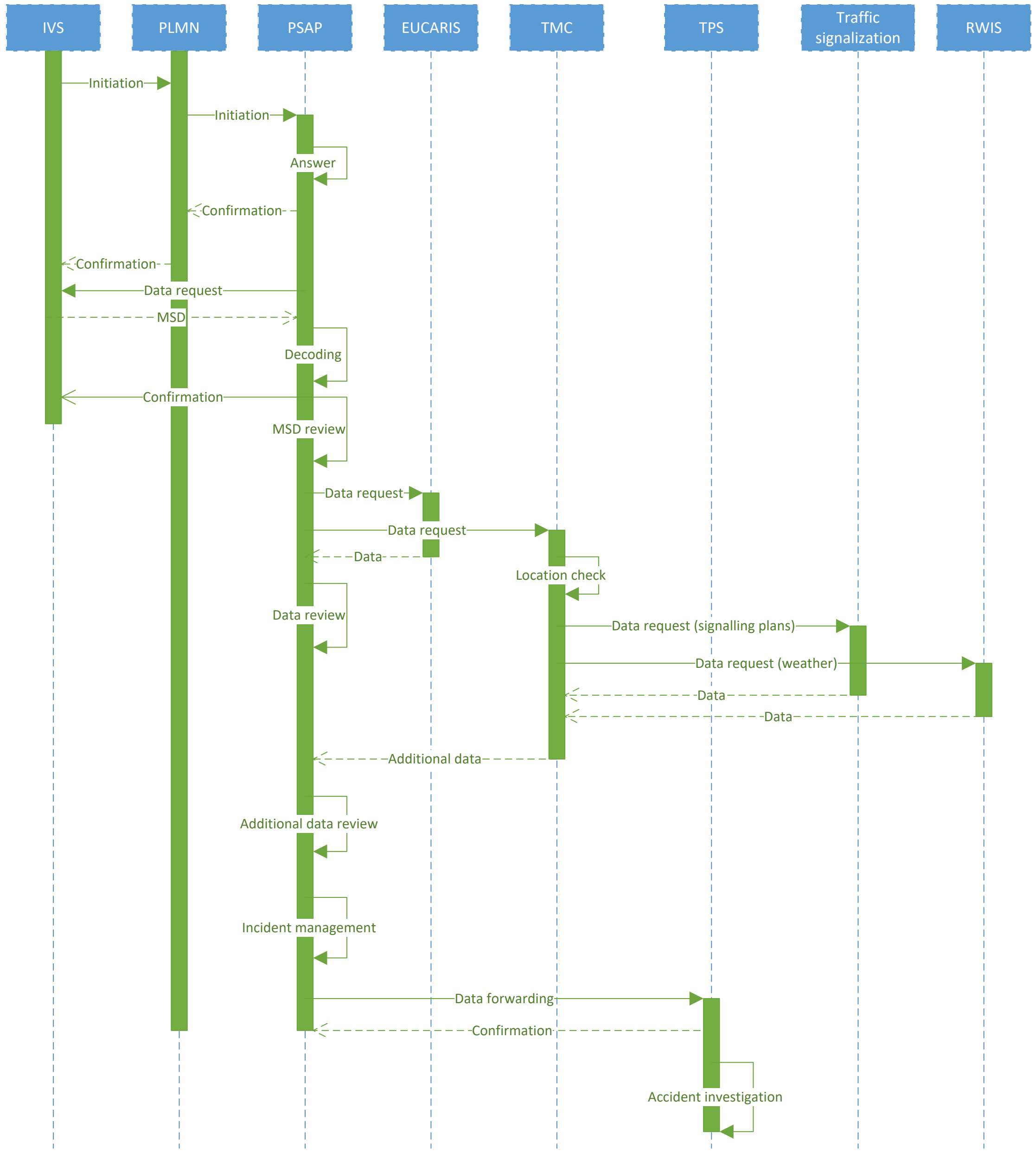

Figure 7 – Sequence diagram for one case of eCall session

4. CONCLUSION

As seen from the available results of field tests referenced in this paper, the eCall system can significantly reduce the time needed for emergency response to the location of an accident and provide essential information to the incident management personnel enabling more efficient and safe accident clearance. Most time savings originate from the reduction of time needed for accident detection and verification since the eCall system provides automatic and manual initiation of the eCall session, immediately upon the accident occurrence. Additional savings in time are achieved by MSD transmissions that provide the PSAP operators exact location of the accident; thus, enabling fast dynamic routing of emergency vehicles to/from the accident scene.

Currently, the MSD contains only basic information about the vehicles involved in the accident and their location, even though modern vehicles are collecting a much wider set of data from their onboard sensors. Thus, with this paper, we argued for introducing EMSD to include another type of data that can give an insight also on the driver behavior at the time of the accident. We believe that this new information can significantly improve the incident management and accident investigation processes.

Apart from IVS upgrades, our OOM of the new eCall system includes expansion of the PSAP functionalities as well. Namely, the connection between the PSAP and local/regional/national TMC is introduced. The communication between these two objects would enable different synergies, resulting also in improved safety (prevention of secondary incidents due to the fast and reliable trip and pre-trip travel information dissemination) and accuracy of accident investigation since traffic signaling plans could be joined with other accident related information.

REFERENCES

[1] World Health Organization. World report on road traffic injury prevention: summary. Geneva: World Health Organization; 2004.

[2] Wood S, Bellis MA, Watkins S. Road traffic accidents: a review of evidence for prevention. Liverpool John Moores University; 2010.

[3] HeERO. Document no. D6.5 Implementation roadmap and guidelines for eCall deployment in Europe. HeERO Harmonized eCall European Pilot project; 2015 [cited 2016 Nov 2]. Available from: http://www.heero-pilot.eu/ressource/static/files/heero_wp2_d2-2_functional_specification_final.pdf.

[4] Filjar R, Vidović K, Britvić P, Rimac M. eCall: Automatic notification of a road traffic accident. Proceedings of the 34th International Convention MIPRO; 2011 May 23-27; Opatija, Croatia.

[5] Matulin M, Mrvelj Š, Bošnjak I. Defining system requirements for new IP based incident management service – eCall. Proceedings of the 21st Central European Conference on Information and Intelligent Systems; 2010 Sep 22-24; Varaždin, Croatia.

[6] Carroll J, Seidl M, Cuerden R, Stevens A. eCall Technical considerations regarding type-approval testing of eCall in-vehicle system. EC Project Number SI2.671420. TRL Client Project Report CPR1868; 2014.

[7] Öörni R, Korhonen TO. eCall minimum set of data transmission – results from a field test in Finland. IET Intelligent Transport Systems. 2014; 8(8):639-647. doi: 10.1049/iet-its.2013.0113.

[8] European Commission. eCall: Time saved = lives saved. 2017 [cited 2017 Mar 25]. Available from: https://ec.europa.eu/digital-single-market/en/ecall-time-saved-lives-saved.

[9] Smolka J, Skublewska-Paszkowska M. A method for collision detection using mobile devices. Proceedings of the 9th International Conference on Human System Interactions; 2016 Jul 6-8; Portsmouth, United Kingdom. doi: 10.1109/HSI.2016.7529620.

[10] Fernandes B, Gomes V, Ferreira J, Oliveira A. Mobile application for automatic accident detection and multimodal alert. Proceedings of the 81st Vehicular Technology Conference; 2015 May 11-14; Glasgow, United Kingdom. doi: 10.1109/VTCSpring.2015.7145935.

[11] Öörni R, Goulart A. In-vehicle emergency call services: eCall and beyond. IEEE Communications Magazine. 2017; 55(1):159-165. doi: 10.1109/MCOM.2017.1600289CM.

[12] Blancou J, Almeida J, Fernandes B, Silva L, Alam M, Fonseca J, Ferreira J. eCall++: An enhanced emergency call system for improved road safety. Proceedings of the Vehicular Networking Conference (VNC); 2016 Dec. 8-10; Columbus, OH, USA. doi: 10.1109/VNC.2016.7835964.

[13] HeERO. Document no. D2.2 eCall system functionalities' specification. HeERO Harmonized eCall European Pilot project; 2015 [cited 2016 Aug 16]. Available from:

http://cordis.europa.eu/docs/projects/cnect/5/325075/080/deliverables/001-HeERO2D65eCallGuidelinesv11ICOORAres2222865.pdf

[14] Žardecki D, Pijanowski B. Information in the motor vehicle safety system with the „e-Call“ function. The Archives of Automotive Engineering. 2012.

[15] 3GPP. eCall data transfer; In-band modem solution (Release 8). 3rd Generation Partnership Project; 2007 [cited 2017 Jan 15]. Available from: http://www.qtc.jp/3GPP/Specs/26967-801.pdf

[16] Hadjidimitriou SN, Öörni R. A framework for appraising European member states' readiness level for eCall deployment. Proceedings of the 18th International Conference on Intelligent Transportation Systems (ITSC); 2015 Sep.5-18; Las Palmas, Spain. doi: 10.1109/ITSC.2015.371.

[17] Walker R, Stevens A, Anjum O, Suriarachchi M, McNamara K. Benefits of automatic crash notification for traffic management. Proceedings of the Road Transport Information and Control Conference and the ITS United Kingdom Members' Conference; 2010 May 25-27; London, United Kingdom. doi: 10.1049/cp.2010.0381.