Paper number EU-TP0122

State of the art assessment Powered Two-Wheeler (P2W) eCall

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Abstract

As “Emergency Call” (eCall) systems become mandatory for passenger cars and light commercial vehicles in the EU, the standardization and regulation for these systems is already well advanced. In contrast to this, for the application on Powered Two-Wheelers (P2W), there are no standards available. This paper is summarizing the first steps of the P2W part of the I_HeERO project.

Within this paper an overview about existing eCall and eCall-like systems is given. A focus is set on the existing automotive standards. These are the basis for a motorcycle eCall system and therefore must be analysed carefully.

The second part of this paper includes the description of the specific characteristics of P2W and the arising challenges for a P2W-eCall-system out of these. A key point in this part is an investigation based on naturalistic riding data.

In the last part of this paper, the most relevant eCall-systems are assessed with regard to an application on P2W.

Keywords:
ECALL, P2W, I_HEERO

Introduction / Motivation

The number of P2W was increasing much faster than the number of passenger cars between 2001 and 2010 [1]. In addition to this, the risk of P2W riders is much higher than for four-wheelers. The account of P2Ws is about 8% of the motorised vehicle fleet, but the account of fatalities is about 17% [1]. For example, the risk of dying in a traffic accident in Germany is 18 times higher for a P2W rider than the risk for a car driver [1]. Therefore, the safety of P2W becomes more and more important.

There are three different categories of countermeasures for reducing the crash severity [2]:

- Crash avoidance (Pre-Crash-Phase)
- Protection against injuries (Crash-Phase)
- Optimization of rescue (Post-Crash-Phase)

Today automatic eCall systems are part of the third category. Such a system can reduce the injury severity by shortening the therapy free interval. Figure 1 shows a detailed description of the therapy free interval.

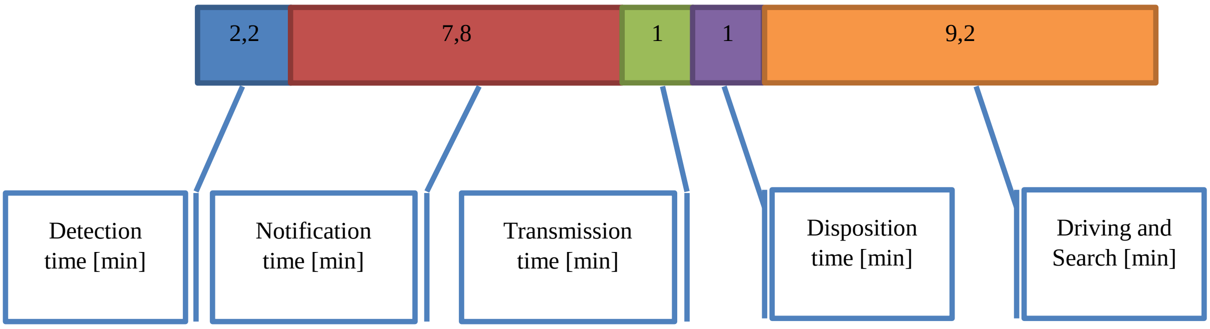

Figure 1 - Therapy free interval [2]

An eCall system has an impact on two parts of the therapy free interval. The “Detection time” can be reduced due to the automatic triggering. By transmitting the accident location with GNSS coordinates, the “Driving and Search” time can also be significantly reduced. According to [3] the rescue time in rural areas can be shortened from 21min to 12min by automatic eCall systems.

In summary, the potential of eCall systems for reducing fatalities and injury severity especially for P2W is significantly high.

As eCall systems become mandatory for passenger cars and light commercial vehicles in the EU, the standardization and regulation for these systems is already well advanced. In contrast to this, for the application on P2W, there are no standards. Because of this a consortium, consisting of universities, public research institutes, suppliers and OEMs, is working out a proposal for minimum functional requirements for P2W eCall as a preliminary step for standardization within the EU-funded project I_HeERO. This paper is summarizing the first steps of the P2W part of the I_HeERO project.

eCall and eCall-like systems

Whereas the focus of this paper is on eCall systems for motorcycles, there are many other eCall or eCall-like systems available on the market. In this paper, an eCall system is a system, which can automatically detect an eCall relevant situation and can execute an emergency call directly to a public safety answering point (PSAP). Compliance to the underlying standards is also obligatory for an eCall system.

In contrast, an eCall-like system is a system capable of sending a distress call or message to someone, when automatically detecting a potentially dangerous situation. eCall-like systems can be found in different fields, like:

- Health care
- Bicycles
- Motorbikes
- Cars
- Smart Apps
- Insurance telematic boxes (vehicles).

Such eCall-like systems can be classified according to many different features. The most relevant are:

- Accident detection sensor (manual, accelerometer, in-vehicle, others)
- Communication method (mobile network (GSM or higher), other)
- Responder (friend number, operators, emergency authorities, others)
- Communication type (text message, phone, call-back)
- Integrated communication (Yes, No)
- Portable (Yes, No)

In Figure 2 below, an example of the (approximate) distribution of different sensors and different responding-modes, within the considered six fields, is displayed. Notice that each field has specific features.

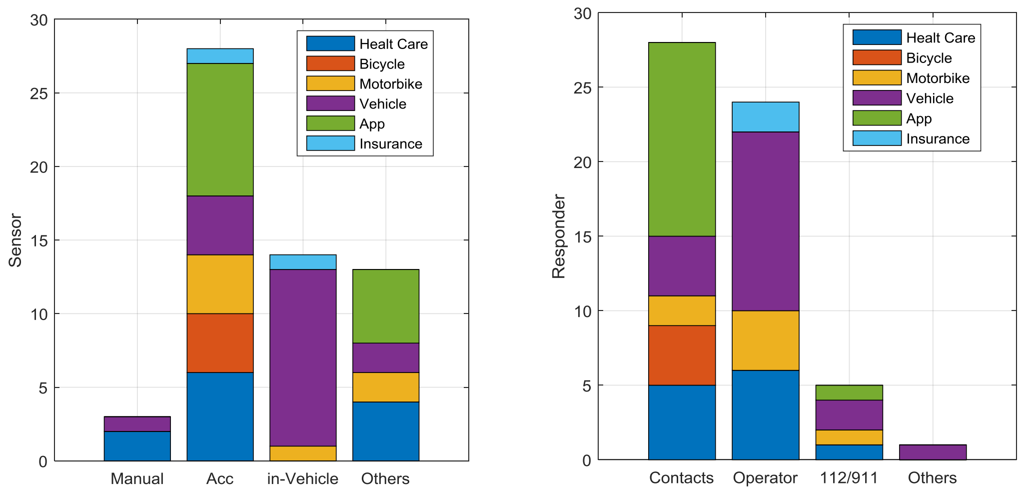

Figure 2 - Distribution of different types of sensors (left) and responding-method (right) within the eCalls systems of the six main considered fields

Examples of eCall or eCall-like systems, out of the vehicular (cars or motorcycles) fields are:

- Healthcare field:
    - pendant and/or wristband and/or belt and base station.
    - vital monitoring adhesive patch with smartphone app
- Bike field:
    - bike taillight and smartphone app
    - helmet sensor and smartphone app
    - keyless bike lock and smartphone app
- App field (only app – no other device):
    - crash detection, speed monitoring, location tracking
    - detect immobility periods, scheduled check-in timers, location tracking, panic button.

Current status of eCall for passenger car and light commercial vehicle

As eCall systems become mandatory in the EU for defined vehicle categories, the standardization and regulation for these systems is already well advanced.

In the context of "Intelligent Transport Systems" (ITS), eCall can be described as an automatic or user instigated system to provide notification to PSAP, by means of wireless communications, that a vehicle has crashed, and to provide coordinates, a defined Minimum Set of Data (MSD), and where possible a voice link to the PSAP [5].

eCall operation sequence

The very highest-level generic eCall architecture is described in Figure 3.

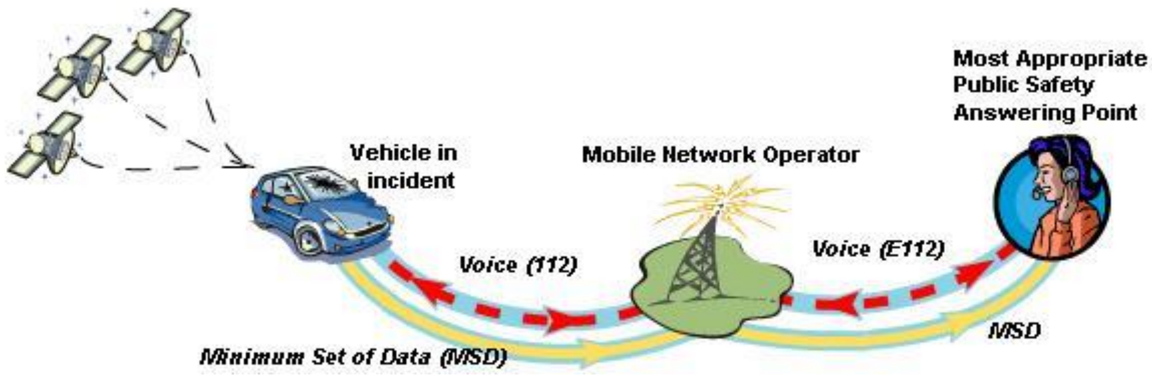

Figure 3 - eCall operation sequence

As soon as the in-vehicle system (IVS) is triggered automatically or manually by the vehicle occupants, the system dials the pan European 112 emergency number. The call then will be routed with a specific flag signalling to the most appropriate PSAP. A sequence of data, the Minimum Set of Data (MSD), is transmitted as part of the established eCall. This data contain the exact geographic location of the vehicle, the direction of travel, the triggering mode (automatic or manual), the Vehicle Identification Number and other information to enable the emergency response teams to quickly locate and provide medical and other life-saving assistance to the accident victims. The subsequent established voice link enables the vehicle occupants to provide additional information of the accident if they are able to speak.

eCall standards

The underlying eCall standards are defined and approved by European Standardisation Bodies, namely ETSI and CEN. The European Standards specify the general operating requirements and intrinsic procedures, the communication protocols and interfaces but also the conformity assessment and third party support operating requirements. The list of standards related to pan European eCall is shown in Figure 4 (CEN) and Figure 5 (ETSI).

Description	Reference	Title
eCall Minimum Set of Data	CEN EN 15722	Intelligent transport systems – eSafety – eCall minimum set of data (MSD)
High Level Application Protocols	CEN EN 16062	Intelligent transport systems – eSafety – High Level Application Protocols (HLAP)
Operating requirements	CEN EN 16072	Intelligent transport systems – eSafety – Pan-European eCall operating requirements
Operating requirements for third party support	CEN EN 16102	Intelligent transport systems – eCall - operating requirements for third party support
End to end conformance testing	CEN EN 16454	Intelligent transport systems – eSafety – eCall end to end conformance testing

Figure 4 – CEN Standards

Description	Reference	Title
General description	ETSI TS 126 267	eCall data transfer; Inband modem solution; General description
ANSI-C reference code	ETSI TS 126 268	eCall data transfer; In-band modem solution; ANSI-C reference code
Conformance testing	ETSI TS 126 269	eCall Data Transfer; In-band modem solution; Conformance testing
Characterization report	ETSI TS 126 969	Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); eCall data transfer; In-band modem solution; Characterization report
HLAP Conformance Testing; Abstract Test Suite (ATS)	ETSI TS 103 321	Mobile Standards Group (MSG); eCall HLAP Conformance Testing; Abstract Test Suite (ATS) and Protocol Implementation eXtra Information for Testing (PIXIT)
Network Access Device Protocol test specification	ETSI TS 102 936-1	eCall Network Access Device (NAD) conformance specification; Part 1: Protocol test specification
Network Access Device Test Suites	ETSI TS 102 936-2	eCall Network Access Device (NAD) conformance specification; Part 2: Test Suites
eCall Communication equipment	ETSI TR 102 937	eCall communications equipment; Conformance to EU vehicle regulations, R&TTE, EMC & LV Directives, and EU regulations for eCall implementation
USIM	ETSI TS 131 102	Characteristics of the Universal Subscriber Identity Module (USIM) application
UMTS abstract test suite	ETSI TS 134 123 - 3	Universal Mobile Telecommunications System (UMTS); User Equipment (UE) conformance specification; Part 3: Abstract test suite (ATS)

Figure 5 - ETSI Standards

Automatic eCall triggering mechanism

It is a basic functional premise of eCall that in the event of a collision the system is able to detect the collision and initiate the eCall. This is based on the assumption that the collision is of a severity that is potentially injurious and that the occupants of the vehicle may not able to initiate the call themselves. Thereby there is some benefit associated with automatic triggering of a call to the emergency services. In passenger cars, the automatic triggering is initiated by a signal emanating from one or more signals or a signal-processing unit within the vehicle to the eCall IVS. This triggering signal is generated by in-vehicle equipment such as an airbag unit to identify a probable collision. The mandatory equipping of vehicles with the eCall in-vehicle system will initially apply only to new passenger cars and light commercial vehicles (categories M1 and N1) which are fitted with acceleration sensors in order to deploy airbags and thus for which an appropriate triggering mechanism already exists.

There are accidents where a serious or life threatening injury is likely and others where a serious or fatal injury is very unlikely. The eCall triggering should follow this spectrum to make sure that eCall is not activated when there is no risk of injury and thus PSAPs won't be inundated with (low-urgency) superfluous or false calls. There are two ends of the spectrum. The one describes accident severities, where an eCall must be launched and the other where an eCall must not be triggered. The middle part of the spectrum represents a region of uncertain outcome, where it is left to the discretion of the manufacturer as to whether eCall should be triggered or not (Figure 6).

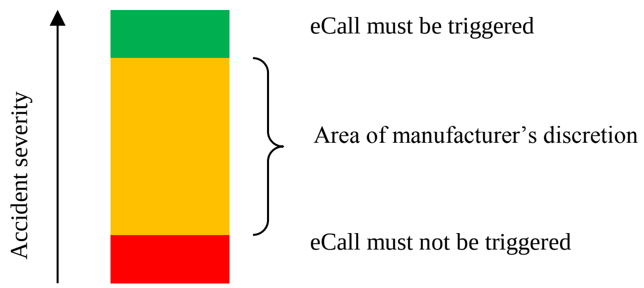

Figure 6 - Spectrum of automatic eCall triggering

The current proposals for the type-approval process describe how the manufacturer has to prove the strategy chosen to trigger an automatic eCall. This strategy has to ensure triggering also in accident configurations dissimilar from and/or of a lower severity than the collisions simulated in the applicable full-scale crash tests defined in UN Regulation No. 94 and No. 95. Moreover, a documentation of the strategy to prevent unjustified eCalls (falls calls) from being made in case of impacts of a severity level that is not considered a severe accident [6] has to be provided.

Challenges P2W

The biggest challenge for a P2W eCall system is the identification of a reliable triggering mechanism. For cars, there are already sensors and crash detection logics available, e.g. for airbags. The first airbag systems were available in the 1970s. Since then the crash detection algorithms for airbag triggering were further developed and are now very advanced. In contrast to this, for motorcycles there are no dedicated sensors or algorithms available, which could detect accidents. The only sensor, which is mandatory and can detect something similar to an accident, is the "Roll-over-detection". The "Roll-

over-detection" has to switch off the engine in case the motorcycle flips over. Unfortunately, the "Roll-over" is not a sufficient characteristic of a P2W accident as shown in Figure 7.

Figure 7 is showing the statistical distribution (GIDAS) of the final position of the motorcycle after an accident. Especially for accidents in which the motorcycle stands still, there is a significant portion of accidents, where the motorcycle ends up upright.

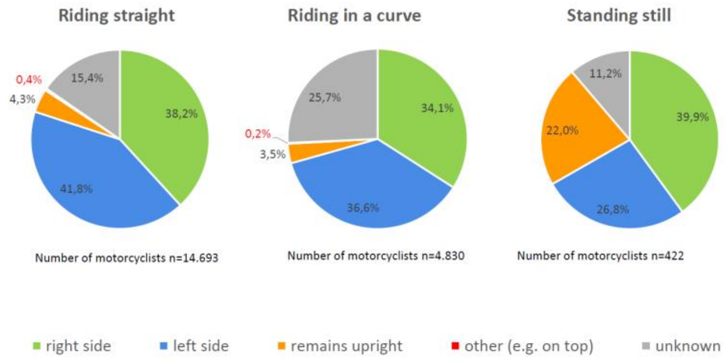

Figure 7 - Final position motorcycle [4]

In most cases, these accidents are collisions between motorcycles and cars, when the motorcycle is pinched by the car. Figure 8 shows a picture of such an accident. In this case, the motorcycle was hit in the back by the car.

Figure 8 – Accident [4]

As there is no available triggering logic for a P2W eCall system, one big part of this project is the description of a very rudimentary generic detection algorithm. There is one fundamental requirement for such a system. The system has to be an in-vehicle-system (IVS). This ensures that the system will work for every rider regardless of the availability of special rider-based equipment.

The focus on IVSs leads to another challenge, the possible separation of motorcycle and rider in an accident situation. It is obvious, that the rider will be separated from the bike in an accident situation, because normally there are no mechanical occupant restraint systems available on a motorcycle. For a "fall accident", the median throwing distance of the rider is 6m whereas the median throwing distance of the motorcycle is 10m. So in most cases, there is a significant distance between motorcycle and rider, Figure 9.

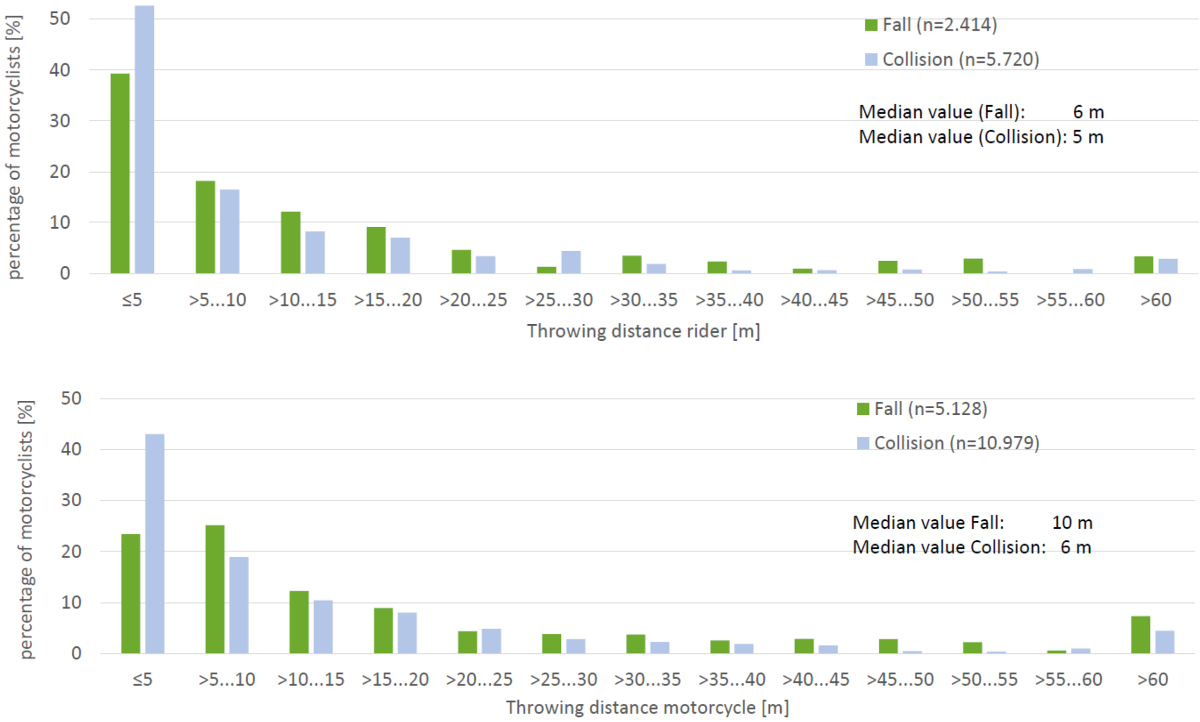

Figure 9 – Throwing Distances [4]

Due to this fact, the severity of a P2W accident has to be estimated according to the values of the first relevant incident. For the first relevant incident, the probability that the rider is still on the motorcycle is very high and consequently the movement of the rider should be similar to the movement of the bike. After the first relevant incident, this cannot be guaranteed anymore.

Obviously, there are situations where the crash severity hardly could be estimated by the first incident, e.g. a lowsider at relatively low speeds with a secondary impact with another vehicle. There are two possible configurations:

1. The car hits only the motorcycle
2. The car hits only the rider

For the first configuration, the crash severity could be estimated correctly with the first relevant incident. For the second configuration however, the crash severity is underestimated with the first relevant situation. At the moment this disadvantage cannot be solved only with sensors on the motorbike. However, the focus of this project is on an IVS, as described above, because at the moment there is no mandatory rider-based equipment which is equipped with suitable sensors.

For the development of the triggering algorithm an accident database study was started. The target of this study is to identify the most relevant accident scenarios of an eCall triggering. Based on this study the crash severity and the corresponding injury severity should be estimated by a statistical approach.

Another big challenge is the avoidance of false calls. In the automotive sector, an automatic voice connection between the car and the PSAP will be established, once the eCall was triggered. Via this voice connection, the PSAPs are able to check the necessity of dispatching the rescue services and they are able to get more information about the severity.

On a motorcycle, this is far more difficult. The first problem is that in case of a false call, the rider won't be able to hear any request from the PSAPs due to the ambient noise and the helmet. (It is assumed, that the speaker and the microphone is fixed directly to the motorcycle)

In case of a justified eCall, the probability is very high, that the rider is too far away from the motorcycle in order to answer any voice communication, Figure 9.

So the question of the meaningfulness of a mandatory voice connection has to be investigated.

The last challenge is the positioning of all necessary elements of a P2W eCall system. The application on a motorcycle has some special characteristics, e.g. the permanent exposure to environmental influences or the missing crush-collapsible zone. It has to be ensured, that in an accident situation, the system is able to gather all relevant information and send out the MSD. The crash resistance of all elements must be guaranteed.

However, the triggering algorithm is the crucial part for avoiding false calls. In order to ensure a robust triggering algorithm naturalistic riding data will be analysed.

Considering the specificities of the eCall for P2W, the triggering algorithms and thresholds will be verified using naturalistic riding data. In this direction, data collected via naturalistic riding experiments will be analysed. Data were collected while experienced riders were riding equipped motorcycles in several environments, including urban and highway (two lanes per direction) environment. Data include video recordings of the front scene, as well as time, longitudinal, lateral and vertical acceleration (in g), speed (km/h), yaw, pitch and roll rate (deg/s), throttle position (%), brake pressure rear (%), steering position (%), brake activity front and rear (%), wheel speed (km/h) and GPS data.

No accidents occurred, so no data from accidents of any type are available. Still, several incidents that could result to critical riding situations of high risk were identified. Such situations included the motorcycle braking and moving on the right to avoid opposing vehicle, hard braking due to pedestrians, motorcycle moving to the left to avoid stationary object. There are numerous incidents in which some sensor values are significantly different from the values during normal riding. Therefore, the data sets are adequate for verifying the triggering algorithm to be developed. The objective is to fine-tune the algorithms and any selected thresholds in order to reduce the number of false eCalls.

Summary

The motivation for eCall systems in particular for P2W is obvious. The risk of severe injuries is much higher for motorcycle riders as for car occupants. Therefor everything has to be done to reduce this risk. ECall systems are offering a huge potential for improving the safety.

The preceding chapters have shown, that it is not possible to deduce the structure and proceeding for a P2W eCall system from the automotive sector. There are crucial differences between these two systems, even if the output and the infrastructure is the same. Especially the triggering mechanism, the voice connection and the separation between motorcycle and rider need a fresh look.

With all these challenges, it always has to be kept in mind, that such a system must not be limited to expensive motorcycles. The system has to be cost-efficient, practicable and robust in order to guarantee a deep market penetration for all motorcycle classes and a high user acceptance. Only in this case, it can be assured, that this system has a significant impact on the safety of P2Ws.

The present paper has just an introduction into the topic of P2W eCall systems. This is part of the first sub-activity 3.1. The structure of the whole project is shown below:

- A3.1: Meta-Analysis
- A3.2: Verification requirements
- A3.3: Data Transmission
- A3.4: Architecture and Validation
- A3.5: Classification of Severity
- A3.6: Retrofit

The consortium behind this project consists of public research institutions, universities, OEMs and Suppliers: ACEM, BMW, BOSCH, CATAPULT, CEIT, CETEM, CUT, HONDA, ICCS, ICOM, KTM, PIAGGIO, POLIMI, STS, TEAMNET and YAMAHA.

The target of this project is to define a minimum description of a P2W eCall system, which then can be a basis for a standardisation process.

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