Corporate Research

BOSCH

From
CR/AEV1

Our Reference
Alexander Skiera

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Renningen
05 March 2018

Report Number
18/011

R&D Report: **Final Report**

Security Class: Internal Export control relevant: No

Title: I_HeERO: eCall for powered two wheeler

Abstract

1. Issues (situation, motivation and tasks)

eCall system for passenger cars will be mandatory from April 2018 onwards. The standards regulating the requirements for such an eCall system are already in place.

The European commission aims to extend eCall also for other vehicle types. As specific standards for these types do not exist so far, the European commission delegated the CEN/TC 278 work group 15 to prepare standardization proposals for these vehicle types. In parallel to these EU internal activities, the I_HeERO project, Infrastructure Harmonised eCall European Deployment, was running as a public funded project from 2015 until 2017. Main objective of the I_HeERO activity 3 – Preparation for deployment for eCall P2W – was to derive the specific requirements for a P2W eCall system installed at point of manufacture, to give a proposal for eCall standardization and to point out the differences to the already existing approach for passenger cars. The following report deals with the P2W related I_HeERO project results and proposals.

2. Results

Because of the probable separation of rider and bike, following significant differences for a P2W standard compared to passenger cars were proposed:

1. Voice Connection (VC) to PSAP (mandatory for cars) to become optional for P2W
2. Manual triggering (mandatory for cars) to be optional and only in combination with voice connection
3. Pre-warning time & suppression button (special for P2W) to reduce false calls
4. Verification procedure of automatic triggering defined to guarantee maximum robustness
5. Requirements for retro fit solutions should follow OEM solution

3. Conclusions and Consequences

Main outcome of the I_HeERO P2W part is that eCall requirements for passenger cars cannot just be copied, but some major changes have to be done to apply them also for P2W. The derived requirements and proposals were transferred to working group 15 within the European commission, which currently prepares the draft for P2W eCall standard.

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Document approval			
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ABBREVIATIONS

CCU .... Connectivity Control Unit
FARS .... *Fatality Analysis Reporting System*
GES .... *Gerneral Estimate System*
GIDAS .... *German in depth accident study*
HGV .... *Heavy goods vehicle*
HMI .... Human Machine Interface
I_HeERO .... *Infrastructure Harmonised eCall European Deployment*
MSD .... Minimum Set of Data, *Minimum Set of Data*
P2W .... *powered two-wheeled vehicle*
PSAP .... *Public-safety answering point*
PTI .... Periodic Technic Inspection
QM .... Quality Management
VUFO .... *Verkehrsunfallforschung Dresden*

FIGURES

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Long Version

1. Issues (situation, motivation and tasks)

eCall system for passenger cars will be mandatory from April 2018 onwards. The standards regulating the requirements for such an eCall system are already in place.
The European commission aims to extend eCall also for other vehicle types. As specific standards for these types do not exist so far, the European commission delegated the CEN/TC 278 work group 15 to prepare standardization proposals for these vehicle types. The group itself instructed PT1507 to prepare a technical report and proposal for a P2W eCall standard. In parallel to these EU internal activities the I_HeERO project was running.

The "I_HeERO" project, Infrastructure Harmonised eCall European Deployment, was a public funded project (PFP) by the European commission. It was set-up as a follow up project from "HeERO" and "HeERO 2". Its duration was from 2015 until 2017 and was divided into six activities. The main objectives ((CEF), 2014) of the project were:

1. To prepare the necessary PSAP infrastructure to realise Pan-European eCall
2. To boost Member States investment in the PSAP infrastructure and interoperability of the service within the roadmap (by the end of 2017)
3. Preparation for deployment for eCall for HGV and Dangerous Goods
4. **Preparation for deployment for eCall P2W**
5. Perform PSAP Conformity Assessments
6. To look at advancements in the management of data and next generation 112 for eCall

This report deals solely with the activity 3, "eCall Powered two wheeled vehicles", of the I_HeERO project and its results.

The consortium of activity 3 consisted of powered two-wheeled vehicle OEMs[1], suppliers[2], universities[3] and institutes[4]. Matthias Moerbe and Christian Cosyns from Bosch led activity 3.
CR contributed to the activity with the internal concept study VM-156, Crash detection algorithm for P2W. The main objective of activity 3 was to derive the specific requirements for a P2W eCall system installed at point of manufacture and in the end to give a proposal for eCall standardization and to point out the differences to the already existing approach for passenger cars.

[1] BMW, KTM, Yamaha, Piaggio, Honda
[2] Bosch, DIGADES
[3] POLIMI, UNIMORE
[4] CATAPULT, CEIT, CETEM

Six sub-activities with their individual tasks and deliverables divided activity 3 ((CEF), 2014):

1. Sub-activity 3.1: Meta-Analysis eCall state of the art
   <u>Task:</u>
   Evaluate current eCall solutions/standards and their limitation as regards eCall on P2W. Analysis and update of eCall car systems, standards, etc. for P2W. Collision research, based on current data to evaluate relevant scenarios, which are critical for P2W and would lead to an eCall. During this study the bike and the rider are the focus. The use of naturalistic riding data will be used to support the verification of an eCall triggering event, as the key question in understanding eCall incidents with P2W machines is the nature of the event that will lead to the eCall being triggered, in short what does the event look like.
   <u>Deliverables:</u>
   - Deliverable 3.1.1: List and assessment of state of the art of existing eCall systems and standards including an assessment of the relevance to P2W vehicles
   - Deliverable 3.1.2: List /set of use cases for P2W eCall

2. Sub-activity 3.2: Verification requirements
   <u>Task:</u>
   Based on the relevant scenarios identified in activity 3.1 a generic standard for verification will be developed. This involves the description of test scenarios (minimum set of requirements, which simulate the activity 3.1 defined scenarios and definition of nontriggering scenarios (misuses).
   <u>Deliverables:</u>
   - Deliverable: 3.2 Proposal for conformity with CEN

3. Sub-activity 3.3: Data Transmission
   <u>Task:</u>
   The need of adaptation of the MSD (minimum set of data) is to be created as joint task of vehicle manufacturers, suppliers and rescue services, and an update procedure of the function. This activity includes the evaluation of triggering mode indicator within MSD (manual or automatic).
   <u>Deliverables:</u>
   - Deliverable 3.3 MSD table for P2W for PSAPs

4. Sub-activity 3.4: Architecture and Validation
   <u>Task:</u>
   The minimum functionality of the vehicles, riders and passenger's technical equipment and the standard of functional safety ISO 26262 required for this purpose must be

determined to achieve a satisfactory extent of incident detection and notification. Under consideration of the particular P2W situation, essential generic requirements to function, hardware and HMI need to be defined.

Deliverables:

- Deliverable: 3.4 Basic architecture recommendation document

5. Sub-activity 3.5: Classification of severity

   Task:

   This activity is a study, which aims to classify the severity of the incident. The dynamic data of vehicle and driver are used as basic information. The linguistic differentiation of the countries shall also be considered.

   Deliverables:

   - Deliverable 3.5 Documented analysis of possible determination of injury severity

6. Sub-activity 3.6: Retrofit

   Task:

   The work started in HeERO 2 will be expanded for fast and efficient deployment of eCall function for P2W. The possibilities and limiting conditions of a retrofitting of the existing vehicles are to be developed.

   Deliverables:

   - Deliverable 3.6.1 State of the art definition of a eCall equipped Powered 2 Wheel prototype
   - Deliverable: 3.6.2 Homologation process proposal for retrofit solutions

2. Results

In the following, the major results of activity 3.5 are presented. The order of results is independent from the actual structure of the sub-activities to provide a better understanding. For detailed information to the specific topics, the relevant milestone reports are attached in the appendix of this document.

2.1. Use cases for an eCall system

To define use cases for a P2W eCall system, first the accident situation for P2W was analysed. Second, the relevant accident scenarios were identified and further analysed with special focus on severity and accident parameter. In parallel, the necessity of an eCall launch based on an injury scale was defined. In sub-section 2.1.3 the positive impact of a P2W eCall system on the

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rescue chain was analysed. Finally, in sub-section 2.1.4 the benefit potential for P2W eCall in the European Union has been estimated.

2.1.1. Accident scenarios for P2W

The traffic accident research company VUFO from Dresden was given the task to provide a general overview of the accident situation for P2W and to identify major accident use cases. The analysis from VUFO was mainly based on the German in depth accident study GIDAS.

Use-case	Description	Further distinction	Accidents	% of all PTW accidents	% of all IS 0	% of all IS 0-1	% of all IS 2-4	% of all IS 3-4
1a	Collision with a car (DS, DC, SS)	PTW: front Car: side	2.546	12.8%	3.8%	11.9%	13.0%	13.2%
1b		PTW: front Car: front	1.594	8.0%	1.2%	3.4%	9.2%	11.3%
1c		PTW: side/front Car: side	1.502	7.5%	2.5%	10.2%	6.8%	6.5%
1d		PTW: front Car: rear end	1.188	6.0%	3.6%	7.4%	5.6%	5.3%
1e		PTW: side Car: front/rear	716	3.6%	0.0%	3.8%	3.5%	3.1%
1f		PTW: rear end car: front	645	3.2%	3.2%	7.1%	2.2%	1.5%
1g		PTW: side car: edge	461	2.3%	0.0%	2.3%	2.3%	2.2%
2a	Braking and fall	Driving straight	3.667	18.4%	11.6%	20.3%	17.9%	13.0%
2b		Driving curved	2.048	10.3%	2.9%	5.6%	11.5%	13.9%
3a	Collision with an object	Driving curved	1249	6.3%	0.0%	1.9%	7.4%	9.1%
3b		Driving straight	696	3.5%	1.9%	1.2%	4.1%	3.8%
4a	Collision w/ ped./ bic./ ani.*	Driving straight	880	4.4%	26.6%	9.6%	3.1%	4.0%
~~4b~~		~~Driving curved~~	~~159~~	~~0.8%~~	~~12.1%~~	~~2.5%~~	~~0.4%~~	~~0.3%~~
5a	Constant ride and fall	Driving straight	417	2.1%	3.5%	1.2%	2.3%	1.4%
5b		Driving curved	215	1.1%	1.3%	0.2%	1.3%	2.2%
15 proposed USE-CASES			17.983	90.2%	74.1%	88.5%	90.6%	90.6%
ALL P2W accidents (total numbers)			19.946	19.946	688	4.112	15.834	6.924

Figure 1: 15 major accident scenarios out of GIDAS

Major results:

- 15 accident scenarios were described, which cover 90% of all accidents within GIDAS
- In about 95% of all accidents the bike is laying on the right or left side after the collision

More information can be found in (Harnischmacher, M23 - List and set of use cases, 2016).

2.1.2. Necessity of an eCall launch

Not in every P2W accident, the rider needs the launch of an eCall, as in many cases no injuries occur. To distinguish accidents where an eCall is necessary from cases where it is not, a criteria based on the injury level of the rider was defined. The main assumption was that, when a rider was injured so that he needed treatment in hospital, an eCall would have been necessary. On the other hand, when the rider was not injured or only slightly, an eCall is not necessary.

Injury severity scale (IS)	Injury severity	eCall necessity
IS4	Fatal (died within 30 days)	eCall is necessary
IS3	Severe (hospitalisation > 24h)	eCall is necessary
IS2	Slight, with hospitalisation (< 24h)	eCall is necessary
IS1	Slight, without hospitalisation	eCall can be necessary
IS0	No injuries	eCall not necessary

Figure 2: Injury severity levels and eCall necessity

According to the introduced injury scale, this means that for all accidents with an injury severity IS2 and more an eCall is necessary, for all accidents with an injury severity IS1 or IS0 an eCall is not necessary.

Major results:

- ➢ An injury scale (IS) from IS0 to IS4 was introduced and all accidents with an IS2+ defined as an accident where eCall is necessary

More information can be found in (Harnischmacher, M23 - List and set of use cases, 2016).

2.1.3. Effect on rescue chain by an eCall system

The effect of an eCall system on the rescue chain has been analysed. Major potential can be seen in the immediate notification of an accident to the PSAP. Additionally by providing the exact location of the accident via the MSD the approach time of the rescue teams can be minimalized. By minimizing the time between accident and first treatment by the rescue team the impact of an accident and suffer from injuries can be reduced. In very urgent cases even lives might be saved.

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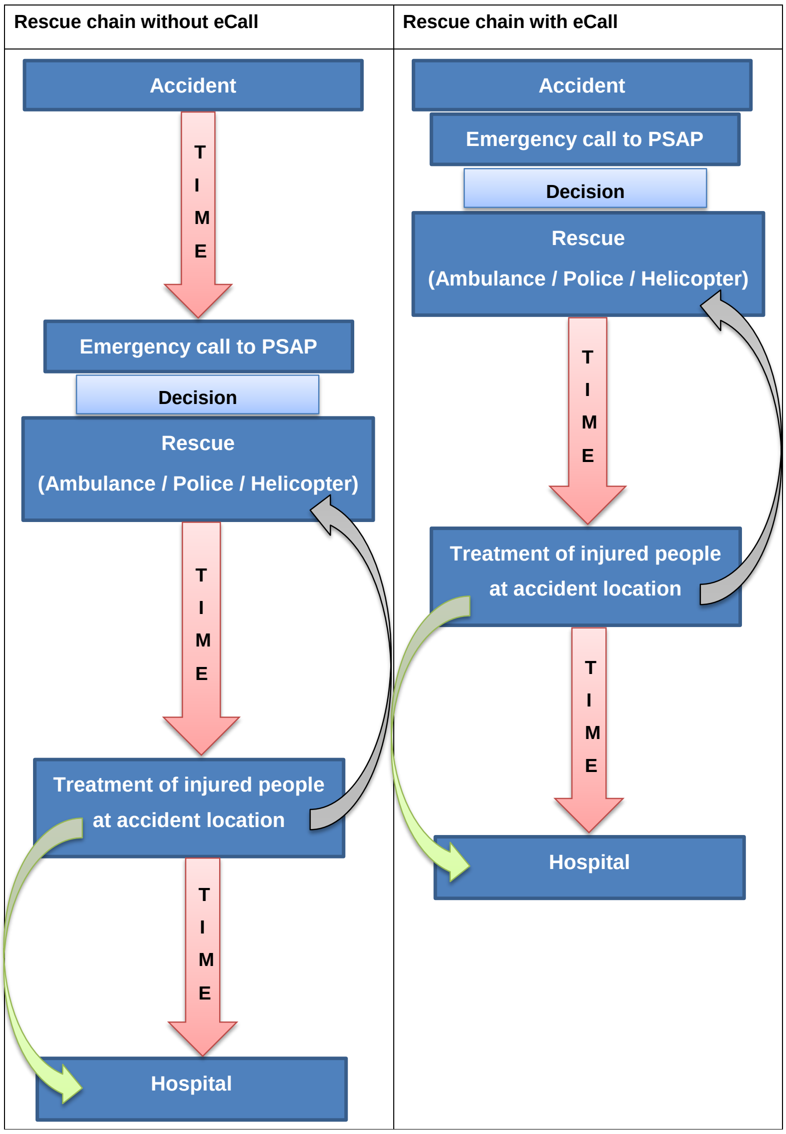

Figure 3 Rescue chain with and without eCall in comparison

Major results:

- eCall has the potential to minimize the treatment free time in an accident and thereby reduce the injury severity.

More information can be found in (Skiera, 2017).

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2.1.4. Benefit potential by an eCall system

At the beginning, available studies estimating the eCall benefit were analyzed. As a result, six studies were found which have done their own estimation of an eCall benefit. However, these results were only for passenger cars.

Therefore an own analysis approach to estimate the benefit potential by a P2W eCall system for the European Union has been chosen. The P2W eCall benefit potential has been assessed by defining benefit accident scenarios and assessing them by a rating schema. Benefit accident scenarios were defined as scenarios where it is expected that an immediate notification of the PSAP cannot be ensured or where the severity is such, that every second could be lifesaving.

A high eCall benefit is expected in the following scenarios:

1. In accidents happening during darkness
2. In single vehicle accidents
3. In accidents with severe injuries
4. In accidents In rural areas
5. In accidents abroad

The above scenarios were identified for seven European countries and rated by a rating schema (Table 1).

Accident characteristic	Benefit rating scheme
Location	Urban= +1, Rural= +3
Involved parties	>1 Party= +1, 1 Party= +3
Light condition	Daylight= +1, Darkness= +3
Severity	Light injuries= -3, Serious injuries= +3 Fatalities= +4

Table 1 Rating schema for eCall benefit

Based on the sum of points from the rating, the accidents were classified into three benefit potential levels (Table 2).

Benefit potential level	Expected benefit
Low (0-6)	No/ only slight severity reduction expected
Medium (7-9)	Severity reduction expected
High (10-13)	High severity reduction expected

Table 2 eCall benefit potential levels

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By applying this procedure for every country and finally extrapolating the numbers for the European Union, the following results could be obtained.

Country	Year	Benefit potential	Resulting average potential range within P2W users injury category		
			Fatalities	Seriously injured	Slightly injured
EU 28[1] All P2W	2014	Low	0	14,000 - 18,000	~238,000
		Medium	3,200 - 3,600	17,000 - 18,000	0
		High	1,000 - 1,400	9,000 - 13,100	0

Major results:

- Based on available studies, the total number of fatalities could be reduced by up to 3% - 8% and by up to 10% for seriously injured passenger car occupants (depending on the country).
- Based on own estimation, for 1,400 P2W fatalities annually a high P2W eCall benefit is expected (EU28)

More information can be found in (Skiera, 2017).

2.2. Trigger criteria for an eCall algorithm

A basic understanding about the possible triggering mechanism of an eCall system for P2W is necessary to define the functional requirements and propose a verification procedure for such a system. In the following, criteria, suitable for a P2W crash detection and to determine the eCall necessity, were derived. Using these criteria, classification methods were developed to determine the need of an eCall and their performance theoretically assessed. In the end of this section, a proposal for a meta algorithm for a P2W eCall system is given.

2.2.1. Criteria for triggering

To determine criteria for triggering an eCall, information of accident databases as well as naturalistic driving data were used.

2.2.1.1. Criteria for P2W crash detection

The GIDAS database was analysed to determine criteria, which indicate a P2W accident. As most significant parameter for a crash detection, the final position of the bike was found. In 95% of all police reported accidents w/ casualties in Germany the bike was laying on its side at the end of the collision (see Figure 4).

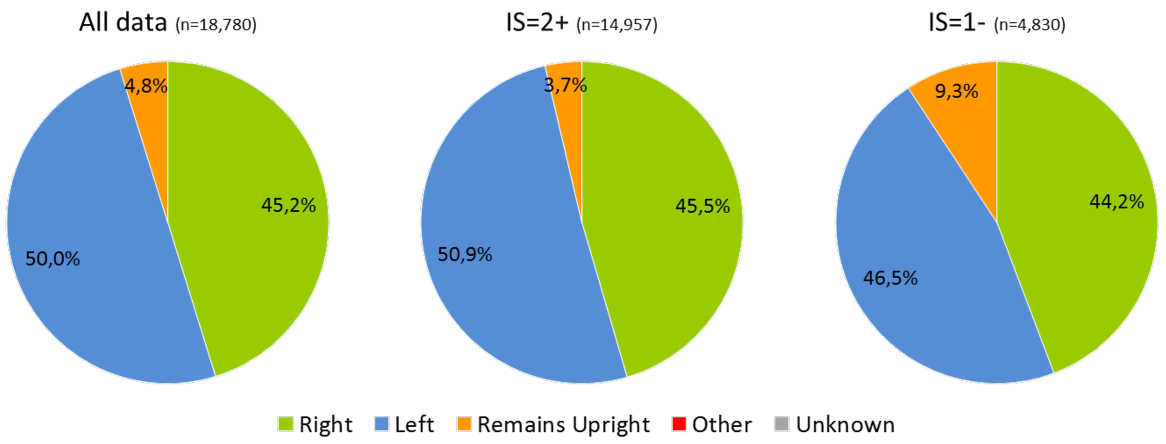

Figure 4: Final vehicle position after crash (GIDAS "FZGENDL")

Furthermore, initial sensor data of naturalistic riding were analysed and compared to crash data. Based on this analysis the roll angle, roll rate and acceleration values were identified as crash significant criteria (Figure 5).

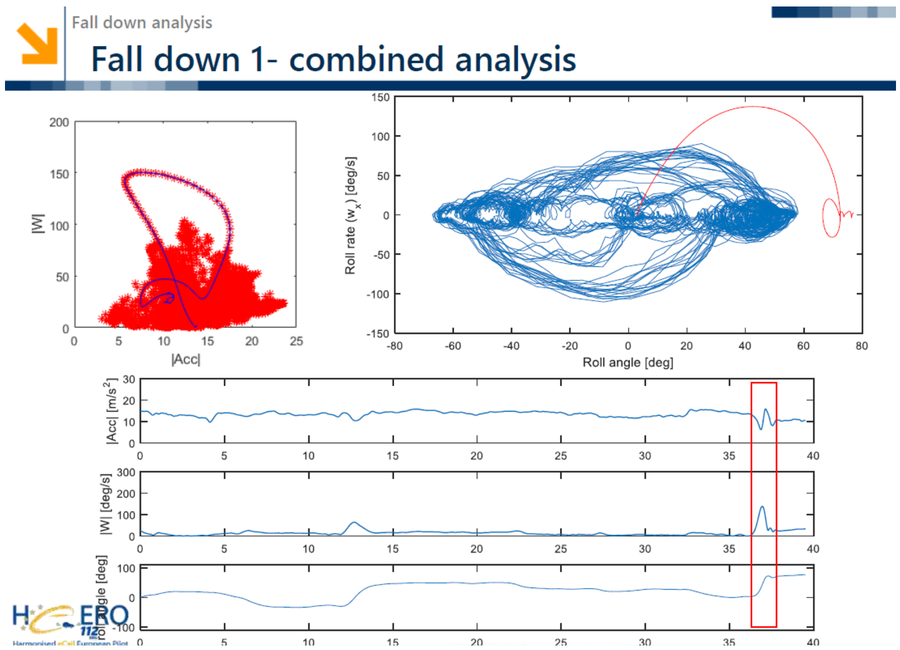

Figure 5: Acceleration and roll angle sensor signals of a P2W crash

Summarizing the results following criteria were found to determine a P2W crash:

- Final position of the bike (roll angle)

- Change of role angle (roll rate)
- Change in speed (acceleration)

More information can be found in (Borin, 2017).

2.2.1.2. Criteria for eCall triggering

Like already discussed, not in every accident an eCall activation is necessary. Therefore, further criteria are needed to distinguish accidents where an eCall activation is needed from one where it is not.

For this analysis, again the GIDAS data were used. The target was to find parameter which have a clear correlation with the injury severity and thereby the eCall necessity. It was found that the collision speed and the change of collision speed (Delta v) are providing a good correlation with the eCall necessity (Figure 6). Based on these results, it was proposed to use both information to trigger an eCall. If either delta v or the collision speed is above a certain threshold, the eCall should be activated.

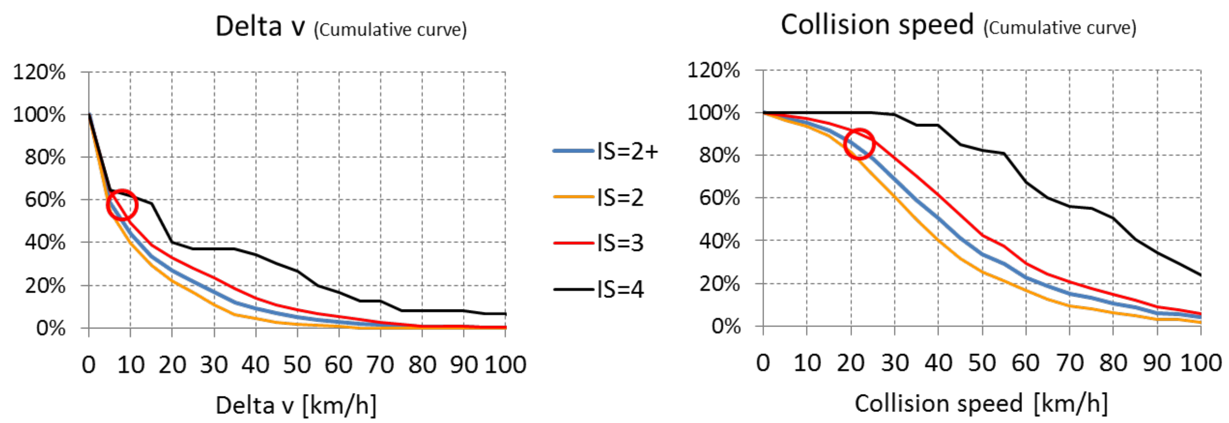

Figure 6: IS vs. Delta V and Collision speed for P2W

Summarized eCall trigger criteria can be defined as:

- Delta v > threshold
- Collision speed > threshold

More information can be found in (Borin, 2017).

2.2.2. Classification of eCall necessity

Within the last subsections, criteria were presented, which should be suitable for an algorithm, calculating the necessity of an eCall launch. In the following now, two different approaches to develop such an algorithm are presented and their performance is assessed.

2.2.2.1. Classic developed algorithm

First approach was to use the derived triggering criteria from subchapter 2.2.1. An accident was detected by using the final position information. If this criterion was true, the collisions speed was then compared to a threshold. Exceeding this threshold, the system activates the eCall. The logical flow diagram can be seen in Figure 7.
At the end, the collision speed threshold was defined at 25kph.

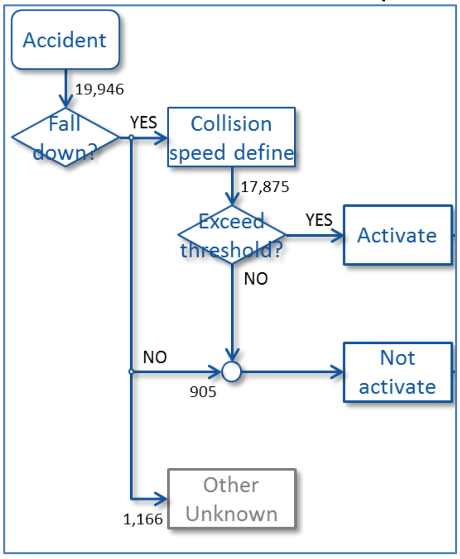

Figure 7: Flow Diagram – classic developed eCall algorithm

Summarized, a classical eCall algorithm was developed and is triggered when:

- Bike lying on its side &
- Collision speed > 25kph

More information can be found in (Borin, 2017).

2.2.2.2. Classification by machine-learning

As second approach to determine the need of an eCall, machine-learning methods were applied. For the development the accident databases GIDAS and FARS / GES were used. These databases provided the necessary data regarding the injury severity (eCall necessity) and accident /collision describing parameters. In a first step, the databases were divided into independent training and testing sets (see Figure 8). Within the training set, parameter, which were not independent from the injury severity, were selected and used as input parameter for the classification methods. As classification methods, logistic regression and random forest were used. The parameters for the classification models were then determined by using machine-learning algorithms. After building up these classification models, they were used on the second dataset to assess their performance. The results of that are presented in the next section.

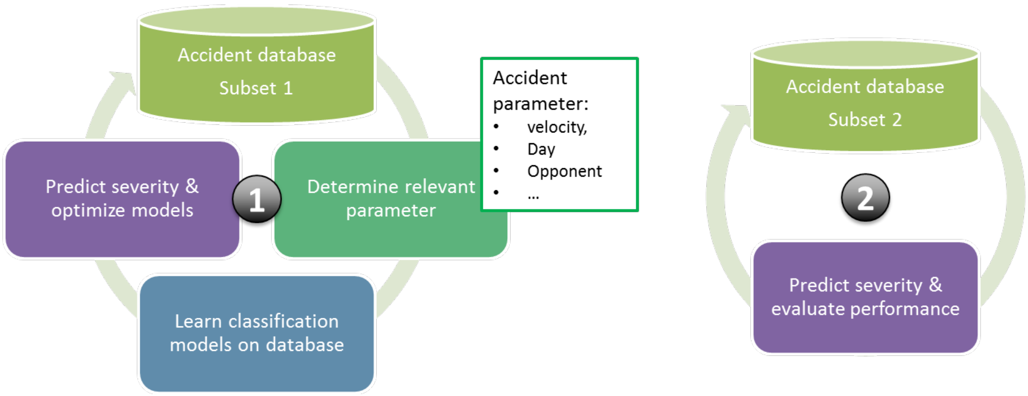

Figure 8: Development procedure for machine-learned classification methods

Summarized, two classification models were developed to determine the need of an eCall:

- Logistic regression model
- Random forest model

More information can be found in (Skiera, 2017).

2.2.2.3. Performance assessment of theoretical algorithms

To assess the performance of the three developed algorithms, which can classify the need of an eCall, they were applied on the different accident databases and their performance assessed. For this purpose, three different performance criteria were used:

1. Accuracy in eCall relevant accidents
   Ratio between eCall relevant accidents predicted as such by the classifier vs. total number of eCall relevant accidents
2. Accuracy in eCall non-relevant accidents
   Ratio between eCall non-relevant accidents predicted as such by the classifier vs. total number of eCall non-relevant accidents

3. Total accuracy
   Ratio between correct predicted accidents vs. total number of accidents

Classification Method	Accuracy in eCall relevant	Accuracy in eCall non-relevant	Total Accuracy
Classic algorithm	92%	48%	83%
Logistic regression	80%	80%	80%
Random forest	89%	91%	90%

Table 3: Performance of eCall classifier

In Table 3 the results were summarized:

- Random forest model provided the best overall classification results

More information can be found in (Skiera, 2017).

2.2.3. Meta algorithm

Based on the found triggering conditions, a first prototype of an eCall algorithm was developed. There are two conditions triggering the algorithm:

1. The motorcycle was ridging above a certain speed (Vs(t)>Vmin). After Ts seconds the bike is lying on its side (θ(t) > θmax) and its speed is close to zero (Vo(t)<Vdeadzone).
2. The motorcycle is standing still (V(t)<Vdeadzone). Suddenly the bike is strongly accelerating ((|VHPx(t)|>VHPxmin or |VHPy(t)|>VHPymin)) in the horizontal plane.

The triggering variable Firecall(t) takes the following values:
Firecall(t) =1
IF
{θ(t) > θmax AND Vo(t)<Vdeadzone AND Vs(t)>Vmin AND k(t-Ts)=1}
OR
{V(t)<Vdeadzone AND V(t+To)<Vdeadzone AND (|VHPx(t)|>VHPxmin or |VHPy(t)|>VHPymin) AND k(t-Ts)=1}
ELSE
Firecall(t)=0

A similar algorithm was finally implemented into a prototype and demonstrated. The results are presented in subchapter 2.4.2.

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More information can be found in (Borin, 2017).

2.3. Function requirements for an eCall system

During this project, the specific requirements for an eCall system for P2W were intensively studied and compared to the one for passenger cars. In the following, only the most important results are presented.

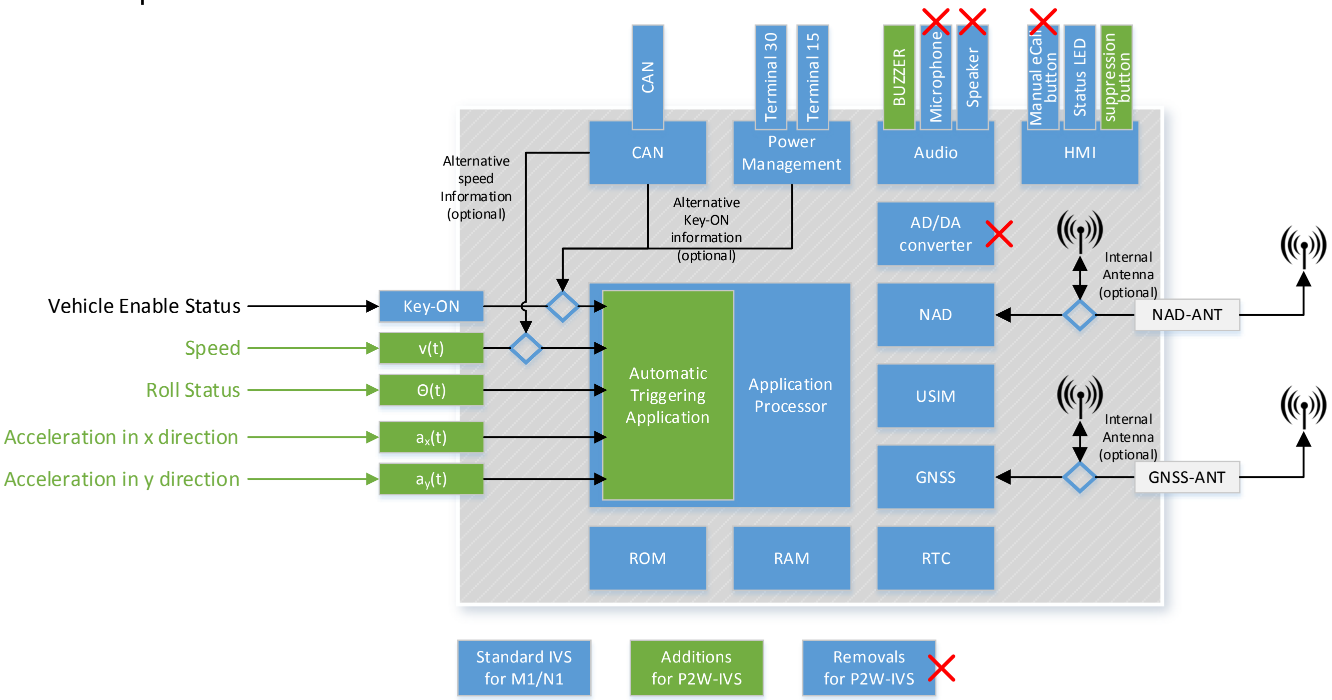

Figure 9: Functional blocks of an in-vehicle system for P2W

Compared to passenger cars following main adjustments were proposed:

1. Button to suppress launch of an eCall (see Figure 9)
2. Manual eCall trigger optional and only in combination with voice connection
3. No mandatory voice connection
4. Buzzer as HMI to inform rider about eCall activation (see Figure 9)
5. eCall system categorized as QM level
6. Adding additional parameter within MSD indicating if voice connection is available

More information can be found in (Borin, 2017; Iparraguirre, M25 - List of Parameters in Extended MSD, 2017).

2.4. Verification proposal

Beside the proposal of requirements for an eCall system, the proposal of verification procedure as basis for a possible standard was the most important result of the project. The verification procedure should ensure that every eCall system is triggered in severe accidents and that it is not triggered during normal usage. Therefore, general use- and misuse scenarios were defined (see Figure 10). These general scenarios were then transferred into specific testing procedures.

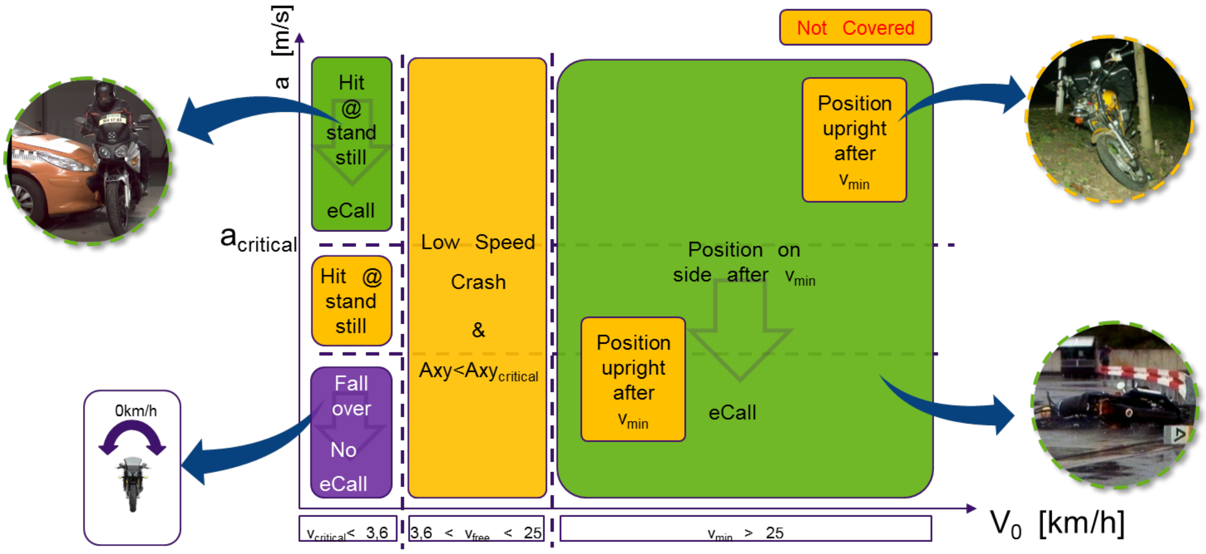

Figure 10: Generalized threshold of use and misuse cases for eCall activation defined by collision speed, acceleration level and final position.

2.4.1. Verification testing procedure

For an eCall system, special focus should be laid on the system robustness. Therefor several non-trigger test were defined, which have to be successfully tested with an eCall system to be verified:

1. Speed bumps
   Three speed bumps are arranged in a row. The test is conducted with two different heights of the bumps and different speeds:
   Test “speed bump” 1: height 70 mm, speed 30 km/h.
   Test “speed bump” 2: height 50 mm, speed 50 km/h.
   Each test should be driven three times in a row.
2. Kerbstones

a. The motorcycle is driven with a speed of 40 km/h on a horizontal plain. It is driven down a 150 mm kerbstone with constant speed. The test should be driven three times in a row.
b. The motorcycle is driven with a speed of 15 km/h on a horizontal plain. It is driven *up* a 150 mm kerbstone with constant speed. The test should be driven three times in a row.

3. Riding on different road surfaces
   a. Riding of at least 1000 km on public roads (urban / country road / motorways). At least 10 % driven on urban streets and at least 60 % on country roads. On country roads every kind of roads should be driven on equally. On urban and nonurban roads there should also be crossing of rail tracks.
   b. Driving on farm roads and unpaved roads with up to 80 km/h (scaling in 10 km/h steps)
4. Misuse manoeuvre
   a. Wheelie
      Wheelie-manoeuvre with lifting of the front wheel up to at least 45° or the limit of the motorcycle. Speed is at least 50 km/h. Afterwards strong breaking with the rear wheel brake. The test should be done three times in a row at least.
   b. Stoppie
      Stoppie-manoeuvre with a lift of the rear wheel up to an angle of at least 30°, then sudden release of the front wheel brake. The test should be done three times in a row.
   c. Falling motorcycle
      i. Falling over of the fully upright standing, stationary P2W to the left hand side and the right hand side with activated ignition.
      ii. Falling over of the P2W to the left hand side and the right hand side with activated ignition while it is being pushed by a person. Speed: 5 km/h (walking speed).
      iii. Riding against a rigid wall with 5 km/h without braking and tilting. After the impact the motorcycle is standing still and upright. The test should be done three times in a row.

As mentioned before, the general use-cases were also transferred into specific test scenarios, which have to be fulfilled:

1. Single accident
   a. Requirement for eCall trigger:
      The ignition of the motorcycle must be activated. In a driving situation, the threshold of the lean angle $\theta(t)$ and longitudinal speed $v(x)$ are exceeded at the

same time t (according to Report M24, Meta-algorithm), an eCall system has to be triggered.

   b. Test scenario:
   A test object shall be moving (simulated or real) with a longitudinal speed at threshold value and lean angle 0°. At start of test the lean angle shall increase until threshold value is exceeded, latest at that time longitudinal speed is decreased to 0 km/h.
   At all tests it has to be ensured that the test object is equipped with the complete eCall system which is ready for production. The manufacturer must state the reasons for the selection of the test method in a detailed and comprehensible manner.
   c. Test methods:
      i. Hardware in the Loop (HiL) test
      ii. Test on a sled with a tilting device
      iii. A full vehicle test with a test driver
      iv. A full scale crash test

2. Impact situation while P2W is at stand still
   a. Requirement for eCall trigger:
   The ignition of the motorcycle must be activated. At stand still the motorcycle receives an impulse from an arbitrary direction on the x-y-plane. If the resulting acceleration over time exceeds the threshold an eCall must be triggered.
   b. Test scenario:
   A test object shall be at stand still (simulated or real). At start of test a resulting acceleration of the test object in x-y-plane according to Figure 12 shall be applied. The test shall be conducted at least in six directions:
      i. Acceleration in positive x direction
      ii. Acceleration in the negative x direction
      iii. Acceleration in positive y-direction
      iv. Acceleration in negative y-direction
      v. Acceleration under 45 ° in the positive xy direction
      vi. Acceleration under 45 ° in negative xy direction
   At all tests it has to be ensured that the test object is equipped with the complete eCall system which is ready for production. The manufacturer must state the reasons for the selection of the test method in a detailed and comprehensible manner.
   c. Test methods:
      i. Hardware in the Loop (HiL) test

ii. Test on a sled
iii. A full scale crash test according to ISO 13232

The presented test scenarios are a first proposal out of this project. For a standard, they need further specification.

The detailed description can be found in (Dippel, 2017).

2.4.2. Prototyping and demonstration

Another major result of the project was the built up of an eCall prototype implemented into two motorcycles and the demonstration of these prototypes by physical test to representative of the European commission.

2.4.2.1. eCall prototype

The eCall prototype was set up using as much already available components as possible. Therefore, motorcycles were used with an integrated ABS and on board sensor box. Additionally a CCU was integrated, which provided the communication to the PSAP sever. Finally, a button was installed to indicate the launch of an eCall and to provide the suppression functionality. The crash algorithm was developed within the internal project VM-156 and running on the ABS-ECU. Via CAN communication the eCall trigger was then send to the CCU, where the MSD was created and then send to the PSAP sever.

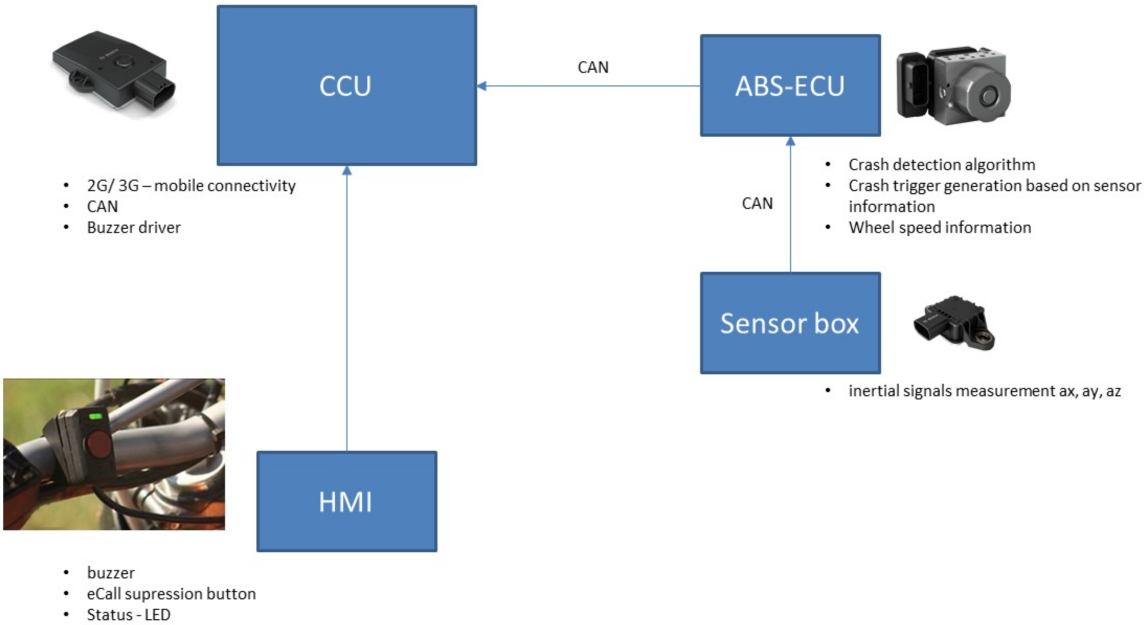

Figure 11: Concept of eCall prototype

Further information can be found in (Borin, 2017; Mayer & Klews, 2017).

2.4.2.2. eCall demonstration

On the 20th of October 2017, a demonstration of the eCall prototypes to representative of the European commission took place in Renningen, Germany. Thereby, a professional stunt rider rode several misuse and use-cases (see Figure 13). During this demonstration, the complete eCall chain, from detecting the crash to receiving the incoming MSD at a PSAP server, was presented.

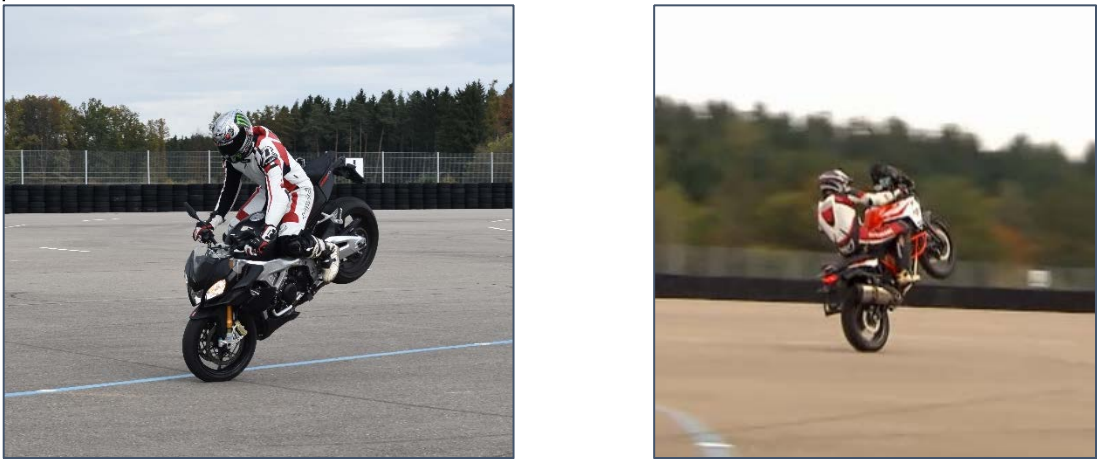

Figure 12: Demonstrated critical situations - no eCall triggering

Figure 13: Demonstrated use-case - Rear impact (50 kph)

Further information can be found in (Borin, 2017; Mayer & Klews, 2017).

2.5. Retrofit

This project has also studied the special requirements of retrofit solutions. Regarding the system architecture, the system cannot use in vehicle information and therefore must contain initial sensors for the crash algorithm (see Figure 14).

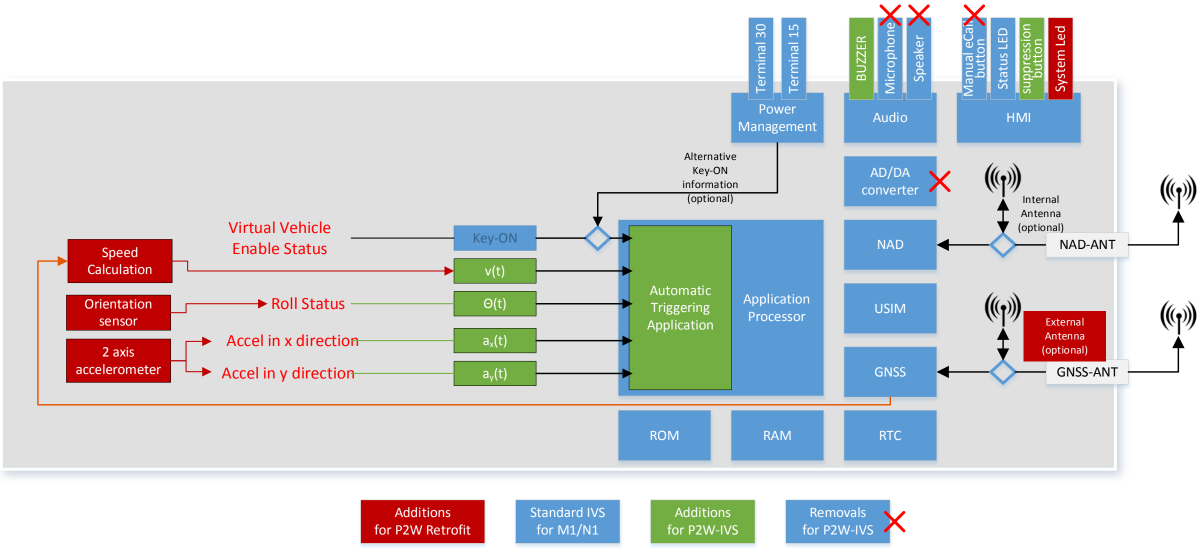

Figure 14: Functional blocks of an in-vehicle retrofit P2W system

Regarding verification requirements, retrofit P2W systems have to fulfil the same verification test as solution fitted at point of manufacture. Further studies should define the requirements for retrofit solution in more detail.

Further information can be found in (Iparraguirre, M28 - State of the art definition of a eCall equipped Powered 2 Wheel prototype, 2017) (Iparraguirre, M29 - Homologation process proposal for retrofit solution, 2017).

2.6. Severity estimation

A special aim was to evaluate the possibility to predict the injury severity of the rider in an accident. For further generations of eCall systems this information might be useful.

A simulative approach was chosen to find out, if there exist a clear correlation between measurable accident parameter and rider injury level (see Figure 15). By simulating various crash constellations between motorbike and car or motorbike only, physical loads on the bike and rider were calculated. Assessing these loads by injury risk curves, they provided the rider severity probability for different body parts.

From
CR/AEV1

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Renningen
05 March 2018
Report Number
18/011

R&D Report: **Final Report**

Security Class: Internal
Export control relevant: No
Title: I_HeERO: eCall for powered two wheeler

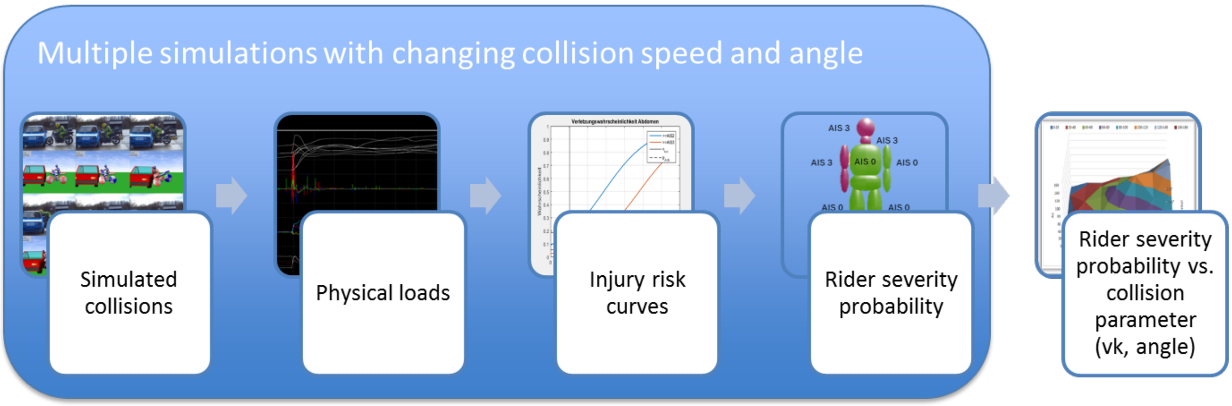

Figure 15: Simulation approach for severity estimation

As result, one received injury risk curves depending on the collision-speed, -angle, -opponent and –constellation (see Figure 16).

Major conclusions were:

- P2W-vehicle accidents:
  - Opponent and collision point information necessary to evaluate related injury severity for IVS
  - No correlation between opponent vehicle mass and injury severity seen
- Single accidents:
  - Slight correlation between in-vehicle information and injury severity given
  - Better results by using sensors on the rider expected

Further details can be found in (Skiera, 2017; Nasser, 2017; Mayer & Klews, 2017)

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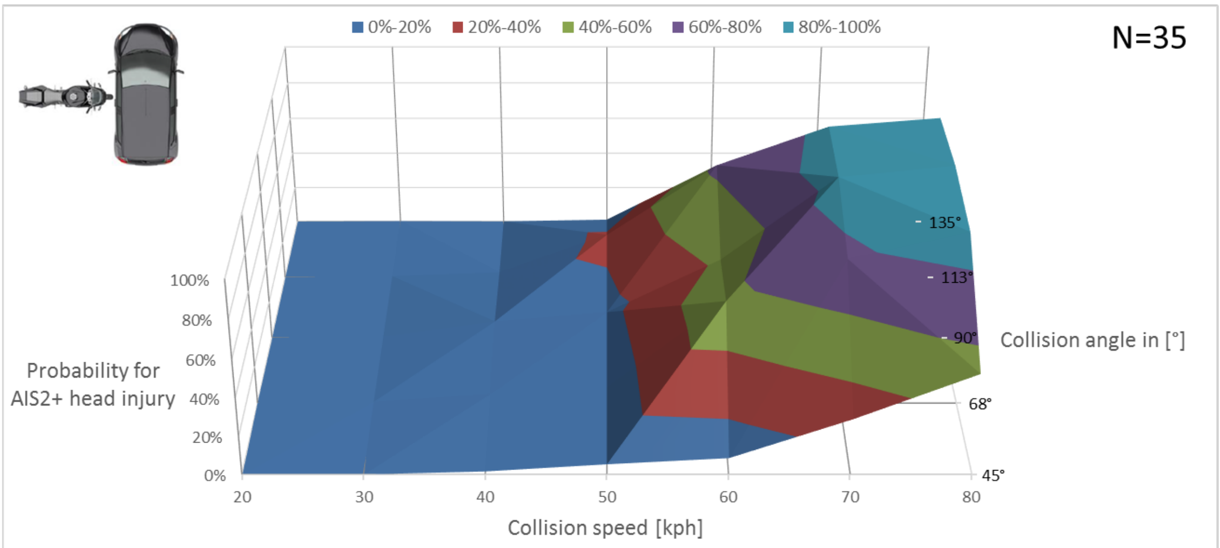

Figure 16: Simulated probability for AIS2+ head injury of motorcycle rider in collision of a P2W into a car's side

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3. Conclusions and Consequences

Activity 3 of the I_HeERO project has fulfilled all tasks within the grand agreement ((CEF), 2014). During its 3 years duration, it provides the basis for a future standard for P2W. Main conclusion of the project is that eCall requirements for passenger cars cannot just be copied, but some major changes have to be done to apply them also for P2W.
The main achievements are:

1. Minimum requirements (basic set of functions) defined (Chapter 2.3)
2. Voice Connection (VC) to PSAP to become optional for P2W (Chapter 2.3)
3. Manual triggering to be optional and only in combination with voice connection (Chapter 2.3)
4. Pre-warning time & suppression button to reduce false calls (Chapter 2.3)
5. Verification procedure of automatic triggering defined (Chapter 2.4.1)
6. Cooperation with standardization bodies (CEN TC 278 WG15 and PT1507) established and results from I_HeERO transferred
7. A basic architecture proposal for retrofit solutions defined (Chapter 2.3)
8. Retrofit requirements should follow OEM solution (Chapter 2.5)
9. Development of rider severity estimation models (Chapter 2.6)

All results were documented in specific reports, which were handed over to the European commission and are appended to this document. The working group 15 within the European commission currently prepares the draft for P2W eCall standard. If the results of activity 3 will be taken into account and integrated into the standard can't be foreseen and has to be checked in the future.
During the project, the need for further studies for specific topics was disclosed.
Open topics are:

- In depth definition for retrofit solutions (Certification & PTI)
- Define requirements for other categories like L2 or L4,L5,L6
- Extend severity models and study their integration into bikes
- Benefit of severity information for rescue chain to be assessed by PSAP experts/medics
- Assess benefit by P2W eCall system for European Union

At the end, it is worth to point out, that the I_HeERO project and the internal project VM-156 is a perfect example for the joint benefits of a public funded project with an internal development project. The content of the projects had a large overlap and therefore contributed to each other.

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Enclosures	
Enclosure number	**Title**

Underlying documents	**please link documents**		
Document number	**Title**	**Date**	**Responsible person**
17/034	VM-156: Advanced Crash Detection for PTW eCall	14.12.2017	Mayer Florian (CR/AEV1) ; Klews Matthias (CR/AEV1)
1	VM-156 Crash Detection for PTW eCall	29.06.2017	Mayer Florian (CR/AEV1) ; Skiera Alexander (CR/AEV1) ; Henzler Markus (CR/AEV1)
	Motorcycle accident simulation and injury severity estimate	28.02.2017	Abdel Nasser Amir (CC-AS/EST4) ; Mayer Florian (CR/AEV1)

This report invalidates			
Document number	**Title**	**Date**	**Responsible person**

4. Bibliography

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Harnischmacher, F. (2017). *M22 - List and assessment of state of the art of existing eCall systems and standards.* I_HeERO.

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Iparraguirre, O. (2017). *M29 - Homologation process proposal for retrofit solution.* I_HeERO.

Mayer, F., & Klews, M. (2017). *VM-156: Advanced Crash Detection for PTW eCall* . FEBER.

Nasser, A. A. (2017). *Motorcycle accident simulation and injury severity estimate.* FEBER.

Skiera, A. (2017). *M27 - Documented analysis of possible determination of injury severity.* I_HeERO.

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APPENDIX

5. Official I_HeERO reports

5.1. I_HeERO – eCall for P2W – Executive summary report

Executive summary report - PTW eCall

Harmonised eCall European Deployment

Version number:	1.0
Main author:	Matthias Moerbe, Christian Cosyns
Dissemination level:	external
Lead contractor:	Bosch
Due date:	31/03/2018
Delivery date:	
Delivery date updated document	

This project is funded under the Connected Europe
Fund Annual Programme
Grant agreement no. 1031743

CONTROL SHEET

Version history			
Version	**Date**	**Main author and contributors**	**Summary of changes**
0.1	31/01/2018	Matthias Moerbe (Bosch)	First document
0.2	19/03/2018	Matthias Moerbe (Bosch), Christian Cosyns (Bosch), Karl-Maria Grugl (KTM), Marc Torlo (BMW), Olatz Iparraguirre (Ceit), Andrea Borin (Yamaha), Alexander Skiera (Bosch) integrated by Christian Cosyns (Bosch)	All contributions integrated
0.3	23/03/2018	Christian Cosyns (Bosch)	Update after review
1.0	26.03.2018	Christian Cosyns (Bosch)	Final version

	Name	Date
Prepared	Christian Cosyns (Bosch)	19/03/2018
Reviewed	Shaddy Riaz (Honda), Frederik Harnischmacher (KTM), Alexander Skiera (Bosch)	23/03/2018
Authorized		

Circulation	
Recipient	**Date of submission**
Project partners	
I_HeERO Steering Group	
INEA	

TABLE OF CONTENTS

Summary

Taking inspiration from private third party service emergency call systems in the market, public 112 eCall has been standardised over the last years, and its market introduction in Europe is expected starting April 2018, based on a European regulatory framework. The I_HeERO Activity 3 project looked from various angles at how eCall could be realised as an in-vehicle solution for powered two-wheelers (PTW) in order to investigate differences to M category vehicles (Cars) and the technical challenges involved. The project investigated the conceptual requirements of eCall for PTW and also provided a demonstration of a prototype solution.

The project concluded that PTW eCall is significantly different to that for cars and that there are technical challenges particularly from the point of view of the high likelihood of rider separation from the motorcycle post-crash.

The output of this project is expected to flow into the standardisation process for Technical Specification (TS) and that actual experience from the field may lead to further improvements on the proposed concept in years to come. This would ensure a reliable and satisfactory system for PTW users and PSAP's.

In the same way as 112 car eCall does not yet exist in the market, and for which real world experience needs to be collected, the I_HeERO PTW eCall concept will require trials and initial careful market introduction in order to determine if the concept is suitable for widespread deployment. For this reason further investigation is recommended.

Motivation and Background

The introduction of eCall as mandatory equipment for passenger cars (M1) and light trucks (N1) was foreseen since a long time. Associated standards were created for those vehicles categories and by April 2015 with the regulation …

> ***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***

… a Pan European 112 eCall was introduced.

On the basis of considering (citation from Directive 2007/46/EC) …

> *The mandatory equipping of vehicles with the 112-based eCall in-vehicle system should initially apply only to new types of passenger cars and light commercial vehicles (categories M_1 and N_1) for which an appropriate triggering mechanism already exists. The possibility of extending the application of the 112-based eCall in-vehicle system requirement in the near future to include other vehicle categories, such as heavy goods vehicles, buses and coaches, <u>powered two-wheelers</u> and*

agricultural tractors, should be further assessed by the Commission with a view to presenting, if appropriate, a legislative proposal to that effect.

…obviated the need to investigate such an eCall function for other road users. In particular motorcycle accidents situations, riders would benefit from such technology.

At the eCall days in Berlin in 2013 and 2014 a solution was presented for Powered Two Wheeler (PTWs) which realized the significant differences to 4wheelers such as the separation of rider and vehicle. This fact would cause an independent approach for PTWs which didn't have to be standardized for cars necessarily at that point of time.

A lot of discussions started about which system design might bring the best benefit for a motorcycle rider. This included the fundamental question how to detect the severity of injuries by means of equipment on the vehicle.

Due to the fact that riding gear is not falling under the responsibility of motorcycle manufacturers, any upcoming proposal has to be part of the vehicle. However, optional additional interfaces for such equipment could improve the information content to a rescue team.

The partners of the project I_HeERO Activity 3 eCall for PTW came to the conclusion that the huge variety of motorcycles in terms of size, design and price range has to be covered with a minimum set of requirements to generate a high population in a short period of time.

On the other hand, such a system has to cover the expectations of the motorcycle user. Within the project a customer study was done to get a better understanding of their expectations. Among positive positions a major concern was, not to be traced by any mean in normal riding conditions.

Structure of I_HeERO project – Activity 3

This project was set up in an opposite way than usual in funded EU-projects. All interested partners were asked to indicate the amount of budget which was required to support the targets of 112eCall for PTWs. At this point of time only a rough idea existed to which degree the project needed to be developed.

Some content proposals were distributed by the cluster leader and have been adapted to the targets of the partners.

The entire content was divided into work packages. To all of those work packages a portion of the budget was allocated by each partner. An average hourly rate was used to define working hours.

To get a good management structure, all packages were referred to sub-activities. Each of the six sub-activities has got a leader and deliverables were formulated.

The deliverables shown in Figure 1 were the basis for the grant agreement and gave the obligation to the sub-activity leader to deliver in time and budget.

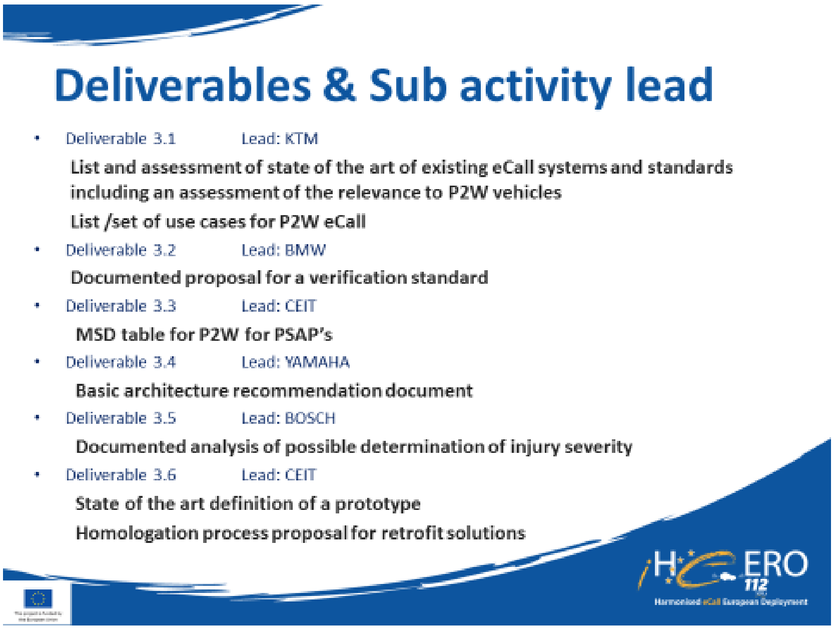

Figure 1: Structure of sub-activities, the leaders and the deliverables.

On top, the progress of project was controlled via a "Gantt chart", to establish a logical sequence and the dependencies amongst the activities. At the end all tasks were fulfilled to 100%.

Recommendation

Background

According to the European Commission eCall action plan, the eCall function should operate automatically after the detection of a serious crash by In-Vehicle sensors and/or processors.

In comparison to already existing standards, there are significant differences between eCall scenarios for M1 and N1 category vehicles and PTWs, which are:

- the probable separation of rider & vehicle due to vehicle dynamic peculiarity,
- the fundamental difference of crash dynamic between cars and PTW with regards to injury patterns and severity,
- the identification of a fall (with or without collision of vehicle with a solid obstacle) and
- the specific characteristic that a voice connection is not present or cannot be established

As per the eCall action plan, the scope of PTW eCall should be focused to those riders, that "Must Have" emergency support after a crash. From the study, it is considered for minimum requirement that IS2+ “Must Have” emergency support as shown in Figure 2. This definition signifies those that require hospitalization.

Injury Severity			
↑	IS4	Fatal (died within 30 days)	eCall is necessary
	IS3	Severe (hospitalisation > 24h)	
	IS2	Slight, with hospitalisation (< 24h)	
	IS1	Slight, without hospitalisation	eCall can be necessary
	IS0	No injuries	eCall not necessary

Figure 2: Triggering requirement

The following chapters will explain the differences, minimum requirements and recommendations for the PTW eCall.

Pre-warning

In the case of PTW accidents, the consequence of an accident on vehicle and on rider/passenger can be unpredictable. It can be that there are light consequences for vehicle but severe injuries for rider or, conversely, the vehicle could be totally destroyed but with only light or no injuries to the rider at all. Due to the difficulties in determining the precise injury level in every accident scenario, a so called “Pre-warning” timer has been introduced, allowing an eCall to be suppressed before triggering an eCall to the PSAP, thus limiting the number of false calls. If real injury level of rider is lower than what has been estimated by eCall system, the call can be suppressed by simply pushing a dedicated button, if rescue is not necessary. On the contrary, if the rider is injured to such an extent that they do not suppress the eCall, it will be launched automatically after the pre-warning time has elapsed. The rider will be aware that the eCall has been launched with a specific visual and auditory feedback.

Voice connection

The I_HeERO project recommends that voice connection should not be mandatory but only optional, because of the following considerations:

- possible distance between rider and PTW after accident in most of the accident scenarios and on the other hand side the minimum distance between the microphone and the rider to enable voice communication,
- the direction of the accident vehicle and thus the microphone and final position of the rider,
- The acoustical attenuation effects of the riders helmet and potential protection (e.g. ear plugs),
- Quality of sound: in order to hear the rider. This would require a large microphone to be present on the vehicle

- Technical effort to ensure uniform and reliable performance over time on a wide range of different vehicle models

To inform PSAP about the non-presence of voice communication, an indication within the MSD is recommended.

Manual trigger

It should be stipulated that any system including a manual trigger MUST have a voice communication capability in order to allow the user to justify the triggering to the PSAP.

In order to avoid misuse of the eCall function and thus to reduce false calls, it is highly recommended only to have Manual Triggering as optional to the minimum required standard.

Testing for certification

On the basis of existing standards and type-approval requirements for eCall in-vehicle system (IVS) in passenger cars, I_HeERO produced recommendations for the testing of an eCall IVS for PTW in order to create the base for a future certification process (type-approval, roadworthiness inspection). Due to significant differences between eCall IVS for passenger cars and PTW, the carry-over of type-approval requirements for PTW from cars was not possible without adjustment and addendum.

L categories

The I_HeERO project studies and analysis, as well as reference data (i.e. GIDAS), have been conducted referring only to L3 category PTW types.

Therefore, all the recommendations proposed in this document have been specialized for the vehicles belonging to the L3 category.

Nonetheless it is worth noticing that results and recommendations could apply to other L-category vehicles, but in-depth analysis of the specific subsets of other L-categories must be made to confirm whether a similar eCall system can be applied or not.

Corresponding modifications of the recommendations of eCall system for other L-categories are out of scope of the analysis made by expert in I_HeERO project.

Finally, it is highly recommended that a further study into PTW eCall is implemented in order to assess its effectiveness and potential development of improvements and extensions.

The following paragraphs describe the sub-activities and their achievements in more detail. The order follows the logical flow of the project and not the nomenclature of the sub-activities.

Meta-Analysis eCall state of the art (Sub-activity 3.1)

Sub-activity 3.1 valuates the current eCall solutions and standards and their limitations as regards eCall on PTW.

Accident research based on current data is performed to identify and evaluate the relevant scenarios, critical for PTW and potentially requiring an eCall. During this study, the motorcycle as well as the rider is the focus.

Naturalistic riding data is used to support the verification of an eCall triggering event, as the key question in understanding eCall incidents with PTWs is the nature of the event that will lead to the eCall being triggered, in short what does the event look like.

Within this sub activity data, literature and other information is analysed to support the subsequent sub activities with fundamental information.

Task 3.1.1 Analysis of existing PTW accident databases

Several accident databases are analysed, first to evaluate if they are suitable for deeper analysis within the subsequent tasks. With the assistance of the Verkehrsunfallforschungs-GmbH of the TU Dresden (VUFO) the GIDAS database is selected for the analysis within the subsequent tasks.

Task 3.1.2 Analysis of distinct variables (parameters) to describe the accident

Based on the data provided by the GIDAS data base, parameters are identified which can be used to distinguish an accident from naturalistic riding. A major part of these analysis is dedicated to the different crash dynamics of a PTW compared to a passenger car. The differences are related to the movement of the vehicle itself and the high probability of the separation of the rider and the PTW in the course of the accident.

The separation of rider and vehicle has relevant influence on the use case definition for a PTW eCall system and the specific functional requirements of such a system.

These PTW specificities have in turn an influence on the triggering mechanism (accident detection by means of vehicle on-board data), HMI and the performance of an audio connection between the rider and the PSAP.

Task 3.1.3 Definition of uses cases

Use cases for a PTW specific eCall system are defined, considering in vehicle system (IVS) functions as well as the primary user (motorcycle rider), the telecommunication system, service/maintenance and the PSAPs.

Based on the results of the accident data analysis, the uses cases are including specific (additional and optional) functions which differ from the current standardized set of functions for passenger cars (M1, N1 vehicle category).

Task 3.1.4 Investigation of existing eCall systems

Today there is a number of devices available which can detect a potential accident or emergency situation and are able to send either data (text) or recorded voice messages to predefined phone numbers. These systems are differing from each other quite a lot, be it with respect to the triggering of the event or the information which is sent out.

In order to be able to categorize these systems the project team defined that an “eCall” system has to comply with the relevant (current or future) standards for an eCall system, that it has to transmit the eCall to the next appropriate PSAP or to a certified third party service (TPS) and that it must be ensured, that the data is only allowed to be transmitted in the case of an emergency and the content of data is limited to the standardized minimum set of data (MSD). All other systems are “eCall-like” systems.

Task 3.1.5 Investigation of existing eCall standards

With reference to the use cases there are many elements related to the initiation and transmission of an eCall which are already standardized.

Generally speaking the elements related to the content of an eCall and the processing of the data are standardized by CEN. While the telecommunication/transmission part is mainly standardized by means of ETSI standards.

Task 3.1.6 State-of-the-art assessment

An eCall system can potentially optimize the rescue (post-crash phase). The automatic triggering of the accident and the automatic notification to the PSAP are potentially reducing the time to activate the rescue chain.

The very detailed information within the MSD related to the location of the accident potentially reduces the time needed by the rescue team to reach the accident scene. Additional information (i.e. audio connection with the vehicle occupants) can further optimize the rescue. However, for what concerns accidents with PTWs especially the audio connection is limited in performance due to the fact (cfr. 3.1.2) that the rider and the vehicle will very likely separate from each other during the accident. Therefore, this task investigates the potential level of additional support to the rescue by means of audio connection with the occupants.

Data from the US is showing that a number of car drivers were not able to assess and rate their medical condition properly.

These results are important for the further sub activities on defining the set of functions for a PTW specific eCall system.

Architecture and Validation (Sub-activity 3.4)

The sub-activity 3.4 – Basic Architecture Recommendations – include all studies done by Activity 3 cluster members to propose the most suitable solution for the eCall implementation in PTW vehicles. This has been undertaken by defining the minimum set of functionalities (recommendations) suitable for the implementation of the eCall function in a PTW and by maintaining close alignment with the already defined and regulated standard solution for passenger cars, categories M1 and N1. The proposed solution considers the requirements from both end users and PSAP as well as the practicalities of the technical implementation of the solution.

The sub-activity is made of five tasks covering the left side of the classic development "V-cycle" as shown in the picture below.

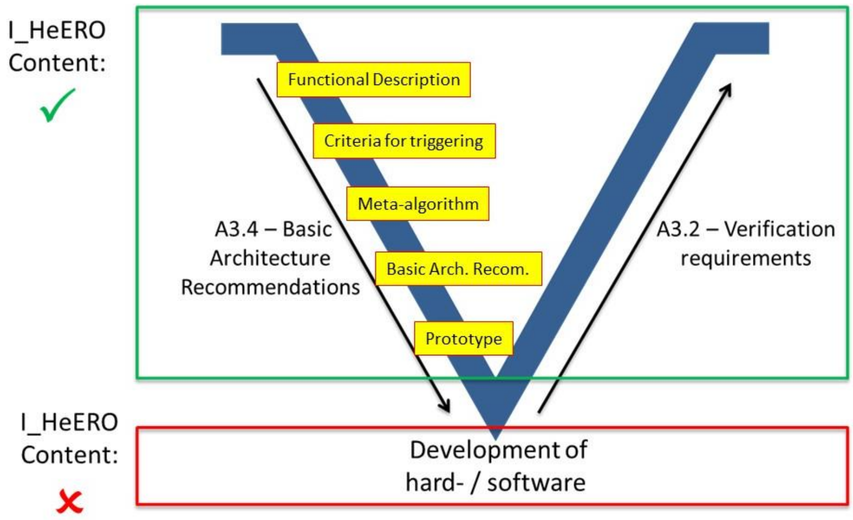

Figure 3: V-model approach

It is worthwhile to underline that the definition of a specific triggering algorithm was out-of-scope of the project and is left to each specific implementation by PTW OEMs or IVS suppliers.

Functional Description

The Functional Description has been done by using as reference the EN 16072:2015 and Reg. (EU) 2015/758 for M1/N1 vehicles and by considering the specific issues of the PTW vehicle. The macro-function diagram has been created and main functions modelled by SySML language.

The result of the study are the main recommendations for an eCall implementation in a PTW vehicle as follows:

- Audio Connection only optional
- Pre-warning time & suppression
- Manual trigger only optional
- Specific HMI for PTW
- Some other specifications of current standard need to be revised for PTW implementation (i.e., battery capacity)

Criteria for Triggering

The separation of motorcycle and rider in almost all accident cases make the study of suitable criteria for triggering quite complex. In this specific task, I_HeERO Act. 3 experts decided to make a statistical approach based on the analysis done in sub-activity 3.1 and supplementary data research inside the main European accident data-bases.

The result is the definition of a minimum set of parameters (variables) to be measured and a meta-algorithm allowing to detect most of the accident cases identified in 3.1. In addition, the level of "under-triage" and "over-triage" associated to such parameters and meta-algorithm has been calculated to give an indicator of the system's "accuracy".

Basic Architecture Recommendations

This task takes the results achieved by previous two and define a set of recommendations for a practical implementation of an eCall IVS in a PTW vehicle. The study has been done taking into deep consideration what has been designed and developed for the passenger cars (state-of-the-art), considering the main issues to implement same functions if a PTW vehicle and proposing suitable solutions.

Prototype

In order to demonstrate the functionality of a complete PTW vehicle eCall system, two demonstrators have been prepared. For testing the system adaptability, the chosen bikes were of different type, a travel bike (KTM 1290 Super Adventure R) and a sports bike (Aprilia Tuono 1100). The prototype vehicles have been demonstrated in the I_HeERO final event hold in Bosch (Renningen) on Oct 20th, 2017.

During the demonstration it has been successfully shown the correct behaviour of the eCall in the following situations:

- Standard (normal) riding → no activation
- Rider goes to limit / Critical situations → no unwanted activations unless a real accident occurs (low sider)

- No activation in several misuse cases (i.e., the bike fall down at gas station)
- Collision by another vehicle (i.e., a car) with PTW at speed = 0kmh → activation

ISO 26262 – Hazard Analysis and Risk assessment

The necessity of safety measures for the eCall system with minimum requirement, from the viewpoint of functional safety, has been investigated by a Hazard Analysis and Risk Assessment (HARA) according to ISO 26262 functional safety standard. As a result, QM is assigned for all possible hazardous events derived from an assumed system shown in functional description (minimum requirements).

Data transmission (Sub-activity 3.3)

The Minimum Set of Data (MSD) is already defined and regulated standard for passenger cars, categories M1 and N1 at EN 15722. The purpose of the sub-activity 3.3 “Data Transmission” is to study the particular case of the motorcycle and, based on the existing MSD standard, define the most suitable parameters to be transmitted through the eCall message taking into account the specific necessities of a PTW vehicle.

The parameters of interest were obtained from the study of the realised questionnaires to the users, OEMs and PSAPs and in concordance with the results of the sub-activity 3.4 “Architecture & Validation”. Therefore, the proposal of the I_HeERO Activity3 group for the extended MSD is as follows:

MSD PARAMETER			
Severity	OAD	ENUMERATED	Abbreviated Injury Scale (AIS)
voiceConnection	M	BOOLEAN	0 = Voice connection available 1 = Voice connection not available

Figure 4: Parameters of the extended MSD proposal

This MSD proposal has been implemented in PTW schema ASN.1 structure following the requirements defined in CEN standard EN 15722. In addition a MSD coder/decoder tool has been developed in accordance with this PTW schema and it is ready to be used in further tests.

Verification requirements (Sub-activity 3.2)

The sub-activity 3.2 – Verification requirements – has produced a recommendation, a minimum set of requirements, for the testing of an eCall device for PTW in order to create the base for a future certification process (conformity, periodical technical inspection).

Existing standards and type-approval requirements for eCall IVS in passenger cars have been used as a starting point. Due to significant differences between eCall IVS for passenger cars and PTW, carrying-over passenger car type-approval requirements and existing standards to PTW certification is not possible without adjustment and addendum. As an example EC-type-approval for passenger cars (M1/N1 category) requires two full-scale crash tests including eCall IVS. EC-type-approval for category L3 (and L1) vehicle does not require a crash or similar test.

The recommendations for new scenarios in PTW validation cover following subjects:

- Naturalistic riding / common usage of a PTW does not trigger an automatic eCall
- Relevant accident situation will trigger an automatic eCall
- Robustness of IVS components (e.g. shock resistance etc.)
- Checking within periodical technical inspection (PTI)

The results of sub-activity 3.1 “Meta-Analysis eCall state of the art” concerning end-user survey and naturalistic riding together with the OEM’s, suppliers and universities’ expertise in common usage of PTWs lead to a list of situations and conditions that shall not trigger an eCall. The most critical ones with regard to false calls have been identified. Findings and recommendations of sub-activity 3.1 “Meta-Analysis eCall state of the art” concerning relevant accident scenarios for PTW eCall and sub-activity 3.4 “Architecture and Validation” concerning triggering criteria for PTW eCall lead to a description of must-trigger situations and conditions.

Verification tests for eCall IVS in PTW have been discussed in order to create the base for a future certification process. Following areas have been evaluated:

- Privacy and liability aspects
- Privacy and data protection
- Conformance to relevant technical standards (ETSI)
- Automatic eCall triggering of must-trigger situation for PTW
- Non-trigger situation for PTW
- Shock resistance of IVS
- Periodical technical inspection (PTI)

Based on assessment of existing eCall regulation *Privacy, liability aspects and data protection* as well as *Conformance to relevant technical standards* (ETSI standards) are already covered. The relevant existing requirements need no adaption for PTW.

For *non-trigger* and *must-trigger* situations with PTW eCall systems verification tests have been proposed. Based on results of sub-activity 3.1 “Meta-Analysis eCall state of the art” and sub-activity 3.4 “Architecture and Validation” tests have been developed which simulate the relevant must-trigger and non-trigger situations. In order to condense the large variety of eCall relevant accident situations to a reasonable number of test scenarios the situations have been sorted in clusters. For each cluster a test scenario has been defined. Existing standards and type-approval requirements for eCall IVS in passenger cars have been used as a starting point for these tests. Finally new PTW test scenarios were proposed and described in a generic way.

With regard to *shock resistance,* an approach similar to passenger cars is recommended. As there is no data of high severity PTW crash tests (loads, acceleration etc.) publically available further investigations need to be done.

For *PTI* of PTW the recommendation is to make no extra provisions in PTW until requirements for M category vehicles are available. Yet PTI testing of eCall IVS in passenger cars is not regulated in detail. The future requirements for M category vehicles shall be evaluated concerning feasibility for PTW.

Generally it is important that all verification tests are designed in a way to make them simple, repeatable and the results reproducible. The intension of I_HeERO is not to describe the tests in a highly detailed and specific way. Additionally not all relevant data is publically available. Thus, after the end of I_HeERO project further investigations have to be conducted in order to provide required data and prepare detailed test specifications.

Retrofit (Sub-activity 3.6)

The purpose of the sub-activity 3.6 “Retrofit” is to study the state of the art of the OEM solution defined in the A3.4 “Architecture and Validation” and to describe the corresponding modifications needed to fit an aftermarket PTW eCall retrofit system.

The process of identification and analysis of the issues that must be kept into consideration when dealing with L3 class vehicles lead to the conclusion that the basic architecture recommendations for the global architecture of OEM fitted eCall devices are also valid for retrofit devices, except as described in the following:

- Vehicle Enable Status is critical for avoiding false negative calls. Robust virtual signal generation is a challenge
- Regarding the triggering algorithm, the installation of additional sensor is needed (accelerometers and orientation sensors) as well as a GNSS in order to determine location and eCall triggering threshold.
- The retrofit HMI solution needs to include an additional LED to inform that the nomad system is working properly
- It is recommended to install a GNSS external antenna for a good radio reception.

On the other hand, is has been also analysed the homologation and certification process of the retrofit system and the recommendation of the I_HeERO Activity 3 group is to refer to the dealers or certified workshops for the correct installation of the system and its certification. About the PTI of these devices, it seems not necessary to have an additional regular test since the status is evaluated in the auto-diagnosis mode of the device itself.

However due to the extension of the PTW retrofit implementation issue; the scope of I_HeERO cannot cover all the detailed studies this problem requires by the end of the project. Therefore, the open issues for a future work has been enumerated in this section.

Classification of severity (Sub-activity 3.5)

The sub activity 3.5 dealt with the classification of the injury severity. First focus was laid on analysing the effect of PTW eCall on European rescue chain and thereby on the reduction potential of injured PTW users. Secondly, alternative methods to determine the necessity of an eCall launch were analysed. Finally, the possibility to estimate the injury severity of the rider within an accident was studied.

As a result of this study, it was estimated that up to 1.374 fatally injured PTW users could highly profit by an eCall system for PTW. Further it was shown, that by using statistical classification methods, like random forest, the robustness of determining the necessity of an eCall launch can be increased compared to statistical methods. As most interesting result, first injury severity estimation models for different crash constellation based on collision-speed and -angle were developed.

PTW accident situation

Starting point for the analysis of the accident situation for PTW was the WHO accident report providing a good overview of the worldwide accident situation. After that, the fatality numbers of the European Union were analysed. Based on the detailed accident statistic of seven European countries, missing information on European level were estimated in the end.

In 2013, every fourth road fatality was a user of PTW worldwide. In the European Union, still every fifth road fatality died riding a PTW. For the European Union the total PTW accidents casualties were estimated to 286.871, including 4.564 fatalities and 44.515 seriously injured.

Organization of rescue chains in Europe

To understand the effect of PTW eCall on the European rescue chains, their general structure was analysed and optimization potential by an eCall system identified.

As the rescue chain structure is quite similar all over European countries, the effect of eCall systems can be analysed in a more general manner. The largest effect can be seen in minimizing the time between accident occurrence and the notification to the next PSAP[1]. Another positive effect could occur by reducing the arrival time of the rescue team, as the exact location of the accident is provided by the eCall system. By reducing the total time without treatment between accident and arrival of the first rescue team, there is the possibility to reduce the injury severity of accident casualties.

eCall potential benefit estimation

To quantify the effect of PTW eCall for the European Union, available studies analysing the eCall benefit were reviewed. Because of missing analysis for PTW eCall, an alternative approach was chosen to estimate at least a rough potential for PTW.

For passenger cars, available studies are pointing out a reduction potential for road fatalities by 3% up to 8% and for seriously injured up to 10%. The sub-activity 3.5 analysis of the eCall potential for PTW users based on the accident circumstances shows that 30% of all fatalities and seriously injured PTW users in the European Union could benefit highly from an eCall system. However, it cannot be concluded that this benefit results in reduction of severity in all these cases. Therefore further studies are needed.

eCall necessity by statistical methods

A fundamental problem for eCall systems after detecting an accident is the decision, if an eCall launch is needed in the specific accident. On one hand, not triggering of an eCall in urgent cases is to be avoided. On the other hand, PSAPs should be relieved from unnecessary eCalls. To solve this classification problem, statistical models based on logistic regression and random forest were developed and applied on two big datasets. In the end, their prediction accuracy was determined and compared to each other.

The analysis have shown that within the used classification models, random forest provides, with 90 % accuracy, the best overall performance in determining the need of an eCall launch.

Severity prediction model

For further optimization of European rescue chain, it could be interesting to provide the injury severity of the rider to the PSAPs. To analyse the possibility to predict the injury severity for PTW users and to build up first models, a simulation-based approach was chosen.

To build up severity estimation models, several PTW-vehicle crashes and single PTW accidents were simulated. The simulation software PC-Crash provided the physical loads on the rider’s body parts, which were then transferred using injury risk criteria into an injury severity probability of the rider. Finally, first injury severity probability models based on collision speed, collision angle and crash constellation could be developed. These models are showing

[1] Public-safety answering point

a good correlation between the actual injury severity for PTW-vehicle accidents. For single PTW it is assumed that severity models based on rider information are needed.

Proposed follow-up actions

In order to bring the recent years' work to a satisfactory conclusion the IHeERO PTW eCall members are engaged in the following **short term follow up actions**:

- Definitions of a Technical Specifications for PTW eCall are currently ongoing with CEN WG15.
- Definitions of a Technical Specifications for other L-Category vehicles (L2, L4, L5, L6).
- Compliance assessment (to the Technical Specifications) will also need to be defined.

Additionally, **further studies** are considered useful to improve upon the work carried out so far.

- A more in-depth definition for Retrofit Solutions (with compliance assessment).
- Further study into defining accident severity models and assessing this informations usefulness to the rescue chain (PSAP, experts, paramedics).
- Assessment of the benefit of the PTW eCall system for the European Union.

5.2. M22 – State-of-the-art assessment P2W eCall

M22 - State-of-the-art assessment P2W eCall

Harmonised eCall European Deployment

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CONTROL SHEET

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INTRODUCTION

1.1 Purpose of Document

As “Emergency Call” (eCall) systems become mandatory for passenger cars (M1) and light commercial vehicles (N1) 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. However, there are already systems available which have functionalities similar to an eCall system and are suitable for an application on P2W.

The purpose of this document is to give an overview about existing eCall, eCall-like and automatic crash notification (ACN) systems. Furthermore, a focus is set on the existing automotive standards, because these are the basis for a motorcycle eCall system and therefore must be analysed carefully. In addition to this, a clear differentiation between eCall- and eCall-like systems is provided, in order to avoid misunderstandings and to clarify the functional range of a P2W eCall system.

Within in the last part of this document, the previously presented systems and standards are assessed in regards to an application on P2Ws.

1.2 I_HeERO Contractual References

I_HeERO stands for Infrastructure Harmonised eCall European Pilot.

I_HeERO is an action under the Grant Agreement number INEA/CEF/TRAN/A2014/103743 and the project duration is 36 months, effective from 01 January 2015 until 31 December 2017. It is a contract with the Innovation and Networks Executive Agency (INEA), under the powers delegated by the European Commission.

<u>Communication details of the Agency:</u>

Any communication addressed to the Agency by post or e-mail shall be sent to the following address:

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For Niedersächsisches Ministerium für Wirtschaft, Arbeit and Verkehr: Michael Schäfer Friederickswall 1, 30159 Hannover, Germany

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2 State-of-the-art analysis

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 being involved in an accident 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.

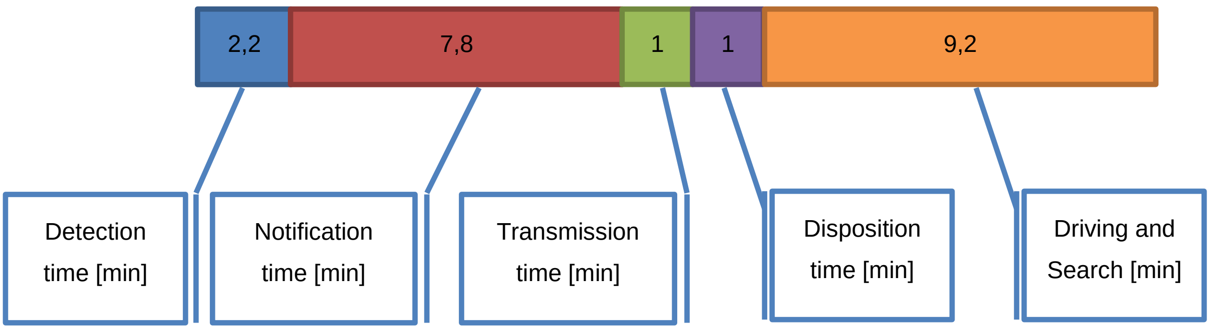

Figure 1: Therapy free interval [2]

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.

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.

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. 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.

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 attenuation by the helmet if the audio equipment is installed on the motorcycle as part of the IVS.

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.

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 within its defined characteristic must be guaranteed.

2.1 ECall- and eCall-like systems

We present three main fields were an automatic notification of an accident is needed. The leading industries produce different devices and the growing and evolution of portable sensorized devices represents a challenge for manufactures. First, we present the health care field, which has consolidated products. Then for four-wheeled vehicles there are already standardized Advanced Collision Notification (ACN) systems developed by major companies, but some independent products are presented on the market. Finally, also for motorcycles and bicycles there are some merchandised devices.

Health Care Field

In the health care field, the first devices produced are pendants, wristbands and/or base stations that simply allow the user to click on a panic button for an emergency call to industrial operators or preselected numbers (family or assistant numbers). These devices are equipped with speakers and work with landline connection. Portable devices have a wide range (around 150 meters) while base stations are in an established room and are equipped with high volume speakers and microphone. Automatic fall detection is not present or is optional. Such apparatus is produced by [4], [5], [6], [7] and many other industries. This type of accessory is the first step for an automatic falling down notification.

The second generation of such products present accelerometers on portable devices connected with a fixed base station. With this type of configuration, it is possible to being monitored 24 hours per day (unless there is need of a battery recharge of the device). The portable pendant is often water resistant and with a high battery capacity [8], [9], [10]. The major companies develop also this type of product as an upgrade of the previous devices.

The successive step is to add a GNSS sensor for location tracking of the user. There is still the need of a base unit connected to the landline for the emergency call and a panic button and the automatic fall down detection. Products of this type are commercialized by [11], [12], [13] and others. In Figure 2 successive generations of this type of products are compared.

Figure 2: First type of automatic fall down notification for elderly people.

Because of the target of the product, which are elderly people, companies develop also devices that monitor daily activity. With a wristband and a clip equipped with accelerometers and GNSS, [14] company develop automatic fall down detection and monitor for abnormal activity. This device, shown in Figure 3, won the British Healthcare Awards in 2014 due to its innovation and potential. There is still a panic button but the dock station was employed only with a recharge purpose.

Figure 3: Buddi automatic fall down detection device.

A health vital monitoring patch which is equipped with different monitoring sensors was developed by [15] and [16]. First there is a, accelerometer for the fall down detection, then there are ECG electrodes for the heart rate and thermistor for skin temperature. The difference from the two products is that the former is connected to a speaker while the latter to a smartphone, both through Bluetooth connection. The smartphone app gives also the possibility to the user to check its own status. In Figure 4 the two vital patches are presented.

Figure 4: The two vital patch sensor built

Also an intelligent watch was developed by [17], with the purpose of monitoring daily life, see Figure 5. Among its features there is location tracking, fall detection through accelerometers and heart rate monitor. There is a cloud-based storage of all the event history data and it is compatible with android smartphone. It was initially developed for detecting epileptic seizure.

Figure 5: Intelligent watch for fall detection and daily monitoring.

Then there are several products for monitoring workers' activity. [18] sells a belt device for immobility and fall detection. It is connected, via a radio channel (3.5 kilometres of range), to a supervised network. It was created for workers in a building site. There is no speaker installed and the location is retrieved from the radio network. [19] builds a wireless pendant, shaped as a ID badge, with GNSS and accelerometer sensors for movements monitoring and fall down detection. Also manual alert can be done. The device is connected to the smartphone and the emergency communication is done by a proper application.

Four-wheeled Vehicle Field

There are already on the market specialized devices containing accelerometers for crash detection, GNSS sensors for the localization and a Bluetooth module for smartphone connection. These devices are black boxes that need to be located in specific positions on the vehicle, according to their features. Crash detection is made by inspecting acceleration data. If either a too high acceleration is registered or a rollover is encountered, then the accident is detected: accordingly, through the cellular network module of the smartphone, the notification is sent. This set-up is implemented by [20] which sends a text message to preselected numbers with the vehicle location and by [21] with a call to specific operators. If the driver is unable to communicate and does not speak then the operators automatically receive the vehicle localization (from now on we call this procedure call-back).

With the same detection algorithm, [22] develops a device, see Figure 6, which is not connected to the smartphone. The notification is made by a Radio-Frequency Identification (RFID) module with a call-back to the driver, who needs to be registered, by Telepathx operators.

Figure 6: ACN device with RFID connection.

Other products have the advantages to being portable. A plug-n-play device equipped with accelerometers, GNSS, speakers and a cellular network module was developed by [23]. This is a complete portable and autonomous device. It has to be placed in the 12V outlet of the vehicle, as the lighter socket, and it is shown in Figure 7. No smartphone is needed and a call-back approach is adopted. This smart solution has the potential of being completely independent from any other system (vehicle, smartphone or GNSS) except for the 12V outlet, but a battery backup is added for preventing absence of electricity after a crash.

Figure 7: ACN lighter socket device.

The benefit of a device not fixed to the vehicle is fascinating and there are other products that can be connected to the OBD port of the vehicle, see [24], [25]. These are adapters, shown in Figure 8, equipped with a Bluetooth module connected to the smartphone. The idea is to detect the accident with in-vehicle sensors and to use the GNSS and cellular network modules of the smartphone for the localization and the notification of the crash. The call-back approach is adopted with these products which are not completely independent from other devices but are robust in terms of false alarm, due to the use of in-vehicle sensors.

Figure 8: ACN device connected to the OBD port.

Some other devices [26], [27], [28] are developed by specialized industries and are directly connected with the vehicle electronic unit. Crash detection is made by in-vehicle sensors. These devices implement the notification system. There is also the possibility of manually activate the notification because the communication module is installed in the vehicle cabin, see Figure 9. This solution is already adopted by some automotive industries (as OnStar system for Opel).

Figure 9: OnStar ACN fixed on the rear-view mirror.

There are some automotive companies which have developed their own ACN systems. There are two main types of ACN: with Bluetooth connection [29], [30], [31] and with integrated SIM [32], [33], [34]. Both use in-vehicle sensors for crash detection but the former needs a smartphone for the notification, while the latter has an integrated SIM preventing smartphone connection and damaging problems.

Two-wheeled Vehicle Field

Usually the bicycle is not an instrumented vehicle, even if some electric or pedal assisted bike is now equipped with some useful sensor. For this reason, the devices on the market are external devices that need to be fixed on the vehicle. An instrumented tail light was developed by [35], see Figure 10. Accelerometer sensors are used for crash/fall detection and a GNSS module is used in order to connect the device with the users' smartphone, ensuring localization and notification of the accident. The notification is a text message sent to preselected contacts.

Figure 10: Taillight device for fall down detection and notification.

A smart device fixed to the drivers' helmet was developed in [36], and it is shown in Figure 11. The apparatus is equipped with accelerometers and pressure sensors for crash detection. There is always a Bluetooth module for connecting the device with the smartphone of the user. A text message is sent to a selected contact with the position retrieved by the GNSS sensor. There is also a panic button for a manual alert of the accident. In [37] a similar device is presented but it is fixed under the bicycle seat, see Figure 12. A different device was produced by [38]. It is a keyless bike lock (Figure 13) and it is equipped with accelerometers for fall detection. A powerful Bluetooth antenna is installed to increase the range of connection with the smartphone and, to avoid battery life problem, a small solar panel is used in order to recharge the batteries during daylight. Thus also an anti-thief algorithm is implemented. There is still a panic button for manually alerting preselected numbers with a text message with GNSS coordinates for the drivers' location.

Figure 11: Icedot ACN device.

Figure 12: Biketag ACN device.

Figure 13: Bicycle lock equipped with accelerometer for ACN.

For motorcycle there are some devices analogous to the ones produced for the bicycle. By fixing a black box, equipped with accelerometers for crash detection, GNSS for the localization and an integrated SIM for the cellular network communication, it is possible to develop a fall down/crash notification system with a call-back approach [39], see Figure 14 or with a text message to preselected contacts [40].

Another possibility is the crash detection using a tilting sensor. This sensor detects when the vehicle falls down. Then with an integrated GNSS and cellular network module it is possible to notify the location of the crash to appropriated operators [41]. Other device uses both accelerometers and tilting sensor for crash detection [42], (see Figure 15). There is also a panic button installed on the handlebar and a call-back procedure is adopted.

Figure 14: Phantom ACN for motorcycle.

Figure 15: Dguard ACN for motorcycle

A smart helmet, in collaboration with BMW, was developed by Schuberth, see [43]. The crash detection is checked by examining the vehicle sensors (accelerometer and tilting sensors). Then the helmet is connected to the drivers' smartphone and a call-back procedure is adopted for gathering information about the users' crash. A panic button is installed on the handlebar for manually notify the accident. In Figure 16 the developed system for CAN is shown.

(a) (b)

Figure 16: Schuberth helmet (a) and BMW handlebar (b) of ACN which use in-vehicle sensor.

Honda developed a complete system for ACN in motorcycle [44]. The developed system is similar to the one made for a four-wheeled vehicle, thus the crash detection is made by analysing in-vehicle sensors data and an integrated GNSS and cellular network module is adopted for the notification.

Finally, there are all the devices not related to the vehicle dynamics. In [45] a belt clip device is presented: it is rigidly connected to the vehicle and to the driver with a cable/chain, see Figure 17. This device is equipped with a contact sensor. If the chain is detached from the vehicle, due to a fall down, an accident is detected. Then through the integrated GNSS and cellular network modules, the position of the driver is sent to preselected contacts with a text message.

Figure 17: Ridersmate ACN device.

2.2 Market product analysis

There are some common features among the presented devices in the three analysed fields. We have identified five major ones:

- Sensor: the type of sensor used to detect the accident is a categorization of the adopted and accepted techniques for crash detection. Acceleration carries the information of the impact caused by a crash or a fall down. In-vehicle sensors of a car or motorcycle represent the most robust solution, due to the abundance of suitable sensors, such as airbag deployment, seat belt tensioner activation, pressure sensor and others in a four-wheeled vehicle. Other sensors, such as tilting, contact or gyroscope sensors have been used for detecting the position of the subject.
- Responders: this feature implicitly shows the acceptance of crash detection algorithms. Direct call to emergency responders (911 for USA or 112 for Europe) requires a total absence of false alarm, while sending text messages to preselected numbers is a less constrained solution. Call-back procedure does not require total absence of wrong notification but still needs high rejection of them.
- Communication: the type of communication could be text message (to specific operators or preselected numbers), call-back procedure (to 911, 112 or company operators) or direct call.
- Integrated communication: an integrated cellular network module (or other type of communication) is preferable in order to avoid the need of a connection of the smartphone to the device because an external phone can be damaged during an accident.
- Portability: lastly this characteristic is a requirement because the device can be used in different vehicles and the driver can share his safety system with familiar or friends.

In Figure 18 the number of products analysed is categorized by the crash sensor feature. The histogram reports also the information about the field. For health care in-vehicle sensor has no meaning, but it is clear that the accelerometer sensor is the most adopted choice for detecting an impact. Also in-vehicle sensors are often used but only for cars which are the most sensorized vehicles. Manual detection could be added to an ACN system but this is not a priority. In the health care field there is a high number of products using different sensors such as a gyroscope or a tilting sensor.

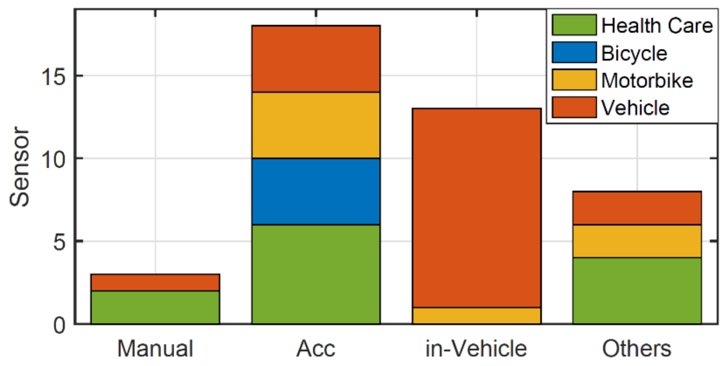

Figure 18: Categorization by crash sensor used

Responders type categorization of a collision notification is shown in Figure 19. In general, the preferred choice is to notify operators of the company of the product, with the exception of bicycle devices because they are not produced by leading industries. Direct call to emergency authorities is rarely used so far due to the possibility of false alarm. Signalling an accident to a preselected contact is also suitable for ACN system and all the fields have some device with this type of receiver. As already mentioned, this implicitly shows that ACN systems are not already completely reliable and that the risk of a wrong call drives industries to prefer a notification to own operators.

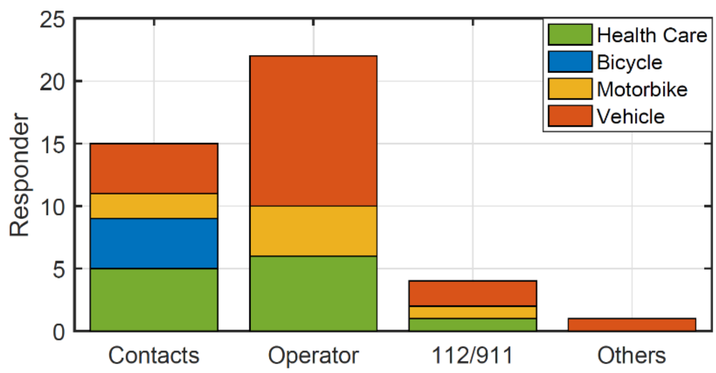

Figure 19: Categorization by responders of automatic notification.

The type of communication: text message, direct call or call-back procedure, is a characteristic related to the previous one. Text messages are sent to preselected contacts, while the call-back procedure is linked to the operators' service. Direct phone calls are made especially when emergency authorities are notified (see Figure 20 for details). The histogram shows that most of the devices send a text message or use the call-back approach, thus avoiding direct call to 911 or 112, because the ACN systems are not completely trusted by industries yet.

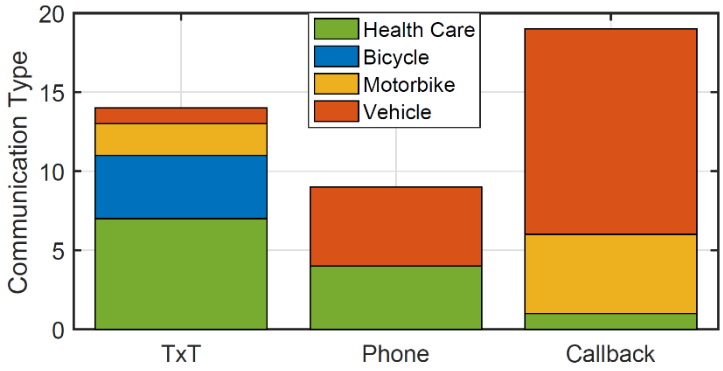

Figure 20: Categorization by type of communication done.

In Figure 21 one can see the clusterization by considering the need of users' smartphone. Even if smartphone number and computational load is continuously growing, industries prefer to integrate a communication module in the ACN system (especially in health care field). For four-wheeled vehicles there is a little preference for using drivers' smartphone. This is due to the fact that with this solution no new component in the vehicle is required and also because in the car cabin there is little probability to damage the smartphone during an accident. Moreover, by directly connecting the vehicle to the cellular network (or internet) the car is exposed to hackers [46], thus adding a cellular network module implies direct exposure to external cyber-attack. In a two-wheeled vehicle during an accident there is a high possibility of damaging the drivers' smartphone, thus it is preferable to integrate the cellular network module and fix the component to the motorcycle. With a bicycle the problem of integrating a connection module is related to the battery load. There is no possibility of supplying the device with electricity, thus adding another component is critical for battery life.

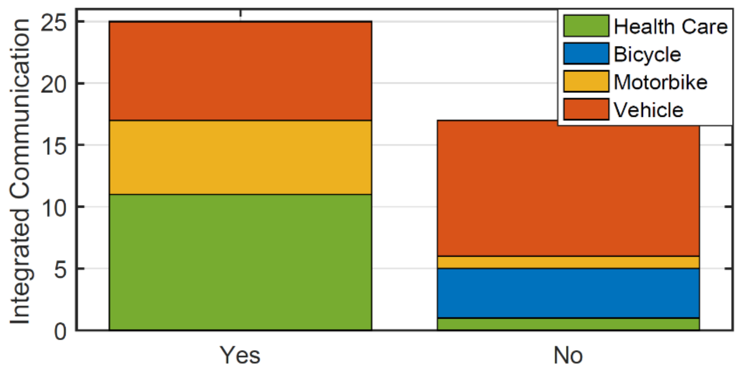

Figure 21: Categorization by the need of the own cell phone.

The last feature to take into account is the portability of the device. In Figure 22 the categorization of the products is shown. Without considering the health care field, since all devices need at least a landline connection, for a bicycle all products are portable because they only need to be connected to the smartphone and no power supply is required. Even if portable devices are useful for drivers, in motorized vehicles the analysed devices are mainly not portable. This is depending on the fact that a vehicle is a closed system and it is preferable to avoid users to be directly connected to the vehicle. The OBD port represents a high potential alternative for producing portable devices, but that port is also connected to the main CAN bus of the car which is a broadcast channel. All the subsystem connected to the channel can both read and send messages. Subsystem components of the vehicle cannot know the sender of a message due to the characteristic of the CAN bus; as a consequence, an external and dangerous component can send wrong messages and, for instance, set wrong engine rpm or change volume of the radio or even turn the steering wheel. Also reading data can cause high problem. Modern cars can be connected to the smartphone and read for example email messages. It is thus possible to steal identity by accessing to the vehicles' CAN bus. Recently, Wired journal [47] published a web article where a pair of security researchers explain what can be done with vehicle hacking. Federal Bureau of Investigation warns Americans about vehicular cyber-attack.

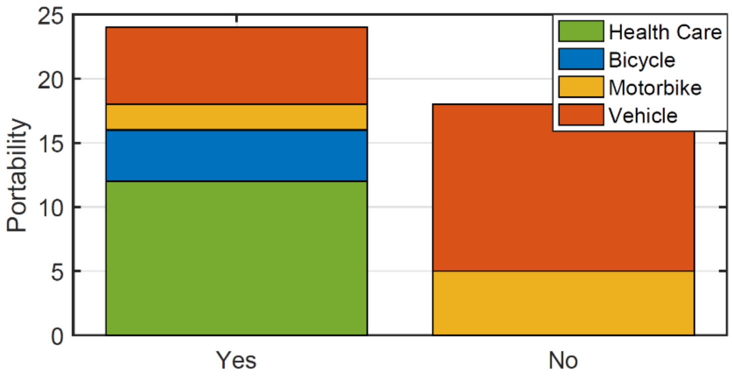

Figure 22: Categorization by device portability.

2.3 ECall standards

The underlying eCall standards are defined and approved by European Standardisation Bodies, namely ETSI 3GPP and CEN TC278 WG15. 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).

2.3.1 General Overview

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 23: 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 24: ETSI standards

Regarding the certification scope for communication, reference is made to the HeERO Task Force on Standardisation and Certification, who summarised all eCall communication specific standards as per below picture.

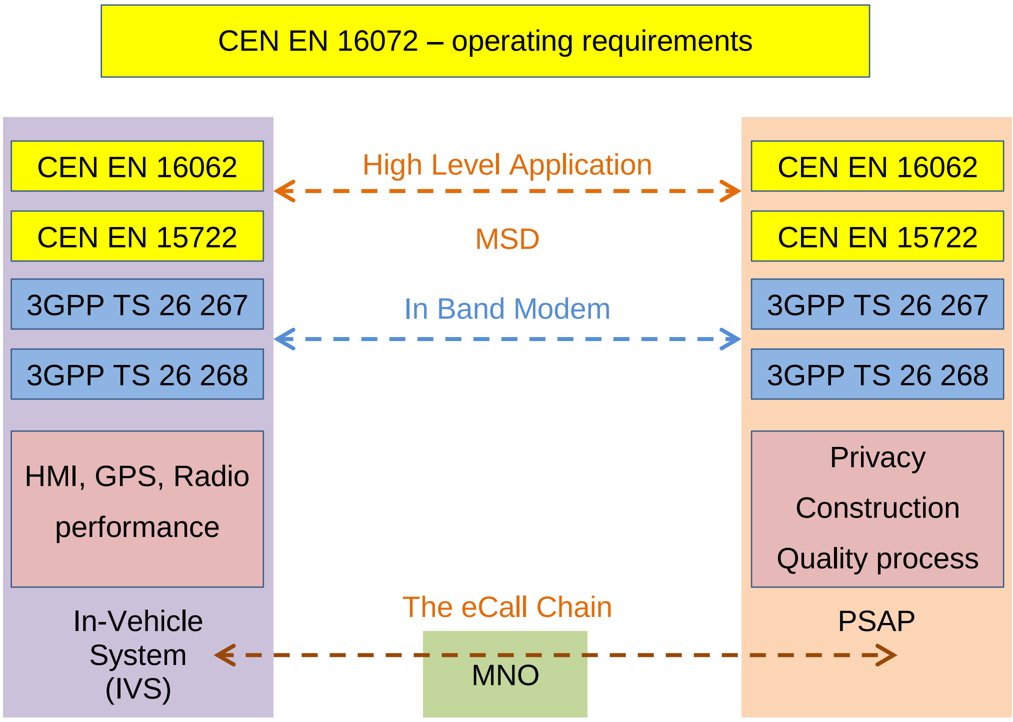

Figure 25: eCall communication specific standards

While studying the state-of-the-art situation in terms of standards around pan-European eCall the focus was in line with the main identified challenges of eCall for P2W. These are:

- 112-based emergency call triggering, being manually or automatically triggered,
- Requirements for an audio connection and handling of silent calls
- Injury prediction measures and requirements
- Retrofit.

The other functional and non-functional requirements not specifically mentioned in this report deserve the same level of importance.

CEN EN 16072 is describing the general operating requirements of pan-European eCall.

CEN EN 15722 is dealing with the minimum set of data (MSD), CEN EN 16062 with the eCall high level application requirements, CEN EN 16102 with eCall operating requirements for third party support and CEN EN 16454 with eCall end to end conformance testing. These standards describing requirements out of CEN EN 16072 in more detail.

2.3.2 CEN EN 16072 operating requirements [48]

The European Standard CEN EN 16072 specifies the general operating requirements and intrinsic procedures for in-vehicle emergency call (eCall) services in order to transfer an emergency message from a vehicle to a Public Safety Answering Point (PSAP) in the event of a crash or emergency, via an eCall communication session and to establish a voice channel between the in-vehicle equipment and the PSAP. The very highest-level generic eCall architecture is described in Figure 26.

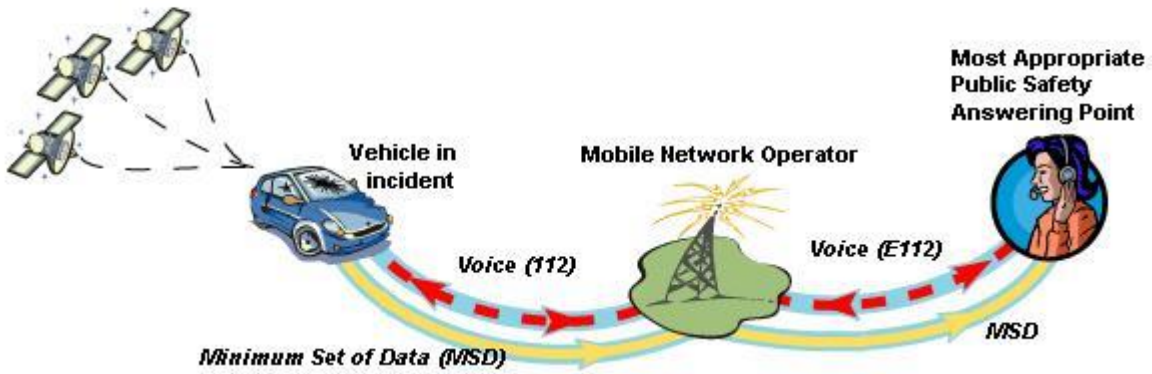

Figure 26: eCall operation sequence

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. These 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 involves a number of different stakeholders all with separate responsibilities and tasks, which may overlap. These are:

- in-vehicle equipment provider(s);
- Mobile telecommunication network operator (MNO);
- Public Safety Answering Point (PSAP).

The CEN EN 16072 will be assessed in the following paragraph focusing on the challenges for P2W. (Citations are highlighted in *italic* and referencing the edition of the document listed in the bibliography only)

Post-crash performance of the in-vehicle equipment

CEN EN 16072:

The automotive manufacturer and/or equipment supplier shall make best reasonable effort to enable an audio channel to be established so long as the relevant equipment has not been disabled in the crash. Furthermore the crash itself is described and referenced to the Directive 96/79, amended by Directive 1999/98 (or equivalent ECE R94-01) for frontal crashes and Directive 96/27 (or equivalent ECE R95-02) for lateral crashes.

The main difference between eCall for M1, N1 vehicles and eCall for P2W is the probable separation of driver/ rider & vehicle during an accident due to vehicle dynamic peculiarity and the identification of a fall, with or without a collision of the vehicle with a solid object. One key objective of the project is the definition of a crash event from P2W perspective, from which use cases for triggering as well as recommendations for verification are derived from.

In-vehicle 'Human Machine Interface' (HMI) aspects

CEN EN 16072:

Beside other requirements the eCall IVS shall wherever practicable alert the vehicle occupants that an eCall message has been sent and that the system shall attempt to make a direct voice connection with the PSAP. The means by which this alert is made, and the nature of the alerts, shall be a function of product design and it is not defined in this European Standard.

For eCall systems on P2W this requirements needs to be investigated considering a probable separation of rider and vehicle.

Triggering aspects

CEN EN 16072:

Automatic triggering shall be generated by a signal emanating from one or more sensors or processors within the vehicle to the eCall in-vehicle equipment.

Without specifying the means of achievement, the following general requirements shall be met (a selection):

- *the automatic eCall trigger signal is generated by in-vehicle equipment to identify a probable collision. The nature of this device and its operational process shall be at the discretion of the vehicle manufacturer/equipment supplier;*
- *the eCall shall be generated to reflect as many different crash types as possible (e.g. front, rear, side crashes). The automatic eCall trigger shall be safe, robust, reliable, and designed so as to maximise the number of valid eCalls whilst minimising the number of false eCalls, generated by the eCall generator.*

In M1, N1 vehicles an accident trigger signal will mostly be provided by an airbag ECU, which is not available at P2W and thus needs to be generated by other means.

With regards to manual triggering the requirements are as follows:

The availability of the manual triggered eCall with ignition off shall be at the discretion of the vehicle manufacturer/eCall in-vehicle equipment provider. For P2W usage the manual eCall triggering need to be assessed in terms of practicability.

Termination of an eCall

CEN EN 16072:

The in-Vehicle System responsible for the eCall system may allow vehicle occupants to abandon a manually initiated eCall (in order to cancel an unwanted triggering) before the eCall has been activated, but once the eCall trigger has been confirmed within the in-Vehicle System responsible for the eCall system and therefore the eCall has been activated, the eCall transaction shall not be terminated by the vehicle occupants. In the case of an automatic eCall, it shall not be possible for the eCall transaction to be terminated by the vehicle occupants.

The need to trigger an eCall on P2W in multiple use cases on the one hand side and the requirement to minimize the number of false eCalls on the other requires a dedicated multi-stage triggering strategy which may involve the rider himself. The regulation for the abandonment of a launched eCall is an important input for this study.

An in progress eCall shall not be terminated by the IVS responsible for the eCall system (other than because of expiry of a timer) and shall be terminated only by the PSAP.

Voice Channel aspects

CEN EN 16072:

The IVS responsible for the eCall system shall attempt to establish a 'hands-free' audio connection between the occupants of the vehicle and the PSAP.

In addition to the sending of the MSD the MNO system shall make best reasonable efforts to maintain a direct audio channel between the vehicle and the PSAP to give opportunity to the PSAP to speak directly with the occupants of the vehicle.

The applicability of a voice call for M1, N1 vehicles and on P2W is significantly different. The specific characteristic of a voice connection need to be investigated and an appropriate conclusion derived. The need for the so called silent calls for PSAP’s and rescue services have to be considered.

2.4 Patents / Utility Patents

Patent databases are one of the biggest knowledge databases available. Therefore these databases must be analysed to get a full picture about a technical system. Furthermore, patent databases are more up to date, because patents must be filed before a product gets officially announced and even if it does not come to a product, normally the patents are already filed. Consequently patent databases are part of the state-of-the-art definition.

In this case the scope of the patent research was limited to P2W eCall systems or applications. Automotive applications and data transmission were not considered. The most relevant patents and utility patents are summarized in Table 1. More detailed information regarding these patents are available in the annex. The legal state of the patents is not part of the description, because this information is only valid for the moment of the query. A reliable information cannot be given.

Current Applicant or Assignee Name	Normalized Patent Numbers	English title
HONDA MOTOR CO LTD	WO200187695; US20020158754; US6587042; EP1197426; DE60138517; JP2001328580; JP4345948; CN1362923; CN1140434C; TW-587561U; KR20020022642; KR100468405; NO200200322; NO-329860; NO201001101; NO-331738	Automatic accident reporting apparatus for two-wheeled vehicles
ROBERT BOSCH GMBH	DE102014216926	Method for operating an emergency call device
BAYERISCHE MOTOREN WERKE AG (BMW)	EP3033859; WO201522153; DE102013216177; CN105308660	Method, device, computer program, and computer program product for transmitting an emergency call, and method, device, computer program, and computer program product for receiving an emergency call for a motorcycle

ROBERT BOSCH GMBH	WO2014131534; DE102013203215	Method for automatically transmitting an emergency call in the event of an accident of a motorized two-wheeled vehicle
ROBERT BOSCH GMBH	EP2822845; WO2013131670; US20150232091; DE102012203647; JP2015511552; CN104144847; IN2014DN06469	Method for preventing an accident or for reducing the effects of the accident for a rider
ROBERT BOSCH GMBH	WO2011131558; US20130124035; US9043077; DE102010027969	Method and device for determining a type of an impact of an object on a vehicle
ROBERT BOSCH GMBH	DE102010003317	Method for combining data of e.g. acceleration sensors for classification of left-sided collision of car, involves receiving time courses of sensor signals over interface, and combining time courses to obtain time course of combined signal
CONTINENTAL TEVES AG & CO OHG	EP2155540; WO2008145510; US20100302029; DE102008023243	Transmission of an emergency call from a motor cycle
BOURGINE DE MEDER LAURENT	EP1523434; WO200409415; US20060164217; US7567166; FR2842493; AU2003273429	Safety/security method and device for two-wheeled vehicles and similar
SCHUBERTH GMBH	WO201118168; DE102009036828	System for detecting an accident situation and emergency call activation and method for same

HONDA MOTOR CO LTD	WO2010101013 ;EP2404792; JP2010208381; JP5419495; JP2010208380; JP5419494; CN102341281; CN102341281B; BR201016248	Abnormality detection and vehicle tracking device
BAYERISCHE MOTOREN WERKE AG (BMW)	EP2897496; WO201444554; US20150191105; US9452689; DE102012217140; JP2015529171; CN104619213	Seat occupancy detection device
OPKAMP HERBERT	DE202006005793; DE202006016991	Automatic rescue system for detecting motorcyclist, has transponder provided at clothes/body of motorcyclist, and reader to send emergency signal over global positioning system-systems to service station, during accident of motorcyclist
MAI ANDREAS; OPKAMP HERBERT	DE20316019	Emergency call system for use by motorcycle riders to signal emergency services that an accident has occurred base on worn sensor output signal
OPKAMP HERBERT	DE20315968; DE202004003196	Emergency release cord for motor cycle drivers interrupts connection to transmitter when pulling force is applied and emergency call is triggered
MOTOROLA INC	GB200207340; GB2387006	Motorcycle wireless communication system employing a tilt sensor to detect an emergency situation which is transmitted to a remote location
MURKUTE DHANASHREE PARESH	IN01706CH2014	Vehicle fall detection and notification system and method therefore
DAINESE SPA	EP2079613 WO2007IB54299 IT2006RM00571 AT20070826830	Method and device for the prediction of a fall of a person from a vehicle or the like

BAYERISCHE MOTOREN WERKE AG	US6496763 EP20000126369 ES20000126369 JP20000392795	Device for detecting roll-over of a vehicle
YAMAHA MOTOR CO LTD	EP2881921 JP20130253279	Tip-over detection device for motor vehicle
ALPS ELECTRIC CO LTD	EP2881921 JP20130253279	Vehicle accident notification apparatus
YAMAHA MOTOR CO LTD	EP2268507B1 IT2008MO00127 WO2009IB05411	Device for sensing operating states of a vehicle
META SYSTEM SPA	EP2268507 IT2008MO00127 WO2009IB05411	Safety apparatus for motor vehicles or the like
DAINESE SPA	EP2632772 ES20110797123 IT2010MI02027 WO2011IB54803	Apparatuses, system and process for detecting accidents

Table 1: Patents and Utility Patents

Assessment

The most frequently named sensors in all these patents is a roll angle or inclination sensor. The usage of this type of sensor is described in DE102008023243, EP1197426, GB2387006 and WO200409415. In all of these patents, except GB2387006, the inclination sensor is combined with an acceleration, velocity or movement sensor.

The most detailed description of a triggering mechanism can be found in EP1197426. Here the described systems includes also a cancellation button as well as a surveillance of the power supply of the system. A surveillance of the power supply is also described in WO2010101013. In this patent the so called abnormality detection is conducted, when the in-vehicle battery is removed.

Besides these triggering mechanism, there is also a description of a triggering line system, DE20315968. Such a system was already described in 2.1.

The usage of signals from other systems is described in DE102012203647. Here, the eCall device uses signals from accident-preventing systems (e.g. ABS).

The HMI of eCall devices are also included in the patents. Cancellation buttons and acoustic warnings are frequently mentioned (DE102013216177, DE102014216926, and DE102008023243).

DE102013203215 and DE102012217140, systems are described which surveil the presence of the rider. In DE102013203215 the grip of the rider on the handlebar is surveilled, whereas in DE102012217140 the seat occupancy is watched.

3 Differentiation eCall vs eCall-like systems

As shown in the previous chapters, there are already many systems on the market for nearly every field of application. On the one hand many of these systems provide functionalities beyond the eCall functionality but on the other hand do not fully comply with the relevant standards. Therefore a clear differentiation between eCall- and eCall-like systems will be given in this chapter.

ECall-system

An eCall-system within this project has to have the following characteristics:

- Automatic triggering functionality, manual triggering is optional.
- ECall must be transmitted to the next appropriate PSAP or to a certified Third-party-service (TPS) according to CEN EN 16102.
- The system must comply with all relevant standards.
- It must be ensured, that the user cannot be tracked by the system or any external person or system. A transmission of data is only allowed in case of an emergency. The content is limited to the defined MSD and OSD (Optional set of data).

All other systems which do not fulfil these characteristics are called eCall-like systems.

Especially the last point regarding the users' privacy is a crucial point for the user acceptance. Figure 27 is showing the results of a User survey regarding P2W eCall. Question 14 is dealing with the negative points of eCall-systems. More than 50% of the users are worried that data could be used for other reasons than eCall functionalities. So privacy is one of the most important points, which must be considered for eCall-systems. Therefore extended functionalities like route tracking, position sharing or speed monitoring, just to mention some examples, are not permitted to address this concern.

14. In your opinion, what could be the negative points of eCall for PTW? (Please select 3 answers) (This question requires an answer)

		Response Percent	Response Total
1	False activation	72.02%	1488
2	If there was a high cost involved	40.95%	846
3	The concern that GPS data is not only used for eCall	50.34%	1040
4	Security against hacking	19.12%	395
5	Cost of ambulance/police call out	14.71%	304
6	In case I do not want to report an accident.	31.12%	643
7	In case of an accident that is not serious	50.92%	1052
8	Making riding too complicated	5.61%	116
9	In case of circuit riding	10.99%	227
10	Other (please specify): View	4.11%	85
		answered	2066
		skipped	0

Figure 27: I_HeERO P2W User survey – Q14

4 Assessment

As already mentioned in chapter 2, there are two crucial points for the development of an eCall system for Powered-Two-Wheeler. The first one is the core part of an eCall system, the automatic accident detection. The second one is the voice communication, which is more difficult in comparison to an automotive application.

These two points will be discussed deeply in the next paragraphs.

4.1 Accident monitoring / Accident detection / Triggering

The triggering algorithm is the core part of an automatic crash notification system. First of all, the performance targets must be defined. Then in a second step triggering criteria and triggering thresholds must be defined. For these points a literature study was performed, as a baseline for discussion.

Performance targets

The target must be to trigger an eCall in all relevant situations without triggering an eCall in situations, where no medical help is needed. It is obvious, that in reality there is no clear borderline between situations where help is needed and situations where no help is needed. There is a lot of uncertainty. First thoughts may occur, that triggering in uncertain situations is the best way to deal with this problem, but this won't be the right way to proceed because of two very important points:

- User acceptance:

  One of the biggest fears of P2W user is the occurrence of false calls, Figure 27. In order to achieve a high user acceptance, false calls must be minimized.

- Resources of rescue services:

  The second very important point is the handling of the resources of rescue services. It must be assured, that the resources of the rescue services are not wasted due to false activations. In a worst case, there are not enough resources to handle all situations in which the help is really needed.

In order to measure the rate of correct and incorrect eCalls, the terms under triage and over triage will be introduced as quality measurements. In general, triage is the process of classifying patients according to injury severity and determining the priority for further treatment [49]. Therefore and according to [50] over triage and under triage is defined as:

- Over triage occurs when a patient receives more care than necessary
- Under triage occurs when a severely injured patient fails to get the necessary care

The still remaining question is, what values are suitable for an eCall system. According to the "The American College of Surgeons Committee on Trauma" an over triage rate of 50% is necessary to get an acceptable under triage rate. Besides this, they are suggesting, an under triage rate of 5%, which is an acceptable error when minimizing over triage [51].

Within [52] an under triage rate not bigger than 10% and over triage rate not bigger than 50% is suggested.

So an under triage rate between 5% and 10% and over triage rate close to 50% is perceived to be suitable for an P2W eCall-system.

At this point it must be mentioned, that over triage rates can only be estimated with a high reliability when real systems are running on the market. Under triage rate are always difficult to be analysed, because therefore the accidents must be reported by an external person and then, afterwards, they must be linked to an eCall-system.

For the development of a system these measures can only be roughly estimated.

Accident detection / eCall triggering

The algorithm for accident detection and eCall triggering is probably the most complex and most important part of eCall-systems. Information regarding motorcycle accident detection algorithms are not available therefore the most similar sector with available information, the automotive sector, will be analysed. Almost all automotive OEMs are offering eCall-systems and moreover the standardisation for this sector is already well advanced. The standards are very vague with regards to triggering algorithms.

[53] is providing a good summary about the existing parts which are dealing with eCall triggering for automotive:

- HELPNET System Specifications - AECS-03-05e, Japan:
    - Automatic triggering is linked to airbag deployment
- GOST R 54620, Sections 6.1 and 6.2:
    - For vehicles of category M1 – this is expected to be based on automatic triggering in the event of an accident in which there is a substantial likelihood of threat to life and health of people in the vehicle at the time of the accident
- Draft UN Regulation No. XX on AECD/ AECS, Part I:
    - Automatic triggering shall occur at least under the conditions of UN R94 and UN R95 crash tests

As mentioned in the HELPNET System specifications, triggering an eCall can be linked to the deployment of an airbag. So in the automotive sectors there are already systems and sensors available which can detect an accident and which fulfil these requirements. 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 28.

Figure 28 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.

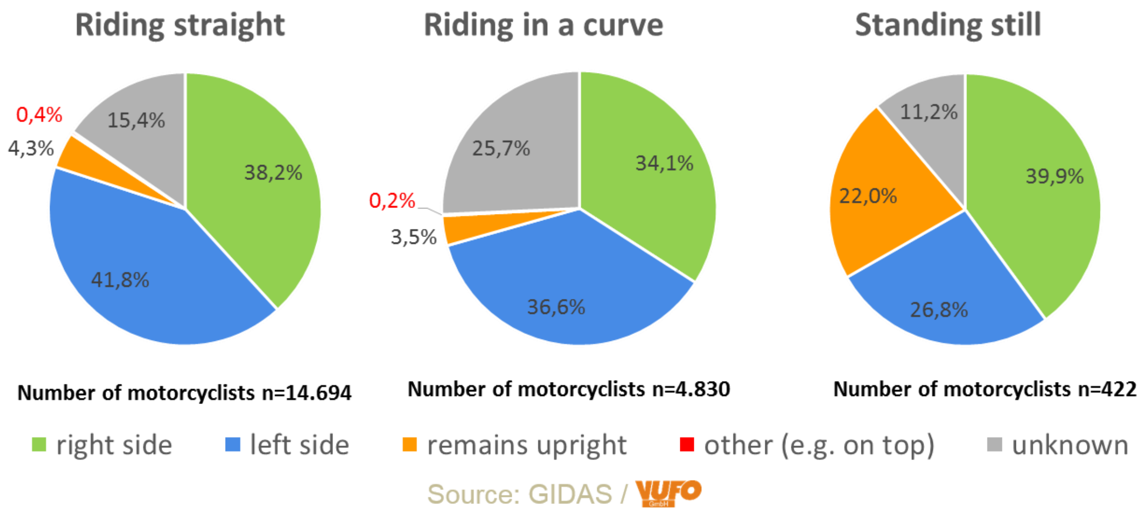

Figure 28: Final position motorcycle [54]

However, the automotive sector is already on step ahead and is already providing advanced or enhanced automatic collision notification systems (AACN / EACN). AACN systems or algorithms are estimating injury outcome based on crash parameters [55].

According to [55] and [56] these crash parameters can be:

- Crash deltaV in the longitudinal and lateral directions
- Crash type
- Safety belt status / Seatbelt use
- Airbag deployment status
- Occurrence of multiple impact
- occurrence of rollover
- Principal direction of Force (PDOF)
- Vehicle type
- Occupant height [cm], weight [kg], age [years] and gender
- Vehicle registration [calendar year]

By using some of these parameters, the injury outcome can be estimated and the rescue services can send the appropriate help [56]. However, for a motorcycle application some of these parameters are also valuable but most of them are not.

It was already shown in [57] that *deltaV* and *crash type* are parameters which have influence on injury outcome and therefore are valuable for eCall-systems. The *principal direction of force* is most likely also a valuable parameter, although it was not explicitly examined, but the identified crash types give already an indication to the direction of force, especially for collision accidents.

The parameters *safety belt status* and *airbag deployment status* cannot be used because most of P2Ws do not have any kind of such systems.

As shown in Figure 28, rollover is also not usable as a parameter for estimation of injury outcome because the system P2W itself is already unstable and therefore the rollover is very likely and does not give an indication for injury severity.

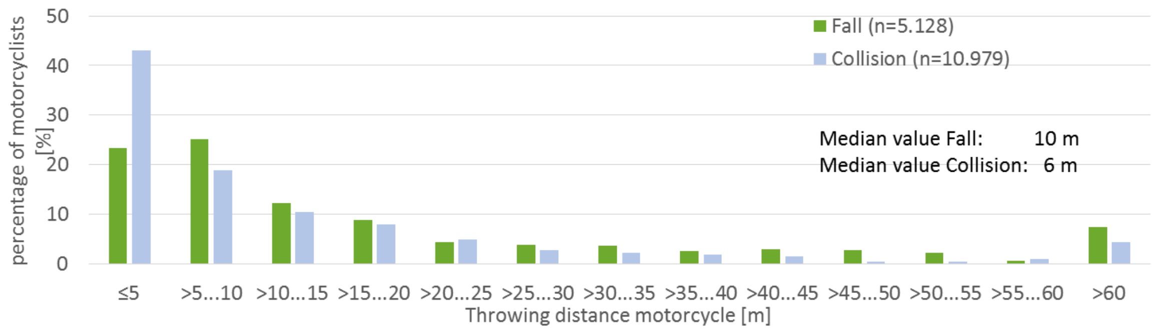

Figure 29: Throwing distance motorcycle [54]

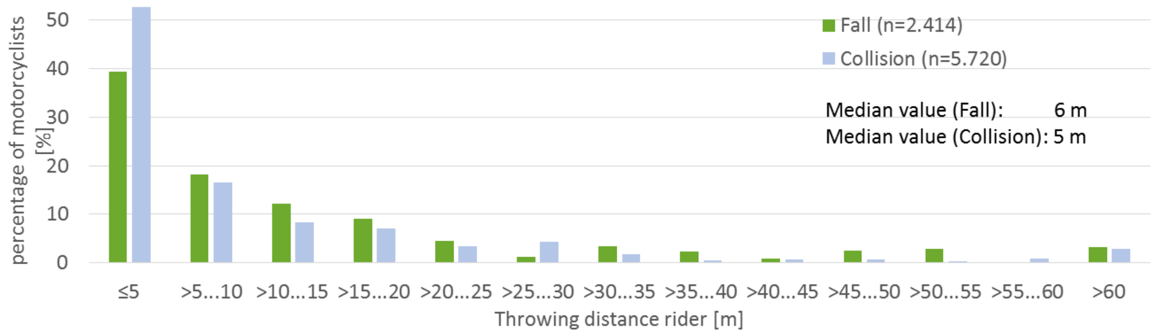

Figure 30: Throwing distance rider [54]

Is has already been mentioned that P2Ws do not have passenger restraint systems whereas in cars these systems are mandatory. If such systems are used, the movement of the passenger is similar to the movement of the vehicle. Without these systems, the driver can be and probably will be separated from the vehicle itself. In Figure 29 and Figure 30 the throwing distances of motorcycle and rider are shown. By comparing the median values of the throwing distances it can be seen, that there will be a significant distance between rider and motorcycle at the end of an accident. At which point or in which phase the rider will be separated from the motorcycle cannot be identified. Due to this reason, the severity of the accident must be evaluated at the moment of the first significant incident (e.g. impact or ground contact) because at this point, the rider is most likely still connected to the P2W. After this point this cannot be guaranteed anymore. Consequently the parameter *occurrence of multiple impacts* is not relevant. Subsequent impacts of the vehicle do not mean that the rider has also subsequent impacts. Subsequent impacts of the rider can only be measured with body-fixed sensor, but the focus of this project in on IVS and therefore such sensors are out of scope.

Vehicle type and *Vehicle registration* are also parameters which do not have any influence on the injury level of motorcycle accidents, because there are no passive safety systems available. The progress in regards of safety are only made on the active safety system levels, so the crash avoidance was the focus of the development. Passive safety systems for example crumple zones are not realisable on motorcycles.

The personal parameters of the rider (*Occupant height [cm], weight [kg], age [years]* and *gender*) indeed have an influence on injury outcome, but for a general application of an eCall-system they are not usable, because then, the system must be personalized.

4.2 Communication – Voice connection

The communication link between PSAP and the rider is an integral part of the automotive eCall-system. For this application, the microphone and the loudspeaker must cover the passenger compartment, which is a closed and well-defined area. In contrast to this, the P2W application does not offer such an area. Beyond that, the rider will be separated from the vehicle. As shown in Figure 29 and Figure 30 the distance between the motorcycle and the rider will be several meters after most accidents. In order to be useful for the majority of accident victims the coverage of the system must be at least 4m. Furthermore, the helmet will constrain the speech and the hearing. Therefore the technical implementation of microphone and loudspeaker is very difficult especially if it should provide a significant benefit and could be used in the majority of accidents.

At this point it must be mentioned, that not only the communication between PSAP and victim can be useful but also the so called “silent calls”. Even if no direct communication is possible, the PSAP can hear into the situation and judge the situation based on the surrounding noises.

However, there are also situations in which a voice connection is not helpful, namely when the victim is unaware of the injuries.

In [56] there is an analysis of verbal responses after accidents. An analysis of ACN crashes in the USA from 2006 to 2008 (Figure 31) shows that in 70% of all crashes no injury was reported

("No information about injury" is assumed to be "Uninjured"). In 20% of the cases an injury was reported and in 10% of the cases a phone connection was established but the occupant did not answered the call. The lack of response could indicate a very severe injury (the rider was not able to answer the call due to the injuries) or it could also indicate a minor crash (the driver left the car right after the incident for example to examine the damage).

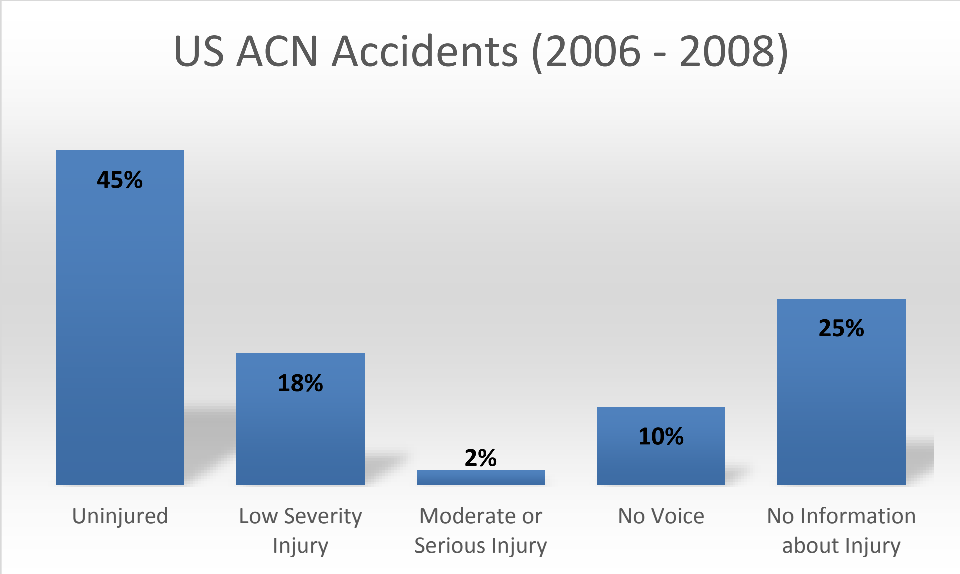

Figure 31: US ACN Accidents [56]

A second evaluation of eACN data from Florida from 2006 to 2008 (Figure 32) is focussing on the cases with no verbal response and on the cases in which the occupants reported no injuries [56].

In this dataset in 12% of all cases no verbal response was given. In these "no-response-cases" 20% of the victims had light or medium heavy injuries and 5% were heavily injured, Figure 33. 63% of the occupants reported, that there are no injuries, but in the end 23% of these victims were injured, Figure 34. This shows that the victims are sometimes unaware of their injuries. Especially very serious internal injuries like thoracic aorta or injuries to the liver are often not recognized by the victim [56]. Consequently a voice connection does not have to be useful in every situation.

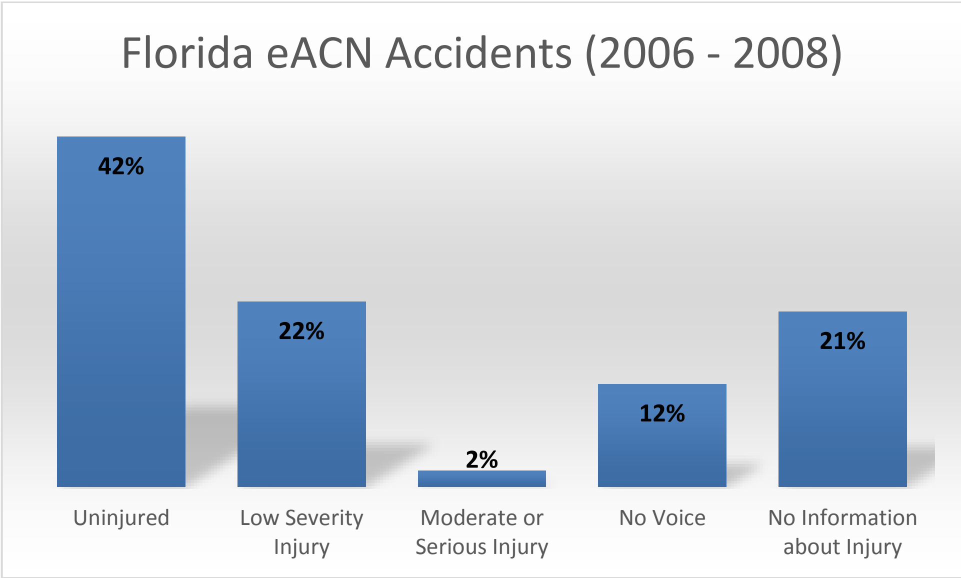

Figure 32: Florida eACN Accidents [56]

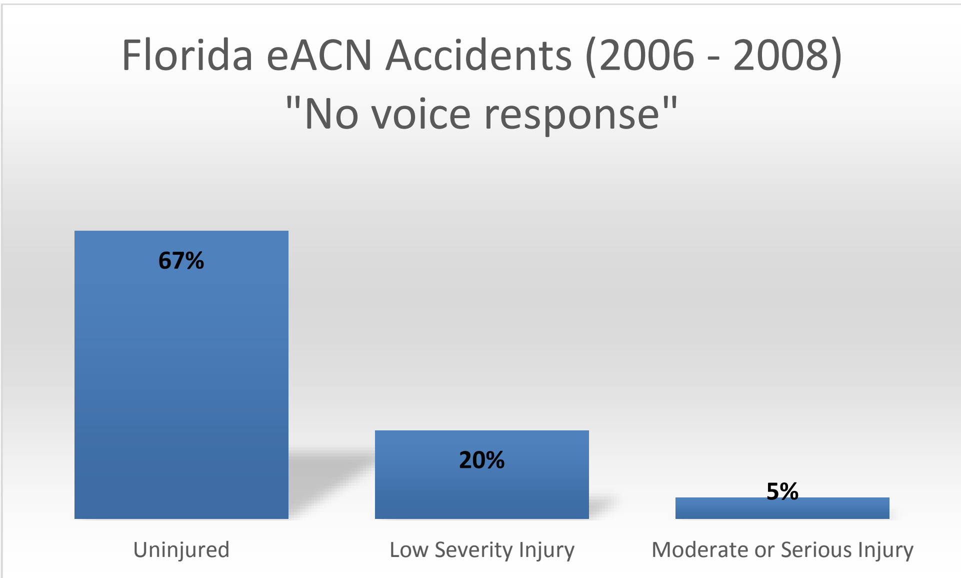

Figure 33: Florida eACN Accidents – No voice response [56]

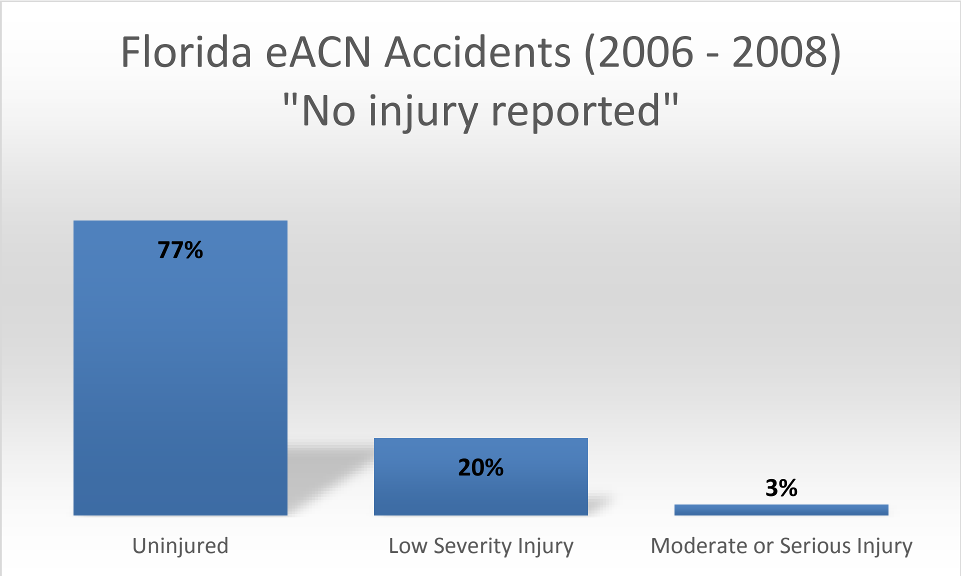

Figure 34: Florida eACN Accidents - No injuries reported [56]

ANNEX 1 - PATENTS

Applicant or Assignee Name:

- HONDA MOTOR CO LTD

Patent Numbers:

- WO200187695; US20020158754; US6587042; EP1197426; DE60138517; JP2001328580; JP4345948; CN1362923; CN1140434C; TW-587561U; KR20020022642; KR100468405; NO200200322; NO-329860; NO201001101; NO-331738

Title:

- Automatic accident reporting apparatus for two-wheeled vehicles

  Automatic accident informing apparatus for two-wheel vehicle

  Automatic accident reporting apparatus for two-wheeled vehicles

  Automatic accident notifying device for two wheeler

  Automatic accident reporting apparatus for bicycle

  Automatic accident reporting apparatus for two-wheeled vehicles

  Accident automatic notification equipment of two-wheeled vehicle

Abstract:

- An automatic accident informing apparatus for a two-wheel vehicle is provided which can detect the occurrence of accident with the use of a simple arrangement.

  The automatic accident informing apparatus for a two-wheel vehicle includes an accident detecting module 3 for detecting an accident of the vehicle and an accident informing module 7 arranged responsive to the occurrence of the accident detected by the accident detecting module 3 for informing an external party(s) of the accident.

  The accident detecting module 3 includes an inclination sensor 2 for measuring the inclination angle of the vehicle and an accident judgment unit 340 for judging that the vehicle met with the accident when the inclination of the vehicle remains higher than a predetermined degree throughout a specific length of time.

Applicant or Assignee Name:

- ROBERT BOSCH GMBH

Patent Numbers:

- DE102014216926

Title:

- Method for operating an emergency call device

Abstract:

- The invention relates to a method for operating an emergency call device for a vehicle (14) (10), comprising the steps of: receiving a signal from the vehicle (10), an emergency call, activating an emergency mode of the device (14) according to the emergency signal, issuing a warning signal to (27) an application of (12) (10), checking, whether the occupant (12) is input, to prevent the emergency call, the checking is performed for a limited time, and transmitting an emergency signal (36), a negative result for the time when the step of testing.

Applicant or Assignee Name:

- BAYERISCHE MOTOREN WERKE AG (BMW)

Patent Numbers:

- EP3033859; WO201522153; DE102013216177; CN105308660

Title:

- Method, device, computer program, and computer program product for transmitting an emergency call, and method, device, computer program, and computer program product for receiving an emergency call for a motorcycle

  Method, apparatus, computer program, and computer program product for transmitting an emergency call method, apparatus, computer program, a computer program product for receiving an emergency call for a motorcycle

Abstract:

- In a method for transmitting an emergency call for a motorcycle (M), an emergency text message (NTN1) relating to an emergency is transmitted, and a continuous acoustic signal (AR1) is generated as an acoustic response to the transmission of the emergency text message (NTN1).

  In response to receiving an emergency confirmation message (NBN) by means of a communication interface of the motorcycle (M), the continuous acoustic signal (AR1) is terminated dependent on the received emergency confirmation message (NBN).

  In a method for receiving the emergency call for the motorcycle (M), a rescue service message (RN) is transmitted to a rescue service by means of an external communication interface arranged externally of the motorcycle (M) in response to receiving the emergency text message (NTN1), which has been transmitted in relation to an emergency, dependent on a specified confirmation of the emergency text message (NTN1).

  An emergency confirmation message (NBN) is transmitted dependent on the specified confirmation of the emergency text message (NTN1).

Applicant or Assignee Name:

- ROBERT BOSCH GMBH

Patent Numbers:

- WO2014131534; DE102013203215

Title:

- Method for automatically transmitting an emergency call in the event of an accident of a motorized two-wheeled vehicle

  Method for the automatic transmission of an emergency call in the event of a motorized bicycle

Abstract:

- The invention relates to a method for automatically transmitting an emergency call in the event of an accident of a motorized two-wheeled vehicle.

  An accident is detected if no hand contact is detected on least one handlebar grip and the inclination angle of the two-wheeled vehicle exceeds a specified threshold, and an emergency call is emitted independently of the driver when an accident is detected.

Applicant or Assignee Name:

- ROBERT BOSCH GMBH

Patent Numbers:

- EP2822845; WO2013131670; US20150232091; DE102012203647; JP2015511552; CN104144847; IN2014DN06469

Title:

- Method for preventing an accident or for reducing the effects of the accident for a rider

  Method for preventing an accident or for reducing the effects of the accident for a rider

  Method for avoiding an accident or for reducing the effects of an accident for a motorcycle rider

  Method for preventing or reducing movement of an accident for accident ate

  The method of preventing the accident of the driver, or lightening the accident result

  Method for preventing an accident or for reducing the effects of the accident for a rider

  Method for preventing an accident or for reducing the effects of the accident for a rider

Abstract:

- A method for avoiding an accident or for reducing the effects of an accident for a rider of a vehicle, especially a two-wheeled or three-wheeled vehicle, includes a first method step in which information is ascertained by a first accident-preventing system and/or a first system for mitigating the effects of an accident; a second method step in which the information is transmitted to a second accident-preventing system and/or a second system for mitigating the effects of an accident; and a third method step in which the second accident-preventing system and/or the second system for mitigating the effects of an accident are/is preconditioned on the basis of the information.

  The first and second accident-preventing systems differ from each other, and the first and second systems for mitigating the effects of an accident differ from each other.

Applicant or Assignee Name:

- ROBERT BOSCH GMBH

Patent Numbers:

- WO2011131558; US20130124035; US9043077; DE102010027969

Title:

- Method and device for determining a type of an impact of an object on a vehicle

  Method and device for determining a type of an impact of an object on a vehicle

  Method and apparatus for determining a type of impact of an object to a vehicle

Abstract:

- The invention relates to a method (500) for determining a type of an impact of an object (160) on a vehicle (100).

  The method (500) comprises a step of reading in (510) an acceleration value.

  The method (500) further comprises a step of determining (520) a transverse acceleration value (AccYTrans) representing a difference between the lateral acceleration value (AccYmeasured) and an acceleration value (AccYRot) on the basis of the rotational acceleration value (?) for an acceleration transverse to the longitudinal axis of the vehicle and/or determining a longitudinal acceleration value (AccXTrans)representing a difference between the longitudinal acceleration value (AccXmeasured) and an acceleration value (AccXRot) on the basis of the rotational acceleration value (?) in the longitudinal direction of the vehicle.

  The method finally comprises a step of detecting (530) the type of impact if the transverse acceleration value (AccYTrans) or a transverse signal (DvYTrans) derived therefrom has a prescribed relationship to a first threshold and/or if the longitudinal acceleration value (AccXTrans) or a longitudinal signal (DvXTrans) derived therefrom has a prescribed relationship to a second threshold value."

Applicant or Assignee Name:

- ROBERT BOSCH GMBH

Patent Numbers:

- DE102010003317

Title:

- Method for combining data of e.g. acceleration sensors for classification of left-sided collision of car, involves receiving time courses of sensor signals over interface, and combining time courses to obtain time course of combined signal

Abstract:

- The method involves receiving time courses of sensor signals over an interface, where the sensor signals represent signals provided by different sensors (102, 104, 106).

  The time courses of the sensor signals are combined using a combining unit (110) to obtain a time course of a combined signal for classification of a collision.

  The sensor signals are scaled to a common value range.

  Amounts of the sensor signals are assigned to different physical quantities.

  The amounts of the sensor signals are standardized based on a set of common values.

  Independent claims are also included for the following: (1) a device for combining sensor data for classification of a collision of a car (2) a computer program product comprising a set of instructions to perform a method for combining sensor data for classification of a collision of a car."

Applicant or Assignee Name:

- CONTINENTAL TEVES AG & CO OHG

Patent Numbers:

- EP2155540; WO2008145510; US20100302029; DE102008023243

Title:

- Transmission of an emergency call from a motor cycle

  Transmission of an emergency call from a motor cycle

  Transmission of an emergency call from a motor cycle

  Transmission of an emergency call from a motorcycle

Abstract:

- A control unit determines whether an accident of a motorcycle has occurred in that corresponding measurement data from a sensor system are analyzed.

  Following this, a fully automatic emergency call is emitted.

  The emergency call is transmitted via a voice channel after the emergency call data have been subjected to a media conversion.

Applicant or Assignee Name:

- BOURGINE DE MEDER LAURENT

Patent Numbers:

- EP1523434; WO200409415; US20060164217; US7567166; FR2842493; AU2003273429

Title:

- Safety/security method and device for two-wheeled vehicles and similar

  Safety/security method and device for two-wheeled vehicles and similar

  Safety/security method and device for two-wheeled vehicles and similar

  Process and safety device for vehicle two wheels and similar

  Safety/security method and device for two-wheeled vehicles and similar

Abstract:

- The invention relates to a safety/security method and device for two-wheeled vehicles and similar.

  The inventive device comprises a processor which is connected to a geographic positioning centre (CL) and to a communication unit (UT) with a cellular telephone system which can communicate with a party.

  The aforementioned processor is also connected to a start/stop sensor (M/A), a movement sensor (AC) and an inclinometer (CV) and to means of identifying the vehicle and/or the driver.

  The processor is programmed so as to: centralise and store the data originating from the above-mentioned sensors; select a device state from numerous pre-determined states including one or more sensitive states; and, when a sensitive state has been selected, compose and transmit a message containing data relating to said state, vehicle and/or driver identification data and geographic positioning data.

Applicant or Assignee Name:

- SCHUBERTH GMBH

Patent Numbers:

- WO201118168; DE102009036828

Title:

- System for detecting an accident situation and emergency call activation and method for same

  System for detecting an accident and emergency activation and method thereof

Abstract:

- The invention relates to a system and method for detecting an accident situation and emergency call activation, having a protective helmet (1) that is equipped with at least one first sensor unit (10) for detecting accident characteristics and a transmission unit (11) by means of which sensor data of the sensor unit (10) or an activation signal are transmitted to a control unit (3).

  A sensor (4) coupled to the control unit (3) is also provided for the purpose of detecting an emergency call signal.

  The system also comprises a motor vehicle (2).

  The motor vehicle (2) comprises a second sensor unit (20) for detecting accident characteristics, which is connected to the control unit (3).

  An analysis unit (30) is associated with the control unit (3), which checks for the presence of accident characteristics in both sensor units and, if accident characteristics are present, activates the transmitter (4).

Applicant or Assignee Name:

- HONDA MOTOR CO LTD

Patent Numbers:

- WO2010101013; EP2404792; JP2010208381; JP5419495; JP2010208380; JP5419494; CN102341281; CN102341281B; BR201016248

Title:

- Abnormality detection and vehicle tracking device

  DEVICE OF DETENTION OF ABNORMALITY AND TRACKING OF VEHICLE

Abstract:

- An apparatus which senses an abnormality and setting off an alarm when an in-vehicle battery is removed, and prevents false sensing when the battery is dead is provided.

  The apparatus (10) that senses an abnormal state of a vehicle on the basis of a battery voltage of an in-vehicle battery (63) includes a switching means (17) for switching to an operational mode in which warning means (40) is activated when it is determined that the vehicle is in an abnormal state.

  When the battery voltage is reduced to a predetermined voltage within a predetermined time after an ignition SW (60) is switched off, the switching means (17) does not determine the abnormal state.

  When the battery voltage is reduced to the predetermined voltage after the predetermined time has elapsed, and a reduction rate of the battery voltage is higher than a predetermined value, the switching means (17) determines that the vehicle is abnormality, and switches the operational mode to an operational mode in which the warning means (40) is activated."

Applicant or Assignee Name:

- BAYERISCHE MOTOREN WERKE AG (BMW)

Patent Numbers:

- EP2897496; WO201444554; US20150191105; US9452689; DE102012217140; JP2015529171; CN104619213

Title:

- Seat occupancy detection device

  Seat Occupancy Device

  Seat possession state identification device

Abstract:

- A seat occupancy detection device for a vehicle, particularly for a motorcycle, has at least one electrode of a capacitor, which is arranged in a seat area and takes the form of a wire.

  The seat occupancy detection device includes an electronic unit connected to the wire, which unit has a function generator to generate an electrical signal, and an analyzer.

  The electrical signal generated by the function generator can be modified by occupation of the seat area.

  Further, an assistance system may activate or deactivate an assistance unit depending on the detection by the seat occupancy detection device.

Applicant or Assignee Name:

- OPKAMP HERBERT

Patent Numbers:

- DE202006005793; DE202006016991

Title:

- Automatic rescue system for detecting motorcyclist, has transponder provided at clothes/body of motorcyclist, and reader to send emergency signal over global positioning system-systems to service station, during accident of motorcyclist

  Automatic rescue system for locating injured motorcyclist, has transponder in or on clothes or body of motorcyclist and transponder reader inserted or attached to motorcycle at variable places

Abstract:

- Automatic rescue system has a transponder reader, which is placed in a stable box and inserted or attached to the motorcycle at variable places.

  The clothes or the body of the motorcyclist has a transponder.

  The alternate unit, proximity sensor can be reed contacts and reed relays.

Applicant or Assignee Name:

- MAI ANDREAS; OPKAMP HERBERT

Patent Numbers:

- DE20316019

Title:

- Emergency call system for use by motorcycle riders to signal emergency services that an accident has occurred base on worn sensor output signal

Abstract:

- The motorcycle or the rider is fitted with a sensor that responds to a sudden change in velocity that is indicative of an accident or collision.

  Linked to the sensor is a transmitter that communicates with emergency services such as police and ambulance.

  The unit can combine with a GNSS system to locate the position.

Applicant or Assignee Name:

- OPKAMP HERBERT

Patent Numbers:

- DE20315968; DE202004003196

Title:

- Emergency Rice Line for had an accident Motorcyclists

  Emergency release cord for motor cycle drivers interrupts connection to transmitter when pulling force is applied and emergency call is triggered

Abstract:

- The emergency release cord interrupts a connection to a transmitter using a certain pulling force and an emergency call is triggered.

  The transmitter and the fixed connection of the release cord is provided either at the motor cycle or at the clothing of the motor cycle driver.

Applicant or Assignee Name:

- MOTOROLA INC

Patent Numbers:

- GB200207340; GB2387006

Title:

- Motorcycle wireless communication system employing a tilt sensor to detect an emergency situation which is transmitted to a remote location

Abstract:

- A wireless communication arrangement comprises a wireless communication unit (110) attachable to a vehicle 100, having: a receiver for receiving a wireless alarm signal, a processor 208 and a transmitter.

  The system further comprises a remote sensor 230, which may be attached to a user of the wireless communication unit 110 or the vehicle, distal from the wireless communication unit 110, such that an alarm signal is transmitted to the wireless communication unit 110 in response to sensing a tilt relative to a vertical axis of the user or the vehicle.

  In response to the alarm signal, the transmitter of the wireless communication unit 110 transmits an emergency signal.

  In this manner, an emergency wireless signal is generated and transmitted when a radio user or a vehicle of the radio user, e.g. a motorcycle, becomes substantially horizontal, for example in the case of a traffic accident.

Applicant or Assignee Name:

- MURKUTE DHANASHREE PARESH

Patent Numbers:

- IN01706CH2014

Title:

- Vehicle fall detection and notification system and method therfor

Abstract:

- A vehicle fall detection and notification system for detecting an accident of a two-wheeler vehicle and providing timely first aid to a rider, comprises a fall detection unit (FDU), a communication device and an accident server. The FDU is mounted on the two-wheeler vehicle and is in communication with a communication device associated with the rider. The communication device is in communication with the accident server. When the two-wheeler vehicle travelling at a high speed, trips or falls down in the event of an accident of the two-wheeler vehicle, the FDU detects the fall and transmits a message indicating the fall of the vehicle to the communication device associated with the rider. The communication device transmits an emergency message to the accident server whereupon the accident server notifies a medical center to enable the medical center to provide timely first aid and medical services to the rider.

Applicant or Assignee Name:

- DAINESE SPA

Patent Numbers:

- EP2079613; WO2007IB54299; IT2006RM00571; AT20070826830

Title:

- Method and device for the prediction of a fall of a person from a vehicle or the like

Abstract:

- Method for the prediction of a fall of a person from a vehicle or the like, comprising the steps of: a) measuring at least one component of the angular velocity of the person or the vehicle or the like; and b) calculating a risk index as instantaneous value of a risk function depending on said angular velocity; device apt to be mounted onto the body of a person or onto a vehicle or the like, implementing said method for the prediction of the fall.

Applicant or Assignee Name:

- BAYERISCHE MOTOREN WERKE AG

Patent Numbers:

- US6496763; EP20000126369; ES20000126369; JP20000392795

Title:

- Device for detecting roll-over of a vehicle

Abstract:

- In a system for detecting imminent or occurring rollovers in a vehicle having at least one rollover sensor for detecting a vehicle rollover and for emitting a corresponding signal, at least one rotational wheel speed sensor is provided which emits a signal corresponding to the respective rotational wheel speed to a control unit which is indirectly or directly connected with the at least one rollover sensor. The control unit is constructed such that a triggering signal can be generated for a safety system on the basis of the rollover signal, taking into account the at least one rotational wheel speed signal.

Applicant or Assignee Name:

- YAMAHA MOTOR CO LTD

Patent Numbers:

- EP1304544; CN20021046508; DE20026030376; EP20020023603; ES20020023603T; JP20020273003; JP20080325475; TW20020122847; US20020278764

Title:

- Tip-over detection device for motor vehicle

Abstract:

- A vehicle includes a tip over detection device that uses a vertically oriented sensor to improve the accuracy of detecting when the vehicle has tipped over. An ECU communicates with the accelerometer and controls engine operation. The ECU stops the engine, preferably gradually, when the vehicle has tipped over. The sensor can also detect lean in additional directions that are orthogonal to the vertical direction.

Applicant or Assignee Name:

- ALPS ELECTRIC CO LTD

Patent Numbers:

- EP2881921A1; JP20130253279

Title:

- Vehicle accident notification apparatus

Abstract:

- A vehicle accident notification apparatus (100) includes a vehicle-mounted wireless communication unit (200) disposed on a motorcycle, a first microcomputer (10), which controls devices mounted on the motorcycle, and a mobile wireless communication unit (300) carried by a rider. Wireless communication is carried out between the vehicle-mounted wireless communication unit (200) and the mobile wireless communication unit (300). If they are separated from each other by a predetermined distance (wireless communication range) or longer, the wireless communication is disabled. If the wireless communication is disabled for a predetermined time or longer and measured values from a speedmeter mounted on the motorcycle fall abruptly to or below a predetermined value for a predetermined time or longer, the first microcomputer (10) determines that the motorcycle has had an accident and causes the motorcycle to automatically drive its headlight, horn, and directional indicators to raise alarms.

Applicant or Assignee Name:

- YAMAHA MOTOR CO LTD

Patent Numbers:

- EP1184233; DE20016001128; EP20010121014; US20010945311

Title:

- Device for sensing operating states of a vehicle

Abstract:

- Device for sensing operating states of a vehicle, in particular a motorcycle, comprising an acceleration sensor (3), wherein the acceleration sensor is installed in the electronic control unit (1) of the motorcycle and is adapted to detect fall and/or collision of the motorcycle, additionally. The device for sensing operating states of a vehicle provides an installation structure of an acceleration sensor (3) which is used as a fall sensor and/or collision sensor to make it possible to detect acceleration with a high accuracy, to reduce installation space, to simplify vehicle structure, and to reduce costs.

Applicant or Assignee Name:

- META SYSTEM SPA

Patent Numbers:

- EP2268507; IT2008MO00127; WO2009IB05411

Title:

- Safety apparatus for motor vehicles or the like

Abstract:

- The safety apparatus for motor vehicles or the like comprises a support element associable with a motor vehicle or the like and suitable for supporting an instant acceleration/deceleration measuring device for the motor vehicle along at least one direction, and a communication unit, integrally associated with the support element, associated with the acceleration/deceleration measuring device and suitable for sending at least an emergency signal in the event of the vehicle having an accident, detected by the acceleration/deceleration measuring device.

Applicant or Assignee Name:

- DAINESE SPA

Patent Numbers:

- EP2632772; ES20110797123; IT2010MI02027; WO2011IB54803

Title:

- Apparatuses, system and process for detecting accidents

Abstract:

- A method for detecting accidents is described. The method has the following operating steps: obtaining at least two axial accelerations; integrating at least one first axial acceleration and one second axial acceleration of said at least two axial accelerations for obtaining at least two axial acceleration integral values; calculating an energy modulus according to the at least two axial acceleration integral values; and comparing the energy modulus with an energy threshold. An apparatus and a system which can carry out the method is also described. Furthermore, vehicles that have the apparatus are described as well.

ANNEX 2 - REFERENCES

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5.3. M23 – Use Cases P2W eCall

M23 – Use Cases P2W eCall

Harmonised eCall European Deployment

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Main author:	Frederik Harnischmacher
Dissemination level:	PU
Lead contractor:	KTM AG
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Delivery date:	13/10/2016
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CONTROL SHEET

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1.2	19.09.2016	A. Borin (Yamaha) F. Harnischmacher (KTM)	Review 2.4

	Name	Date
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Authorized		

Circulation	
Recipient	**Date of submission**
Project partners	
I_HeERO Steering Group	
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INTRODUCTION

1.1 Purpose of Document

The definition of Use Cases for automatic crash notification system for powered-two wheeler (P2W eCall) should provide a baseline for a functional description of such a system. The purpose of this document is to summarize the steps which lead to the definition of such Use Cases.

1.2 I_HeERO Contractual References

I_HeERO stands for Infrastructure Harmonised eCall European Pilot.

I_HeERO is an action under the Grant Agreement number INEA/CEF/TRAN/A2014/103743 and the project duration is 36 months, effective from 01 January 2015 until 31 December 2017. It is a contract with the Innovation and Networks Executive Agency (INEA), under the powers delegated by the European Commission.

Communication details of the Agency:

Any communication addressed to the Agency by post or e-mail shall be sent to the following address:

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For submission of requests for payment, reports (except ASRs) and financial statements: INEA-C3@ec.europa.eu

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Innovation and Networks Executive Agency (INEA)
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TEN-Tec shall be accessed via the following URL:

https://webgate.ec.europa.eu/tentec/

Any communication details of the beneficiaries

Any communication from the Agency to the beneficiaries shall be sent to the following addresses:

For Niedersächsisches Ministerium für Wirtschaft, Arbeit and Verkehr: Michael Schäfer Friederickswall 1, 30159 Hannover, Germany

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2 Use Cases P2W eCall

The definition of Use Cases (UCs) is the baseline for the definition of the functional description of an automatic crash notification system for powered two wheelers (short: P2W eCall system) as shown in Figure 1. Within this project, the focus is set on In-Vehicle Systems (IVS), consequently all Use Cases are identified according to this assumption.

The Use Case description and the diagram should summarize the User needs, the results of the accident analysis and the relevant regulations for the communication between the different stakeholders. In this chapter, a general introduction to Use Cases is given. Furthermore, the User needs and expectations are analysed and described. Then the Use Cases will be derived.

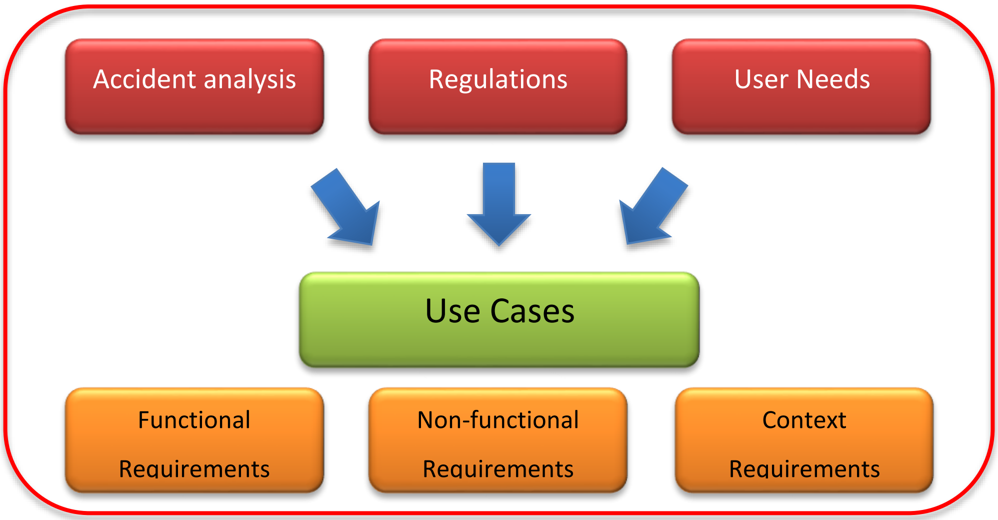


Figure 1: General structure

2.1 Concept of Use Cases

This first chapter should give a short overview about the concept and fundamentals of Use Cases, according to [1]. The graphical representation of the Use Case is based on System modelling language [2].

A "Use Case" (UC) describes the behaviour of the system from the point of view of a user. The primary target of a "Use Case" is to satisfy a user's goal. So the important thing is, "what" the user expects and not "how" this is reached.

The main elements of a Use Case diagram are

- Actor
- Use Case
- Relationships (<<include>> / <<extend>>)
- Communication / Association

<u>Actor</u>

An Actor is someone or something that interacts with the Use Case. The actor must be outside of the systems boundaries and has to initiate or trigger a Use Case.

Examples for Actors are:

- Humans
- Machines
- Sensors

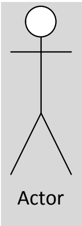


Figure 2: Actor

<u>Use Case</u>

The Use Case describes a function of a system, which can be automated or manual.

Figure 3: Use Case

Communication / Association

If an actor communicates with a Use Case, it is described with an association connection. The connection can be extended by an arrow to highlight the direction of communication.

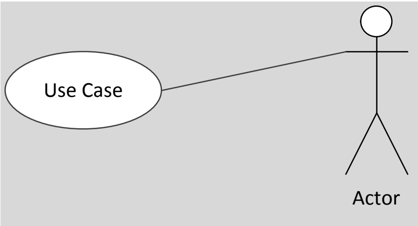


Figure 4: Communication / Association

Relationships

Relationships are connections between Use Cases. There are two different connections

<<include>>

Include describes a must-relationship, so UC1 must include UC2

<<extend>>

Extend describes a relationship, in which UC2 can extend UC1. The <<extend>> relationship can be upgraded by an extension point. This extension point describes a condition that must be fulfilled for UC2.

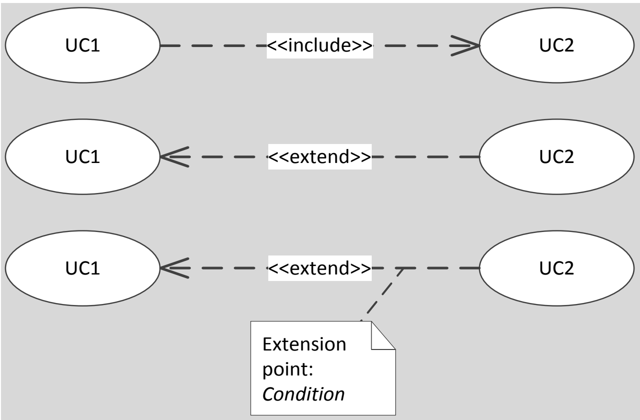


Figure 5: Relationships

2.2 User needs

As described in the previous chapter, the Use Cases are characterising a system from the user point of view. So the first step for generating good Use Cases (UC) is to analyse the expectations and needs of the users.

The I_HeERO P2W cluster carried out a user survey to investigate this during the summer of 2016. The survey included sections on awareness of eCall for Automobiles and expectations of what a system for P2W should deliver as well as what it should avoid.

Additionally the investigation looked at accident situations to gain insight into issues relevant to understanding user needs in case of emergency situations.

The survey provided a total of 2066 responses from mainly Germany (997), Italy (319), Austria and Switzerland (300) as well as other countries including Greece, Cyprus, UK, Sweden, Spain, France and Poland (450).

Deriving Use-case requirements from the user needs.

Two questions in the I_HeERO P2W User survey are dealing with this topic.

Figure 6 shows the results from the user survey regarding the user expectations of an eCall system. In summary, the main expectations are

1. Getting help quickly, if the rider is unable to call help (Q13: Answer 1, 2, 3, 5, 6)
2. Transmission of the exact location, even in remote areas (Q13: Answer 7)

In addition to this, in Figure 7, there are the negative expectations for eCall systems. So the system must ensure that these points are avoided. Summarizing these results the system must provide the following options:

1. Possibility to interrupt / cancel eCall (Q14: Answer 1, 5, 6, 7)
2. Must not be able to track the user (Q14: Answer 3, 4)

From these user expectations, the Use Cases can be derived, as shown in the next chapter. Regarding the second point “Must not be able to track the user”, this issue is not affecting a specific Use Case but must be considered a requirement to be included in the Communication Requirements (M26-D3.4). The privacy concerns are very important topics and are crucial for the acceptance of the system.

13. In your opinion what could be the positive points of eCall for PTW? (Please select 3 answers) (This question requires an answer)		Response Percent	Response Total
1	For getting help quickly	55.18%	1140
2	For accidents in an isolated location	55.91%	1155
3	If I'm unable to call for help	75.02%	1550
4	Give my family a better feeling	4.65%	96
5	In case the accident spot is hidden	18.20%	376
6	In case I'm travelling alone	43.32%	895
7	Accurate sending of the exact accident location	45.11%	932
8	Other (please specify): View	2.42%	50
		answered	2066
		skipped	0

Figure 6: I_HeERO P2W User survey – Q13

14. In your opinion, what could be the negative points of eCall for PTW? (Please select 3 answers) (This question requires an answer)		Response Percent	Response Total
1	False activation	72.02%	1488
2	If there was a high cost involved	40.95%	846
3	The concern that GPS data is not only used for eCall	50.34%	1040
4	Security against hacking	19.12%	395
5	Cost of ambulance/police call out	14.71%	304
6	In case I do not want to report an accident.	31.12%	643
7	In case of an accident that is not serious	50.92%	1052
8	Making riding too complicated	5.61%	116
9	In case of circuit riding	10.99%	227
10	Other (please specify): View	4.11%	85
		answered	2066
		skipped	0

Figure 7: I_HeERO P2W User survey – Q14

2.3 Use Cases – General description

The first step to generate a Use Case is to identify the primary actor and to write a short story, which describes the usage of the system from the point-of-view of the primary actor. For an eCall system, the primary actor is the user of the P2W. From the riders point-of-view, there are three basic stories with some extensions.

1. Normal riding / Idle mode

   User is riding a P2W. No accident situation is happening.

   → *UC: Idle mode (normal riding)*

   a. The eCall system detects no accident situation. Nothing happens.

   b. The eCall system detects an accident, although there is no real incident and triggers an eCall. The user recognizes that an eCall is triggered and declines the emergency call.

      → *UC: Get information about triggering*

      → *UC: Cancel or suppress emergency call*

2. Accident, automatic triggering

   User is riding a P2W and an accident happens.

   a. User is maybe not able to make an emergency call, but the eCall system detects the incident and triggers the eCall. The system sends all relevant information to the public safety answering point (PSAP). PSAP tries to communicate with the user, in order to get more information about the accident. If more information is available more suitable help can be provided. The rescue services are notified and are moving to the crash scene.

      → *UC: Accident: Trigger eCall automatically*

      → *UC: Communicate with PSAP*

   b. The eCall system detects the incident, but the rider is unharmed and does not need help. The user is notified by the system that an eCall was triggered and can decline or suppress the emergency call manually.

      → *UC: Get information about triggering*

      → *UC: Cancel or suppress emergency call*

3. Accident, manual triggering

   User is riding a P2W and an accident happens (eCall relevant situation occurs).

   a. The eCall system does not detect the incident, but the rider wants to get help. The user triggers the emergency call manually. The rescue services are notified and are coming to the crash scene.

      → *UC: Accident: Trigger eCall manually*

In addition to these basic stories, there are some additional functions, which have to be implemented into the system. The information about the status of the system is a feature, which has to be provided. The User must be aware of the functioning of the system during normal riding.

→ *UC: Get information about system status*

Furthermore, an extended diagnostic must be provided for the workshop.

→ *UC: Check system*

The stakeholders in this description are the following ones:

- User (rider)
- Powered two wheeler (P2W)
- Global navigation satellite system (GNSS)
- Workshop / Inspection
- Telecommunication network
- Public safety answering point (PSAP)
  - Optional: Third-party-services (TPS)
  - eCall IVS must be able to contact PSAP if TPS is not available
  - In the following chapters only PSAP will be used but PSAP can be replaced by TPS.

2.4 Use Cases – Diagram

In the following paragraph, a verbal description of the Use Cases is provided. The corresponding Use Case diagram is shown in Figure 8. The Use Case diagram is extended by the most relevant standards and regulations. For detailed information regarding standards and regulations refer to M22 – State-of-the-art assessment.

Especially for the communication with the GNSS, telecommunication network and PSAP, there are already standards and regulations in place. In order to give a comprehensive overview, these are mentioned in the following Use Case diagram.

Besides the Use Case diagram there is an overview about the most relevant accident scenarios, Figure 9. The proceeding to identify these accident scenarios is shown in chapter 3.

Idle Mode (Accident monitoring)

Mode during normal riding. Only on public roads (no road racing, no offroad racing). The user turns ON the key (Main Switch → ON) and receive a feedback from eCall system about diagnosis status on a dedicated visual notification. During the normal riding the eCall system monitor continuously the sensors installed on bike to detect the occurrence of an accident. No particular feedback is provided to the user by the Human-Machine-Interface (HMI). The current location is periodically updated. It is necessary to store more than one location (FprEN 15722) in order to verify the position of the accident scene and to send at least one old position if localisation after the crash is not feasible (first in, first out). It should be assured, that a reconstruction of the collision speed is not possible with this information.

Accident – Trigger eCall automatically

Detection of an eCall relevant incident by an accident detection algorithm. The user will be notified, that a relevant incident was detected and that an eCall will be send out (→ *UC: Get information about triggering*). Update of position, registering to network and sending of all relevant information to PSAP. All relevant information include at least the minimum set of data (MSD) according to FprEN 15722. System tries to establish a communication connection between user and PSAP (→ *UC: Communicate with PSAP*). The eCall must be terminated by the PSAP, the eCall system returns in UC “Idle mode (accident monitoring)”.

This Use Case summarizes the most relevant accident scenarios, Figure 9. The identification of these scenarios will be described in chapter 3.

Accident – Trigger eCall manually

User triggers eCall manually by using a dedicated Human-Machine-Interface (HMI). Manual eCall can only be triggered during still stand. Manual triggering is only possible, when system is in "Idle mode". Update of position, registering to network and sending of all relevant information to PSAP. The user is informed about on-going eCall through a dedicated HMI. System tries to establish a communication connection between user and PSAP (→ *UC: Communicate with PSAP*). The eCall must be terminated by the PSAP, the eCall system returns in UC "Idle mode (accident monitoring)".

Get information about system status

Information about system status during normal riding (Idle mode). Rider must be informed if system is not working correctly by a dedicated HMI.

Get information about triggering

Information about detection of eCall relevant incident. Information for rider if eCall was send out correctly or not through a dedicated HMI.

Cancel / suppress emergency call

User can cancel or suppress an eCall manually. User must be informed, if cancellation or suppression was carried out correctly through a dedicated HMI.

Options:

- Suppression: Before emergency call was sent out. Therefore, the sending of the emergency call must be delayed.
- Cancellation: After emergency call was sent out, by communicating with PSAP. PSAP has to cancel the emergency call. The call cannot be cancelled by the user anymore, but the user can inform the PSAP, that no help is required. The cancellation of the emergency call is the responsibility of the PSAP.

After the cancellation or suppression the eCall system returns in UC "Idle mode (accident monitoring)".

Communicate with PSAP

Communication between User and PSAP.

Check system

Technical check of system by workshop (at least communication with GNSS and telecommunication network). The technician creates specific conditions on eCall system inputs in order to activate diagnostic mode and receive a feedback through a dedicated connection.

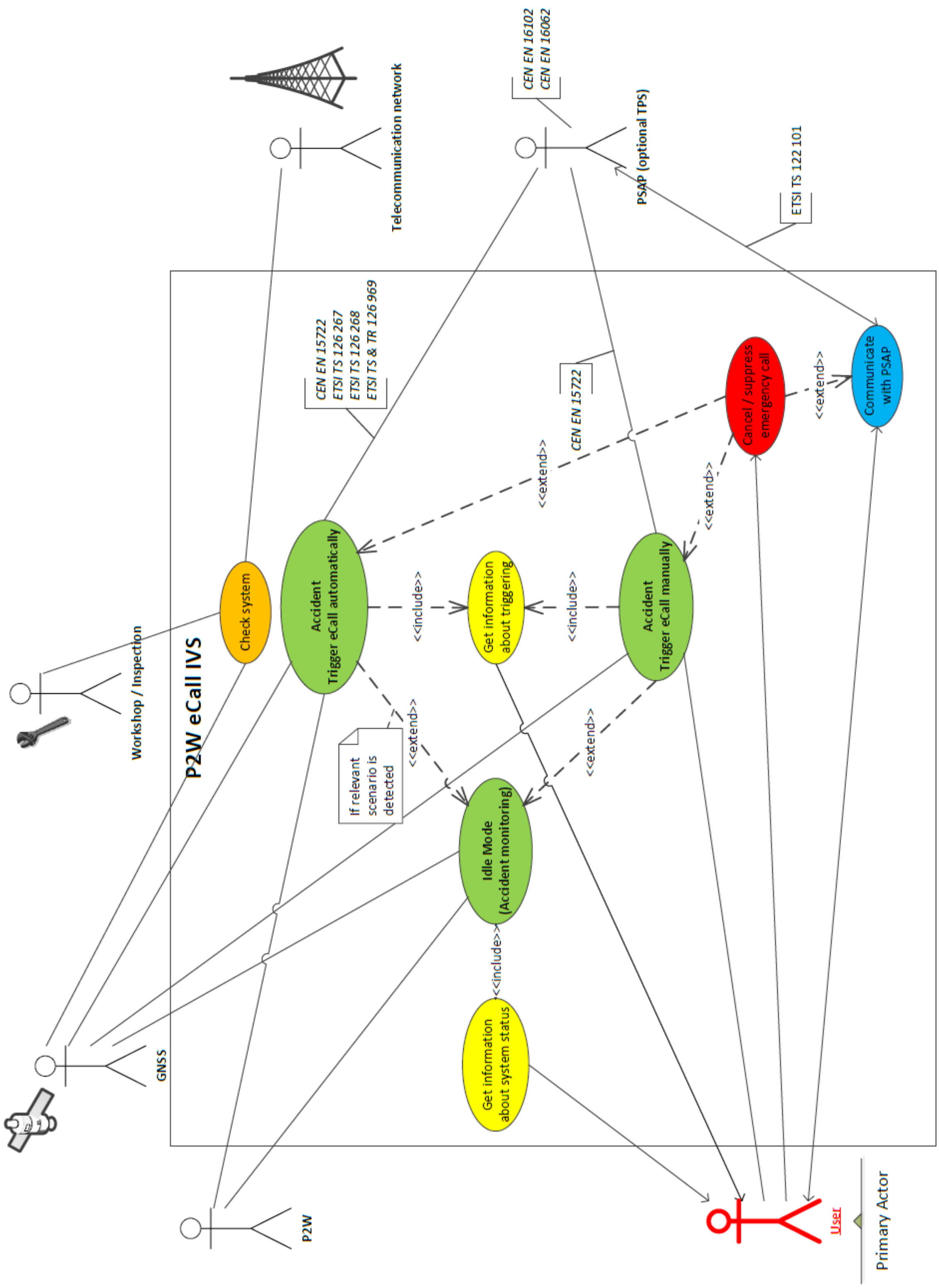


Figure 8: Use Case diagram

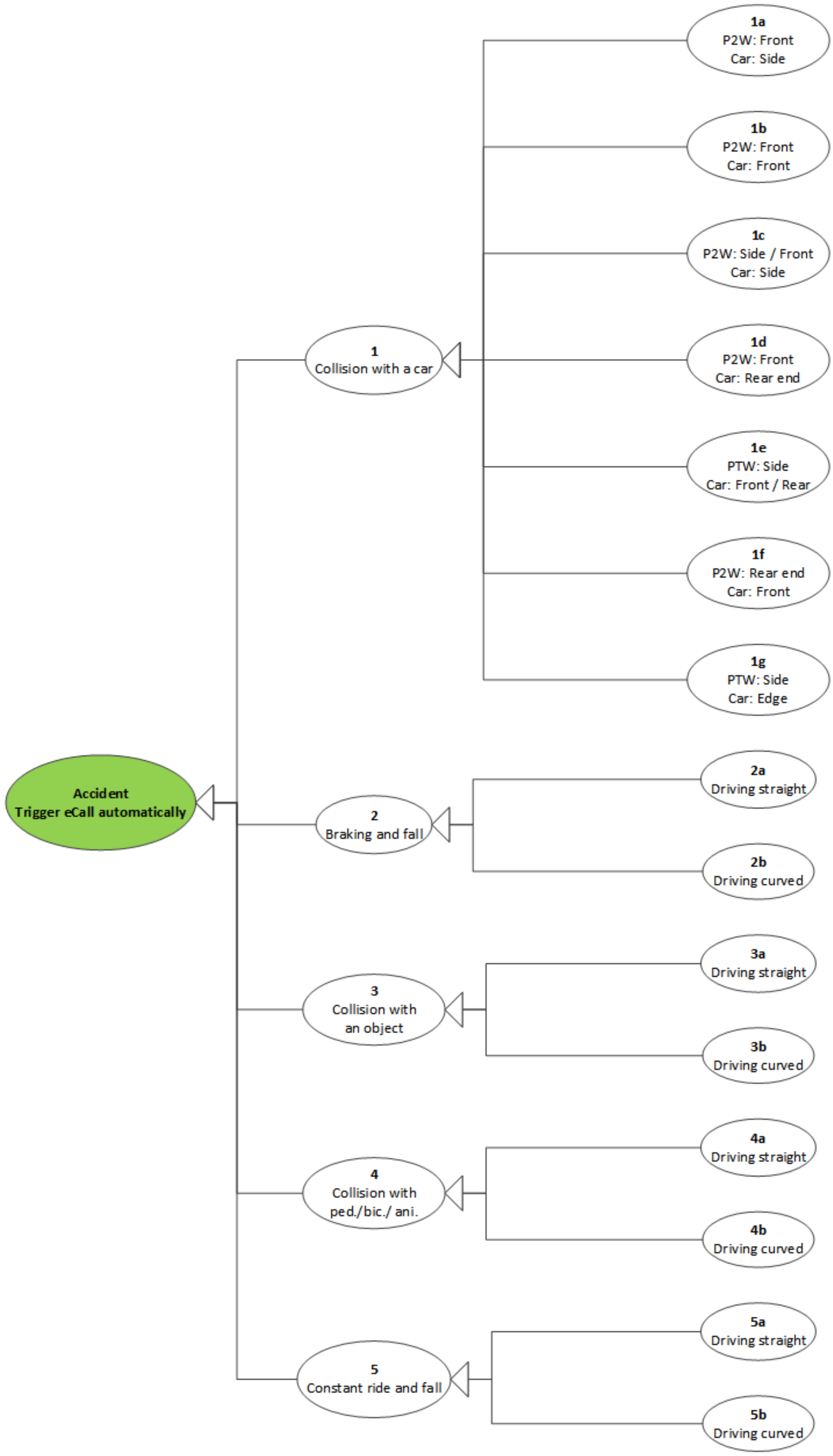


Figure 9: Accident scenarios

3 Accident Cases for automatic eCall triggering

3.1 How to derive Accident Cases

Relevant situations are incidents when an automatic triggering of a P2W eCall system is required. These situations are always linked to accidents and an injured rider who probably is not able to call the rescue service (automatic trigger situations, see page 13). The scope of identifying accident cases is limited to public roads, no race track or Off-Road accidents. Normal riding or critical, “almost – accident situation” must not trigger an eCall.

In this sense accident databases are the only sources that provide information about the accidents and their relevance for triggering an eCall system. Major criteria to characterize relevant situations from accident databases are:

- Injury severity of the rider (need of medical help / ability to call rescue services)
- Frequency of occurrence of accident situations

There are limitations with this approach:

- The accident databases cover accidents that are reported to Rescue services and / or Police. Unreported accidents, including those with injured riders who are not medically treated at the accident spot, are not available in accident databases.
- The accident databases provide no detailed information regarding the rider’s ability to call the rescue services after an accident.
- In most cases rider and P2W separate during an accident. Thus the injury severity is not necessarily dependent from the accident scenario and crash severity.

This means that there are uncertainties in finding the relevant situations but usage of accident databases provide the best information currently available. In order to derive the relevant accident cases from accident databases four tasks have to be performed:

1) Identification and comparison of relevant databases / data sources:

   → Overview about accident scenario with identification of useful data sources (macro-level and in-depth data)

2) Analysis of P2W accidents on macro-level:

   → Assessment of the relevance of P2W accidents and eCall relevant accidents (if possible on macro-level)

3) Analysis of P2W accidents on micro-level (in-depth data):

   → Analysis of single P2W accidents

4) Definition and description of accident cases for a P2W e-Call system:

→ Identification and characterization of accident cases for eCall systems

3.2 Analysis of P2W existing accident database(s)

National statistics and in-depth accident databases are analyzed with regard to P2W accidents. The aim is to get information from as many different countries as possible to get a comprehensive overview about the global accident scenario of P2W. National statistics are useful in terms of general (macro-level) analyses ensuring representative results. However, due to the limited number of parameters in national statistics in-depth databases are considered to get additional information. The content, availability, and approximated yearly case numbers of all identified databases are compared in a matrix (see Figure 10).

Data source	DESTATIS	GIDAS	IGLAD
Country	DE	DE	AU,AT,CN CZ,DE,FR, IN,IT,SP, SE,US
Kind of data source	national statistics	in-depth data	in-depth data
Availability	aggre-gated	single cases	single cases
Representative?	yes	yes	no
Cases / year[1]	≈ 300.000	≈ 2.000	≈ 1.200
PTW cases / year	≈ 17.500	≈ 140[2]	≈ 290
		ACCIDENT LEVEL	
Accident location	☑	☑	☑
Main accident type	☑	☑	☑
Detailed accident type	☒	☑	☑
Main accident cause	☑	☑	☑
...			
		VEHICLE LEVEL	
Type of vehicle	☑	☑	☑
Engine capacity	☑	☑	☑
Make and model	☒	☑	☑
Type of PTW	☒	☑	☒
...			
		PERSONAL LEVEL	
Injury outcome	☑	☑	☑
MAIS	☒	☑	☑
Age	☑	☑	☑
Gender	☑	☑	☑
...			
		INJURY LEVEL	
Single injury severity	☒	☑	☒
Severity (body region)	☒	☑	☑
Injury causation	☒	☑	☒
...			
		RECONSTRUCTION AVAILABLE	
	☒	☑	☑

1 accidents with personal damage only
2 PTW with more than 125 ccm
3 accidents with fatalities only
4 after weighting process

Figure 10: Matrix of compared accident databases

Regarding this analysis only GIDAS database has sufficient detail level and case number for further micro level analysis. With a weighting process GIDAS data can be extrapolated to DESTATIS data. So all definition of relevant accident scenarios are based on detail analysis from GIDAS representing German data.

In order to make sure that these results are also relevant in other European countries the IGLAD database was intended to be used for checking plausibility, but due to the following limitations, this is not feasible. There are following limitations in IGLAD database:

- The P2W cases include the drivers of all motorized two-wheelers with more than 4kW engine power.
- The case selection in the most IGLAD countries is not representative (in many countries the proportion of fatally and seriously injured persons is overrepresented). These countries are marked with „*“.
- Sweden has a very low proportion of P2W accidents (4 cases) in the database.

	Passenger Car	Motorbike	Pedestrian	Bicycle	Bus	Truck	Other	Total
AT*	364	34	44	14	4	38	9	507
CZ	270	24	29	12	3	15	5	358
DE	756	60	65	175	9	26	21	1112
FR	426	16	132	6	3	5	11	599
IT*	463	129	89	26	5	43	13	768
SE	230	4	4	0	3	22	8	271
SP*	141	16	4	0	3	10	15	189
Overall	**2650**	**283**	**367**	**233**	**30**	**159**	**82**	**3804**

Figure 11: Macro-level analysis of all IGLAD accidents on type of participant

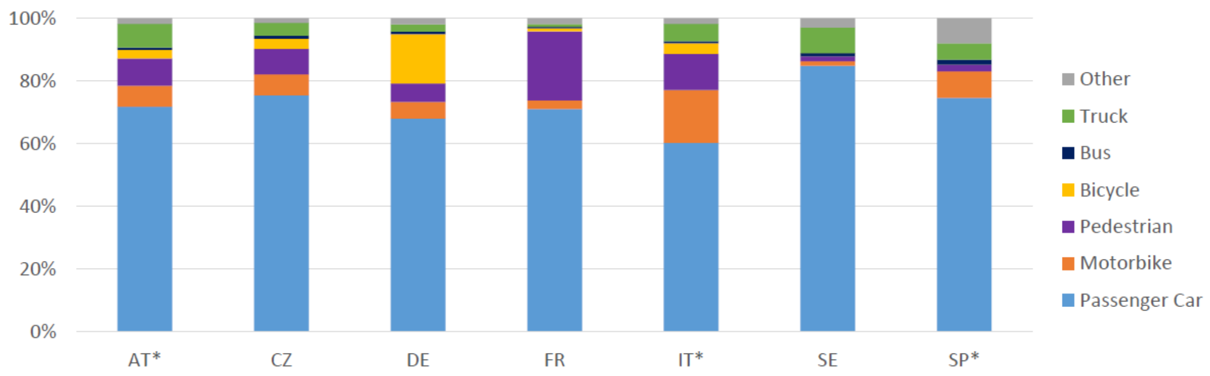


Figure 12: Graphical representation of country-based distribution of IGLAD participants

3.3 Analysis of distinct variables to describe the accident

Accident databases contain different kinds of variables, describing the accident, vehicles, participants, infrastructure, injury level etc. Depending on the type of database the number of variables clearly differs. A macro database contains a large number of cases but only limited number of variables. With a micro data base (in-depth data) the situation is vice versa, small number of cases but a large number of variables and additional information. The GIDAS database contains approximately 2600 different variables (parameters) with approximately 3500 single information and 100 - 200 pictures per accident.

In order to describe the accident from the perspective of the P2W the variables have to be assessed:

- Independent variables like situations or physical data
- Dependent variable describing the necessity of triggering an eCall

Figure 13 shows how independent variables describing the event of an accident are sorted in hierarchy and summed to reasonable clusters. The total number of accidents (weighted to German national statistics) stays constant throughout the tree.

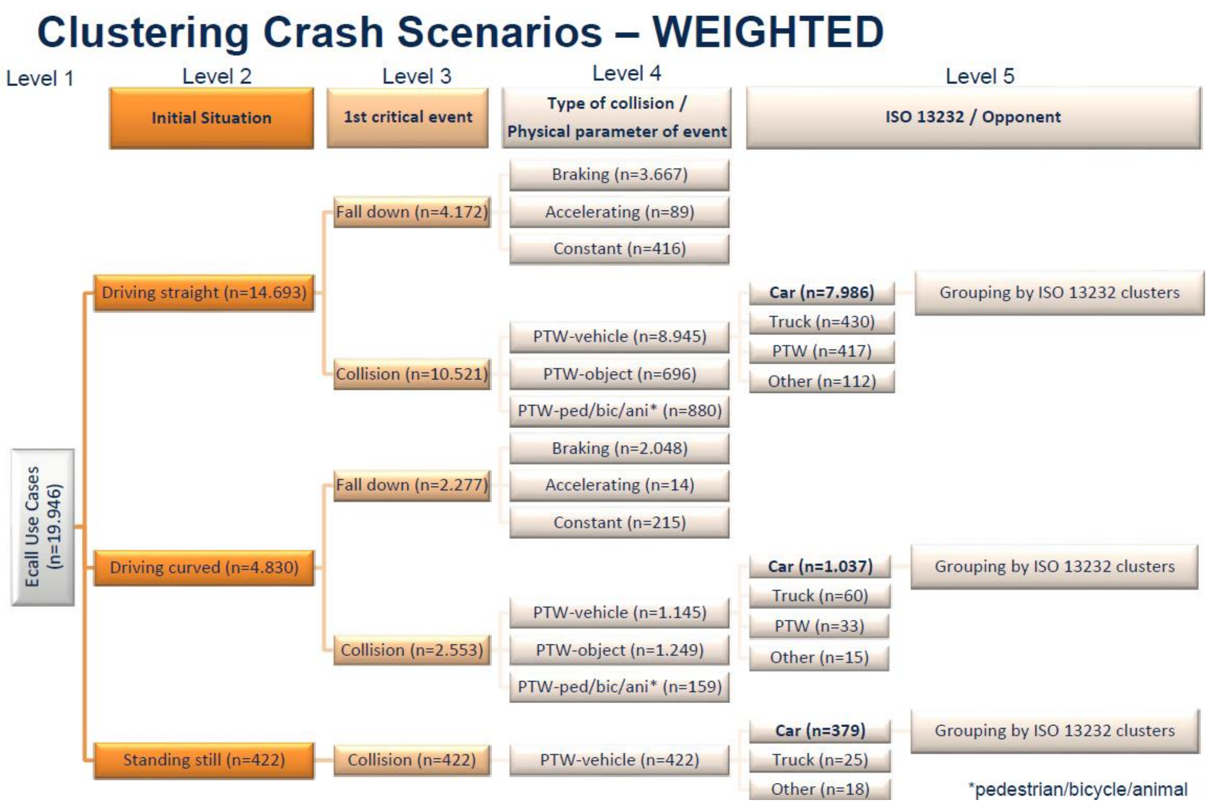


Figure 13: Clustering crash scenarios

Level 5 in Figure 13 shows that the majority of P2W accidents with another vehicle happen with cars. The ISO 13232 provides a scheme to cluster such kind of accidents with regard to point of collision at P2W and car, relative heading angle etc. The clusters according to ISO 13232 are summed up to seven groups, shown in Figure 14. These groups account for 43,4% of all P2W accidents.

Decription	Further distinction	Number of accidents	All accidents [%]	
Collision with car (PTW driving straight, driving curved, standing still)	PTW: front Car: side	2546	12,8	213 312 313 314 412 413 414 512 513 514 612 613 618
	PTW: front Car: side	1594	8,0	114 115 214
	PTW: front Car: side	1502	7,5	211 225 241 311 315 324 325 331 341 411 415 441 511 515 541 641
	PTW: front Car: side	1188	6,0	711 712 718
	PTW: front Car: side	716	3,6	127 143 227 243 723 747
	PTW: front Car: side	645	3,2	131 132
	PTW: front Car: side	461	2,3	226 242 623 624 648
	all	**8652**	**43,4**	

Figure 14: Clustering crash scenarios according to IS013232

Concerning physical data the variables have to be chosen following two prerequisites. First the data has to be reliable with regard to accuracy in accident database. For example velocity information derived from reconstruction is more reliable than from rider interview. Second the data has to be measureable on the motorbike with sensors that are already available. The following variables fulfill both prerequisites:

- Collision speed of P2W at first collision
- Change of velocity (delta v) of P2W during first collision

With regard to a dependent variable describing the necessity of triggering an eCall system accident databases provide no detailed information regarding the rider's ability to call the rescue services after an accident. Injury severity can be used to estimate the rider's ability to call the rescue services. In order to cover a large number of injuries and cluster them to a small number of severity levels hospitalisation is used as criterion. It is assumed that the fact of not being hospitalised is an indicator of being able to call the rescue service. Figure 15 shows the definitions of injury severity and Figure 16 highlights the triggering conditions for an emergency call.

Injury Severity (IS) 4:	Fatal (died within 30 days)
Injury Severity (IS) 3:	Severe (hospitalisation > 24h)
Injury Severity (IS) 2:	Slight, with hospitalisation (< 24h)
Injury Severity (IS) 1:	Slight, without hospitalisation
Injury Severity (IS) 0:	No injuries

Figure 15: Injury severity levels

Injury Severity		
↑	IS4	eCall is necessary
	IS3	
	IS2	
	IS1	eCall can be necessary
	IS0	eCall not necessary

Figure 16: Triggering requirement, User

3.4 Accident cases

Regarding the micro level analysis shown in Figure 17 the most common accident scenarios of P2W accidents are listed as follows. These accident scenarios are representing 90,6% of all analysed P2W accidents and for every scenario the injury severity distribution is shown.

Use-case	Description	Further distinction	Accidents	% of all PTW accidents	% of all IS 0	% of all IS 0-1	% of all IS 2-4	% of all IS 3-4
1a	Collision with a car (DS, DC, SS)	PTW: front Car: side	2.546	12.8%	3.8%	11.9%	13.0%	13.2%
1b		PTW: front Car: front	1.594	8.0%	1.2%	3.4%	9.2%	11.3%
1c		PTW: side/front Car: side	1.502	7.5%	2.5%	10.2%	6.8%	6.5%
1d		PTW: front Car: rear end	1.188	6.0%	3.6%	7.4%	5.6%	5.3%
1e		PTW: side Car: front/rear	716	3.6%	0.0%	3.8%	3.5%	3.1%
1f		PTW: rear end car: front	645	3.2%	3.2%	7.1%	2.2%	1.5%
1g		PTW: side car: edge	461	2.3%	0.0%	2.3%	2.3%	2.2%
2a	Braking and fall	Driving straight	3.667	18.4%	11.6%	20.3%	17.9%	13.0%
2b		Driving curved	2.048	10.3%	2.9%	5.6%	11.5%	13.9%
3a	Collision with an object	Driving curved	1249	6.3%	0.0%	1.9%	7.4%	9.1%
3b		Driving straight	696	3.5%	1.9%	1.2%	4.1%	3.8%
4a	Collision w/ ped./ bic./ ani.*	Driving straight	880	4.4%	26.6%	9.6%	3.1%	4.0%
~~4b~~		~~Driving curved~~	~~159~~	~~0.8%~~	~~12.1%~~	~~2.5%~~	~~0.4%~~	~~0.3%~~
5a	Constant ride and fall	Driving straight	417	2.1%	3.5%	1.2%	2.3%	1.4%
5b		Driving curved	215	1.1%	1.3%	0.2%	1.3%	2.2%
15 proposed USE-CASES			17.983	90.2%	74.1%	88.5%	90.6%	90.6%
ALL P2W accidents (total numbers)			19.946	19.946	688	4.112	15.834	6.924

Figure 17: Overview accident scenarios

Based on the injury severity distribution the relevance for an eCall was defined as:

Criticality IS3-4:

Probability of severe or fatal injuries:

$$Cr_{3-4} = \frac{No.\ \ of\ accidents\ \left(Injury\ severity = 3{,}4\right)}{No.\ \ of\ accidents\ (Injury\ severity = 0{,}1{,}2{,}3{,}4)} * 100\%$$

Criticality IS2-4:

Probability for a need of an automatic emergency call (must trigger situations):

$$Cr_{2-4} = \frac{No.\ \ of\ accidents\ \left(Injury\ severity = 2{,}3{,}4\right)}{No.\ \ of\ accidents\ (Injury\ severity = 0{,}1{,}2{,}3{,}4)} * 100\%$$

False call rate:

Probability of false calls:

$$Fcr = \frac{No.\ \ of\ accidents\ \left(Injury\ severity = 0\right)}{No.\ \ of\ accidents\ (Injury\ severity = 0{,}1{,}2{,}3{,}4)} * 100\%$$

Triggering an emergency call with injury severity 1 is not a false call, because there was a need for a medical treatment. In these situations, an emergency call does not need to be triggered but it is tolerable, Figure 16. It must be mentioned, that the False call rate is not correct, because accidents without injuries are heavily underrepresented in GIDAS.

Due to the small intervals of collision speed and delta-v (5 kph steps) and small case numbers (especially at high speeds) the criticality curves have been smoothed.

Therefore the following approach was used:

1) Exclusion of fields without / less data
2) Calculation of **moving average** (3 values each)
3) **Defining "100%"** if two lower speeds/delta-v already reached 100%
4) Use of **maximum function** (monotonically non-decreasing curve)

As an example for accident scenario 1a (collision with car; P2W: front / car: side) the resulting dependencies between injury severity and collision speed and delta-v is shown in Figure 18.

Type	Description
Pre-crash movement	Driving straight/curved or standing still
Physical event	-
Collision type	Collision with car PTW: front / Car: side
Frequency (All accidents)	12.8%
% IS 0 (All IS 0 riders)	3.8%
% IS 0-1 (All IS 0-1 riders)	11.9%
% IS 2-4 (All IS 2-4 riders)	13.0%
% IS 3-4 (All IS 3-4 riders)	13.2%
Characteristic parameter(s)	collision speed delta-v

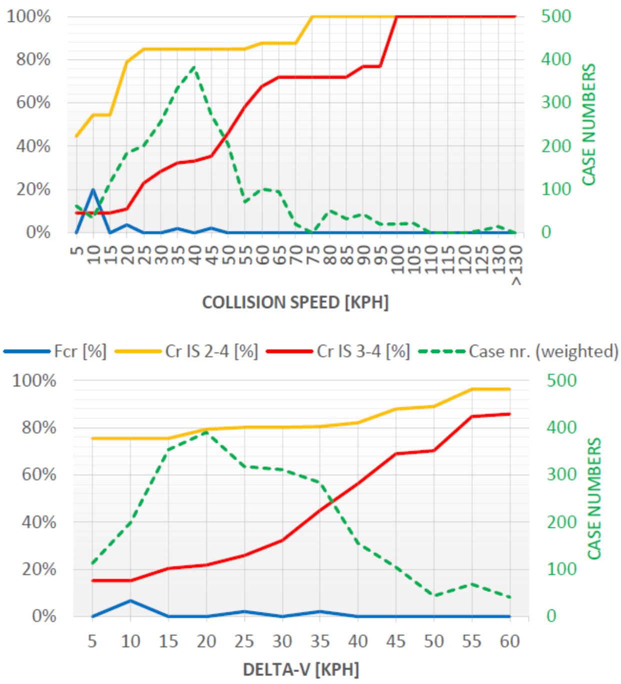


Figure 18: Accident scenario 1a (collision with car; P2W: front / car: side)

All accident scenarios will be listed in annex.

4 Summary

4.1 List and set of Use Cases

Main Use Cases					
No.	Use Case	Triggered by	Additional actors	Is included in Use Case …	Extends Use Case …
1	Idle Mode	P2W	• GNSS	--	--
2	Get information about system status		• User	• Idle Mode	--
3	Accident Trigger eCall automatically	P2W	• GNSS • Telecommunication network • PSAP	--	• Idle Mode
4	Accident Trigger eCall manually	User	• GNSS • Telecommunication network • PSAP	--	--
5	Get information about triggering		• User	• Accident: Trigger eCall automatically • Accident: Trigger eCall manually	--
6	Cancel / suppress emergency call	User	--	--	• Accident: Trigger eCall automatically • Accident: Trigger eCall manually • Communicate with PSAP
7	Communicate with PSAP	PSAP	• User	--	• Cancel emergency call
8	Communicate with PSAP	Workshop / Inspection	• GNSS • Telecommunication network	--	--

Accident Scenarios				
No.	Main Use Case	Initial Situation	Further distinction	
3.1a	Accident: Trigger eCall automatically	Collision with a car	P2W: Front	Car: Side
3.1b	Accident: Trigger eCall automatically	Collision with a car	P2W: Front	Car: Front
3.1c	Accident: Trigger eCall automatically	Collision with a car	P2W: Side / Front	Car: Side
3.1d	Accident: Trigger eCall automatically	Collision with a car	P2W: Front	Car: Rear end
3.1e	Accident: Trigger eCall automatically	Collision with a car	P2W: Side	Car: Front / Rear
3.1f	Accident: Trigger eCall automatically	Collision with a car	P2W: Rear end	Car: Front
3.1g	Accident: Trigger eCall automatically	Collision with a car	PTW: Side	Car: Edge
3.2a	Accident: Trigger eCall automatically	Braking and fall	Driving straight	
3.2b	Accident: Trigger eCall automatically	Braking and fall	Driving curved	
3.3a	Accident: Trigger eCall automatically	Collision with an object	Driving straight	
3.3b	Accident: Trigger eCall automatically	Collision with an object	Driving curved	
3.4a	Accident: Trigger eCall automatically	Collision with ped./bic./ani.	Driving straight	
3.4b	Accident: Trigger eCall automatically	Collision with ped./bic./ani.	Driving curved	
3.5a	Accident: Trigger eCall automatically	Constant ride and fall	Driving straight	
3.5b	Accident: Trigger eCall automatically	Constant ride and fall	Driving curved	

Figure 19: List of Use Cases

4.2 Conclusion

Within this document, the identification of Use Cases for an automatic crash notification system for powered two wheelers was shown. The main Use Cases were derived out of the user needs, identified by a user survey. In addition to these, there are Use Cases which could not be deduced from the User needs but are essential for the maintenance and the surveillance of the system, e.g. “Check system”. The Use Cases are the baseline for the identification of the requirements for such a system.

Furthermore the most relevant accident scenarios were identified, which extend the description of the Use Cases. The identification of the relevant accident scenarios is based on an analysis of national and international crash databases. The most frequent and severe accidents were clustered in fifteen accident scenarios. The clustering includes the initial crash situation and, in case of an accident with a car, the geometrical crash configuration. The description of the geometrical crash configuration is based on the ISO13232. For every accident scenario a fact sheet was created with the most relevant information. The detailed analysis and the statistical distribution of the accidents cluster is based on German accident databases and includes only accidents which were reported to the police.

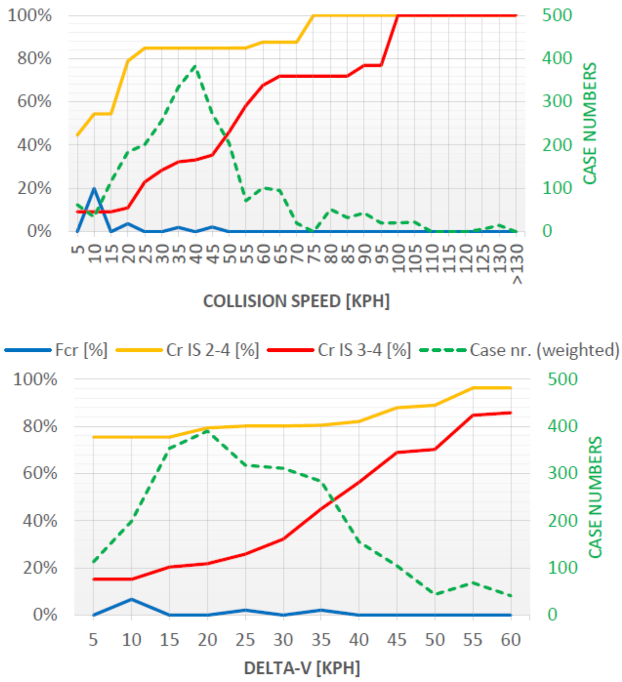
It must be mentioned, that the eCall IVS should trigger an emergency call in the identified situation but cannot necessarily distinguish between these scenarios. Moreover, an estimation of the crash severity must be done by the system. It is essential, that the eCall system only triggers an eCall automatically if the crash severity is significantly high and thus it can be assumed that there are injured persons.

The full list of all Use Cases and accident scenarios is shown in Figure 19.

ANNEX 1 – ACCIDENT SCENARIOS

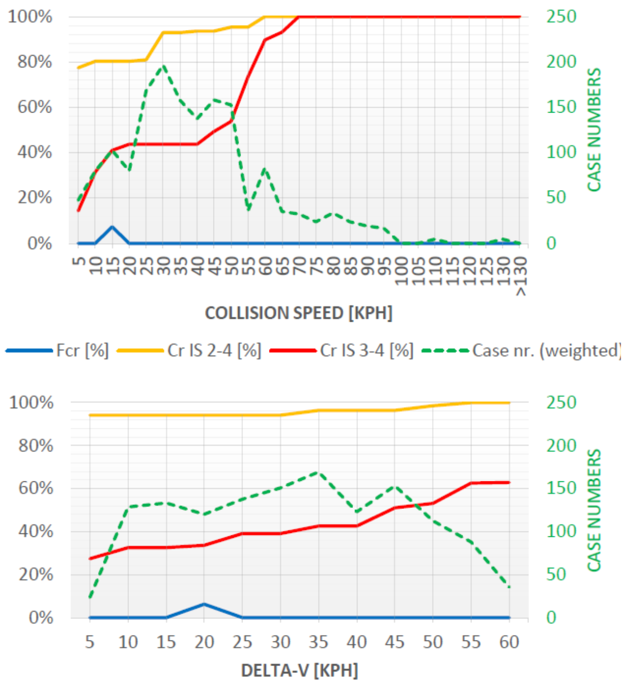
Accident scenario 1a: collision with car; P2W: front / car: side

Type	Description
Pre-crash movement	Driving straight/curved or standing still
Physical event	-
Collision type	Collision with car PTW: front / Car: side
Frequency (All accidents)	12.8%
% IS 0 (All IS 0 riders)	3.8%
% IS 0-1 (All IS 0-1 riders)	11.9%
% IS 2-4 (All IS 2-4 riders)	13.0%
% IS 3-4 (All IS 3-4 riders)	13.2%
Characteristic parameter(s)	collision speed delta-v



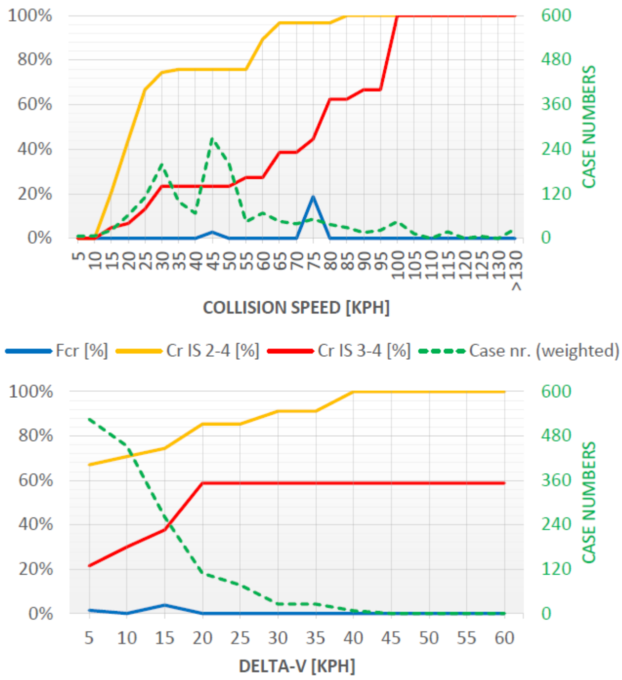
Accident scenario 1b: Collision with car – P2W: front / car: front

Type	Description
Pre-crash movement	Driving straight/curved or standing still
Physical event	-
Collision type	Collision with car PTW: front / Car: front
Frequency (All accidents)	8.0%
% IS 0 (All IS 0 riders)	1.2%
% IS 0-1 (All IS 0-1 riders)	3.4%
% IS 2-4 (All IS 2-4 riders)	9.2%
% IS 3-4 (All IS 3-4 riders)	11.3%
Characteristic parameter(s)	collision speed delta-v



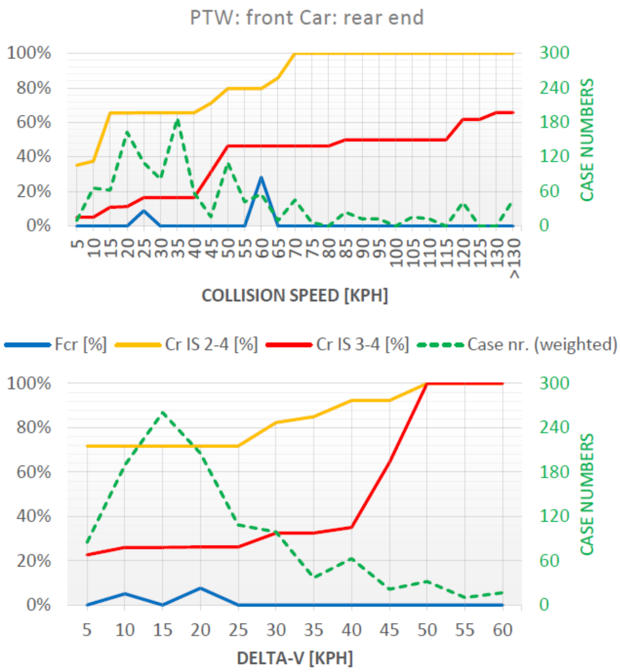
Accident scenario 1c: Collision with car – P2W: side, front / car: side

Type	Description
Pre-crash movement	Driving straight/curved or standing still
Physical event	-
Collision type	Collision with car PTW: side,front / Car: side
Frequency (All accidents)	7.5%
% IS 0 (All IS 0 riders)	2.5%
% IS 0-1 (All IS 0-1 riders)	10.2%
% IS 2-4 (All IS 2-4 riders)	6.8%
% IS 3-4 (All IS 3-4 riders)	6.5%
Characteristic parameter(s)	collision speed delta-v



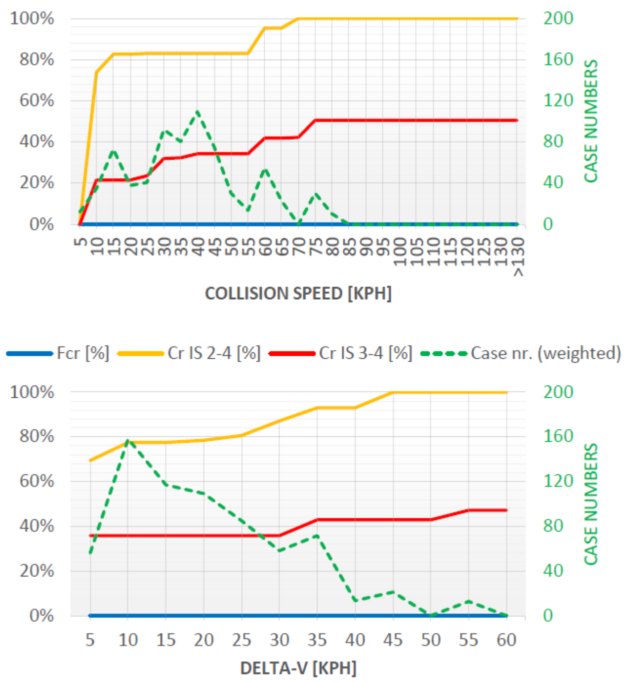
Accident 1d: Collision with car – P2W: front / car: rear

Type	Description
Pre-crash movement	Driving straight/curved or standing still
Physical event	-
Collision type	Collision with car PTW: front / Car: rear
Frequency (All accidents)	6.0%
% IS 0 (All IS 0 riders)	3.6%
% IS 0-1 (All IS 0-1 riders)	7.4%
% IS 2-4 (All IS 2-4 riders)	5.6%
% IS 3-4 (All IS 3-4 riders)	5.3%
Characteristic parameter(s)	collision speed delta-v



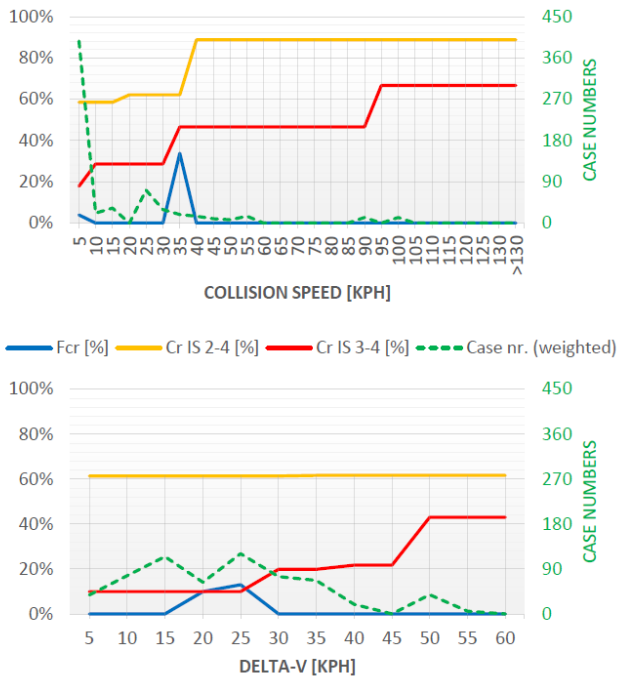
Accident 1e: Collision with car – P2W: side / car: front, rear

Type	Description
Pre-crash movement	Driving straight/curved or standing still
Physical event	-
Collision type	Collision with car PTW: side / Car: front,rear
Frequency (All accidents)	3.6%
% IS 0 (All IS 0 riders)	0.0%
% IS 0-1 (All IS 0-1 riders)	3.8%
% IS 2-4 (All IS 2-4 riders)	3.5%
% IS 3-4 (All IS 3-4 riders)	3.1%
Characteristic parameter(s)	collision speed delta-v



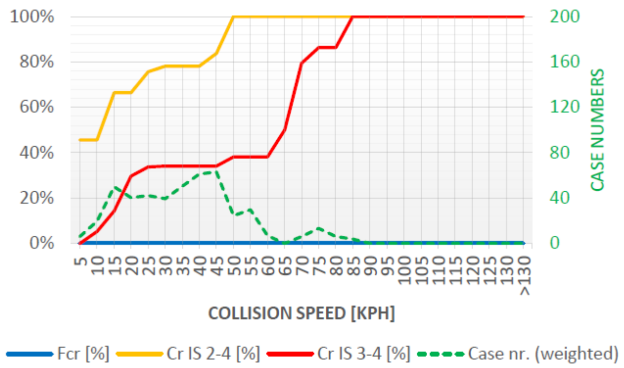
Accident 1f: Collision with car – P2W: rear / car: front

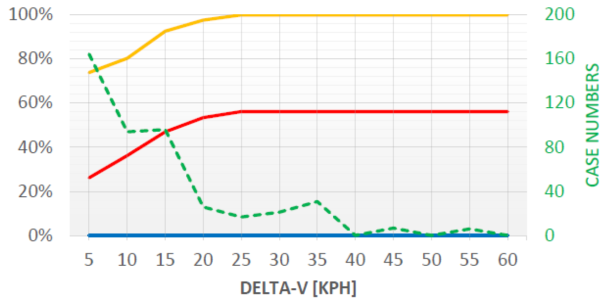
Type	Description
Pre-crash movement	Driving straight/curved or standing still
Physical event	-
Collision type	Collision with car PTW: rear / Car: front
Frequency (All accidents)	3.2%
% IS 0 (All IS 0 riders)	3.2%
% IS 0-1 (All IS 0-1 riders)	7.1%
% IS 2-4 (All IS 2-4 riders)	2.2%
% IS 3-4 (All IS 3-4 riders)	1.5%
Characteristic parameter(s)	collision speed delta-v



Accident 1g: Collision with car – P2W: side / car: edge

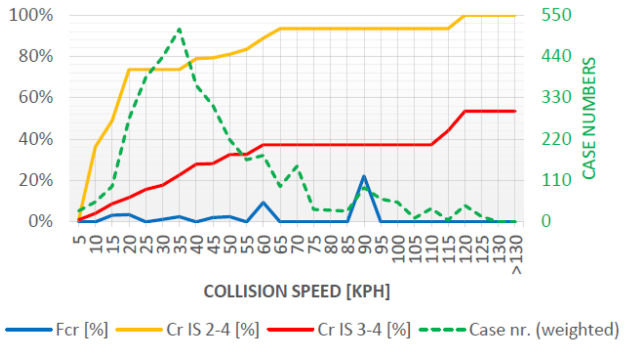
Type	Description
Pre-crash movement	Driving straight/curved or standing still
Physical event	-
Collision type	Collision with car PTW: side / Car: edge
Frequency (All accidents)	2.3%
% IS 0 (All IS 0 riders)	0.0%
% IS 0-1 (All IS 0-1 riders)	2.3%
% IS 2-4 (All IS 2-4 riders)	2.3%
% IS 3-4 (All IS 3-4 riders)	2.2%
Characteristic parameter(s)	collision speed delta-v





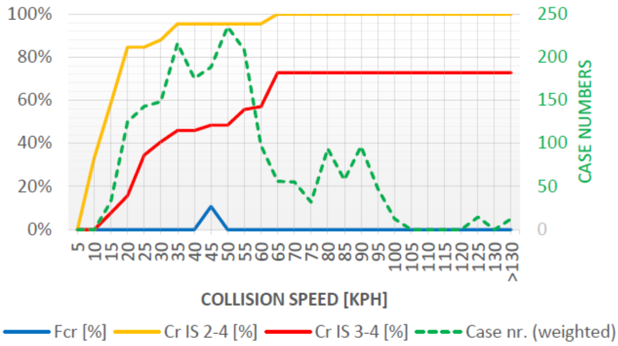
Accident 2a: Driving straight – braking – fall

Type	Description
Pre-crash movement	Driving straight
Physical event	Braking
Collision type	Fall
Frequency (All accidents)	18.4%
% IS 0 (All IS 0 riders)	11.6%
% IS 0-1 (All IS 0-1 riders)	20.3%
% IS 2-4 (All IS 2-4 riders)	17.9%
% IS 3-4 (All IS 3-4 riders)	13.0%
Characteristic parameter(s)	collision speed



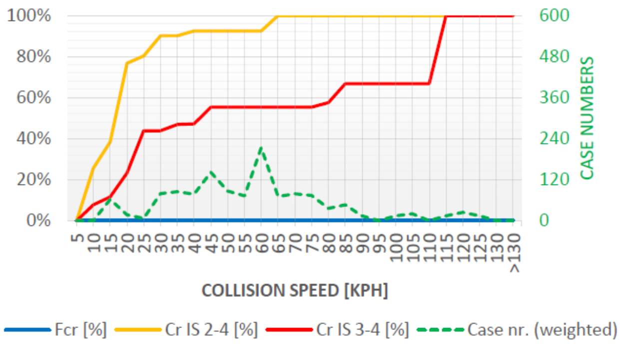
Accident 2b: Driving curved – braking – fall

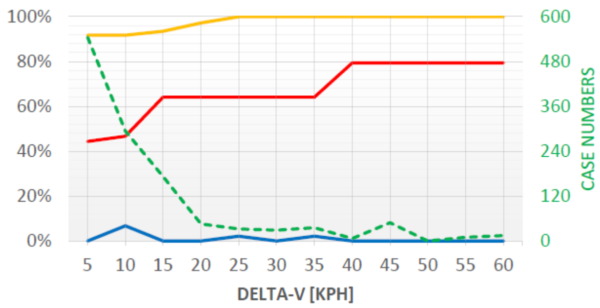
Type	Description
Pre-crash movement	Driving curved
Physical event	Braking
Collision type	Fall
Frequency (All accidents)	10.3%
% IS 0 (All IS 0 riders)	2.9%
% IS 0-1 (All IS 0-1 riders)	5.6%
% IS 2-4 (All IS 2-4 riders)	11.5%
% IS 3-4 (All IS 3-4 riders)	13.9%
Characteristic parameter(s)	collision speed



Accident 3a: Driving curved – collision with object

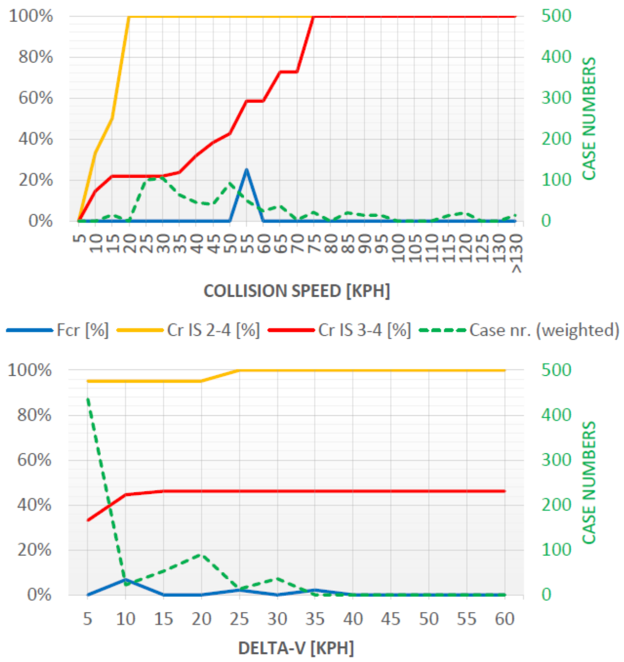
Type	Description
Pre-crash movement	Driving curved
Physical event	-
Collision type	Collision with object
Frequency (All accidents)	6.3%
% IS 0 (All IS 0 riders)	0.0%
% IS 0-1 (All IS 0-1 riders)	1.9%
% IS 2-4 (All IS 2-4 riders)	7.4%
% IS 3-4 (All IS 3-4 riders)	9.1%
Characteristic parameter(s)	collision speed





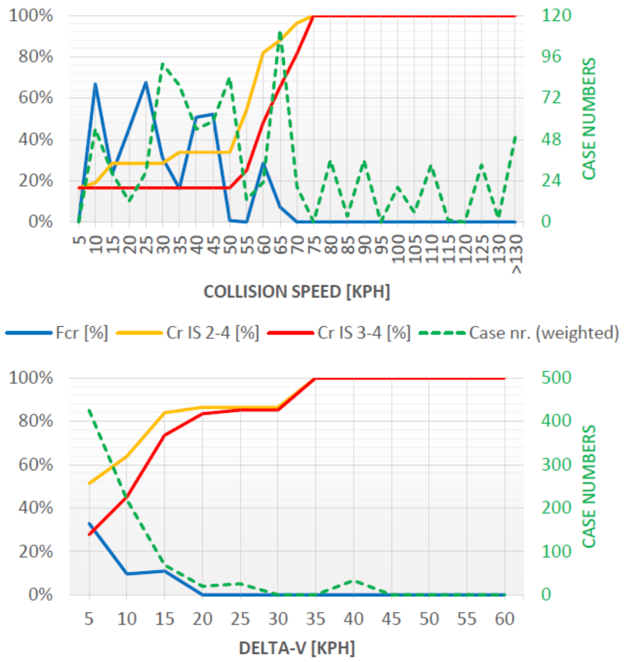
Accident 3b: Driving straight – collision with object

Type	Description
Pre-crash movement	Driving straight
Physical event	-
Collision type	Collision with object
Frequency (All accidents)	3.5%
% IS 0 (All IS 0 riders)	1.9%
% IS 0-1 (All IS 0-1 riders)	1.2%
% IS 2-4 (All IS 2-4 riders)	4.1%
% IS 3-4 (All IS 3-4 riders)	3.8%
Characteristic parameter(s)	collision speed



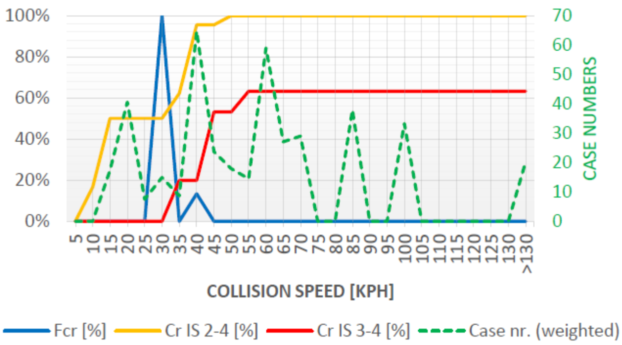
Accident 4a: Driving straight – collision with pedestrian / bicycle / animal

Type	Description
Pre-crash movement	Driving straight
Physical event	-
Collision type	Collision with ped./bic./ani.
Frequency (All accidents)	4.4%
% IS 0 (All IS 0 riders)	26.6%
% IS 0-1 (All IS 0-1 riders)	9.6%
% IS 2-4 (All IS 2-4 riders)	3.1%
% IS 3-4 (All IS 3-4 riders)	4.0%
Characteristic parameter(s)	collision speed



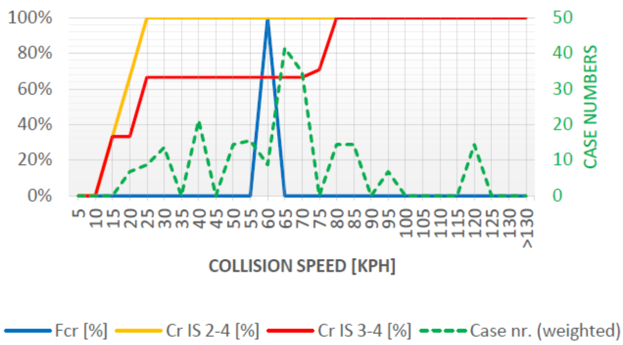
Accident 5a: Driving straight – constant - fall

Type	Description
Pre-crash movement	Driving straight
Physical event	Constant velocity
Collision type	Fall
Frequency (All accidents)	2.1%
% IS 0 (All IS 0 riders)	3.5%
% IS 0-1 (All IS 0-1 riders)	1.2%
% IS 2-4 (All IS 2-4 riders)	2.3%
% IS 3-4 (All IS 3-4 riders)	1.4%
Characteristic parameter(s)	collision speed



Accident 5b: Driving curved – constant - fall

Type	Description
Pre-crash movement	Driving curved
Physical event	Constant velocity
Collision type	Fall
Frequency (All accidents)	1.1%
% IS 0 (All IS 0 riders)	1.3%
% IS 0-1 (All IS 0-1 riders)	0.2%
% IS 2-4 (All IS 2-4 riders)	1.3%
% IS 3-4 (All IS 3-4 riders)	2.2%
Characteristic parameter(s)	collision speed



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2. OMG (2010). UML superstructure ver2.3

5.4. M24 – Verification requirements

M24 - Verification requirements

Harmonised eCall European Deployment

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ABBREVIATIONS

GIDAS .... *German in depth accident study*

IVS .... *In Vehicle System*

Moped .... *Powered Two-Wheeler w/ engine displacement ≤50ccm*

Motorcycle .... *Powered Two-Wheeler w/ engine displacement >50ccm*

P2W .... *Powered Two-Wheeler*

PSAP .... *Public-safety Answering Point*

PTI .... *Periodical technical inspection*

FIGURES

TABLES

INTRODUCTION

1.1 Purpose of Document

This document summarizes the findings, derivation and recommendations of I_HeERO Activity 3 “eCall Powered two wheeled vehicles” concerning sub activity 3.2 “Verification requirements”. The intention is to provide CEN TC278 WG15 / PT1507 with Category L3 specific test scenarios for verification of P2W eCall systems to be considered in future standards.

1.2 I_HeERO Contractual References

I_HeERO stands for Infrastructure Harmonised eCall European Pilot.

I_HeERO is an action under the Grant Agreement number is INEA/CEF/TRAN/A2014/103743 and the project duration is 36 months, effective from 01 January 2015 until 31 December 2017. It is a contract with the Innovation and Networks Executive Agency (INEA), under the powers delegated by the European Commission.

<u>Communication details of the Agency:</u>

Any communication addressed to the Agency by post or e-mail shall be sent to the following address:

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2 Summary

I_HeERO has produced recommendation, a minimum set of requirements, for the testing of an eCall device for P2W in order to create the base for a future certification process (conformity, periodical technical inspection). Existing standards and type-approval requirements for eCall IVS in passenger cars have been used as a starting point. Due to significant differences between eCall IVS for passenger cars and P2W, carrying-over passenger car type-approval requirements etc. to P2W certification is not possible without adjustment and addendum. As an example, EC-type-approval for passenger cars (M1/N1 category) requires two full-scale crash tests including eCall IVS. EC-type-approval for category L3 (L1) vehicle does not require a crash or similar test.

The recommendations for new scenarios in P2W validation cover following subjects:

- Naturalistic riding / common usage of a P2W does not trigger an automatic eCall
- ECall relevant accident situation will trigger an automatic call
- Robustness of IVS components (e.g. shock resistance etc.)
- Checking during periodical technical inspection (PTI)

The Results of sub-activity 3.1 “Meta-Analysis eCall state of the art” concerning end-user survey and naturalistic riding together with the OEM’s, suppliers and universities’ expertise in common usage of P2Ws lead to a list of situations and conditions that shall not trigger an eCall. The most critical ones with regard to false calls have been identified and transferred to test scenarios.

Findings and recommendations of sub-activity 3.1 “Meta-Analysis eCall state of the art” concerning relevant accident scenarios for P2W eCall and sub-activity 3.4 “Architecture and Validation” concerning triggering criteria for P2W eCall lead to a description of must-trigger situations and conditions. In order to condense the large variety of eCall relevant accident situations to a reasonable number of test scenarios the situations have been sorted in clusters. For each cluster a test scenario has been defined.

With regard to shock resistance an approach similar to passenger cars is recommended. As there is no data of high severity P2W crash tests (loads, acceleration etc.) publically available further investigations need to be done.

At the date of preparation of this document checking the eCall IVS during PTI for passenger cars is not regulated in detail and thus cannot be used as starting point. Nevertheless some recommendations for P2W PTI can be given.

Every new P2W test scenario in this document is described in a generic way, the intension of I_HeERO is not to describe the tests in a highly detailed and specific way. It is important that all tests are designed in a way to make them simple and repeatable and the results reproducible. Additional investigations have to be conducted in order to evaluate detailed test specifications after the end of I_HeERO project.

3 P2W eCall IVS

The following chapter summarizes the results and recommendations of sub-activity 3.1 “Meta-Analysis eCall state of the art” and sub-activity 3.4 “Architecture and Validation”. The test object for verification tests, P2W eCall IVS, is described briefly in terms of its functional requirements and system design.

3.1 Functional Requirements

As already discussed in Milestone report M23 there are significant differences between eCall scenarios for passenger cars and P2Ws, these are:

- The crash dynamic of a car and P2W (L3) are fundamentally different with different injury patterns and severity.
- Necessity of identification of a fall (with or without collision of vehicle with an obstacle)
- The probable separation of rider and P2W due to vehicle dynamic peculiarity
- The specific characteristic that a voice connection is not present or cannot be established

At first an in-depth accident analysis based on GIDAS (German in Depth Accident Study) data was conducted to determine the most frequent accident scenarios. The derived accident scenarios are shown in Figure 1. The accident scenarios are covering 90% of all police reported L3 accidents with injuries in Germany.

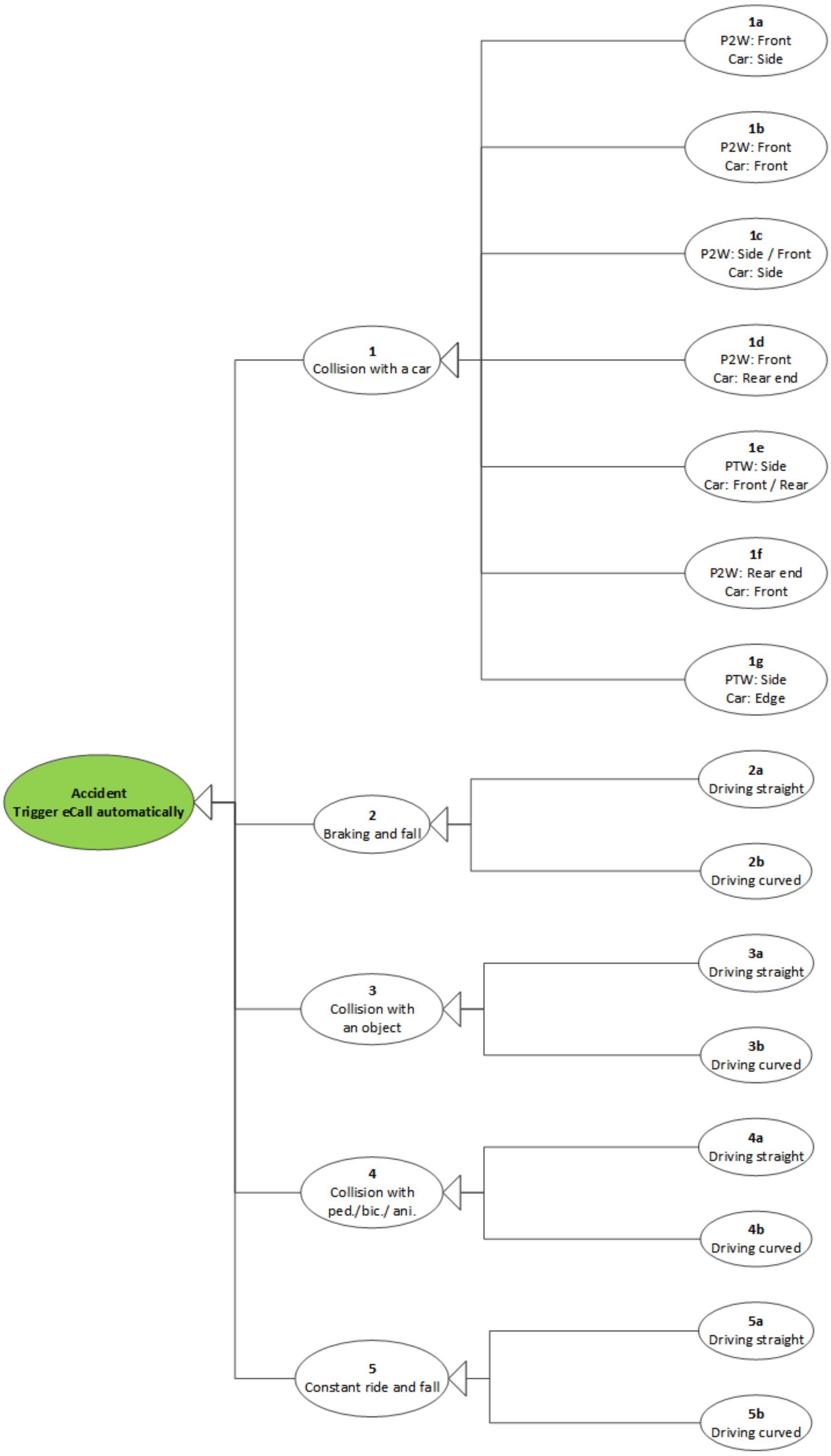

Figure 1: Relevant accident scenarios for automatic eCall triggering

According to the European Commission eCall action plan, the eCall function should operate automatically after the detection of a serious crash by In-Vehicle sensors and/or processors. In accordance to this plan, the scope of P2W eCall should be focused to those riders that “must have” emergency support after a crash. In order to distinguish in the accident data base between “Must have” and “not necessary” concerning emergency support an injury severity scale shown in Figure 2 has been used.

Injury Severity (IS) 4:	Fatal (died within 30 days)
Injury Severity (IS) 3:	Severe (hospitalisation > 24h)
Injury Severity (IS) 2:	Slight, with hospitalisation (< 24h)
Injury Severity (IS) 1:	Slight, without hospitalisation
Injury Severity (IS) 0:	No injuries

Figure 2: Injury severity levels

From the study, it is considered for minimum requirement that IS2+ “must have” emergency support. This leads to triggering requirements shown in Figure 3.

Injury Severity ↑	IS4	eCall is necessary
	IS3	
	IS2	
	IS1	eCall can be necessary
	IS0	eCall not necessary

Figure 3: Triggering requirements

Sensors mounted on the P2W are able to detect accident situations but it is not possible to measure the triggering requirement, namely the injury severity. There is only a statistical link between accident severity and injury severity. Due to the probable separation of rider and P2W this statistical link is not as strong as it is compared to passenger cars. Parameters needed to be defined describing a relevant accident situation with a certain probability of IS2+.

Based on the data studied, it was concluded that the collision speed parameter and detection of a fall down condition would be sufficient to determine triggering of a motorcycle eCall.

According to Milestone report M26 the recommendations for the minimum requirement of the Triggering Criteria are:

1. The falling down of the motorcycle shall be detected.
2. The vehicle speed shall be estimated prior to the fall down detection.
3. An eCall shall be activated when the vehicle falling down is detected and the accident speed exceeds 25km/h
4. An eCall shall be activated when the P2W in a zero-speed condition experiences a significantly high and long acceleration on the xy-plane (namely it is hit by another vehicle)

The falling down of a motorcycle is a clear indication of the P2W being in an unusual condition that warrants attention of some kind. Typically, a vehicle in this condition will be returned to an upright condition and placed on its supporting stand.

For the vehicle speed estimation, it is recommended to review at 3 seconds before the fall down detection. This is defined in ISO13232, as the crash event of a motorcycle accident ends within 3 seconds after first impact.

In order to meet acceptable ratios of under triage and over triage a triggering concept with a pre-warning was chosen. If the fall down and speed conditions are met, then the system should trigger a pre-warning of the eCall. At this point if the rider is OK and wants to suppress the eCall before it is sent to the PSAP they can activate the suppression function within the HMI. In case the rider considers an eCall warranted or is unable to suppress the eCall, the eCall itself will be triggered after the pre-warning time has elapsed.

An overview of the defined must-trigger events as well as the non-trigger events are summarized in Figure 4. Basis is the above minimum requirements of the triggering criteria and its boundary conditions.

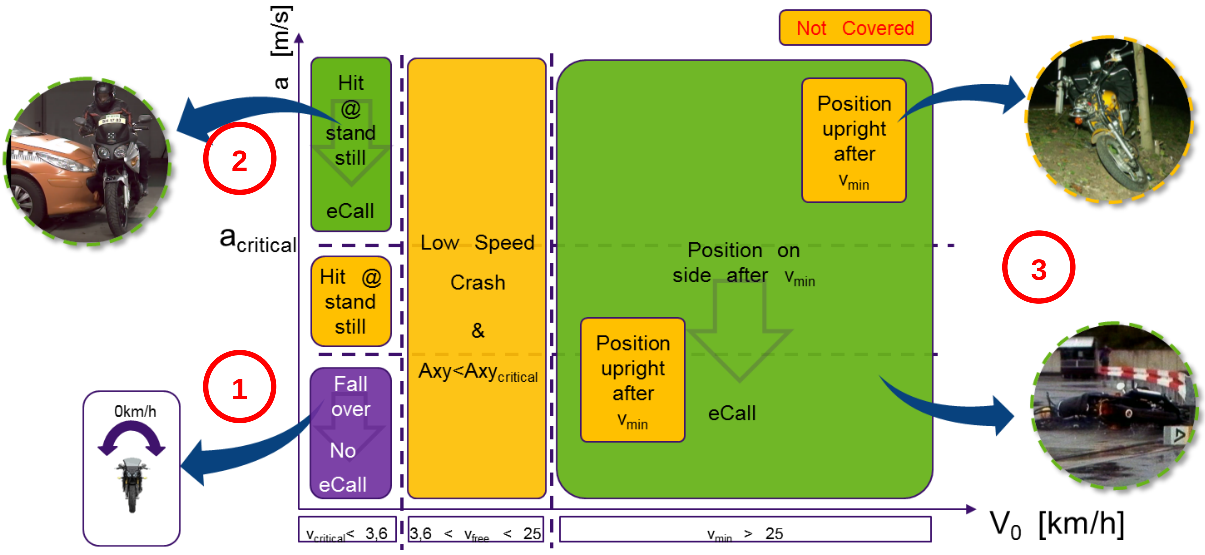

Figure 4: Generalized threshold of use and misuse cases for eCall activation defined by collision speed, acceleration level and final position.

3.2 System Design

The functional requirements discussed in Chapter 3.1 lead to following main results concerning eCall IVS basic architecture for L3 category vehicles:

- **Pre-warning:**
  In case of an eCall relevant situation detected by IVS a timer shall be introduced, allowing the rider to suppress an eCall before it is sent to PSAP. While the timer is running there shall be an audio and visual signal from the P2W to inform the rider. In case of no need of assistance the eCall can be suppressed and thus the number of false calls will be reduced.

- **Voice connection optional:**
  In a crash or fall situation of a P2W most likely rider and vehicle are separated. The resulting distance between rider and vehicle and the fact that the rider is wearing a helmet makes it very unlikely that a voice communication to the IVS without non IVS technical equipment (i.e., Bluetooth headset) is possible.

- **Manual eCall optional (only in combination with voice connection):**
  A manual eCall always needs the presence of a voice connection in order to explain the nature of the emergency case.

- **Adaption of MSD:**
  In order to signal to the PSAP whether the P2W is equipped with a voice connection device or not an existing mandatory field in MSD shall be used. Further optional information can be transmitted in optional fields of MSD.

In conclusion an in-vehicle system for P2W shall follow the proposal as shown in Figure 5 (high level architectural view). Starting from the functional blocks of an in-vehicle eCall system for M1/N1 class vehicles (highlighted in blue) there are additions and removals recommended for a P2W application.

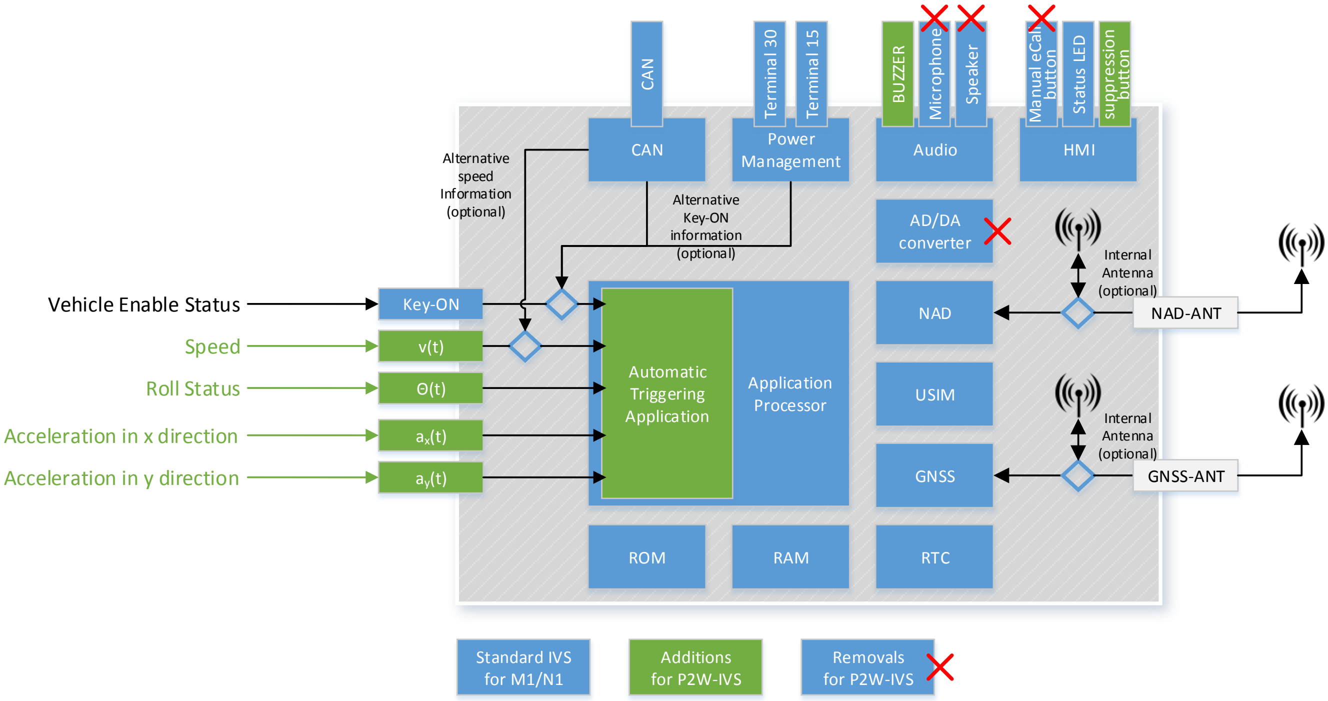

Figure 5: Functional blocks of an in-vehicle system for P2W

4 Existing Norms, Regulation, Requirements concerning conformance of eCall IVS

The first step to create a proposal for verification tests is an enquiry in existing standards etc. concerning eCall IVS. ECall IVS for passenger cars will be mandated starting April 2018 thus the focus of the enquiry lies on passenger cars. The following chapters list existing Norms and wrap up passenger car type approval and PTI Regulation.

4.1 Norms and Standards

There is a large number of Norms and Standards dealing with eCall. A non-exhaustive list of norms is given below:

- EN 15722, Intelligent transport systems - eSafety - eCall minimum set of data (MSD)
- EN 16062, Intelligent transport systems - eSafety - eCall high level application requirements (HLAP)
- EN 16072, Intelligent transport systems - eSafety - Pan-European eCall operating requirements
- EN 16102, Intelligent transport systems - eCall - Operating requirements for third party support
- EN 16454, Intelligent transport systems - eSafety - ECall end to end conformance testing

For EN 16454 required adjustment and addendum are discussed in Chapter 5.6 and Annex 1. Additionally various ETSI standards for the network access device and cellular mobile networks have to be taken into account.

4.2 Regulation for Passenger car Type approval

As already mentioned type-approval requirements for eCall IVS in passenger cars are used as starting point for P2W eCall IVS verification test proposal. For M1/N1 vehicles directive 2007/46/EC, amended by EU 2015/758 regulates type approval. Detailed technical requirements and test procedures regarding eCall IVS in M1/N1 vehicles are given in Delegated Regulation (EU) 2017/79.

The Delegated Regulation (EU) 2017/79 can be used as a guideline for the definition of conformance tests and requirements. For a P2W standard the following adoptions are proposed with respect to the discussed restrictions and requirements for P2W eCall system (Chapter 3).

For the entire P2W standard(s) should be considered:

1. Full-scale tests are only optional. Hardware testing only on component level
2. Audio and voice connection is only optional.
3. Only automatic trigger of the eCall

That leads to the following amendments on the main topics:

1. Technical requirements and procedures for testing the resistance of eCall in-vehicle systems against severe crashes (high-severity deceleration test)

   → Adapt according to the proposed tests in Chapters 5.4 and 5.5

   → Skip the testing of audio and voice connection

2. Full-scale impact test assessment

   → Not relevant, no full-scale tests required

3. Crash resistance of audio equipment

   → Not relevant, no audio and voice equipment required

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

   → Skip manual trigger tests

5. Automatic triggering mechanism

   → Skip the relation to the full-scale tests and restraint system (including airbag control unit)

6. Technical requirements for compatibility of eCall in-vehicle systems with the positioning services provided by the Galileo and the EGNOS systems

   → Can be adopted completely

7. In-vehicle system self-test

   → Can be adopted completely

8. Technical requirements and test procedures related to privacy and data protection

   → Can be adopted completely

4.3 Requirements for passenger car PTI

Requirements for periodical technical inspection of vehicle categories M, N, O and L vehicles are defined in directive 2014/45/EC. This EU directive foresees periodic roadworthiness tests for vehicles of categories L3, L4, L5 and L7 with an engine displacement of >125cc. According to the directive, member states have to implement the requirements of the directive into their national legislation until 2022.

However directive 2014/45/EU leaves much room in terms of the specific elements of the tests as well as it allows the member states to put in place alternative measures which are providing the same effectiveness.

The frequency of the tests of L-category vehicles shall be "adequate", but is not further specified by the directive.

Different as for other vehicle categories (i.e. M1, N1) the directive 2014/45/EC does not specify the elements to be tested periodically for L-category vehicles. It is left to the member states to define the required tests in their own territory.

Currently an amendment of requirements for periodical technical inspection of category M vehicles is under discussion concerning tests of eCall IVS. Yet the items, range and test methods are not defined.

5 Proposal of verification tests for P2W eCall IVS

After having listed existing standards, mainly for passenger cars, the following chapters deal with an assessment of these standards concerning feasibility for P2W. The relevant areas of verification tests and possible approaches to derive tests are explained. Existing tests specific for P2W are listed and assessed concerning feasibility for P2W eCall. Finally proposals of generic test scenarios are discussed for must- / no-trigger situations, shock resistance, end-to-end conformance and PTI.

5.1 Areas of system verification and conformance testing

As discussed in previous chapters on the one hand a large number of tests for verification and conformance of eCall IVS already exist. On the other hand there are significant differences between eCall scenarios for passenger cars and P2Ws. Following areas are already covered by existing standards which are also applicable for P2W:

- Privacy and liability aspects
- Privacy and data protection
- Conformance to relevant technical standards

With regard to dedicated P2W eCall IVS verification tests following areas are not yet or not fully covered:

- Automatic eCall triggering of Must- / No-trigger situation for P2W:
  Verify that relevant and non-relevant accident scenarios are detected correctly
- Shock resistance of IVS:
  Verify that the eCall IVS resists physical loads due to severe crash and is still operable after a severe crash
- PTI:
  Dedicated tests during PTI to verify that the eCall IVS is operable and works according to specifications

In order to create dedicated P2W eCall IVS verification tests two approaches are possible:

1. Existing test scenarios are expanded, for example tests for type approval
2. New test scenarios are defined.

Approach 1 demands no additional tests and thus is favoured. If this is not possible, for example because the tests are not feasible for P2W, eCall IVS verification approach 2 can be taken.

5.2 Existing test scenarios for P2W

5.2.1 P2W type Approval

Type approval requirements for L3 category vehicles are defined in regulation (EU) No 168/2013, supplemented by delegated regulation (EU) No 44/2014 and delegated regulation (EU) No 3/2014 and delegated regulation (EU) No 134/2014 and (EU) No 901/2014. Table 1 lists the 26 UNECE Regulations required for the Type approval of L3 vehicles.

The majority of those 26 regulations do not describe dynamic tests, especially no crash or sled testing. The only regulation describing dynamic tests is ECE-R 78, involving different braking manoeuvres. This means that tests described in P2W type-approval regulations cannot serve as no-trigger-tests or must-trigger tests for P2W eCall IVS. But performing dedicated no-trigger-tests with the motorcycles already equipped for ECE-R 78 testing can be done without extensive extra efforts.

In addition delegated regulation (EU) No 3/2014 in its Annex XIV prescribes several test procedures with the vehicle in motion in order to prove the vehicle's steer-ability, cornering properties and turn-ability. Some of these tests have to be performed up to the vehicle's maximum design speed.

Table 1: List of UNECE regulations for L3 vehicles

UNECE regulation No.	Subject
1	Headlamps for motor vehicles
3	Retro-reflectors
6	Direction indicators
7	Front and rear position lamps and stop lamps
8	Head lamps for motor vehicles
19	Front fog lamps
20	Headlamps for motor vehicles
28	Audible warning devices
37	Filament bulbs
38	Rear fog lamps
39	Uniform provisions concerning the approval of vehicles with regard to the speedometer equipment including its installation
43	Safety glazing
50	Lighting components for vehicles of category L
53	Installation of lighting (motorcycle)
57	Headlamps for motorcycles and vehicles treated as such
60	Identification of controls tell-tales and indicators
72	Headlamps for motorcycles and vehicles treated as such (HS1)
75	Tyres
78	Braking, including anti-lock and combined brake systems
81	Rear view mirrors
87	Daytime running lamps
90	Replacement brake lining assemblies and drum brake linings
98	Headlamps with gas-discharge light sources
99	Gas-discharge light sources
112	Headlamps with asymmetrical beams
113	Headlamps with symmetrical beams

5.2.2 ISO 13232

ISO 13232 is the standard for test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles. Its purpose is to define common research methods and a means for making an overall evaluation of the effect that devices, which are fitted to motorcycles and intended for the crash protection of riders, have on injuries, when assessed over a range of impact conditions which are based on accident data.

ISO 13232 is applicable to impact tests involving:

- two-wheeled motorcycles with an engine cylinder capacity in the case of a thermic engine exceeding 50 cm3 or whatever the means of propulsion a maximum design speed exceeding 50 km/h;
- the specified type of opposing vehicle;
- either a stationary and a moving vehicle or two moving vehicles;
- for any moving vehicle, a steady speed and straight-line motion immediately prior to impact;

ISO 13232 and its subchapters shape a basic set of test conditions and definition for test description. E.g. the definition of impact conditions in relation to accident data in ISO 13232-2 to specify minimum requirements for the collection and analysis of all motorcycle accident data, in order to provide:

- a standardized and representative sub-set of car/motorcycle accident data;

and

- a sub-set of car/motorcycle impact conditions based on the analysis of this standardized accident data

This standard should be seen as a guide for motorcycle crash tests and is only indirectly relevant for the conformance of an eCall system. The assessment of ISO 13232 and subchapters is listed in Annex 1, Table 3.

5.3 Automatic eCall: No-Trigger tests

5.3.1 List of no-trigger events

There are many different riding situations resulting in sensor signals comparable to those generated in accident situations. Nevertheless, such situations must not lead to a triggering of the eCall system. Naturalistic riding studies (Activity 3.1) as well as knowledge at P2W OEMs, supplier companies and Universities have been used to generate an overview of such situations and driving manoeuvres. As a result the list below shows the most important and most relevant no-trigger conditions in practice. The four areas cover most riding situations without accident that might lead to a false eCall. They are also realistic and often occur in a motorcyclist life.

a) Speed bumps

Speed bumps are widespread and can be found in all European countries. If riding over these, there is a strong impulse to the handlebar, but this impact generally does not lead to a fall / loss of control over the motorcycle.

b) Kerbstones

Riding on a kerbstone is rather rare compared to the driving over speed bumps, but also relevant regarding an eCall. Due to the low speed while riding up a curb the wheel gets a strong impulse. An eCall should not be triggered in these cases, also when descending a curb.

c) Riding on different road surfaces

Riding on different road surfaces often happens when riding a motorcycle. These includes riding on public roads, over cobblestone, on unpaved roads, on a railway crossing or on the roadside. A triggering of the eCall is not desired in these riding situations.

d) Misuse manoeuvre

There are some riding manoeuvres that are not part of the normal use of the motorcycle. Mostly they are a consequence of unintended or unexperienced type of use but without a fall or crash. These exceptional situations are rare and triggering an eCall would be unnecessary. This includes: wheelies, stoppies, fall over of the motorcycle as well as a slow impact on a wall.

5.3.2 Test scenarios of no-trigger events

Based on the driving situations discussed in chapter 5.3.1 no-trigger test scenarios are developed and a list of preferably simple tests are proposed and described. Those tests shall allow a reliable statement about an eCall function in no-trigger situations. For this reason the tests shall apply loads / sensor signals to the motorcycle that are higher than during normal use. They shall mark extended normal use up to misuse. The tests or driving manoeuvres proposed below apply to standard motorcycles. However, there are also vehicles which cannot meet some tests due to their kind of construction. Therefore deviations from the proposed test program are possible. Manufacturers of such vehicles shall provide a technical explanation why their vehicles cannot complete one or more tests. They shall also propose alternatives to the tests concerned, taking into account both the technical requirements of their vehicles and the original meaning of the test(s).

a) Speed bumps

There is no general international standard for speed bumps. Height, length, ramp angles, and geometry vary enormously around the world. The same applies for the tolerated maximum speeds on roads equipped with speed bumps. Common bump-heights in Germany are referred to the speed limits

70mm 5km/h

50mm 20km/h

30mm 30km/h

To cover the overriding situations of those speed bumps with typical speeds driven in urban areas, a test setting was developed. To reduce the number of necessary tests the proposed test setting also covers the scenario of driving through a larger pothole.

- **Proposal of Speed bumps test scenario: Riding over three speed bumps**

The three speed bumps are arranged as outlined in Figure 6. Riding over the first speed bump compresses the front suspension, a deceleration acts on the motorcycle/e-Call sensors. The next bump is located in such a distance that the front wheel is impacting the upper edge. The distance between the first and third bump equates to the test bike’s wheelbase.

The test is conducted with two different heights of the bumps and different speeds: Test “speed bump” 1: height 70 mm, speed 30 km/h.

Test “speed bump” 2: height 50 mm, speed 50 km/h.

Each test should be driven three times in a row.

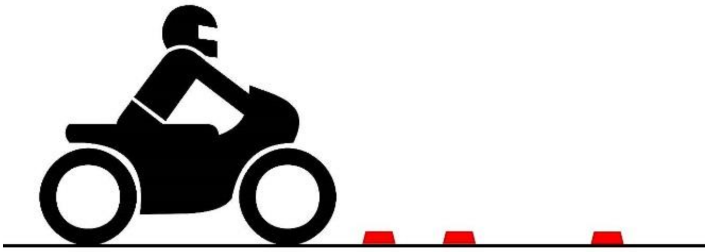

Figure 6: Outline of the speed bump test

b) Kerbstones

Kerbstones separate the road from the roadside. Besides fulfilling several other functions, they are an important contribution for the protection of sidewalk users. Their height varies from country to country and the main purpose. Most of them have a height of 200 mm maximum above street level.

Figure 7: Kerbstone with a height of about 150mm (Foto: Alvimann)

- **Proposal of kerbstone test scenario: Descending a kerbstone**

The motorcycle is driven with a speed of 40 km/h on a horizontal plain. It is driven *down* a 150 mm kerbstone with constant speed. The test should be driven three times in a row. Figure 8 illustrates the test.

Figure 8: Kerbstone test descending

- **Proposal of kerbstone test scenario: Ascending a kerbstone**

The motorcycle is driven with a speed of 15 km/h on a horizontal plain. It is driven *up* a 150 mm kerbstone with constant speed. The test should be driven three times in a row. Figure 9 illustrates the test.

Figure 9: Kerbstone test ascending

c) Riding on different road surfaces

Riding on different road surfaces includes public roads, unpaved roads, on the roadside and cobblestone. There are no unified regulations regarding the size and the installation of cobblestones. Historical reasons are considered, just like planned utilization and the speed limit on the concerned road. Normally cobblestones will be used on urban roads.

- **Proposal of on road / public road test scenario:**

Riding of at least 1000 km on public roads (urban / country road / motorways). At least 10 % driven on urban streets and at least 60 % on country roads. On country roads every kind of roads should be driven on equally. On urban and nonurban roads there should also be crossing of rail tracks.

- **Proposal of unpaved roads test scenario:**

Driving on farm roads and unpaved roads with up to 80 km/h (scaling in 10 km/h steps)

- **Proposal of cobblestone test scenario:**

Driving on a cobbled track with a minimum length of 100 m with speeds from 10 – 50 km/h. Scaled in 10 km/h steps

d) Misuse manoeuvre

Wheelie

There is a number of situations that may lead to a wheelie, depending on different motorcycle parameters (e.g. performance, weight, gear, clutch etc.). For example due to unintended wide opening of the throttle and thus a suddenly high acceleration the front wheel can be lifted. Abrupt closing the throttle or strong breaking on the rear wheel leads to a hard touchdown of the front wheel on the road. Figure 10 illustrates this riding condition.

- **Proposal of Wheelie-manoeuvre test scenario:**

Wheelie-manoeuvre with lifting of the front wheel up to at least 45° or the limit of the motorcycle. Speed is at least 50 km/h. Afterwards strong breaking with the rear wheel brake. The test should be done three times in a row at least.

Figure 10: Wheelie-manoeuvre

Stoppie

In case of strong braking with the front wheel (e.g. emergency braking) the rear wheel can be lifted due to dynamic wheel loads. When the front brake is released the touchdown of the rear wheel onto the road can be hard as well. Figure 11 illustrates this riding condition.

- **Proposal of Stoppie-manoeuvre test scenario:**

Stoppie-manoeuvre with a lift of the rear wheel up to an angle of at least 30°, then sudden release of the front wheel brake. The test should be done three times in a row.

Figure 11: Stoppie-manoeuvre

Falling motorcycle

Accidently a motorcycle can fall over while standing still or being pushed by a person. While standing still such situations can occur because the rider loses control / balance over the motorcycle or it is knocked off the side stand.

- **Proposal of motorcycle falling over (stationary) test scenario:**

Falling over of the fully upright standing, stationary P2W to the left hand side and the right hand side with activated ignition.

- **Proposal of motorcycle falling over (moving) test scenario:**

Falling over of the P2W to the left hand side and the right hand side with activated ignition while it is being pushed by a person. Speed: 5 km/h (walking speed).

Low speed impact

By mistake a motorcycle can impact a rigid obstacle at a low speed with the rider seated on the P2W or while pushing the bike. Due to low velocity and no tilting the motorcycle does not necessarily fall over. In case of falling over the situation is covered by “4.3 Falling motorcycle”

- **Proposal of low speed impact test scenario:**

Riding against a rigid wall with 5 km/h without braking and tilting. After the impact the motorcycle is standing still and upright. The test should be done three times in a row.

5.4 Automatic eCall: Must-Trigger tests

5.4.1 List of must-trigger core accident scenarios

As discussed in chapter 3 there are several relevant accident scenarios for automatic eCall triggering. In order to create a reasonably small number of test scenarios simulating the relevant accident scenarios the situations have been clustered. Table 2 shows the relevant accident scenarios assigned to a core accident scenario according to the nature of the accident situation and the P2W initial velocity as per triggering criteria described in Milestone report 26. The core accident scenarios are assigned in Table 2 as follows:

Table 2: Assignment of core accident scenarios

Relevant accident scenario for automatic eCall triggering	P2W initial velocity acc. to triggering crit.	core accident scenario
1 Collision with a car	0 km/h	Impact situation while P2W is at stand still
	> 25 km/h	Impact situation while P2W is in longitudinal motion
2 Braking and fall	> 25 km/h	Single accident
3 Collision with an object	> 25 km/h	Impact situation while P2W is in longitudinal motion
4 Collision with a pedestrian, bicycle or animal	> 25 km/h	Impact situation while P2W is in longitudinal motion
5 Constant ride and fall	> 25 km/h	Single accident

Single accident

These accidents happen without direct involvement of other vehicle, person or object. The motorcycle gets into an unstable driving condition followed by falling to the left or right side. Afterwards most likely sliding occurs depending from initial velocity. A secondary collision with other vehicles or obstacles alongside the road is not considered with this accident scenario. The reasons for the unstable driving condition and the following downfall may be manifold. Mostly this is due to rider error. The most frequent scenario is: During braking or accelerating out of the turn a low or high sider occurs followed by a fall over of the Motorcycle.

Impact situation while P2W is in longitudinal motion

This scenario involves the impact of a motorcycle into another involved party or into an obstacle as well as the impact of another vehicle or object into the motorcycle. The direction of motion of the motorcycle is always longitudinal, the P2W is not at stand still. The direction of collision is arbitrary. According to the results of accident database research presented in Milestone report 23 most of these accidents end with the motorcycle falling down to the left or right side. Typical accident scenarios are crashes with oncoming vehicles, crashes into vehicles driving ahead, accident in crossings or impacts to obstacles alongside the road.

Impact situation while P2W is at stand still

This scenario involves the impact of another involved party into the motorcycle while the P2W is at stand still. The direction of collision is arbitrary. Typical scenarios are rear-end collisions to the motorcycle or accidents in crossings for example while stopping at a traffic light or yielding.

5.4.2 Test scenarios of must-trigger events

For each of the core accident scenarios described above a simple test scenario is proposed which allows repeatable and reproducible results. Those tests shall allow a reliable statement about an eCall function in must-trigger situations. For each test different methods are proposed. Depending from the method of the detection algorithm it shall be at the discretion of the manufacturer to choose an appropriate testing method. The triggering criteria especially with regard to lean angle are dependent on the type of motorcycle and their kind of construction. Therefore deviations from the proposed test program are possible. Manufacturers of such vehicles must provide a technical explanation why their vehicles cannot complete one or more tests. They shall also propose alternatives to the tests concerned, taking into account both the technical requirements of their vehicles and the original meaning of the test(s).

Single accident

The motorcycle gets into unstable driving conditions, the rider loses control of the P2W and in consequence the motorcycle falls to the left or the right side.

<u>Criteria for eCall trigger:</u>

k(t): vehicle-enabled-status: Ignition on/off

v_x(t) [m/s]: P2W longitudinal speed: Speed in driving direction at time t

θ(t) [°]: lean angle of the P2W: lean angle at time t referred to the gravity direction (motorcycle upright = 0°)

<u>Proposed values:</u>

Lean angle θ(t):

Lean angle is above 70°

Depending on the design and type, each motorcycle has different physical limits regarding the maximum possible lean angle. A lean angle above 70° cannot be reached with a production motorcycle in traffic situations, without causing a fall. Depending on the motorcycle a lower lean angle can already indicate a fall. In this case, the manufacturer has to prove the lean angle limit of “his” P2W and how it was determined.

Longitudinal speed v_x(t):

Motorcycles speed is above 25 km/h.

Requirement for eCall trigger:

The ignition of the motorcycle must be activated. In a driving situation, the threshold of the lean angle θ(t) and longitudinal speed v(x) are exceeded at the same time t (according to Report M24, Meta-algorithm), an eCall system has to be triggered.

Test scenario:

A test object shall be moving (simulated or real) with a longitudinal speed at threshold value and lean angle 0°. At start of test the lean angle shall increase until threshold value is exceeded, latest at that time longitudinal speed is decreased to 0 km/h.

At all tests it has to be ensured that the test object is equipped with the complete eCall system which is ready for production. The manufacturer must state the reasons for the selection of the test method in a detailed and comprehensible manner.

Test methods:

1. Hardware in the Loop (HiL) test
2. Test on a sled with a tilting device
3. A full vehicle test with a test driver
4. A full scale crash test

Impact situation while P2W is in longitudinal motion

This scenario involves the impact of a motorcycle into another involved party or into an obstacle as well as the impact of another vehicle or object into the motorcycle. The initial velocity of the P2W is greater 0 km/h, it is not at stand still. According to the results of accident database research presented in Milestone report 23 most of these accidents end with the motorcycle falling down to the left or right side. With regard to Milestone report M26 the triggering criteria for this scenario are the same as for a single accident. Thus the same test procedures as for *core scenario 1 single accident* can be applied here, (see section above). In case of detection by other means than lean angle θ(t), for example acceleration, Core scenario 1 suggests appropriate test methods as well, however required data (e.g. acceleration data) needs to be generated.

Impact situation while P2W is at stand still

This scenario involves the impact of another party into the motorcycle while the P2W is at stand still. The direction of collision is arbitrary.

Criteria for eCall trigger:

k(t): vehicle-enabled-status: Ignition on/off

a_{xy} (t) [m/s^2]: Minimum resulting acceleration that generates a shock detection on the x-y-plane.

$\Delta t_{shock\ min}$ [s]: Minimum duration of **a_{xy}(t)** to generate a shock detection on the x-y-plane

Proposed values:

As there is no data of P2W crash tests (loads, acceleration etc.) publically available a dedicated test series is recommended with different vehicle concepts to develop accurate thresholds of the variables. The implementation of this test series could not be carried out as part of I_HeERO project. However, a first proposal for thresholds has been developed on the basis of experience, theoretical considerations and the ISO 13232, see Figure 12.

Resulting acceleration a_{xy}(t):

Resulting acceleration in x-/y-plane, exceeds 13 g.

This threshold cannot be achieved with a normal acceleration on a motorcycle in road traffic situations.

Duration $\Delta t_{shock\ min}$:

Duration of Resulting acceleration in x-y-plane, exceeds 30 ms (0.03 s).

Requirement for eCall trigger:

The ignition of the motorcycle must be activated. At stand still the motorcycle receives an impulse from an arbitrary direction on the x-y-plane. If the resulting acceleration over time exceeds the threshold an eCall must be triggered.

Test scenario:

A test object shall be at stand still (simulated or real). At start of test a resulting acceleration of the test object in x-y-plane according to Figure 12 shall be applied. The test shall be conducted at least in six directions:

1. Acceleration in positive x direction
2. Acceleration in the negative x direction
3. Acceleration in positive y-direction
4. Acceleration in negative y-direction

5. Acceleration under 45 ° in the positive xy direction

6. Acceleration under 45 ° in negative xy direction

At all tests it has to be ensured that the test object is equipped with the complete eCall system which is ready for production. The manufacturer must state the reasons for the selection of the test method in a detailed and comprehensible manner.

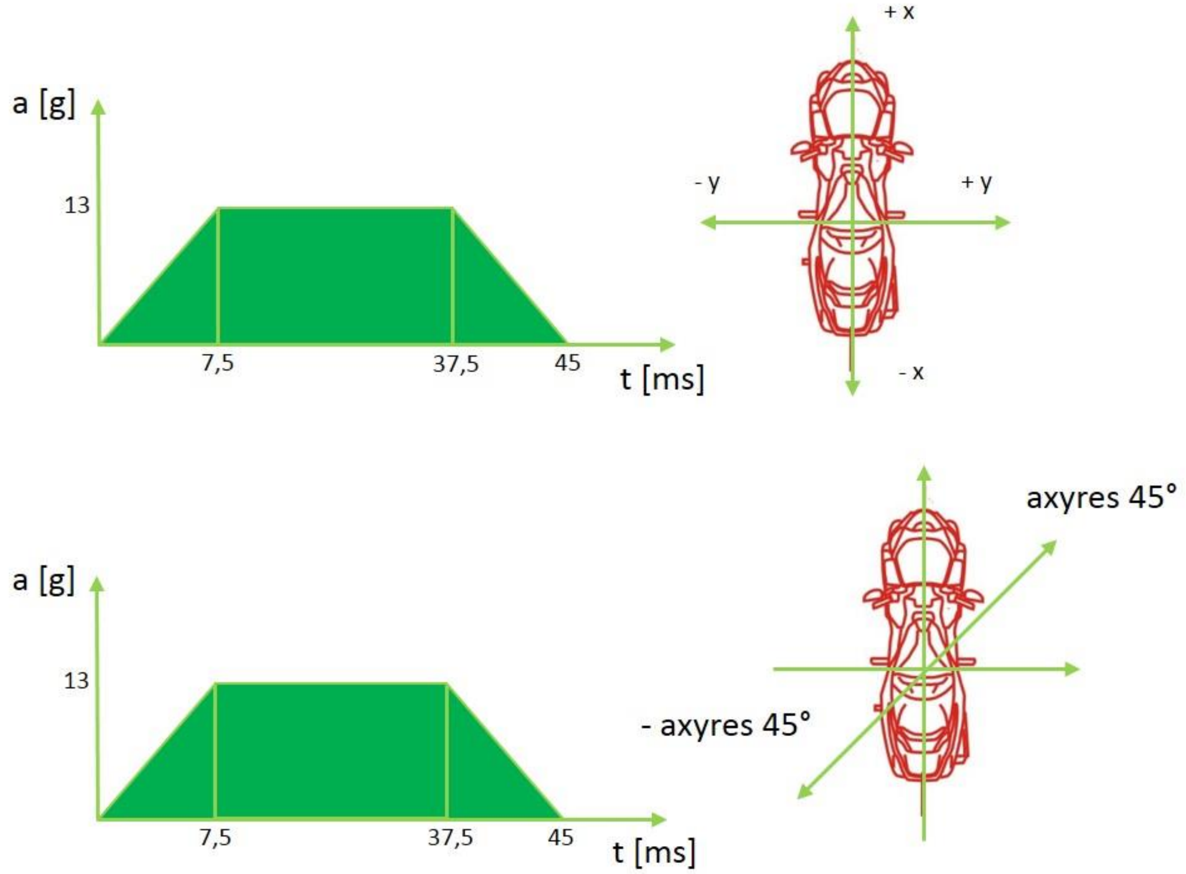

Figure 12: Proposal for an acceleration as a function of time

<u>Test methods:</u>

1. Hardware in the Loop (HiL) test
2. Test on a sled
3. A full scale crash test according to ISO 13232

5.5 Shock resistance of P2W eCall IVS

It has to be ensured that the electrical power supply and P2W eCall IVS withstands loads due to high severity crashes and is capable to provide eCall functionality after such a crash. For passenger cars the Delegated Regulation (EU) 2017/79 describes such a requirement for M1/N1 category vehicles. As there are neither type approval requirements for P2W crash tests nor data of P2W crash tests (loads, acceleration etc.) publically available a dedicated test series is recommended with different vehicle concepts. The proposed test shall be a P2W full vehicle crash test with 50 km/h against a rigid barrier. The results shall be used to derive a pulse corridor for sled testing. This is a similar approach as it has been used for Delegated Regulation (EU) 2017/79.

A possible interim scenario can be conducting sled tests as per Delegated Regulation (EU) 2017/79. The very least a pulse corridor used for passenger cars shall be verified to be applicable for P2W as well.

5.6 End to end conformance, EN 16454

This European Standard provides tests to demonstrate compliance of in-vehicle eCall systems to eCall Standards. It considers the key actors in the eCall chain of service provision:

1. In-Vehicle System (IVS)/vehicle,
2. Mobile network Operator (MNO),
3. Public safety assistance point [provider] (PSAP).

In some circumstances may also involve:

4. Third Party Service Provider (TPSP).

For each of the four key actor groups one high level state diagram is made available. The aim of this document is not to provide a complete list of states nor fully described conformance tests but highlight the focus areas affected by the expert's proposal, how the overall eCall system with its functionality shall look like.

As described in chapter 8.1 of EN16454:2015 Figure 14 illustrate the key areas of necessary conformance testing. The P2W experts studied these areas and introduced a colour code into the diagrams (see Figure 13), which indicates the areas of necessary modifications to meet the proposal for an in-vehicle system for P2W. The other assessed state transition diagrams are listed in Annex 2.

The corresponding standardized conformance test cases are applicable also for P2W	
The corresponding standardized conformity test cases need modification to comply to the proposal for an in-vehicle system for P2W or obsolete	

Figure 13: colour codes

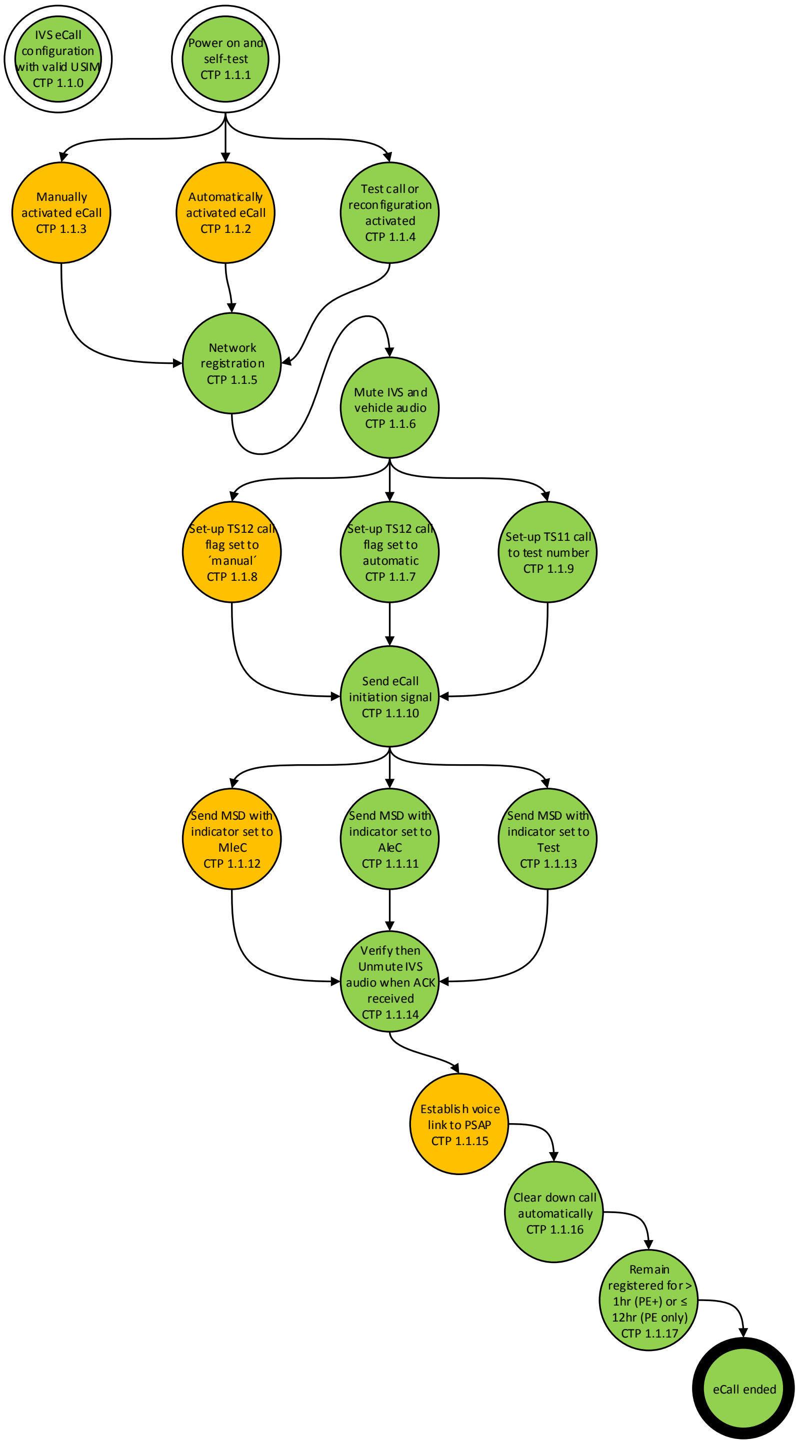

Figure 14: In-vehicle system state transitions- Pan European eCall only

5.7 PTI for P2W eCall IVS

As already mentioned in Chapter 4.3 directive 2014/45/EC defines requirements for periodical technical inspection of vehicle categories M, N, O and L vehicles. Although defined in that directive, not all European member states have PTI systems in place for motorcycles. Additionally requirements for periodical technical inspection of category M vehicles is under discussion concerning tests of eCall IVS. The recommendation for P2W PTI concerning eCall IVS is to make no extra provisions in PTW until requirements for M category vehicles are available. These future requirements for M category vehicles shall be evaluated concerning feasibility for P2W.

6 Conclusion

In this document verification tests for eCall IVS in P2W have been discussed in order to create the base for a future certification process. Following areas have been evaluated:

- Privacy and liability aspects
- Privacy and data protection
- Conformance to relevant technical standards (ETSI)
- Automatic eCall triggering of must-trigger situation for P2W
- No-trigger situation for P2W
- Shock resistance of IVS
- PTI

Based on assessment of existing eCall regulation *Privacy, liability aspects and data protection* as well as *Conformance to relevant technical standards* (ETSI standards) are already covered. The relevant existing requirements need no adaption for P2W.

For *no-trigger* and *must-trigger* situations with P2W eCall systems verification tests have been proposed. Based on results of sub-activity 3.1 “Meta-Analysis eCall state of the art” and sub-activity 3.4 “Architecture and Validation” tests have been developed that simulate the relevant must-trigger and no-trigger situations. In order to condense the large variety of eCall relevant accident situations to a reasonable number of test scenarios the situations have been sorted in clusters. For each cluster a test scenario has been defined. Existing standards and type-approval requirements for eCall IVS in passenger cars have been used as a starting point for these tests. Finally new P2W test scenarios were proposed and described in a generic way.

With regard to *shock resistance* an approach similar to passenger cars is recommended. As there is no data of high severity P2W crash tests (loads, acceleration etc.) publically available further investigations need to be done.

For *PTI* of P2W the recommendation is to make no extra provisions in PTW until requirements for M category vehicles are available. Yet PTI testing of eCall IVS in passenger cars is not regulated in detail. The future requirements for M category vehicles shall be evaluated concerning feasibility for P2W.

Generally it is important that all verification tests are designed in a way to make them simple, repeatable and the results reproducible. The intension of I_HeERO is not to describe the tests in a highly detailed and specific way. Additionally not all relevant data is publically available. Thus after the end of I_HeERO project further investigations have to be conducted in order to provide required data and prepare detailed test specifications.

REFERENCES

M22_D3_1_1_SoA_assessment.pdf

M23_D3_1_2_UseCases.pdf

M26_D3_4_BasicArchReco_1.1_20171016.pdf

https://ec.europa.eu/transport/themes/its/road/action_plan/ecall_en

ISO 13232 1-8 Motorcycles - Test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles

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

EN 15722:2015-08 Intelligent transport systems - ESafety - eCall minimum set of data

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

EN 16072:2015-08 Intelligent transport systems - ESafety - Pan-European eCall operating requirements

EN 16102:2012-03 Intelligent transport systems - eCall - Operating requirements for third party support

EN 16454:2015-12 Intelligent transport systems - ESafety - ECall end to end conformance testing

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

COMMISSION DELEGATED REGULATION (EU) 2017/79 of 12 September 2016 stablishing 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 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

REGULATION (EU) No 168/2013 of the European Parliament and of the Council of 15 January 2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles

COMMISSION DELEGATED REGULATION (EU) No 3/2014 of 24 October 2013 supplementing Regulation (EU) No 168/2013 of the European Parliament and of the Council with regard to vehicle functional safety requirements for the approval of two- or three-wheel vehicles and quadricycles

COMMISSION DELEGATED REGULATION (EU) No 134/2014 of 16 December 2013 supplementing Regulation (EU) No 168/2013 of the European Parliament and of the Council with regard to environmental and propulsion unit performance requirements and amending Annex V

COMMISSION IMPLEMENTING REGULATION (EU) No 901/2014 of 18 July 2014 implementing Regulation (EU) No 168/2013 of the European Parliament and of the Council with regard to the administrative requirements for the approval and market surveillance of two- or three-wheel vehicles and quadricycles

ANNEX 1 – ISO 13232

Table 3: ISO 13232 Assessment

Part:	Description:	Relevance:
13232-1	Definitions, symbols and general considerations	✓
	Comment: Relevant	
13232-2	Definition of impact conditions in relation to accident data	✓
	Comment: The defined crash codes are relevant for further description	
13232-3	Motorcyclist anthropometric impact dummy	×
	Comment: Not relevant	
13232-4	Variables to be measured, instrumentation and measurement procedures	×
	Comment: Not relevant	
13232-5	Injury indices and risk/benefit analysis	×
	Comment: Not relevant	
13232-6	Defined minimum set of full-scale tests	×
	Comment: Not relevant	
13232-7	Requirements for simulation based certification	✓
	Comment: As reference for optional simulation based tests	
13232-8	Documentation and reports	×
	Comment: Not relevant	

ANNEX 2 – EN 16454

Table 4: EN 16454 Assessment

Part:	Description:	Relevance:
5	Conformance	✓
	Comment: Keep the description	
6	General overview of the eCall transaction for pan-European eCall	✓
	Comment: Changes in wording & test suite structure	
7.1	Layout and procedures	✓
	Comment: Relevant	
7.2	System under test	✓
	Comment: Relevant	
7.3	Accelerated test procedures	✓
	Comment: Relevant	
7.4	Accelerated test procedures for IVSs	×
	Comment: Not relevant	
7.5	Accelerated test procedures for MNOs	✓
	Comment: Relevant	
7.6	Accelerated test procedures for PSAPs – PE eCall	✓
	Comment: Relevant	
7.7	Accelerated test procedures for PSAPs – TPS-eCall	✓
	Comment: Relevant	
7.8	Accelerated test procedures for TPSPs	✓
	Comment: Relevant	
8.1.1	Requirements: State transitions	×

	Comment: Only automatic activation, no voice & audio → adjust transitions	
8.1.2	Requirements: Classification of testing	×
	Comment: Only automatic activation, no voice & audio	
8.1.3	Requirements: CTP naming conventions	✓
	Comment: Relevant	
8.1.4	Requirements: CTP naming convention for IVS conformance tests	✓
	Comment: Relevant	
8.2	Requirements: CTP structure	✓
	Comment: Relevant	
9.1	Conformance test requirements for in-vehicle user equipment and systems for Pan European eCall	✓
	Comment: Relevant	
9.2	Test objectives and purposes	✓
	Comment: no voice & audio	
9.3	Classification of testing and referenced tests for in-vehicle user equipment for Pan European eCall IVS	✓
	Comment: Relevant	
9.4.1	Conformance requirement	✓
	Comment: Relevant	
9.4.2	Use case test objectives by stage	✓
	Comment: No audio, voice & manual	
9.4.3	CTP 1.1.0.1 Conformance to ETSI TS 102 936-1 and ETSI TS 102 936-2 – PE eCall IVS	✓
	Comment: No reference available → not assessable!	
9.4.4	CTP 1.1.0.2 Test for conformance to valid SIM/USIM – PE eCall	✓
	Comment: System test of available network	

9.4.5	CTP 1.1.0.3 Automatic eCall triggering does not occur when ignition OFF – PE eCall IVS	✓
	Comment: No trigger for ignition is off	
9.4.6	CTP 1.1.1.1 Power on and self-test – PE eCall IVS	✓
	Comment: System self-test for readiness	
9.4.7	CTP 1.1.2.1 eCall automatically activated – PE eCall IVS	✓
	Comment: only optional, to be evaluated	
9.4.8	CTP 1.1.2.2 Automatically triggered eCall in progress was not disconnected upon a new eCall trigger – PE eCall IVS	×
	Comment: Not relevant – second eCall after crash	
9.4.9	CTP 1.1.2.3 Post-side-crash performance of automatic trigger - IVS	×
	Comment: Not relevant – second eCall side impact after crash	
9.4.10	CTP 1.1.2.4 Post-frontal-crash performance of automatic trigger - IVS	×
	Comment: Not relevant – second eCall front impact after crash	
9.4.11	CTP 1.1.2.5 Performance of automatic trigger – different crash types - IVS	×
	Comment: No reference available → not assessable!	
9.4.12	CTP 1.1.3.1 eCall manually activated – PE eCall IVS	×
	Comment: Not relevant – no manual trigger	
9.4.13	CTP 1.1.3.2 Manually triggered eCall in progress was not disconnected upon a new eCall trigger – PE eCall IVS	×
	Comment: Not relevant – no manual trigger	
9.4.14	CTP 1.1.4.1 Test eCall activated – PE eCall IVS	✓
	Comment: Relevant	
9.4.15	CTP 1.1.5.1 Network registration – PE eCall IVS	✓
	Comment: Network test	

9.4.16	Manual termination of eCall by vehicle occupants not allowed (automatically triggered eCall) – PE eCall IVS	✓
	Comment: Relevant	
9.4.17	CTP 1.1.5.3 Manual termination of eCall by vehicle occupants not allowed (manually triggered eCall) – PE eCall IVS	×
	Comment: Not relevant – no manual trigger	
9.4.18	Automatically triggered eCall in progress was not disconnected when ignition is switched to OFF – PE eCall IVS	✓
	Comment: Relevant	
9.4.19	CTP 1.1.5.5 Manually triggered eCall in progress was not disconnected when ignition is switched to OFF – PE eCall IVS	×
	Comment: Not relevant – no manual trigger	
9.4.20	CTP 1.1.5.6 Priority over conflicting communication – PE eCall IVS	✓
	Comment: Option – no other communication	
9.4.21	CTP 1.1.5.7 Network registration is re-tried when network registration attempt was not successful – PE eCall IVS	✓
	Comment: No test required by standard	
9.4.22	CTP 1.1.6.1 Mute IVS and vehicle audio – PE eCall IVS	×
	Comment: Not relevant – no voice & audio	
9.4.23	CTP 1.1.7.1 Set-up TS12 call with eCall identifier (flag) set to 'automatic' – PE eCall IVS	✓
	Comment: to be evaluated	
9.4.24	CTP 1.1.8.1 Set-up TS12 call with eCall identifier (flag) set to 'manual' – PE eCall IVS	×
	Comment: Not relevant – no manual trigger	
9.4.25	CTP 1.1.9.1 Set-up TS11 call to test number – PE eCall IVS	✓
	Comment: Relevant	

9.4.26	CTP 1.1.10.1 eCall is attempted when no networks are available (limited service condition) – PE eCall IVS	✓
	Comment: Relevant	
9.4.27	CTP 1.1.10.2 Re-dial attempt completed within 2 minutes after eCall is dropped – PE eCall IVS	✓
	Comment: Adjust to P2W time limit	
9.4.28	CTP 1.1.10.3 Duration of eCall Initiation signal – PE eCall IVS	✓
	Comment: Relevant	
9.4.29	CTP 1.1.11.1 Send MSD with indicator set to 'Automatically Initiated eCall' (AIeC) – PE eCall IVS	✓
	Comment: Adjust to P2W MSD	
9.4.30	CTP 1.1.12.1 Send MSD with indicator set to 'Manually Initiated eCall' (MIeC) – PE eCall IVS	×
	Comment: Not relevant – no manual trigger	
9.4.31	CTP 1.1.13.1 Send MSD with indicator set to 'Test Call' – PE eCall IVS	✓
	Comment: Relevant	
9.4.32	CTP 1.1.14.1 Verify MSD transfer – PE eCall IVS	✓
	Comment: Relevant	
9.4.33	CTP 1.1.14.2 Un-mute IVS audio when AL-ACK received – PE eCall IVS	×
	Comment: Not relevant – no voice & audio	
9.4.34	CTP 1.1.15.1 Establish voice link to PSAP – PE eCall IVS	×
	Comment: Not relevant – no voice & audio	
9.4.35	CTP 1.1.15.2 MSD transfer request while eCall conversation in progress – PE eCall IVS	×
	Comment: no voice & audio	
9.4.36	CTP 1.1.15.3 eCall continuation when SEND MSD request not	✓

	received (T5 expired) – PE eCall IVS	
	Comment: Relevant	
9.4.37	CTP 1.1.15.4 Call continuation when AL-ACK not received (T6 expired) – PE eCall IVS	×
	Comment: Not relevant – no voice & audio	
9.4.38	CTP 1.1.15.5 MSD is transferred continuously until T7 expires and IVS reconnects loudspeaker and microphone on its expiry – PE eCall IVS	×
	Comment: Not relevant – no voice & audio	
9.4.39	CTP 1.1.16.1 Clear down call automatically – PE eCall IVS	✓
	Comment: Relevant	
9.4.40	CTP 1.1.16.2 IVS clears down the eCall upon T2 expiry – PE eCall IVS	✓
	Comment: Relevant	
9.4.41	CTP 1.1.16.3 IVS registers recent eCalls – PE eCall IVS	✓
	Comment: Store information, to be evaluated	
9.4.42	CTP 1.1.17.1 Call-back allowed and able to be answered by IVS – PE eCall IVS	×
	Comment: Not relevant – no voice & audio	
9.4.43	CTP 1.1.17.2 Call-back answered by IVS in the event of abnormal termination – PE eCall IVS	×
	Comment: Not relevant – no voice & audio	
9.4.44	CTP 1.1.17.3 MSD transfer occurs upon PSAP request during call-back – PE eCall IVS	×
	Comment: Not relevant – no voice & audio	
9.4.45	CTP 1.1.17.4 Remain registered for ≥1 hr – PE eCall IVS	✓
	Comment: Not relevant – no voice & audio	
9.5.1	State transition test scripts for in-vehicle equipment and system	✓

	to comply to Standards for pan European eCall – additional tests for eCall only systems - General	
	Comment: no manual, voice & audio	
9.5.2	CTP 1.1.1.2 IVS does not perform registration after power-up – PE eCall only IVS	✓
	Comment: Relevant	
9.5.3	CTP 1.1.1.3 IVS periodically scans and maintains a list of available PLMNs – PE eCall only	✓
	Comment: No test required by standard	
9.5.4	CTP1.1.10.4 Verify that PLMN registration procedure is executed upon initiating an eCall – PE eCall only IVS	✓
	Comment: Relevant	
9.5.5	CTP 1.1.17.5 Remain registered for ≥1 hr ≤12 hr – PE eCall only IVS	✓
	Comment: Relevant	
9.6	State transition conformance test requirements for in-vehicle user equipment for eCall TPS-IVS via a third party service provider	✓
	Comment: Relevant as optional provider	
9.7	Use case conformance tests for in-vehicle equipment and system to comply to Standards for third party service provider eCall	✓
	Comment: Adjust to no manual, voice & audio	
9.8.1	State transition test scripts for TPS in-vehicle equipment and system to comply to Standards for third party services supported eCall - General	✓
	Comment: Adjust to no manual, voice & audio	
9.8.2	CTP 1.2.0 Pre operation - TPS-IVS	✓
	Comment: Relevant	

9.8.3	CTP 1.2.1 Power on self-test - TPS-IVS	✓
	Comment: no voice & audio	
9.8.4	CTP 1.2.2 Automatically activate eCall - TPS-IVS	✓
	Comment: Adjust to no manual, voice & audio, no post-crash	
9.8.5	CTP 1.2.3 Manually activate eCall - TPS-IVS	×
	Comment: Not relevant – no manual trigger	
9.8.6	CTP 1.2.4 Stop conflicting communication – TPS-IVS	✓
	Comment: No other communication, to be evaluated	
9.8.7	CTP 1.2.5 Establish voice link to TPSP - TPS-IVS	×
	Comment: Not relevant – no voice & audio	
9.8.8	CTP 1.2.6 Send IVS dataset to TPSP - TPS-IVS	✓
	Comment: Relevant	
9.8.9	CTP 1.2.7 Establish voice link between PSAP and occupants - TPS-IVS	×
	Comment: Not relevant – no voice & audio	
9.8.10	CTP 1.2.8 Clear down call - TPS-IVS	×
	Comment: Not relevant – no manual, voice & audio	
9.8.11	CTP 1.2.9 Allow call-cack into vehicle - TPS-IVS	×
	Comment: Not relevant – no manual, voice & audio	
10	CTP 1.2.3 Manually activate eCall - TPS-IVS	✓
	Comment: Adjust to no manual, voice & audio (10.4.8, 10.4.11, […])	
11.1	Conformance tests for PSAP systems - Test objectives and purposes	✓
	Comment: Relevant	
11.2	Taxonomy of testing and referenced tests	✓
	Comment: Relevant	
11.3	Use case conformance tests for PSAP systems to comply to	✓

	Standards for pan European eCall	
	Comment: Relevant	
11.4.1	State transition conformance tests for PSAPs – PE eCall - General	✓
	Comment: Relevant	
11.4.2	CTP 3.1.0.1 Provide MNOs with appropriate routing data – Member State/ PSAP PE eCall	✓
	Comment: Relevant	
11.4.3	CTP 3.1.0.2 Maintain map geo-information – PSAP PE eCall	✓
	Comment: Relevant	
11.4.4	CTP 3.1.1.1 Receive automatically initiated eCall – PSAP PE eCall	✓
	Comment: Relevant	
11.4.5	CTP 3.1.1.2 Receive manually initiated eCall – PSAP PE eCall	×
	Comment: Not relevant – no manual	
11.4.6	CTP 3.1.2 Receive TS12 data- Caller ID & location – PSAP PE eCall	✓
	Comment: Relevant	
11.4.7	CTP 3.1.3.1 Recognise eCall and route to in-band modem – PSAP PE eCall	✓
	Comment: Relevant	
11.4.8	CTP 3.1.3.2 PSAP equipment failure – PSAP PE eCall	✓
	Comment: Relevant	
11.4.9	CTP 3.1.3.3 PSAP modem failure before link layer ACK is sent – PSAP PE eCall	✓
	Comment: Adjust to no audio	
11.4.10	CTP 3.1.4 eCall received at in-band modem – PSAP PE eCall	✓
	Comment: Relevant	

11.4.11	CTP 3.1.5.1 Validate initiation signal – PSAP PE eCall	✓
	Comment: Relevant	
11.4.12	CTP 3.1.5.2 Route to operator after T4 expiration – PSAP PE eCall	✓
	Comment: Relevant	
11.4.13	CTP 3.1.6 Request MSD – PSAP PE eCall	✓
	Comment: Relevant	
11.4.14	CTP 3.1.7.1 Receive MSD – PSAP PE eCall	✓
	Comment: Relevant	
11.4.15	CTP 3.1.7.2 Verify status bit in AL-ACK upon positive ACK– PSAP PE eCall	✓
	Comment: Relevant	
11.4.16	CTP 3.1.7.3 Verify MSD transfer upon T8 expiration – PSAP PE eCall	✓
	Comment: Relevant	
11.4.17	CTP 3.1.7.4 Verify transfer of corrupted MSD – PSAP PE eCall	✓
	Comment: Relevant	
11.4.18	CTP 3.1.7.5 Verify PSAP behaviour when MSD format check fails– PSAP PE eCall	✓
	Comment: Relevant	
11.4.19	CTP 3.1.8 ACK – PSAP PE eCall	✓
	Comment: Relevant - Covered by CTP 3.1.7	
11.4.20	CTP 3.1.9 Route voice and MSD to operator – PSAP PE eCall	✓
	Comment: Relevant – adjust to no voice	
11.4.21	CTP 3.1.10 Display TS12 data and MSD to operator – PSAP PE eCall	✓
	Comment: Relevant	

11.4.22	CTP 3.1.11 Decode VIN – PSAP PE eCall	✓
	Comment: Relevant	
11.4.23	CTP 3.1.12 Talk to vehicle occupants – PSAP PE eCall	✓
	Comment: Relevant – Adjust to no audio	
11.4.24	CTP 3.1.13 Request new MSD before call clear down – PSAP PE eCall	✓
	Comment: Relevant – adjust to no audio	
11.4.25	CTP 3.1.14.1 Call clear down – PSAP PE eCall	✓
	Comment: Relevant	
11.4.26	CTP 3.1.14.2 Verify status bit in AL-ACK upon clear down - PSAP – PE eCall	✓
	Comment: Relevant	
11.4.27	CTP 3.1.15 Call-back to vehicle – PSAP PE eCall	×
	Comment: Not relevant – no audio	
11.4.28	CTP 3.1.16 Request new MSD after call clear down – PSAP PE eCall	✓
	Comment: Relevant - Adjust to no audio	
11.5.1	State transition conformance tests for PSAPs – TPS-eCall - General	✓
	Comment: Relevant	
11.5.2	CTP 3.2.0.1 TPSP – PSAP agreement – PSAP TPS eCall	✓
	Comment: Relevant – adjust to no voice	
11.5.3	CTP 3.2.0.2 Provide areas of responsibility and contact numbers to approved TPSPs – PSAP TPS-eCall	✓
	Comment: Relevant – Adjust to no voice & audio	
11.5.4	CTP 3.2.0.3 Agreement on necessary language support – PSAP TPS eCall	✓
	Comment: Relevant – no voice but message should be understand	

11.5.5	CTP 3.2.0.4 Agree electronic data connection and provide details to approved TPSPs – PSAP TPS eCall	✓
	Comment: Relevant	
11.5.6	CTP 3.2.0.5 Provide PSAP data addresses and security access to approved TPSPs – PSAP TPS eCall	✓
	Comment: Relevant	
11.5.7	CTP 3.2.1 Receive eCall notification from TPSP (not TS12) – PSAP TPS eCall	✓
	Comment: Relevant	
11.5.8	CTP 3.2.2 Route call to operator – PSAP TPS eCall	×
	Comment: Not relevant – no voice & audio	
11.5.9	CTP 3.2.3 Connection, TSD transmission, display relevant information to PSAP operator –PSAP TPS-eCall	✓
	Comment: Relevant – Adjust to no voice & audio	
11.5.10	CTP 3.2.4 PSAP Operator: Talk with TPSP operator and receive relevant information – PSAP TPS eCall	×
	Comment: Not relevant – no voice & audio	
11.5.11	CTP 3.2.5 Talk to vehicle occupants – PSAP TPS-eCall	×
	Comment: Not relevant – no voice & audio	
11.5.12	CTP 3.2.6 Request new TSD before call clear down –PSAP TPS-eCall	✓
	Comment: Relevant – Adjust to no voice & audio	
11.5.13	CTP 3.2.7 Inform TPSP that call can be ended – PSAP TPS eCall	×
	Comment: Not relevant – no voice & audio	
11.5.14	CTP 3.2.8 Call cleardown with TPSP –PSAP TPS-eCall	×
	Comment: Not relevant – no voice & audio	
11.5.15	CTP 3.2.9 Call-back to TPSP – PSAP TPS-eCall	×

	Comment: Not relevant – no voice & audio	
11.5.16	CTP 3.2.10 Call-back to vehicle – PSAP TPS eCall	✗
	Comment: Not relevant – no voice & audio	
11.5.17	CTP 3.2.11 Call clear down with vehicle – PSAP TPS eCall	✗
	Comment: Not relevant – no voice & audio	
12.1	State transition conformance tests for TPS-eCall - Related specifications and conformance requirements	✓
	Comment: Relevant	
12.2.1	TPSP general tests (applicable to both TPS-eCall responder and TPS-eCall notifier) - General	✓
	Comment: Relevant – Adjust to no voice & audio	
12.2.2	CTP 4.0.1 Agree service level agreement and/or Standard ways of working with PSAPs – TPSP	✓
	Comment: Relevant	
12.2.3	CTP 4.0.2 Receive PSAP areas of responsibility and contact numbers – TPSP	✓
	Comment: Relevant	
12.2.4	CTP 4.0.3 Agree necessary language support – TPSP	✓
	Comment: Relevant	
12.2.5	CTP 4.0.4 Agree electronic data connection details with PSAPs – TPSP	✓
	Comment: Relevant	
12.2.6	CTP 4.0.5 Evidence quality procedures – TPSP	✓
	Comment: Relevant	
12.2.7	CTP 4.0.6 Verify automatic call distribution (ACD) system – TPSP	✓
	Comment: Relevant	
12.2.8	CTP 4.0.7 Check link from MNO – TPSP	✓

	Comment: Relevant	
12.2.9	CTP 4.0.8 Deal with transmission failures – TPSP	✓
	Comment: Relevant	
12.2.10	CTP 4.0.9 Update GIS – TPSP	✓
	Comment: Relevant	
12.2.11	CTP 4.0.10 Protection of privacy – TPSP	✓
	Comment: Relevant	
12.3.1	TPS-eCall responder tests – TPS-R - General	✓
	Comment: Relevant	
12.3.2	CTP 4.1.1 Receive TPS-eCall from vehicle – TPS-R	✓
	Comment: Relevant – Adjust to no voice & audio	
12.3.3	CTP 4.1.2 Process incoming call – TPS-R	×
	Comment: Not relevant – no voice & audio	
12.3.4	CTP 4.1.3 Talk with vehicle occupants and receive relevant information – TPS-R	×
	Comment: Not relevant – no voice & audio	
12.3.5	CTP 4.1.4 Trigger PSAP notification – TPS-R	✓
	Comment: Relevant	
12.3.6	CTP 4.1.5 Make voice connection between vehicle and PSAP if required – TPS-R	×
	Comment: Not relevant – no voice & audio	
12.3.7	CTP 4.1.6 Confirmation received from PSAP that call with vehicle can be ended – TPS-R	✓
	Comment: Relevant	
12.3.8	CTP 4.1.7 Call cleardown with vehicle – TPS-R	✓
	Comment: Relevant	
12.3.9	CTP 4.1.8 Call-back to vehicle – TPS-R	✓

	Comment: Relevant	
12.4.1	TPS-eCall notifier tests – TPS-N - General	✓
	Comment: Relevant – Adjust to no voice & audio	
12.4.2	CTP 4.2.1 Emergency situation likely to require assistance – TPS-N	✓
	Comment: Relevant	
12.4.3	CTP 4.2.2 Establish contact with PSAP – TPS-N	✓
	Comment: Relevant – except the voice connection	
12.4.4	CTP 4.2.3 Talk with PSAP operator and notify relevant information – TPS-N	×
	Comment: Not relevant – no voice & audio	
12.4.5	CTP 4.2.4 Establish voice link between PSAP and vehicle occupants if required by PSAP – TPS-N	×
	Comment: Not relevant – no voice & audio	
12.4.6	CTP 4.2.5 Respond to electronic data update request – TPS-N	✓
	Comment: Voice connection between TPS and PSAP	
12.4.7	CTP 4.2.6 PSAP informs that call can be ended – TPS-N	✓
	Comment: Relevant – Conformance tested by CTP 4.1.6.	
12.4.8	CTP 4.2.7 Call clear down to PSAP – TPS-N	✓
	Comment: Relevant – no conformance tests associated	
12.4.9	CTP 4.2.9 Call-back from PSAP – TPS-N	✓
	Comment: Relevant – Test requirements are covered by CTP 4.1.8	
13	Marking, labelling and packaging	✓
	Comment: Relevant	
14	Declaration of patents and intellectual property	✓
	Comment: Relevant	

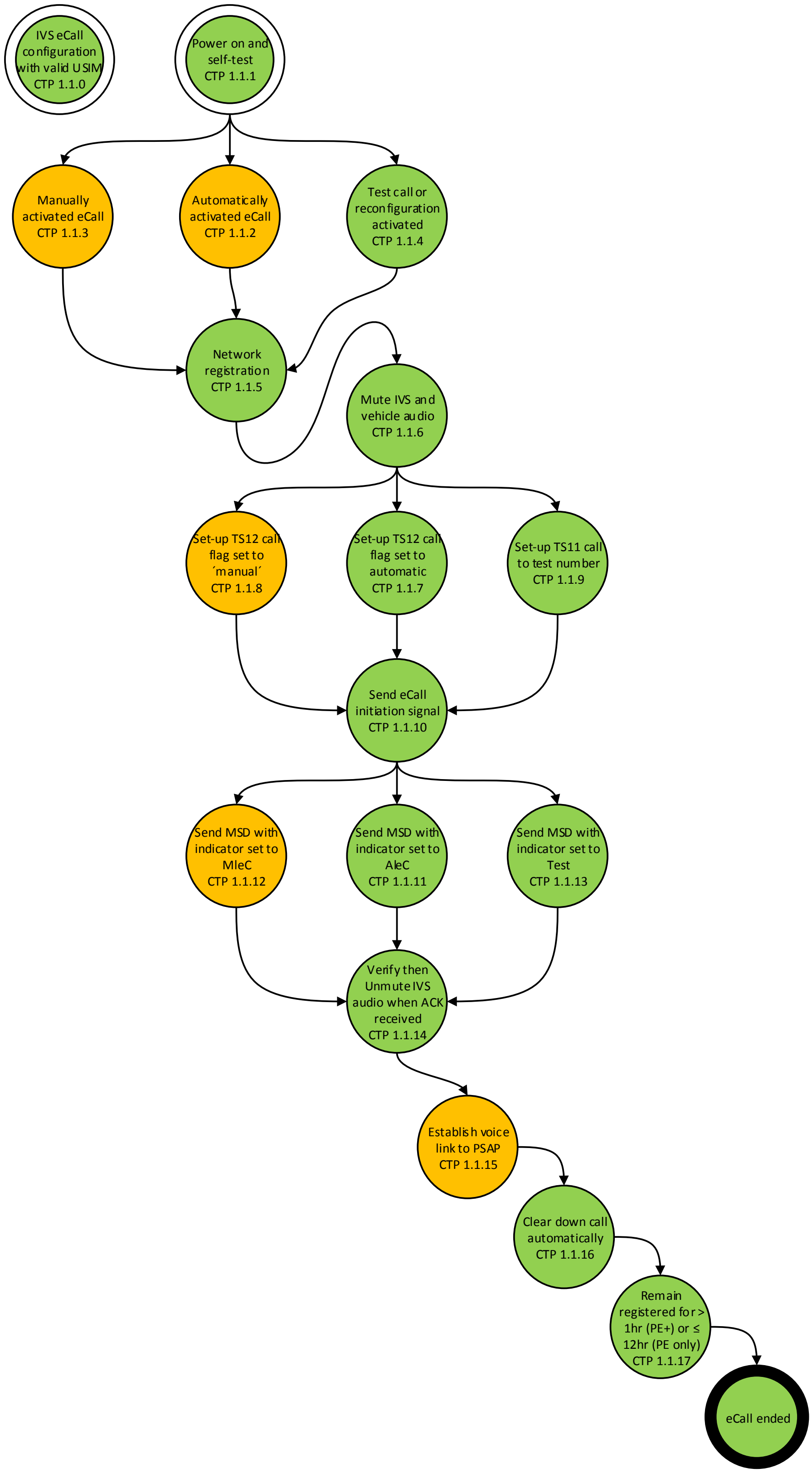

Figure 15: In-vehicle system state transitions- Pan European eCall only

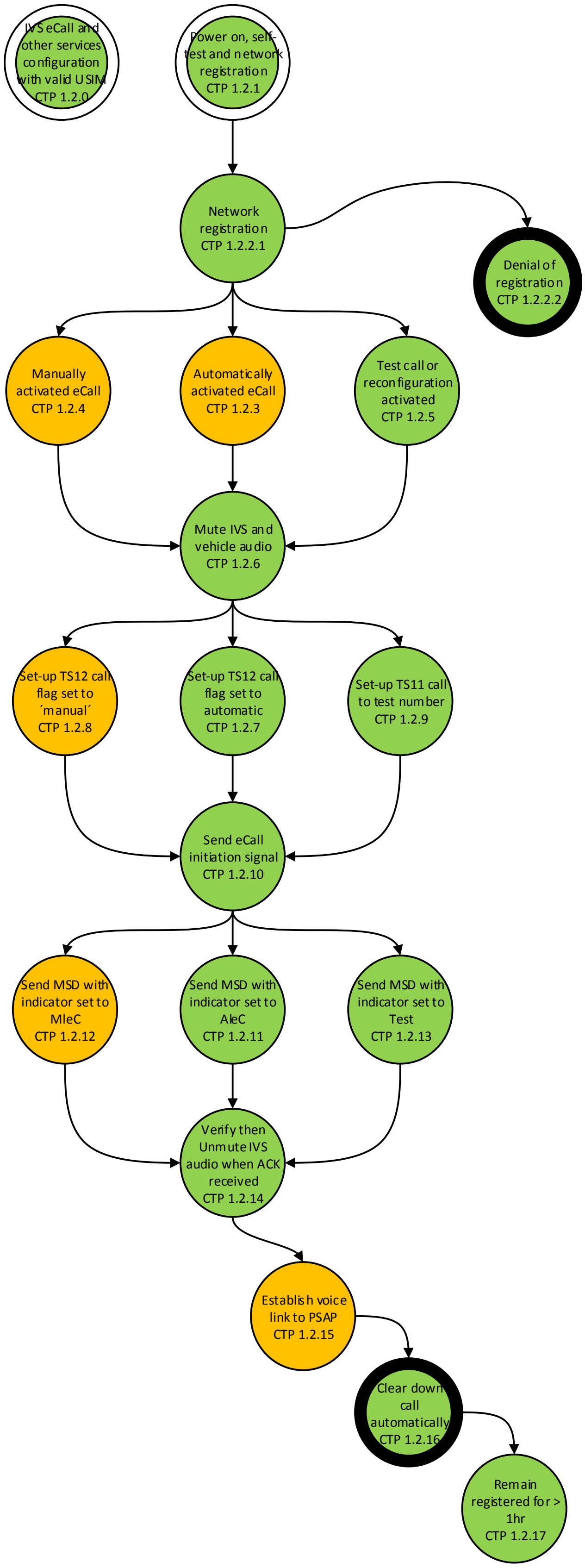

Figure 16: In-vehicle system state transitions- Pan European eCall + other services

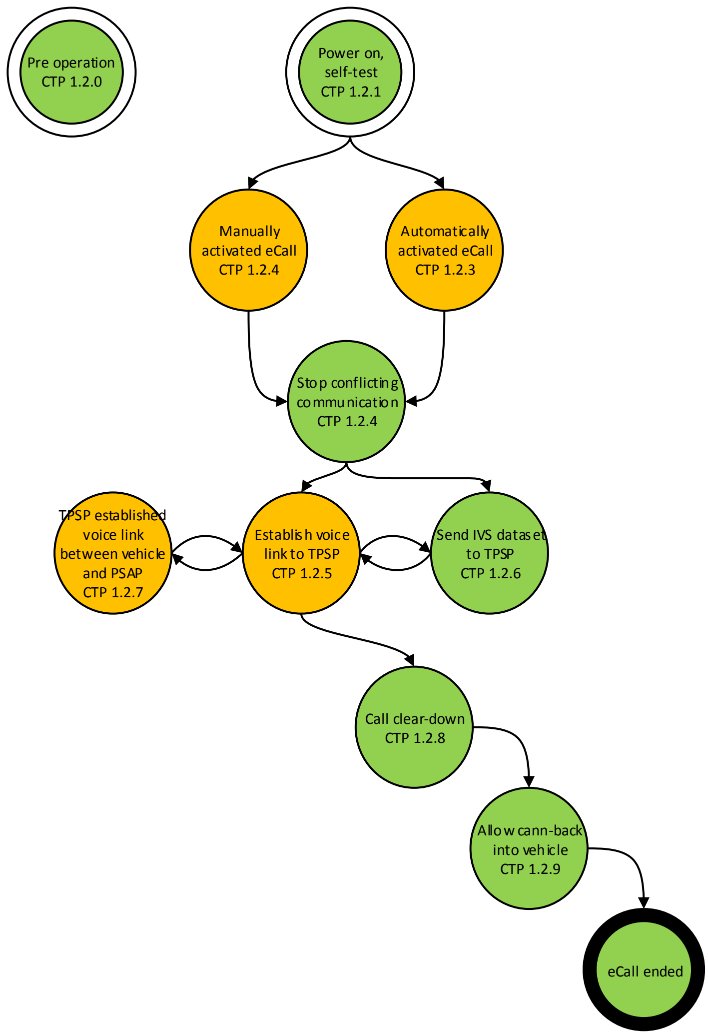

Figure 17: In-vehicle system state transitions — Third party service provider (TPSP) eCall

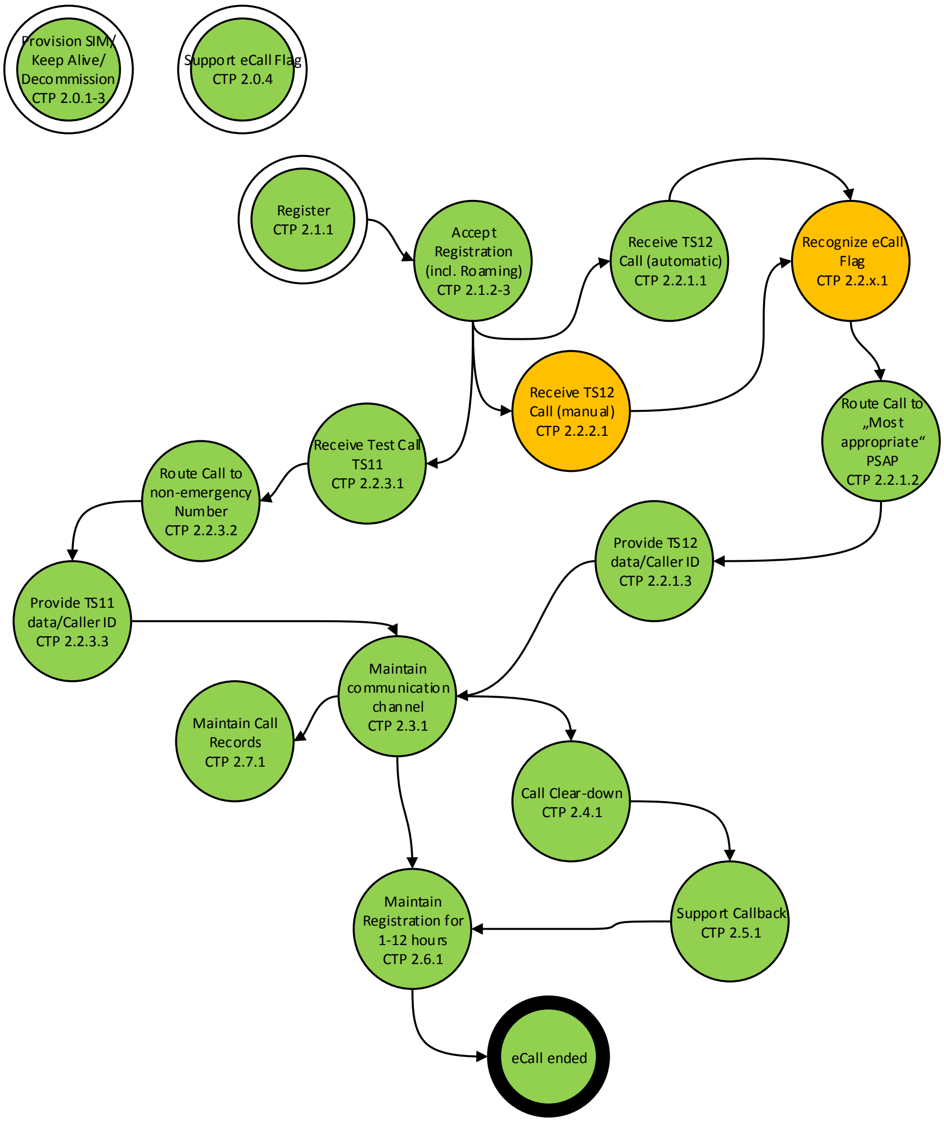

Figure 18: MNO system state transitions

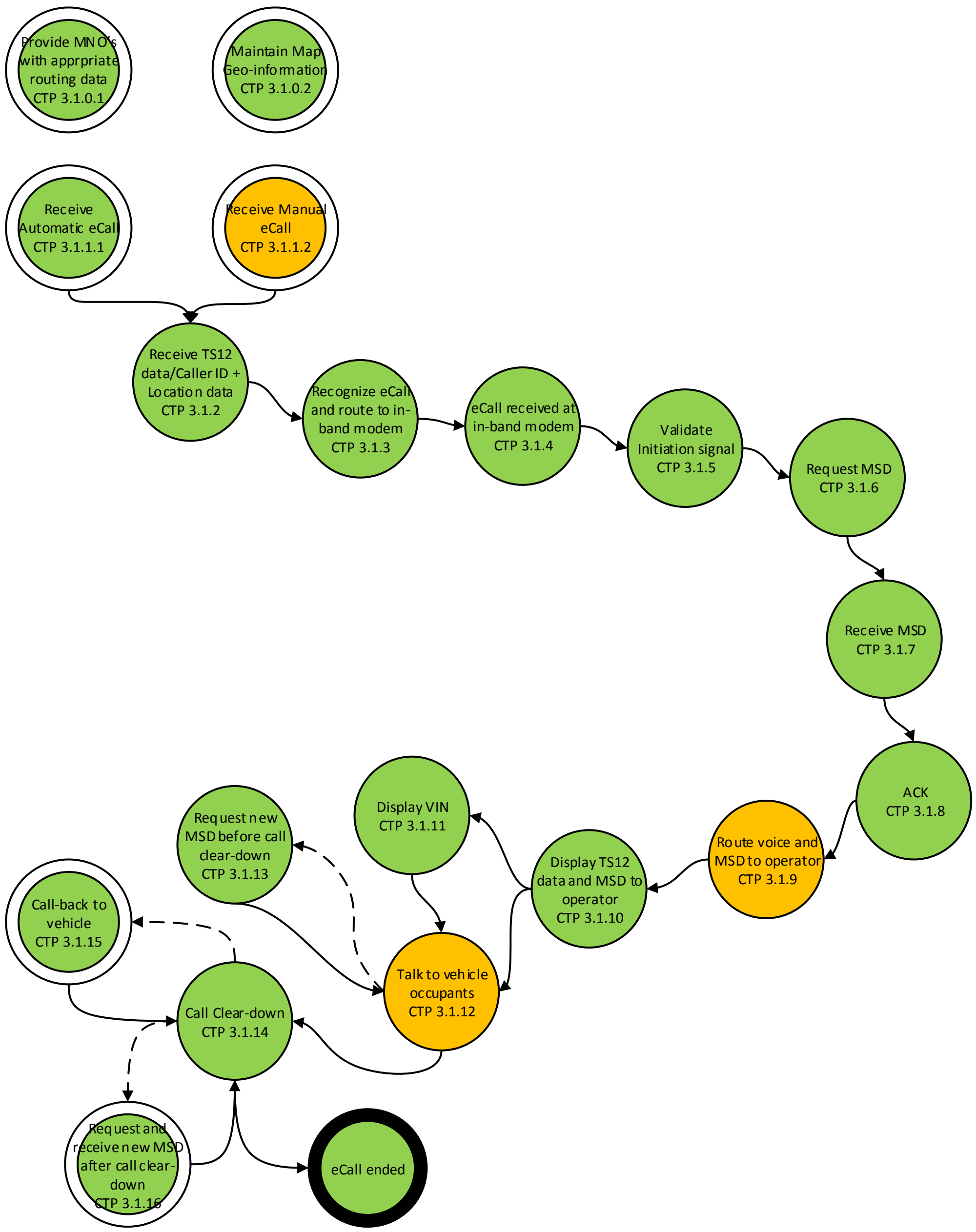

Figure 19: PSAP State transitions- PE eCall

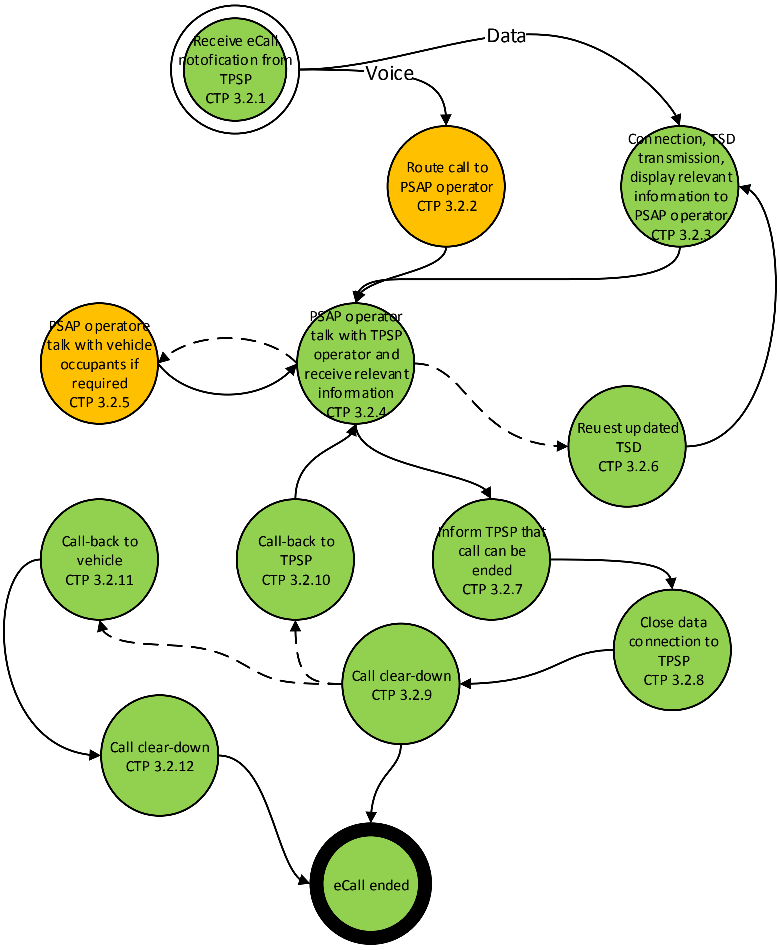

Figure 20: PSAP State transitions- TPS-eCall

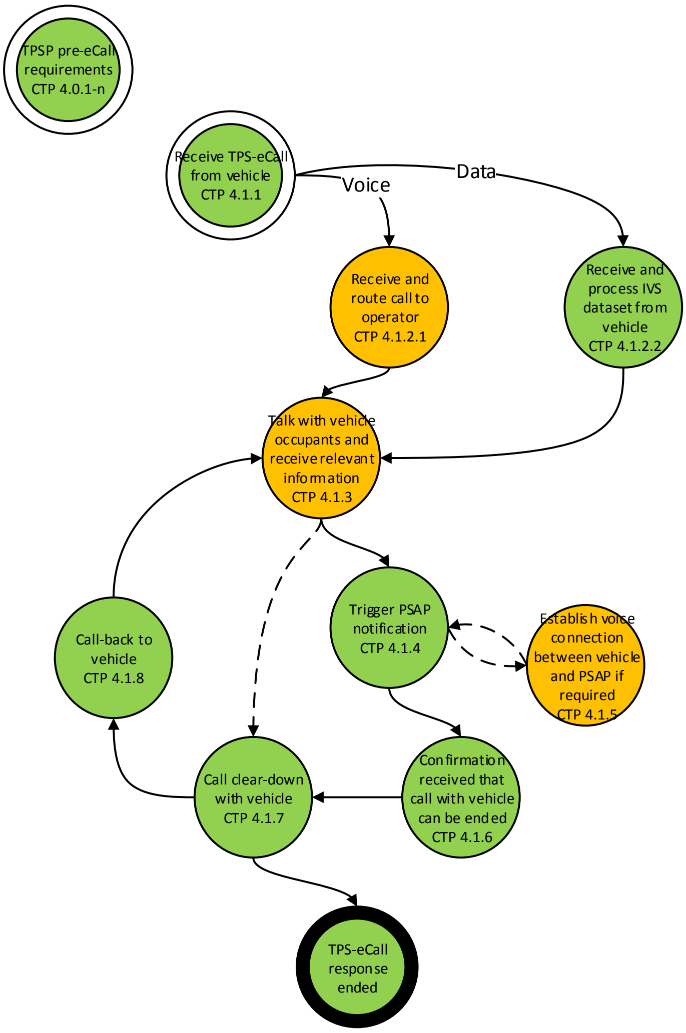

Figure 21: TPS-Responder state transitions

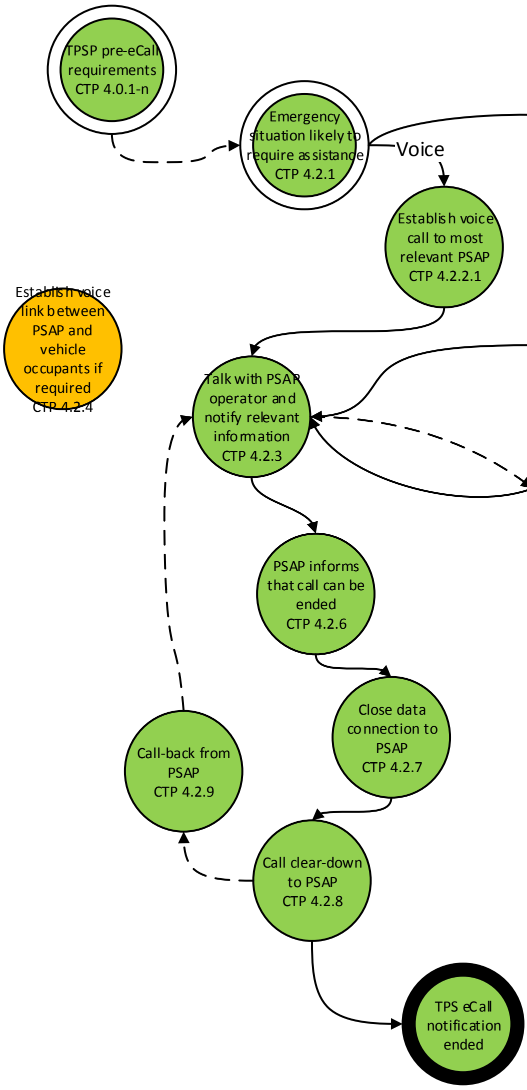

Figure 22: TPS-Notifier state transitions

5.5. M25 – List of parameters in extended MSD

M25 – LIST OF PARAMETERS IN EXTENDED MSD

Harmonised eCall European Deployment

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CONTROL SHEET

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	Name	Date
Prepared	Alfonso Brazalez, Olatz Iparraguirre	
Reviewed		
Authorized		

Circulation	
Recipient	**Date of submission**
Project partners	
I_HeERO Steering Group	
INEA	

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1 INTRODUCTION

1.1 Purpose of Document

The purpose of this deliverable document "M25 – List of Parameters in Extended MSD" is to summarize the results achieved in the sub-activity A3.3 "Data Transmission".

It summarizes the study done by Activity 3 cluster members to define the most suitable parameters to be transmitted through the eCall message taking into account the specific necessities of a Powered Two Wheel Vehicle (P2WV).The Minimum Set of Data (MSD) is already defined and regulated standard for passenger cars, categories M1 and N1 at EN 15722 [1]. The aim of this activity is to study the particular case of the motorcycle and, based on the existing MSD standard, design (if necessary) an extended MSD which would fit the P2W eCall implementation.

The A3.3 sub-activity has been articulated over five different tasks chronologically designed.

1. Definition of additional parameters
2. Definition of the structure of the extended MSD
3. Implementation in the prototypes
4. Integration with next generation eCall
5. Validation with a PSAP

In this deliverable it will be described the followed steps for the definition of the list of parameters for the extended MSD, its validation is still in process.

1.2 I_HeERO Contractual References

I_HeERO stands for Infrastructure Harmonised eCall European Pilot.

I_HeERO is an action under the Grant Agreement number INEA/CEF/TRAN/A2014/103743 and the project duration is 36 months, effective from 01 January 2015 until 31 December 2017. It is a contract with the Innovation and Networks Executive Agency (INEA), under the powers delegated by the European Commission.

<u>Communication details of the Agency:</u>

Any communication addressed to the Agency by post or e-mail shall be sent to the following address:

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For submission of requests for payment, reports (except ASRs) and financial statements: INEA-C3@ec.europa.eu

Any communication addressed to the Agency by registered mail, courier service or hand-delivery shall be sent to the following address:

Innovation and Networks Executive Agency (INEA)
Avenue du Bourget, 1
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TEN-Tec shall be accessed via the following URL:

https://webgate.ec.europa.eu/tentec/

Any communication details of the beneficiaries

Any communication from the Agency to the beneficiaries shall be sent to the following addresses:

For Niedersächsisches Ministerium für Wirtschaft, Arbeit and Verkehr: Michael Schäfer

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2 DEFINITION OF ADDITIONAL PARAMETERS

2.1 Methodology

In this task it was studied which additional parameters could be useful in the Extended MSD for Powered Two Wheelers. For this aim, it is essential to detect the needs of all the subjects involved in the eCall service, from the driver to the PSAP operator. For this reason, the applied methodology starts from the design of different questionnaires that fits with each subject. Afterward, these surveys were analysed to collect the information which is believed to be important for the Extended MSD. Once those possible additional parameters were detected its viability was studied. Finally, Activity 3.3 group reports a list of Parameters for the Extended MSD.

This methodology is summarized in the following schedule:

1) **Research**
   1.1. Focus group definition
   1.2. Analysis of existing questionnaire results
2) **Questionnaires elaboration**
   2.1. Preliminary proposal of additional questionnaires
   2.2. Final version of questionnaires
3) **Data acquisition process**
4) **Analysis**
   4.1. User Needs detection
   4.2. Data Analysis and MSD proposal
5) **Synthesis**
   5.1. Draft proposal of MSD
   5.2. F2F Cluster discussion
6) **Realization**
   6.1. Validation of MSD proposal
   6.2. M1 Parameters in extended MSD

2.2 Research

2.2.1 Focus group definition

The chain of the eCall system was studied for the identification of all subjects who take part on it.

Figure 1 eCall system. Involved people

2.2.2 Analysis of existing questionnaires

A bibliographic study of HeERO1 and HeERO2 projects was done for the research of existing questionnaires and its results.

On the one hand, there were found the operation manuals and the workflow for PSAPs in each countries, which lead to compare and design a general questionnaire that fits with all the architectures.

On the other hand, a long survey is available on the web for P2W eCall end users in different languages. This survey was done in HeERO2 context but it is considered valid for I_HeERO project also. Additionally, the results obtained in the previous phase could be used for this task.

2.3 Questionnaires elaboration

In order to know what additional parameters could be interesting in the MSD, a questionnaire was design for each group depending of their nature and their knowledge about the eCall system.

- OEM & Suppliers: Workers from Yamaha, BMW, and KTM who are involved on this project were asked to fill a **brief survey by e-mail** according to their perspective as an enterprise.

  Available in Annex A

- Users: These questionnaires were collected from HeERO2 project. Motorcycle riders were informed about the impending launch of the eCall system and they were requested to fill **survey available on the web** since it is a large and varied group. They were asked about the information they believe could benefit them in the MSD message could be extracted from their answers.

  Available in Annex B

- PSAP operators: Several emergency call centres from different countries had an **F2F format survey with open questions** where specific information of their proceedings was gathered. Currently they know about the eCall system but mostly all the interviewees had not implemented yet. In the open discussion most of them express their concerns about the eCall regarding false positives calls and what kind of information could let them the certainty of attending those.

Available in Annex C

2.4 Data acquisition process

Four-month period was stablished to gather information from all defined inputs before.

2.5 Analysis

2.5.1 Results of the questionnaires

Users questionnaire

Regarding the questionnaire of the users done in HeERO2 project [2], 636 participants were asked about the accidents they had suffered, the level of acceptance of the eCall service for motorcycles and an open question about their expectations. This last point is the one that provides what kind of parameters could be included in the MSD according to their interests and the results are the following ones:

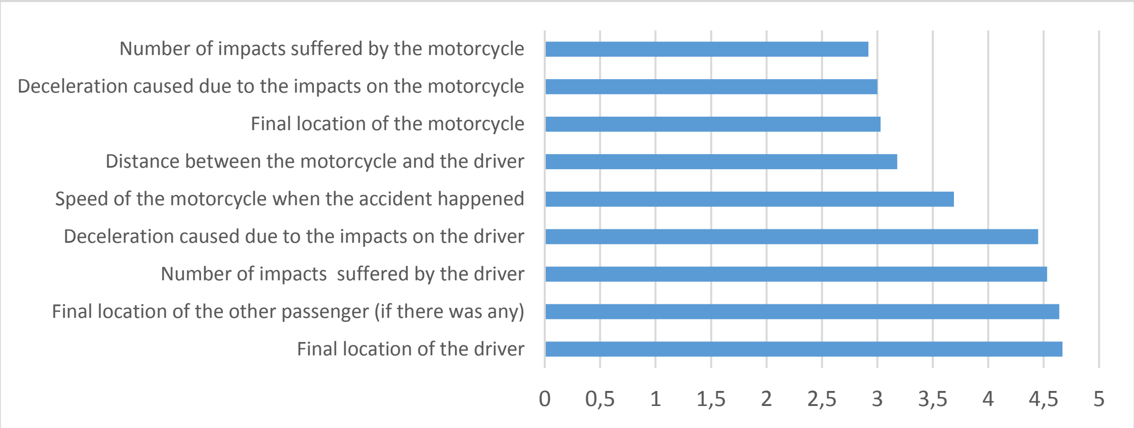


Figure 2. Importance respondents give to different types of information that the eCall service for motorcycles could generate

Therefore the results were grouped into six different proposals:

- Personal data of the driver and passenger (if any)
- Vital signs of the injured users
- Characterization / accident reconstruction
- Environmental conditions at the accident site
- Data after the accident

– Other features

PSAPs questionnaire

Two PSAPs from Spain participate in this questionnaire and when they were asked about the MSD this was their response:

- What additional useful information would you add to the MSD in the case of motorcycle accidents?

Basque Country - 112 Sos deiak see useful information about how many passengers were on the motorcycle at the moment of the accident to save time looking for a "second imaginary participant". The would also like to know an approximate severity range of the accident (measured for example with impact sensors in the motorbike and the helmet) in order to discriminate a false eCall. Other information such as the name of the vehicle owner and the brand of the eCall system manufacturer could be interesting also. To finish with, they ask about having a parameter to know if the eCall system installed in the vehicle had been homologated or not.
"The icing on the cake" would be to have images of the accident as it is already said above.

Murcia – PSAP operators from Murcia think that having the Caller ID number could be very useful since it is not available if the call was routed through a third party telephone operator (for example due to no coverage). Furthermore they see important having some medical info but they point out that this should be defined with extreme care.

OEMs questionnaire

Three motorcycle manufacturers participated in this questionnaire and concerning to the question 'In your opinion, what additional information could be useful to include in the MSD of eCall for motorcycles?' some of them show interest for the severity rate of the accidents and the number of passengers and additionally propose to include information about the voice connection availability.

2.5.2 Analysis of the results

All questionnaires were collected, clustered and analysed for the abstraction of parameters of interest.

USERS	**Medical history**	Identification of allergies, blood type, chronical diseases, etc.
	Biometrical Data	Heart rate, blood pressure, etc.
	Meteorological conditions	Rain, snow, fog, road temperature, slippery road, etc.
OEMs	**System with voice communication present or not**	
PSAP	**Number of passengers**	
	Reliability	Certainty of the emergency call
	Homologation of the HW	
	Owner identification	
OTHERS	**Accident Severity Index related to activity 3.5**	

Table 1. Data Acquisition Results

Firstly, users show interest in monitoring their constants and medical data for a better attention of the first aid services. In addition, they would like to send the meteorological conditions when the accident happens.

Secondly, the OEM questionnaire shows that in its point of view, manufacturers agree to keep the eCall system as simple as possible to ensure its viability. This group, thinks that a flag is needed to know if there is voice connection or not.

Thirdly, PSAP are worried about false positive calls, therefore, they see as crucial parameters the ones that could ensure the feasibility of the call: reliability, homologation and owner identification. In addition, they ask for the number of passengers, which is useful to decide how many ambulances are required.

Finally, in relation with 3.5. Activity group, the Severity index was included as a parameter to discuss.

Therefore, the first MSD parameter draft proposal was the following one:

Focus group	**Parameters**
Users	Medical history
	Biometrical Data
	Meteorological conditions
OEMs	Voice device present
112	Number of passengers
	Reliability
	Homologation
	Owner identification
Others	Severity

Table 2. MSD parameters draft proposal

This table was sent to the members of the P2W Cluster to evaluate the advantages and disadvantages of each variable, and the obtained feedback was the following one:

Parameters	**PROS**	**CONS**
Medical history	– Quick Access to relevant parameter for medical intervention	– Risk of data hacking – Misidentification of the actual driver and/or passenger – No particular advantages because medical history is already available in internet by using authorized access and national health ID – Medical information only available as a single snapshot – No medical sensors mandatory => no standard medical sensors available – No standard for communication technology and protocol =>

		integration possible in a few years (MSD not suitable) – It is not critical for a first AID
Biometrical Data	– Improvement of under triage and over triage	– Cost of sensors – Transfer/duplication of wearable devices/sensors to detect biometrical data – No medical sensors mandatory => no standard medical sensors available – Continuous flow of data transmission not considered in PSAP protocol
Meteorological conditions	– Detection of localized conditions like ice, etc.	– Apparently none because by knowing position we can know meteorological conditions – no meteorological sensors other than temperature available (even not in all models) – temperature is no sufficient criteria – Not useful for PSAP intervention
Voice device present	– Necessary to inform whether the eCall is a min. req. or an extended one (including voice connection) – Mandatory if no voice support available	
Number of passengers	– Useful to organize the rescue activities – Already in MSD	– Cost, because require the installation of a sensor in the passenger seat. – Sensors are expensive
Reliability		– Certainty of the emergency call

Homologation	– Reliability of the overall HW and SW system – Increase security avoiding intrusions	– Not suitable; info will not be updated when bike will be sold in aftermarket
Owner identification	– It could be useful but how to update it in case of different riders on the same bike?	– Owner and rider could be different
Severity	– However, to achieve the needed accuracy biometrical data should be used. If it is already being sent directly to PSAP, which is the meaning to send the IS? – Useful for PSAPs to determine the degree of intervention	– Difficult (impossible?) to define a homologation process. – Unique severity rating necessary for all eCall systems!!!

Table 3. Pros & Cons Feedback for the MSD draft proposal

2.6 Synthesis

A F2F meeting was organised with the P2W Cluster partners for the study of viability of all the parameter presented above. After analysing for and against of the variables, those are the conclusions for the MSD proposal:

MSD Parameter	Decision
Medical history	OAD
Biometrical data	OAD (pending A3.5)
Meteorological Condition	Not to consider
Voice Connection	Mandatory MSD
Number of passengers	OAD
Reliability	Not to consider
Homologation	Out of scope
Owner Identification	Out of scope
Severity	OAD (pending A3.5.)

Table 4. Discussion of MSD proposal. Decisions made.

Finally, I_HeERO P2W cluster considers useful to include Medical history and Biometrical data parameters so as to know the health status of the injured people. The number of passengers in case that the bodies could be thrown from the motorcycle it was considered important to know if the rescue services should search just for the rider or someone else. Additionally and in relation with the Activity 3.5 group, it was taken into account as an OAD parameter the severity level estimation that could be done with a sensor equipped motorcycle. Moreover, the voice connection flag not only was considered interesting but also a potential mandatory MSD parameter.

3 DEFINITION OF THE STRUCTURE OF THE EXTENDED MSD

After the validation of the additional MSD proposal, the structure of the MSD parameters were redefined (note that in the old version of MSD structure (EN 15722:2014 [1]) the number of passengers was already included as a mandatory parameter)

In addition, it is important to point out that, even though the inputs received in the A3.3 T1 questionnaires reflect the necessity to include as Additional Data some personal medical data (medicalHistory and biometricalData) eCall Regulation prohibit to include this kind of information due to privacy concerns.

Therefore, these two parameters would not be considered for the standardisation eCall P2W process and they are not included in this extended MSD structure. For this reason, the proposed MSD structure includes just two modifications for the EN15722 [1] standard: voiceConnection bit as a mandatory parameter in the ControlType field and the severity index as OAD.

MSD				
msdVersion	INTEGER (1..255)	-	M	MSD format version The format described in this document carries version 2 *See 6.1.3 for detailed information.*
Msd				
msdStructure				
messageIdentifier	INTEGER (1..255)		M	Message identifier, starting with 1 for each new eCall transaction and to be incremented with every application layer MSD retransmission following a new 'Send MSD' request after the incident event
Control			M	
automaticActivation	BOOLEAN			true = Automatic activation false = Manual activation
testCall	BOOLEAN			true = Test call false = Emergency
voiceConnection	BOOLEAN			true = Voice connection available false = Voice connection not available
positionCanBeTrustd	BOOLEAN			true = Position can be trusted false = Low confidence in position "Low confidence in position" shall mean that there is less than 95% confidence that exact position is within a radius of ± 150 m of reported position
vehicleType	ENUM			The supported vehicle types are as follows: - passenger vehicle (Class M1) - buses and coaches (Class M2) - buses and coaches (Class M3)

				- light commercial vehicles (Class N1) - heavy duty vehicles (Class N2) - heavy duty vehicles (Class N3) - motorcycles (Class L1e) - motorcycles (Class L2e) - motorcycles (Class L3e) - motorcycles (Class L4e) - motorcycles (Class L5e) - motorcycles (Class L6e) - motorcycles (Class L7e) Vehicle definitions class M, N according to directive 2007/46/EC; class L according directive 2002/24/EC.
VIN[1]	VIN[1]		M	VIN number according to ISO 3779
vehiclePropulsionStorageType			M	*Contains information about the presence of propulsion storage inside the vehicle sending the MSD.*
gasolineTankPresent	BOOLEAN			true = present; false = not present If no information about the propulsion storage is known, all elements should be set to FALSE.
dieselTankPresent	BOOLEAN			
compressedNaturalGas	BOOLEAN			
liquidPropaneGas	BOOLEAN			
electricEnergyStorage	BOOLEAN			
hydrogenStorage	BOOLEAN			

[1] The field is named vehicleIdentificationNumber in the ASN.1 definition. The ASN.1 type VIN is defined in Annex A and codes for a correct representation of the World Manufacturer Index (WMI), the Vehicle Type Descriptor (VDS) and the Vehicle Identification Sequence (VIS) that make up a VIN number, taking into account the preconditions of each part.

otherPropulsionStorage	BOOELAN				
timeStamp	INTEGER $(0..2^{32}-1)$	sec	M		Timestamp of the initial data message generation within the current eCall incident event. NOTE 1 The timestamp is represented in seconds elapsed since midnight January 1st, 1970 UTC. NOTE 2 The initial message generation immediately follows the eCall generation sequence subsequent to a (confirmed) trigger. NOTE 3 Subsequent transmissions within the given incident use the same timestamp, but the messageIdentifier changes. NOTE 4 Failure value for time stamp set to "0"
vehicleLocation			M		*The last known vehicle position determined at the latest moment possible before message generation.*
positionLatitude	INTEGER $(-2^{31}..2^{31}-1)$	milliarcsec			Position latitude (WGS84) calculation example: *48.3003333 = 48°18'1.20" N = 48*60*60.000" + 18*60.000" + 1.20" = 173881.200" = 173881200 milliarcsec* maximum value: 90°00'00.000" = 324000000 minimum value: -90°00'00.000" = -324000000 If latitude is invalid or unknown, the representation of value 2147483647 shall be transmitted. If both latitude and longitude have value 0 then the location shall also be interpreted as invalid/unknown.

				If the transmitter determines either latitude or longitude to be invalid/unknown, then it is recommended to transmit both longitude and latitude as unknown. If the receiver determines either latitude or longitude to be invalid/unknown, then it is recommended to interpret both longitude and latitude as invalid/unknown
positionLongitude	INTEGER ($-2^{31}..2^{31}-1$)	milliarcsec		Position longitude (WGS84) maximum value: 180°00'00.000'' = 648 000 000 minimum value: -180°00'00.000'' = -648 000 000 *See latitude for calculation example and notes.*
vehicleDirection	INTEGER (0..255)	2° (2 degree)	M	The vehicle's last known real direction of travel (expressed in 2°-degrees steps from magnetic north (0– 358, clockwise) determined at the latest moment possible before message generation. calculation example: *due North = 0° = 0 * 2° => 0,* *due East = 90° = 45 * 2° => 45* *due South = 180° = 90 * 2° => 95* *due West = 270° = 135 * 2° => 135* The direction shall be unaffected by random fluctuations of GNSS signals. If direction of travel is invalid or unknown, the representation of value 255 shall be transmitted

recentVehicleLocationN1			O	*Known location of the vehicle some time before the generation of the data for the MSD message.* The recent location shall be chosen such that they could normally assist the receiving party to confirm the current location of the vehicle in different driving environments such as city or motorway.
latitudeDelta	INTEGER (-512..511)	100 milliarcsec		Latitude Delta (+ for North and – for South; WGS84) with respect to vehicleLocation. 1 Unit = 100 miliarcseconds, which is approximately 3m (on Earth) maximum value: 511 = 0°0'51.100'' (±1580m) minimum value: -512 = -0°0'51.200'' (± -1583m)
longitudeDelta	INTEGER (-512..511)	100 milliarcsec		Longitude Delta (+ for East and – for West; WGS84) with respect to vehicleLocation. *See latitudeDelta for details*
recentVehicleLocationN2			O	Known location of the vehicle some time before recentVehicleLocationN1. The recent location shall be chosen such that they could normally assist the receiving party to confirm the current location of the vehicle in different driving environments such as city or motorway.
latitudeDelta	INTEGER (-512..511)	100 milliarcsec		Latitude Delta (+ for North and – for South) with respect to recentVehicleLocationN1. *See recentVehicleLocationN1. latitudeDelta for details*
longitudeDelta	INTEGER (-512..511)	100 milliarcsec		Longitude Delta (+ for East and – for West) with respect to recentVehicleLocationN2.

				See recentVehicleLocationN1. latitudeDelta for details
numberOfPassengers	INTEGER (0..255)		O	Number of occupants in the vehicle according to available information. This information is indicative only as it may be not always reliable in providing exact information about the number of passengers (e.g. because seatbelts may not be fastened by passengers or seatbelts may be fastened for other reasons). If no information about the number of occupants is available, this parameter needs to be omitted or filled with the representation of value 255
optionalAdditionalData			O	
severity	ENUM			Injury severity index. Abbreviated Injury Scale (AIS): -AIS=0 No Injury -AIS=1 Minor -AIS=2 Moderate -AIS = 3 Serious -AIS = 4 Severe -AIS = 5 Critical -AIS = 6 Maximum injury (causes death)

Table 5. MSD parameters list proposed by Activity 3 group

4 IMPLEMENTATION IN THE PROTOTYPES

For the implementation of the extended eCall for P2W vehicles it should be implemented the MSD structure into a motorcycle. There are some steps to follow before final implementation of the defined extended MSD structure into a motorcycle:

1) Definition of the use cases
2) Preparation of a new P2W Schema in ASN.1
3) MSD validation and hardware adaptation

4.1 Definition of the use cases

The defined use cases should include and evaluate all the parameters defined in the tasks above:

4.1.1 Voice connection

The current standard reserves a byte for the Control Type. This parameter is split into three BOOLEAN bits for the definition of the call nature (auto/test) and the certainty of the GPS location and, in the remaining five bits, an ENUMERATED list is allocated for the selection of the vehicle type (see Table 6)

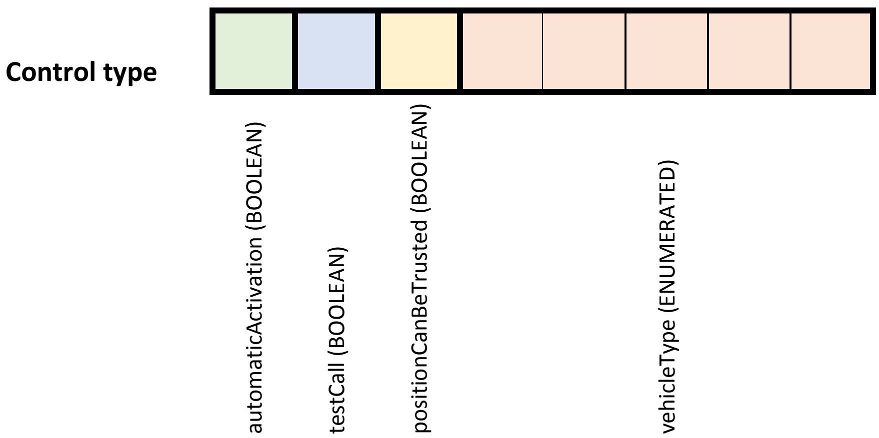


Table 6. Control Type structure (EN 15722 standard)

Nevertheless, in order to inform about the voice device presence and since the defined vehicle type list could be allocated in 4 bits (less than 15 items), the proposal is to include a BOOLEAN bit for the voice connection into this Control type field.

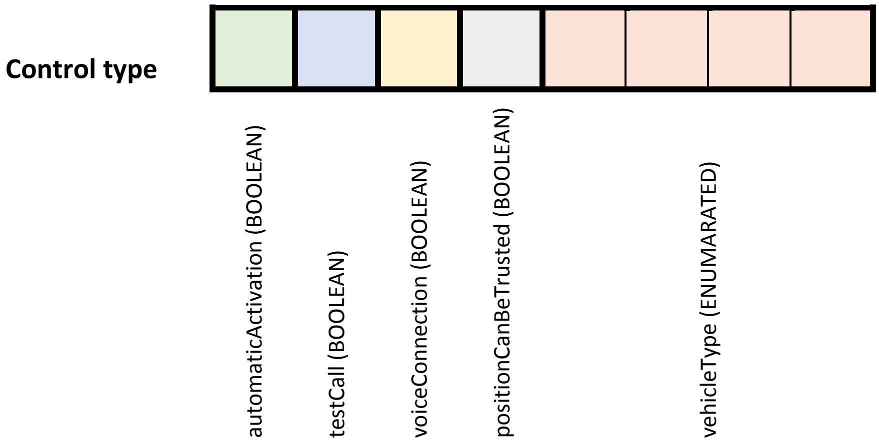


Table 7. Control type structure

4.1.2 Severity

The severity index data would include a scale defined by the conclusions obtained in the Activity 3.5. For the use case definition it is used the Abbreviated Injury Scale (AIS) which goes from 0-6 as it is explained before.

4.2 Preparation of P2W Schema

For the preparation of the Schema it is necessary to follow the EN15722 [1] standard specifications:

[...] The transfer of the MSD for Pan-European eCall using GSM/UMTS (EN 16072/EN 16062) shall be represented in Abstract Syntax Notation (ASN.1) using the 'Unaligned Packed Encoding Rules' (UPER) as defined in ISO/IEC 8825-2, using the ASN1 definitions found in Annex A.

[...]The full eCall MSD, or any optional additional data concept, is preceded by its ISO object identifier. When eCall data is stored or used outside of the eCall context this OID shall be prefixed onto all representations of the MSD or any eCall data concept.

[...] In eCall context, when data is being sent to a specific receiver (e.g. PSAP), the OID may be assumed to be known and is not transmitted. Thus the OID is not transferred over the air between the IVS and PSAP.

[...]

1. identifies the data concept as an ISO parent route standard

0. identifies the arc as being identified by a Standards reference number.

14817. in this case ISO 14817 being the parent standard for ITS data registry

106. emergency-service

2. pre-harmonisation-automated-calls

1. cen-15722

Below this OID three nodes are defined:

*1.0.14817.106.2.1**.1** for 'Mandatory Data Concepts'*

*1.0.14817.106.2.1**.2** for 'Optional Data Concepts'*

*1.0.14817.106.2.1**.3** for eCall data elements*

[...]

eCall has been allocated the OID 1.0.14817.106.2.1. and '2' has been defined to contain 'Optional Additional Data concepts'. So, since The OID for 'Optional Additional Data concepts' (1.0.14817.106.2.1.2) is fixed, it should not be transmitted, for this reason just the last 1.5 is sent in the P2W Schema A.

`P2W Schema A:    1.0.14817.106.2.1.2.`**`1.5`**

Therefore, the construction of the schema should follow the basic contents of the MSD. A summary of the semantic contents of the MSD is shown below:

M – Mandatory data field

O – Optional data field

MSD				
msdVersion	INTEGER (1..255)	-	M	
Msd				
msdStructure				
optionalAdditionalData			O	
OID	RELATIVE-OID			
data	OCTET STRING			

Table 8. Semantic contents of the MSD

And the contents of the optionalAdditionalData block, which are described in the next table:

M – Mandatory data field (ie. mandatory if this encoding scheme is used)

O – Optional data field.

optionalAdditionalData				
OID	RELATIVE OID		M	Fixed value: 1.5
data				*encoded as OCTET STRING*
Severity	ENUM			Injury severity index. Abbreviated Injury Scale (AIS): -AIS=0 No Injury -AIS=1 Minor -AIS=2 Moderate -AIS = 3 Serious -AIS = 4 Severe -AIS = 5 Critical -AIS = 6 Maximum injury (causes death)

Table 9. Optional Additional Data proposal

The whole structure is described in the *Annex D* and *Annex E*.

5 INTEGRATION WITH THE NEXT GENERATION ECALL

Due to the privacy concerns related with the proposed OAD parameters in Task1 (medicalHistory and biometricalData) it has not been possible to address this parameters in I_HeERO project scope. However, it would be interesting to consider including this data for the next generation eCall, so it is proposed to the NG112 group.

In the future, this medical personal data could be treated as a dynamical parameter that changes according to the driver for a shared motorcycle. In addition, accessing to the biometrical data could be a decision of the PSAP, which will be linked, to a database.

6 REFERENCES

[1] *EN 15722:2014, Intelligent transport systems - eSafety - eCall minimum set of data (MSD).*

[2] *HeERO2 Activity 4. D4.3 Final results of the tests with,* 2014.

Annex A

A3.3 T1 OEM Questionnaire

Introduction

Dear OEM or Supplier,

¿Do you know eCall system? eCall is a 112 emergency call triggered either manually by vehicle occupants or automatically as soon as an in-vehicle sensor detects a serious collision. When activated, eCall establishes a voice connection with the relevant Public Safety Answering Point (PSAP). Using the voice line, a Minimum Set of Data (MSD) is sent to the PSAP operator. The most important data is the accurate geo-location of the collision scene, and the exact make and model of the vehicle. Knowing the exact location of the collision is vital allowing the rescue services to arrive much faster at the scene. Time saved translates into lives saved.

This survey has been created by I_HeERO project partners who are working on the eCall implementation for motorcycles. The aim of this questionnaire is to gather information of Suppliers and OEM's perspective about their look into the future for eCall in motorcycles and which parameters could be helpful for them in this context.

Thank you very much for your support.

1. Please tell us a little about your business here.

What is the typology of your company?

☐	Manufacturer
☐	Component supplier
☐	Protective gear supplier
☐	Others (Please, specify)
	Click here to enter text.

Motorcycle's sensors

2. **What kind of sensors could you expect to have in your motorcycles in the future? In this question you can mark what sensors you have nowadays in your motorcycles and future sensors you would like to include.**

	Nowadays	Future
Accelerometer	☐	☐
Gyroscope	☐	☐
GPS	☐	☐
Clock	☐	☐
Velocity	☐	☐
Inclinometer	☐	☐
Compass	☐	☐
Impact sensor	☐	☐
ABS sensor	☐	☐
Stability sensor	☐	☐
Pneumatics pressure	☐	☐
Biometric sensors	☐	☐
Passenger presence	☐	☐
Cameras	☐	☐
Others (please specify)	☐	☐
Click here to enter text.		

In case you have chosen Biometric sensors, ¿which sensor are you referring to? Please, specify.

Click here to enter text.

3. How difficult do you think would be the implantation of the future sensors you have chosen? Differentiate between technological and economic difficulties. Please rate the importance level using a scale of 1 = Not important at all to 5 = Very Important

Future sensor	Technical difficulty	Economic difficulty
Sensor	1 - 5	1 - 5
Sensor	1 - 5	1 - 5
Sensor	1 - 5	1 - 5
Sensor	1 - 5	1 - 5
Sensor	1 - 5	1 - 5
Sensor	1 - 5	1 - 5
Sensor	1 - 5	1 - 5
Sensor	1 - 5	1 - 5
Sensor	1 - 5	1 - 5
Sensor	1 - 5	1 - 5

4. eCall has sensors and communications via SIM that can favour the implementation of other services. Which services would you like to include in your motorcycles?

☐	Anti-theft system
☐	Remote start
☐	Usage profile
☐	User's information service (ie. parking, searcher)
☐	System integration of the fleets
☐	Black box
☐	Mobility data collection
☐	Others (Please, specify)

	Click here to enter text.

5. **How do you estimate eCall could promote your brand image toward the user? Please, rate the importance level using a scale of 1 to 5**

Exceptionally unfavourable	☐	☐	☐	☐	☐	Exceptionally favourable

6. **How do you estimate eCall could promote your brand image toward the PSAPs? Please, rate the importance level using a scale of 1 to 5.**

Exceptionally unfavourable	☐	☐	☐	☐	☐	Exceptionally favourable

Final impressions

7. **Do you think that your users would asses positively to have eCall system? Please, rate your answer using a scale of 1 to 5**

Not at all	☐	☐	☐	☐	☐	Perfectly

8. **Are you planning to introduce eCall in 2018? Please answer YES – NO**

YES - NO

9. **Are you panning that third parties could introduce eCall in your motorcycles? Please answer YES – NO**

YES - NO

10. **Please rate the importance you give to the certification of eCall system from 1 to 5**

Not important at all	☐	☐	☐	☐	☐	Very important

11. **Please rate the importance of having the brand name as part of the MSD information from 1 to 5**

Not important at all	☐	☐	☐	☐	☐	Very important

12. Please rate the importance you give to the false <u>positive</u> eCalls from 1 to 5

Not important at all	☐	☐	☐	☐	☐	Very important

13. Please rate the importance you give to the false <u>negative</u> eCalls from 1 to 5

Not important at all	☐	☐	☐	☐	☐	Very important

14. In your opinion, what additional information could be useful to include in the MSD of eCall for motorcycles?

☐	Severity rate of the accident
☐	Number of passengers
☐	Images of the accident
☐	Others (Please, specify)
☐	Click here to enter text.

Annex B

A3.3 T1 End User Survey

Survey eCall for motorcycles

eCall for motorcycles: the user point of view

From October 2015 all passenger cars in the EU will come with an electronic safety system that, in case of a severe accident, will automatically call the emergency services (112). This system will inform the 112 about the exact location of the accident and will send additional data, such as the number of passengers in the car, the vehicle identification number, etc. shortening the overall rescue time and contributing to save up to 2500 lives a year in Europe.

However, this system won't be initially available for motorcycles!

Within the HeERO2 European project a pilot system for eCall for motorcycles is being developed, and RACC Automobile Club is coordinating a study to investigate the requirements needed to extend the eCall to this kind of vehicles. This study is made in cooperation with the Directorate-General of Traffic in Spain together with other partners of the project.

In order to better understand which specific needs the eCall service for motorcycles should take into account, we would like to ask you, only if you are a motorcycle driver, that you answer the following questions. It will not take you more than 5 minutes and it will be a great source of information for us.

Thank you very much for your cooperation.

[All questions are to be defined as mandatory in the Evalandgo tool]

1. Your gender

a) Male
b) Female

2. Year of birth

(1900/1901/…/up to 1999)

3. Years of driving experience (motorcycle or scooter)
a) 0-5
b) 6-10
c) 10-20
d) 20-30
e) More than 30

4. How often do you drive a motorcycle or scooter?

a) Daily
b) Only weekends, bank holidays or sporadically

5. What kind of motorcycle do you drive most frequently?

a) Custom

b) Enduro / MotoCross

c) Naked

d) Scooter

e) Sport

f) Sport Touring

g) Touring

h) Trail

i) Trial

j) Electric

k) Other: please specify

6. How many km do you usually drive per year by motorcycle or scooter?

a) Less than 1500
b) Between 1500 and 3000
c) Between 3001 and 5000
d) Between 5001 and 10000
e) Between 10001 and 15000
f) Between 15001 and 20000
g) More than 20000

7. Have you suffered any accident that involved the emergency services and/or the traffic police?

a) Yes
b) No

[CONDITIONAL, if answer to question 7. is 'Yes' continue to question 8. if answer in 'No' skip to question 11: be careful to configure this properly in the "Evalandgo" tool]

8. Did you call the emergency services (yourself)?

- **a) Yes, always**
- **b) Yes, in the majority of cases**
- **c) In the majority of cases, No**
- **d) No, never**

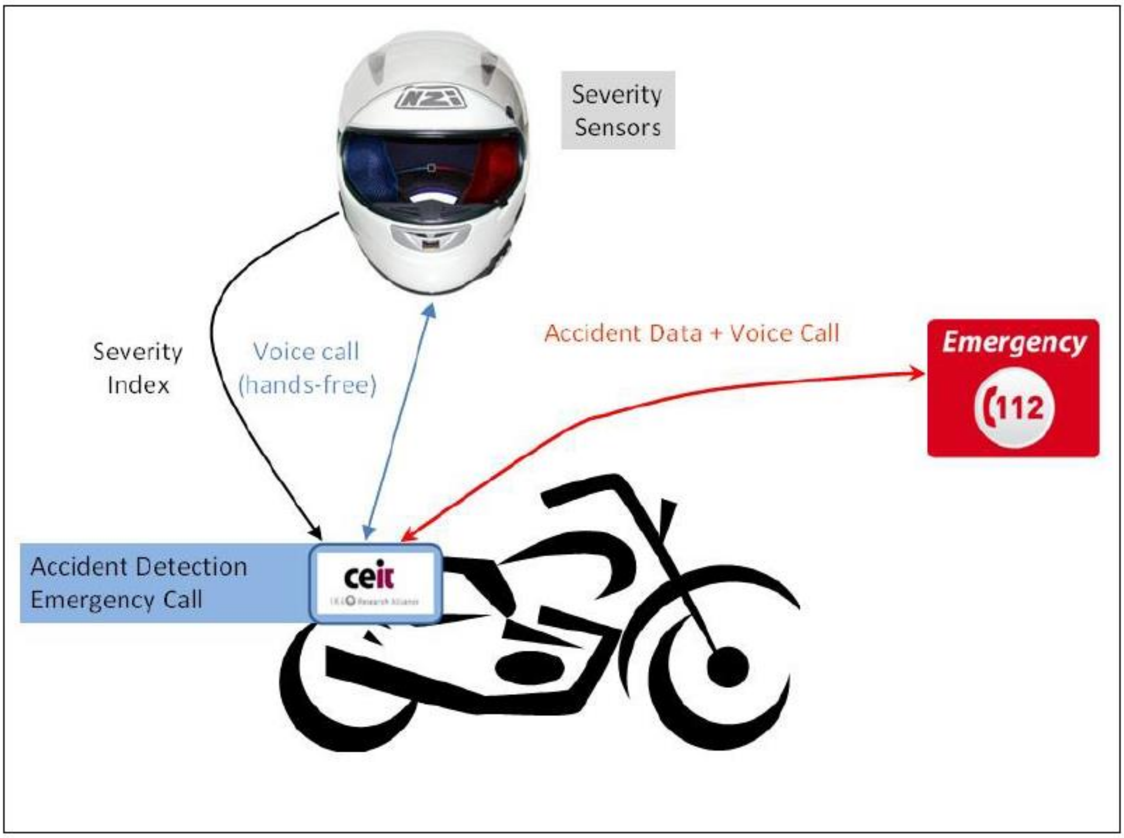
9. How much time elapsed until the emergency services arrived?

- **a) Less than 10 minutes**
- **b) Between 10 and 30 minutes**
- **c) Between 30 and 50 minutes**
- **d) More than 50 minutes**
- **e) I don't remember**

10. The accident was in…

- **a) Urban zone**
- **b) Interurban zone**

In the future eCall service for motorcycles, the motorcycle will have a built-in device able to acquire data from the accident and send it to the 112 emergency services (just like the eCall for cars). Besides, and optionally, if you have an eCall compatible helmet it will be capable of acquiring additional data and send it, together with the rest of data, to the 112. Moreover, the helmet will also allow to automatically establishing a hands-free voice call with the 112.



Now we will ask you some more specific questions about this system…

11. Do you think the eCall for motorcycles would help reduce fatalities and/or injuries caused by motorcycle accidents and, consequently, would you like that your motorcycle or scooter would have this system?

a) I do not agree
b) I partially agree
c) I agree
d) I strongly agree

12. In the prototype system we are proposing, the helmet would have sensors capable of estimating the injuries caused on the driver or passenger (severity of the impact on the head). Besides, the helmet will also help know whether there was an additional passenger in the motorcycle (apart from the driver), determine the final position after the accident, etc.

All this information would also be sent to the emergency services, automatically, in case of accident. For the emergency management, you consider this information as:

a) Not relevant at all
b) A bit relevant
c) Relevant
d) Very relevant

It is estimated that a helmet compliant with eCall will have an extra cost of around 150€ compared with a "conventional" helmet…

13. Would you change your helmet in order to be able to send additional information (about the impact on the head, etc.) and to speak with the 112 after an accident?

a) Yes
b) No

14. You think that the approximate extra cost of 150€ is:

a) Too expensive
b) Expensive
c) A fair price
d) Cheap, considering what the system does

In case of accident, the eCall service will automatically send information about it to the emergency rescue service (112). Among other data, it will send the timestamp and exact location where the accident has occurred.

A motorcycle accident is usually different to an accident involving a car, for this reason it might be interesting to send additional data that are currently not part of the eCall service for cars.

15. Please, rate in a scale from 0 to 5 how important are, in your opinion, the following types of information, where 0 = 'not important at all' and 5 = 'very important'

a) Speed of the motorcycle when the accident occurred
b) Number of impacts (ground, obstacles) suffered by the motorcycle
c) Number of impacts (ground, obstacles) suffered by the driver
d) Deceleration suffered due to the impacts on the motorcycle
e) Deceleration suffered due to the impacts on the driver
f) Final location of the motorcycle
g) Final location of the driver
h) Final location of the passenger (if there is one, and wears a compliant helmet)
i) Distance between the motorcycle and the driver

Please, tell us what other kind of information you would consider useful to be sent (automatically): [free text field] [NOT mandatory]

16. Are you concerned that such a system would have access to your personal data (for example, your location, in case of accident), even if it is a public service?

a) I am not concerned
b) I am a bit concerned
c) I do not know
d) I am concerned
e) I am very concerned

17. If your motorcycle does not have the built-in eCall service… Would you buy and install in your motorcycle an aftermarket device that would be compliant with eCall?

a) No
b) Yes, but only if the total cost of the device (including cost of the installation in my motorcycle) would not exceed 50€
c) Yes, but only if the total cost of the device (including cost of the installation in my motorcycle) would not exceed 100€

d) Yes, but only if the total cost of the device (including cost of the installation in my motorcycle) would not exceed 200€

Annex C

A3.3 T1 PSAP Survey

Interviewer Guide for PSAPs

1. **Explanation of I_HeERO project:**

Explain the objectives of the project

Show the European dimension of the project and its relation to future legislation

Explanation of eCall system if needed

Role of interviewer partner in the project

2. **Explanation of the objectives of the interview:**

Main goal of the interview is to obtain all necessary information from all groups potentially involved in the implementation of a specific eCall for motorcycles that includes specific information for the assistance of these users.

3. **Current PSAP Infrastructure description (Only in some countries)**

Ask if they actually have support for eCall systems.

4. **Information Data flows in the PSAP activity**

It is intended that they explain us the operation of the PSAP itself, since the call is received, how the information is sent to the other groups, how rescue activities are launched, etc. Ask if they are third party actors involved, and in this case, what information is sent to them (outside the PSAP).

5. **Information related to actual calls to 112 on Motorcycle Accidents**

- Try to obtain statistical information on the number of calls received on the 112 service associated with motorcycle accidents

- Try to obtain information on the percentage of motorcycle accidents are received by its location (urban / road / off-road).
- Try to get information on who often make the call, motorbike driver, other users, etc.
- What is the current protocol when motorcycle accident calls are received? Do they differ from other accident calls?
- What information is entered by hand in a motorcycle accident during the call? (Usually obtained in the phone call)
- What tracked back after the call and what information is recorded?
- What information is sent to third parties? courts, insurance, etc. (Own emergency services are excluded)
- Did you plan to send information to third parties in the future?
- Does the service 112 receives information from third parties? (For example medical history, etc)

6. Information associated with the use of eCall in motorcycle accidents

ECall system transmit information in its message and establishes a voice channel with the damaged vehicle.

Explain the contents of the MSD if it is not well known by the PSAP.

- Ask if they actually have a protocol for receiving eCall
- If so, request explanation of the system they have and the protocol they use.
- Is there a protocol in case the voice channel of the eCall is not active or the rider does not respond? If there is not an associated protocol, ask how they will act in they case.

7. Next Generation eCall

Explain what it NG eCall and the differences with standard eCall.

- Does the PSAP planned to implement it?
- Is there any action in this regard?

8. Final Impressions

- After the interview ask about
    - The relevance would you give to the eCall system in general? From 1 to 5
    - and in the specific case of motorcycles? From 1 to 5

- What additional useful information would you add to the MSD in the case of motorcycle accidents?
- Would you like to be informed of the progress of the project?

9. Acknowledgment

Annex D
(normative)

ASN.1 definition of optional datablock

As soon as the OID has revealed the nature of the data as being `P2W Schema A` (using the standard eCall MSD message definition, see EN15722 [1]) the data from the optionalAdditionalData block can be decoded. Either by applying the definition of the datablock to that data (this Annex), or by applying a constituted complete eCall MSD message definition (Annex B).

D.1 Definition of contents of optionalAdditionalData.data `P2W Schema A`

This section contains the ASN.1 definition of the extra data for `P2W Schema A`.

D.1.1 ASN.1 definition

```
MSD_ADDITIONAL_P2W_V2
DEFINITIONS
AUTOMATIC TAGS::=
BEGIN
-- Definition can be used to decode data in the data part
-- optionalAdditionalData in the MSD message.
--
-- can also be used in a constituted definition of an
-- extended MSD definition like so:
--
-- AdditionalData::= SEQUENCE {
-- oid RELATIVE-OID,
-- data OCTET STRING (CONTAINING HGVSchemaA)
-- }
P2WSchemaA::= SEQUENCE {
             severity ENUMERATED{
                    noInjury (0),
                    minor (1),
                    moderate (2),
                    serious (3),
                    severe (4),
                    critical (5),
                    maximumInjury (6),
                    ...           }
}

END
```

D.1.2 Syntax check of ASN.1 definition

```
ASN.1 Studio Version 8.1.1
Copyright (C) 2017 OSS Nokalva, Inc.  All rights reserved.
This product is licensed for use by "Ceit (Trial)", License
"75067Z".

C1310I: No critical errors found, but message(s) were suppressed
due to the compiler's default permissive mode.  Compile with -
noRelaxedMode to see all messages.

ASN.1 syntax check result: C0043I: 0 error messages, 0 warning
messages and 1 informatory message issued.

Compilation summary: The project P2WSchemaA includes 1 PDUs and 0
ASN.1 values
```

D.1.3 Example

The example below is shown in ASN.1 value encoding (plain text):

```
rec1value P2WSchemaA ::=
{
  severity serious
}
```

The same example encoded in UPER (hexadecimal representation, 1 bytes):

```
30
```

Annex E (informative)

ASN.1 definition of complete MSD message with P2W info

ASN.1 has the possibility to include coding rules. Therefor as soon as decoding with the definition from EN 15722 [1] has revealed the OID belonging to `P2W Schema A` , the complete message can be decoded using a constituted decoding scheme. This Annex shows the constituted rules for Schema A. It is informative because EN15722 [1] is normative for the basic part of the MSD message.

E.1 ASN.1 definition of complete extended MSD message, P2W Schema A

```
MSD_ASN1_P2W
-- Definition of the eCall related MSD message in ASN.1
-- Any MSD message will encoded using this scheme, following the
-- UPER encoding rules.
--
-- The MSD message is defined in CEN standard EN 15722.
-- Comments in this definition are taken from that standard. In
-- case of inconsistency in the comment, the text of EN 15722
-- prevails.
DEFINITIONS
AUTOMATIC TAGS ::=
BEGIN
-- Version of this ASN.1 MSD specification
-- (inclusion of this element allows software developers to
-- automatically read out the current version number from the ASN.1
-- compilation for automatic inclusion into the msdVersion parameter
-- of the MSD message, i.e. can reduce the chance of using an ASN.1
-- description of one version but saying it is another)
CurrentVersion::= INTEGER (2)
-- ECallMessage is the top level information element
-- The ECallMessage structure supports only one message type (msd)
-- Extendibility at this level is not allowed, thus ensuring that the
-- msdVersion (message format version) can be extracted directly.
-- Elements:
-- msdVersion: MSD format version
-- The format described in this document carries version 1
```

```
-- msd: Minimum Set Of Data uplink from vehicle
--
-- The OCTET STRING (CONTAINING ...) construct is used to ensure that any
-- implementation can extract the msdVersion value from any version,
-- without decoding errors.
ECallMessage ::= SEQUENCE {
msdVersion INTEGER(0 .. 255),
msd OCTET STRING (CONTAINING MSDMessage)
}
-- The main uplink msd message from the vehicle (excluding msdVersion)
-- Elements:
-- msdStructure: The main MSD structure
-- optionalAdditionalData: Additional data
-- Extendable in future versions at this level e.g. to add extra data
--
MSDMessage ::= SEQUENCE {
msdStructure MSDStructure,
optionalAdditionalData AdditionalData OPTIONAL,
...
}
-- The main MSD structure, excluding additional data
-- Elements:
-- messageIdentifier: Message identifier, starting with 1 for each
-- new eCall transaction and to be incremented
-- with every application layer MSD retransmission
-- following a new 'Send MSD' request after the
-- incident event
-- control: see ControlType
-- vehicleIdentificationNumber: see VIN
-- vehiclePropulsionStorageType: see VehiclePropulsionStorageType
-- timestamp: Timestamp of incident event
-- As seconds elapsed since midnight January 1st, 1970 UTC.
-- Failure value for time stamp set to "0"
-- vehicleLocation: see VehicleLocation
-- vehicleDirection: Direction of travel
-- in 2°-degrees steps from magnetic north
-- (0- 358, clockwise)
-- If direction of travel is invalid or unknown,
-- the value 255 shall be used
-- Only values from 0 to 179 are valid.
-- recentVehicleLocationN1: location delta with respect to
-- vehicleLocation
```

```
-- see VehicleLocationDelta
-- recentVehicleLocationN2: location deltat with respect to
-- recentVehicleLocationN1
-- see VehicleLocationDelta
-- numberOfPassengers: Number of occupants in the vehicle according
-- to available information.
-- NOTE 1 This information is indicative
-- only as it may be not always be reliable
-- in providing exact information about the
-- number of passengers (e.g. because seatbelts
-- may not be fastened by passengers or seatbelts
-- may be fastened for other reasons).
-- NOTE 2 If no information about the number of
-- occupants is available, this parameter needs
-- to be omitted or filled with the representation
-- of value 255
--
MSDStructure ::= SEQUENCE {
messageIdentifier INTEGER(0 .. 255),
control ControlType,
vehicleIdentificationNumber VIN,
vehiclePropulsionStorageType VehiclePropulsionStorageType,
timestamp INTEGER(0 .. 4294967295),
vehicleLocation VehicleLocation,
vehicleDirection INTEGER(0 .. 255),
recentVehicleLocationN1 VehicleLocationDelta OPTIONAL,
recentVehicleLocationN2 VehicleLocationDelta OPTIONAL,
numberOfPassengers INTEGER(0 .. 255) OPTIONAL,
...
}
-- The ControlType is a collection of the following elements:
-- Elements:
-- automaticActivation: true = Automatic activation,
-- false = Manual activation
-- testCall: true = Test call, false = Emergency
-- positionCanBeTrusted: true = Position can be trusted,
-- false = low confidence in position
-- NOTE "Low confidence in position"
-- shall mean that there is less than 95%
-- confidence that exact position is
-- within the limits of a radius of ±150m
-- of reported position
```

```
-- vehicleType: see VehicleType
--
ControlType ::= SEQUENCE {
automaticActivation BOOLEAN,
testCall BOOLEAN,
voiceConnection BOOLEAN,
positionCanBeTrusted BOOLEAN,
vehicleType VehicleType
}
-- Definiton of the vehicle type reporting the incident.
-- NOTE: Vehicle definitions class M, N according directive 2007/46/EC;
-- class L according directive 2002/24/EC
-- Extendable in future versions for new vehicle types
--
VehicleType ::= ENUMERATED{
passengerVehicleClassM1 (1),
busesAndCoachesClassM2 (2),
busesAndCoachesClassM3 (3),
lightCommercialVehiclesClassN1 (4),
heavyDutyVehiclesClassN2 (5),
heavyDutyVehiclesClassN3 (6),
motorcyclesClassL1e (7),
motorcyclesClassL2e (8),
motorcyclesClassL3e (9),
motorcyclesClassL4e (10),
motorcyclesClassL5e (11),
motorcyclesClassL6e (12),
motorcyclesClassL7e (13),
...
}
-- VIN (vehicle identification number) according ISO 3779
-- isowmi: World Manufacturer Index (WMI)
-- isovds: Vehicle Type Descriptor (VDS)
-- Vehicle Identifier Section (VIS) consisting of
-- isovisModelyear: Modelyear from Vehicle Identifier Section (VIS)
-- isovisSeqPlant: Plant code + sequential number
-- from Vehicle Identifier Section (VIS)
VIN ::= SEQUENCE {
isowmi                    PrintableString                          (SIZE(3))
(FROM("A".."H"|"J".."N"|"P"|"R".."Z"|"0".."9")),
isovds                    PrintableString                          (SIZE(6))
(FROM("A".."H"|"J".."N"|"P"|"R".."Z"|"0".."9")),
```

```
isovisModelyear                    PrintableString                    (SIZE(1))
(FROM("A".."H"|"J".."N"|"P"|"R".."Z"|"0".."9")),
isovisSeqPlant                     PrintableString                    (SIZE(7))
(FROM("A".."H"|"J".."N"|"P"|"R".."Z"|"0".."9"))
}
-- VehiclePropulsionStorageType is a collection of elements
-- that contain information about the presence of propulsion
-- storage inside the vehicle sending the MSD.
--
-- For each storage type the following coding applies:
-- false = indicates a type of storage not present
-- true = indicates type of storage which is present
-- The following storage types are supported:
-- Gasoline tank
-- Diesel tank
-- Compressed natural gas (CNG)
-- Liquid propane gas (LPG)
-- Electric energy storage (with more than 42v and 100Ah)
-- Hydrogen storage
-- other storage
-- If the type of energy storage is unknown, then all elements
-- shall be set to false.
-- Extendible in future versions for new fuel storage types
VehiclePropulsionStorageType ::= SEQUENCE {
gasolineTankPresent BOOLEAN DEFAULT FALSE,
dieselTankPresent BOOLEAN DEFAULT FALSE,
compressedNaturalGas BOOLEAN DEFAULT FALSE,
liquidPropaneGas BOOLEAN DEFAULT FALSE,
electricEnergyStorage BOOLEAN DEFAULT FALSE,
hydrogenStorage BOOLEAN DEFAULT FALSE,
otherStorage BOOLEAN DEFAULT FALSE,
...
}
-- VehicleLocation:
-- The current location of the vehicle
-- Elements:
-- Position latitude (WGS84) in milliarcsec
-- 32 bits (4 octets) allocated to make signed value handling easier
-- Real latitude values in 1 milli-arc-second units
-- Valid value range (-324000000 to 324000000)
-- calculation example:
-- 48.3003333 = 48°18'1.20" N
```

```
-- = 48*60*60.000" + 18*60.000" + 1.20"
-- = 173881.200"
-- = 173881200 milliarcsec
--
-- maximum value:
-- 90°00'00.000" = 324000000
-- minimum value:
-- -90°00'00.000" = -324000000
--
-- NOTE 1: if latitude is invalid or unknown,
-- the representation of value 2147483647 shall
-- be transmitted.
-- NOTE 2: if both latitude and longitude have
-- value 0 then the location shall also be
-- interpreted as invalid/unknown.
-- NOTE 3: if the transmitter determines either
-- latitude or longitude to be invalid/unknown,
-- then it is recommended to transmit both
-- longitude and latitude as unknown.
-- NOTE 4: if the receiver determines either
-- latitude or longitude to be invalid/unknown,
-- then it is recommended to interpret both
-- longitude and latitude as invalid/unknown
-- Position longitude (WGS84)
-- 32 bits (4 octets) allocated to make signed value handling easier
-- Real longitude values in 1 milli-arc-second units
-- Valid value range (-648000000 to 648000000)
--
-- see 'Position latitude'
--
VehicleLocation ::= SEQUENCE {
positionLatitude INTEGER(-2147483648..2147483647),
positionLongitude INTEGER(-2147483648..2147483647)
}
-- VehicleLocationDelta:
-- Description of (the delta of) a recent vehicle locatation
-- before the incident
-- Latitude Delta (+ for North and - for South)
-- with respect to vehicleLocation.
-- 1 Unit = 100 miliarcseconds, which is approximately 3m
-- Coded value range (-512..511)
-- representing -51200 to +51100 miliarcseconds,
```

```
-- or from 51,2''S to 51,1''N from the reference position
-- Longitude Delta (+ for East and - for West)
-- with respect to vehicleLocation.
-- 1 Unit = 100 miliarcseconds, which is approximately 3m
-- Coded value range (-512..511)
-- representing -51200 to +51100 miliarcseconds,
-- or from 51,2''W to 51,1''E from the reference position
--
VehicleLocationDelta ::= SEQUENCE {
latitudeDelta INTEGER (-512..511),
longitudeDelta INTEGER (-512..511)
}
-- AdditionalData:
-- Further additional bytes of data encoded as in a
-- seperate ASN.1 definition
-- NOTE: The framework format of this field is defined here,
-- which includes a method to uniquely identify the exact
-- format of the data.
-- Elements:
-- oid: Object identifier which uniquely identifies the format
-- and meaning of the data which follows.
-- data:Transparent optional additional data,
-- according to the format referenced by the oid
-- The user must ensure that the size of this element
-- is restricted to ensure that the total ECallMessage is
-- small enough for the relevant transmission medium.
AdditionalData ::= SEQUENCE {
oid RELATIVE-OID,
data OCTET STRING (CONTAINING P2WSchemaA)
}
-- Several of the elements above are "extendable"
-- according to the ASN.1 standard to facilitate future extensions
-- whilst also maintaining backwards compatibility.
-- Tip for using the extendability marker in later versions:
-- For the extended version put a "," behind the "..."
-- and add new elements ensuring that there is no ","
-- at the end of the list
-- Example: numberOfPassengers,
-- ...,
-- newMsdParameter1 TYPE1,
-- newMsdParameter2 TYPE2
```

```
-- Definition can be used to decode data in the data part
-- optionalAdditionalData in the MSD message.
--
-- can also be used in a constituted definition of an
-- extended MSD definition like so:
--
-- AdditionalData::= SEQUENCE {
-- oid RELATIVE-OID,
-- data OCTET STRING (CONTAINING P2WSchemaA)
-- }
P2WSchemaA::= SEQUENCE {
             severity ENUMERATED{
                   noInjury (0),
                   minor (1),
                   moderate (2),
                   serious (3),
                   severe (4),
                   critical (5),
                   maximumInjury (6),
                   ...
             }
}
END
```

E.2 Example

Given the following UPER encoded message:

```
02 29 5C 06 8C 71 85 28 A1 CF 14 AA EA 1C 00 40
02 3A 05 46 20 AC D2 04 7F 14 E2 2C D2 64 30 B6
00 82 A0 08 78 08 08 04 14 04 C0
```

Decoding with the normal (not extended) rules gives the following result

```
rec1value ECallMessage ::=
{
  msdVersion 2,
  msd
    CONTAINING
    {
      msdStructure
      {
        messageIdentifier 1,
        control
        {
          automaticActivation TRUE,
          testCall FALSE,
          voiceConnection TRUE,
          positionCanBeTrusted FALSE,
          vehicleType motorcyclesClassL1e
        },
        vehicleIdentificationNumber
        {
          isowmi "ECA",
          isovds "LLEXAM",
          isovisModelyear "P",
          isovisSeqPlant "LE02017"
        },
        vehiclePropulsionStorageType
        {
          gasolineTankPresent TRUE
        },
        timestamp 1367878452,
        vehicleLocation
        {
          positionLatitude 18859320,
          positionLongitude 187996428
        },
        vehicleDirection 0,
        recentVehicleLocationN1
        {
          latitudeDelta 0,
          longitudeDelta 10
        },
        recentVehicleLocationN2
        {
          latitudeDelta 0,
          longitudeDelta 30
        },
        numberOfPassengers 2
      },
```

```
      optionalAdditionalData
      {
        oid { 1 5 },
        data '30'H
      }
    }
}
```

Decoding the same message with the extended ruleset gives:

```
rec1value ECallMessage ::=
{
  msdVersion 2,
  msd
    CONTAINING
    {
      msdStructure
      {
        messageIdentifier 1,
        control
        {
          automaticActivation TRUE,
          testCall FALSE,
          voiceConnection TRUE,
          positionCanBeTrusted FALSE,
          vehicleType motorcyclesClassL1e
        },
        vehicleIdentificationNumber
        {
          isowmi "ECA",
          isovds "LLEXAM",
          isovisModelyear "P",
          isovisSeqPlant "LE02017"
        },
        vehiclePropulsionStorageType
        {
          gasolineTankPresent TRUE
        },
        timestamp 1367878452,
        vehicleLocation
        {
          positionLatitude 18859320,
          positionLongitude 187996428
        },
        vehicleDirection 0,
        recentVehicleLocationN1
        {
          latitudeDelta 0,
          longitudeDelta 10
        },
        recentVehicleLocationN2
        {
          latitudeDelta 0,
          longitudeDelta 30
        },
        numberOfPassengers 2
      },
      optionalAdditionalData
      {
        oid { 1 5 },
        data
          CONTAINING
          {
```

```
                severity serious
              }
          }
        }

    }
```

From
CR/AEV1

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Renningen
05 March 2018
Report Number
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R&D Report: **Final Report**

Security Class: Internal
Export control relevant: No
Title: I_HeERO: eCall for powered two wheeler

5.6. M26 – Basic Architecture Recommendations

M26 – Basic Architecture Recommendations

Harmonised eCall European Deployment

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Main author:	Andrea Borin
Dissemination level:	PU
Lead contractor:	Yamaha Motor Europe
Due date:	31/10/2017
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CONTROL SHEET

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Version	**Date**	**Main author**	**Summary of changes**
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0.2 - draft	03/08/2017	A.Borin (Yamaha), T.Tomohiro (Yamaha), S. Riaz (Honda), Y. Kobayashi (Honda), S. Savaresi (Polimi), R. Circa (Bosch), C. Cosyns (Bosch), C. Diglio (Piaggio), A. Georgi (Bosch), A. Dippel (BMW), M. Torlo (BMW)	All contributions integrated
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	Name	Date
Prepared	A. Borin (Yamaha)	16/10/2017
Reviewed	A. Beeharee (Catapult), F. Harnischmacher (KTM)	18/09/2017
Authorized		

Circulation	
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INEA	

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FIGURES

ABBREVIATIONS

ADC .... *Analogue-Digital Converter*
CAN .... *Controller Area Network*
CCU .... *Central Communication Unit*
CPU .... *Central Processing Unit*
DAC .... *Digital-Analogue Converter*
ECU .... *Electronic Control Unit*
GNSS .... *Global Navigation Satellite System*
GSM .... *Global System for Mobile Communications*
HMI .... *Human Machine Interface*
IMS .... *Internet protocol Multimedia core network Subsystem*
IVS .... *In-Vehicle System*
NAD .... *Network Access Device*
OTA .... *Over-The-Air*
PCB .... *Printed Circuit Board*
PLMN .... *Public Land Mobile Network*
PSAP .... *Public Safety Answering Point*
RTC .... *Real Time Clock*
TPSP .... *Third Party Service Provider*
TS .... *Teleservice*
UML .... *Unified Modeling Language*
USIM .... *Universal Subscriber Identity Module*
VIN .... *vehicle identification number*, *Vehicle Identification Number*

TABLES

1 Introduction

1.1 Purpose of Document

The purpose of this deliverable document "M26 – Basic Architecture Recommendations" is to summarize the results achieved in the sub-activity A3.4 "Architecture and Validation".

It summarizes the study done by Activity 3 cluster members to propose the most suitable solution for the eCall implementation in P2W vehicles. This has been undertaken by defining the minimum set of functionalities suitable for the implementation of the eCall function in a P2W and by maintaining close alignment with the already defined and regulated standard solution for passenger cars, categories M1 and N1. The proposed solution considers the requirements from both end users and PSAP as well as the practicalities of the technical implementation of the solution.

The different vehicle and accident dynamics of the P2W vehicle vs. the passenger car requires a solution that is tailored to the P2W vehicle. In addition, given that P2W vehicles can vary largely within the same category (i.e., for L3 we have SuperSport, Touring, Off-road, Naked, Heritage, Sport Scooters, Commuting Scooter and many others) it is necessary to define a "minimum standard" requirement that can be implemented in the various types of P2W vehicles.

The A3.4 sub-activity comprises of five main tasks as shown in Figure 1.

The tasks are linked to other sub-activities and through this interaction, these tasks yield the recommendations for the implementation of an eCall system in a P2W.

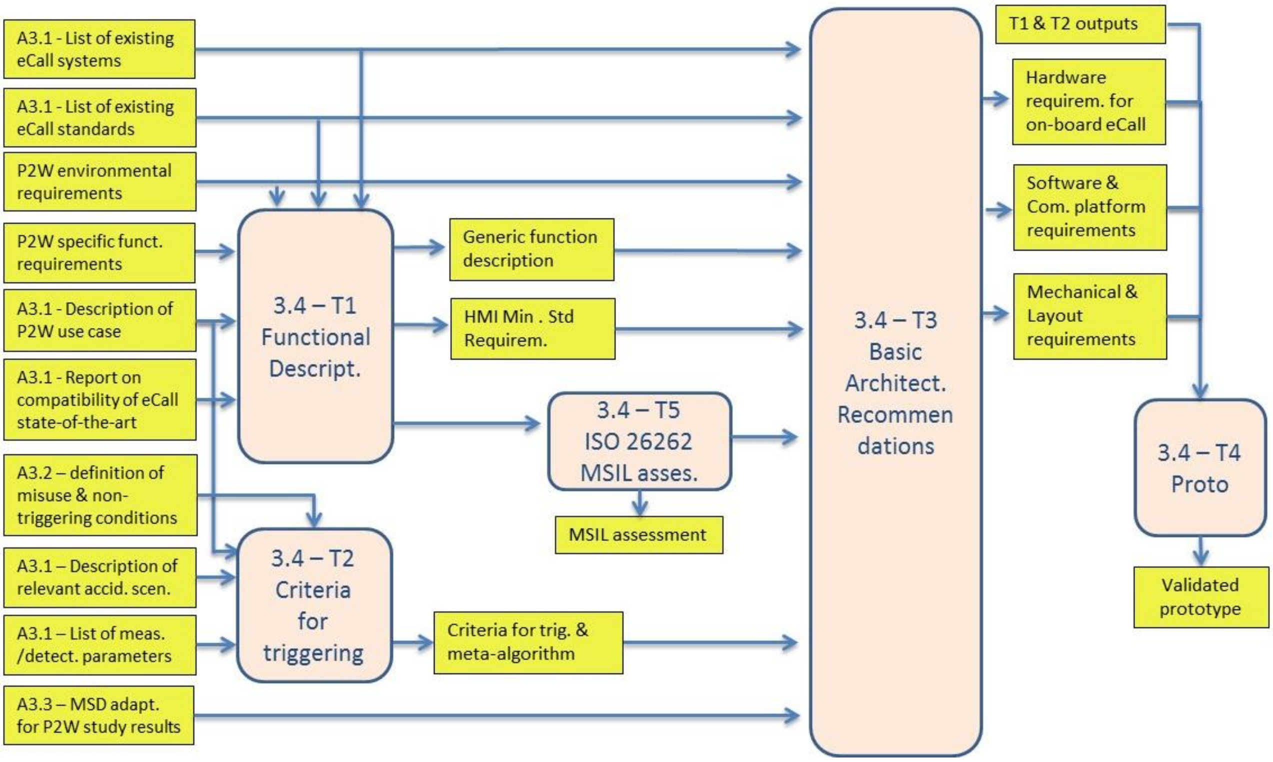

Figure 1 - A3.4 sub-activity task structure

It is worthwhile to underline that the main scope of the sub-activity is not to define the specifics of the eCall system implementation in terms of hardware, software, firmware, etc. In particular, any specific triggering algorithm has been studied and its definition as well as the specific implementation is left to the P2W OEMs or the in-vehicle systems Tier 1.

Figure 2 shows how the sub-activities A3.4 and A3.2 can be considered to follow the classical V-cycle development scheme with the exception mentioned above.

However, in the chapter “Basic Architecture Recommendations” some suggestions for a possible implementation in term of hardware, software, mechanical, … are given.

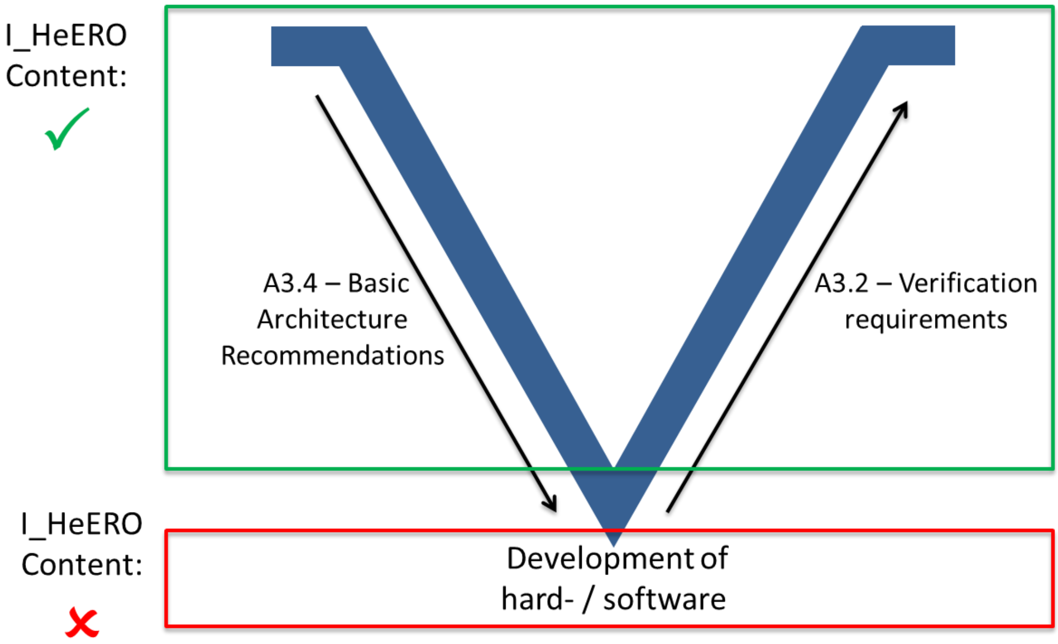

Figure 2 - General structure

1.2 I_HeERO Contractual References

I_HeERO stands for Infrastructure Harmonised eCall European Pilot.

I_HeERO is an action under the Grant Agreement number INEA/CEF/TRAN/A2014/103743 and the project duration is 36 months, effective from 01 January 2015 until 31 December 2017. It is a contract with the Innovation and Networks Executive Agency (INEA), under the powers delegated by the European Commission.

<u>Communication details of the Agency:</u>

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For submission of requests for payment, reports (except ASRs) and financial statements: INEA-C3@ec.europa.eu

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For Niedersächsisches Ministerium für Wirtschaft, Arbeit and Verkehr: Michael Schäfer Friederickswall 1, 30159 Hannover, Germany

e-mail address: iheero@mw.niedersachsen.de

2 Functional Description

The Functional Description has been done by using as reference the EN 16072 (Pan-European operating requirements) [27] which define the behavioural specification of an eCall system for M1/N1 vehicle category and by considering specific issue of the P2W vehicle.

In this analysis, the I_HeERO Act. 3 experts focused on the wide variety of vehicle types that are present in the same P2W category (i.e. L3-category), defining a minimum set of functionalities able to guarantee the required eCall functionalities through a system installed on the vehicle using the vehicles sensors.

The support and connection with external devices (such as helmets, jackets, mobile phone, etc) has not been considered in this analysis being such devices not part of the P2W vehicle.

The Functional Description is composed of four main chapter:

- Chapter 2.1 explains the main differences between P2W and Passenger Cars
- Chapter 2.2 provides the macro-functions overview
- Chapter 2.3 provides more detailed behavioral detail by using SysML language [1]
- Chapter 2.4 presents recommendations for a “minimum requirements” HMI.

2.1 Specific issues of P2W eCall implementation vs. passenger car

To define a behavioural description suitable for an IVS for P2W it is necessary to understand the specifics of a P2W vehicle compared to M1 and N1 class vehicles.
These are:

- The P2W vehicle is an unstable system
- No crash detection systems / sensors available on-board in a P2W vehicle
- The probable separation of the rider & the vehicle due to missing rider/passenger restraint systems
- The crash dynamics of car and P2W are fundamentally different with different injury patterns and severity
- Identification of a fall (with or without collision of vehicle)
- The P2W may not have inherent support for a voice communication available to the rider.

The I_HeERO experts identified several key issues that must be considered when dealing with an eCall for P2W. These issues are explained in detail hereinafter.

2.1.1 Voice connection

In the EN 16072 [27] document it is recommended that an audio connection should be established when possible for the PSAP to get details about the accident and the injury level by talking to the driver who is, usually, inside the cabin of the car following an accident. In the case of a P2W accident (see M22 [2]) the rider is likely to be separated from the motorcycle in most cases, which makes it challenging and in some cases impossible to establish a voice connection.

The following is a list of key reasons for such difficulty.

A. Distance between rider and P2W after accident. The chart below shows the post-crash distance of the rider from the P2W in 310 eCall relevant cases (IS2+, meaning need of hospitalization). In 70% of the cases the distance is 3m or more. In 50% of the eCall relevant cases, the rider has no or limited ability to walk to his P2W vehicle following the crash, meaning a mandatory voice connection would be, to a large extent, redundant.

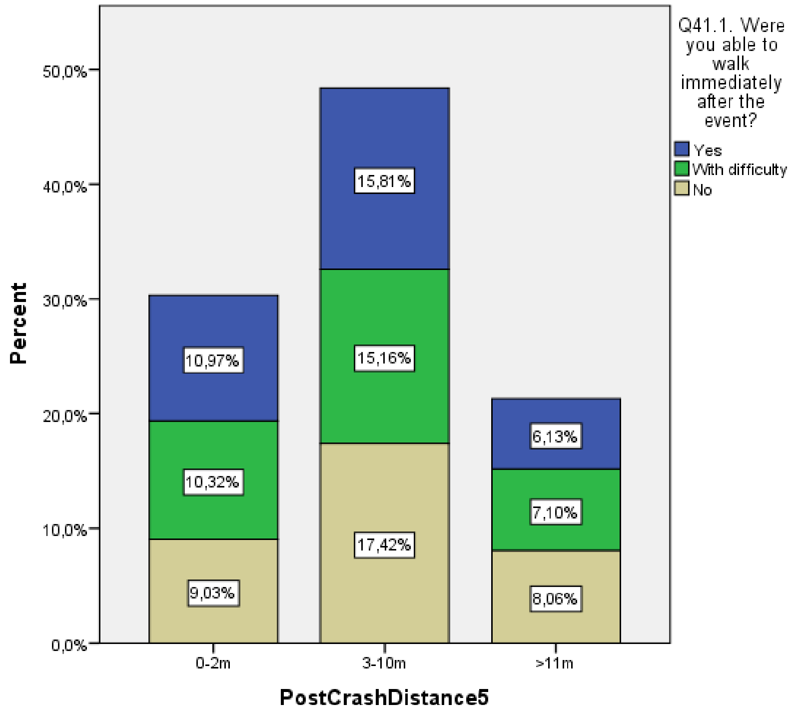


Figure 3 - post-crash distance from I_HeERO user survey

B. For a good reception of voice, it is important to have a minimum distance between the microphone/speaker and the rider and the sound quality would depend on direction of microphone and final position of the rider. Moreover, the microphone installation should be considered carefully in order to avoid its breakage during the accident risking to compromise the function when it is needed. Indeed, the equipment is ‘exposed’ to the outside world as opposed to the car where it is inside the habitat.

C. Due to the vertical structure of a motorcycle it is very complicated to define the most suitable installation (layout) for the microphone/speaker. For instance, in M22 [2] it has been described that in case of accident almost 50% of the case P2W finish by falling on the right side and 50% in the left side. This significantly reduces the possible location for the speaker installation to difficult or almost impossible areas of the P2W.

D. Sound tests and studies done by companies specialized in acoustics have shown that the effects of helmet wearing reduce even more the rider ability to perform a voice call with the PSAP. Additionally, many riders wear ear protection which would limit further an ability to communicate effectively.

E. Technical effort to implement a system on board: Many motorcycles do not have similarly convenient structures that allow for uniform performance and mounting positions of microphone and speakers.

F. Reliability over time of exposed microphone/speaker H/W has not been verified.

G. External devices (such as Bluetooth earpieces), as expressed at the beginning of Chapter 2, are considered out of scope of the project requirement.

Therefore, I_HeERO Activity 3 experts would like to recommend that Voice Connection (VC) should not be mandatory but only optional. When the rider is able to walk, he can return to the P2W and use the suppression function (explained later). In case he/she is unable to walk then the automatic eCall sending is justifiable.

To avoid the situation where the PSAP waits for a voice connection when it is not present from a P2W, an indicator flag within the MSD is highly recommended. The possibility to have a different vehicle type parameter in MSD could be a good solution to avoid changing the mandatory part of the MSD.

2.1.2 Manual eCall trigger

The manual trigger is one of the basic functions included in the EN16072 [27] standard and implemented in current eCall for passenger cars (M1/N1 vehicle categories).

However, Activity 3 experts concluded that any system that includes a manual trigger MUST have a voice connection in order to allow the user to justify the manual triggering to the PSAP - thus reducing the unwanted false calls.

By considering the recommendation made for the voice connection function applied to P2W eCall and to avoid accidental eCall testing and misuse, Activity 3 experts recommend only to have Manual Triggering as optional in the minimum requirements of the P2W eCall specification.

We recommend this to reduce false and prank eCalls, due to possible misuse of manual trigger button given that on P2W it would be accessible to anyone, that would lead to a potentially dangerous waste of emergency resources.

2.1.3 Pre-warning and suppression

In case of P2W, the link between vehicle impact and severity of injuries is hard to establish due to the high probability of separation of rider and P2W. For instance, a rider may suffer severe injuries even if the vehicle is lightly impacted – and vice versa.

Due to the difficulties in determining the precise injury level in every accident scenario, a so called "Pre-warning" time has been introduced, allowing an eCall to be suppressed by the rider during the triggering phase before it is sent to PSAP. This is expected to limit the number of false calls. If real injury level of rider is lower than triggering conditions estimated by the eCall system, the process can be suppressed by the simple pressure of the dedicated suppression button.

The chart below shows the volume of accidents by reporting and injury level. This shows that 84% of IS0 and 48% of IS1 accidents (see [8] for injury severity classification) would benefit from the pre-warning and suppression function. In these cases, approximately 50% of accidents do not need urgent medical rescue.

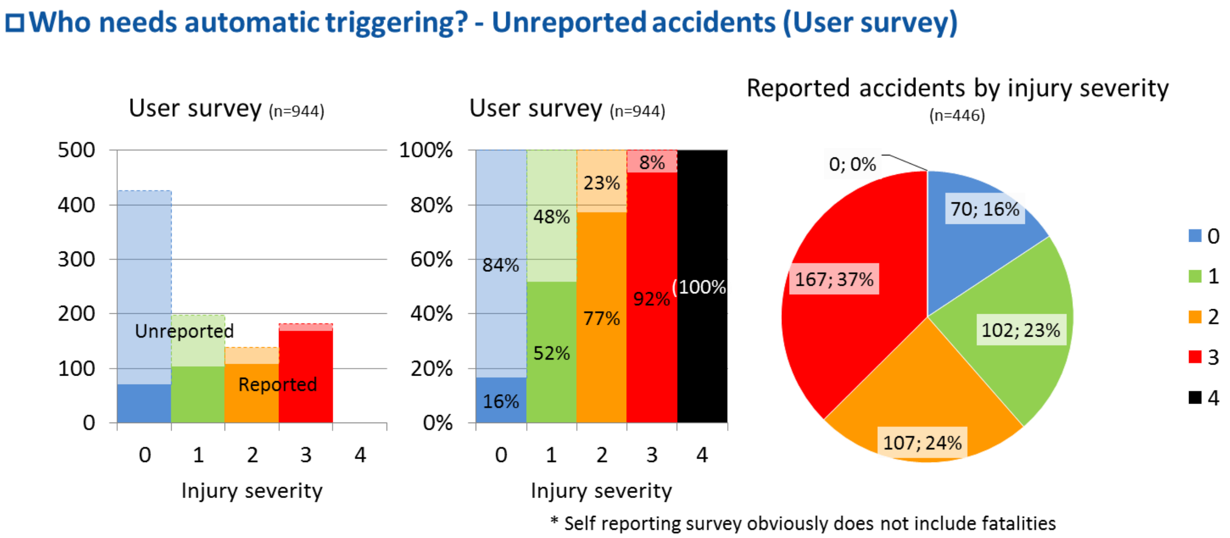


Figure 4 - Reporting Accidents and Injury Severity – I_HeERO user survey

Furthermore, from the I_HeERO end user survey of over 2000 European motorcycle riders, there were two main negative aspects about a P2W eCall system. 72% agreed with the statement of "False Activation" as a negative point and 50% agreed with the statement "in case of an accident that is not serious". Therefore, it is important to have an eCall system that is not overly sensitive to a simple low speed fall over in parking area or campsite for example.

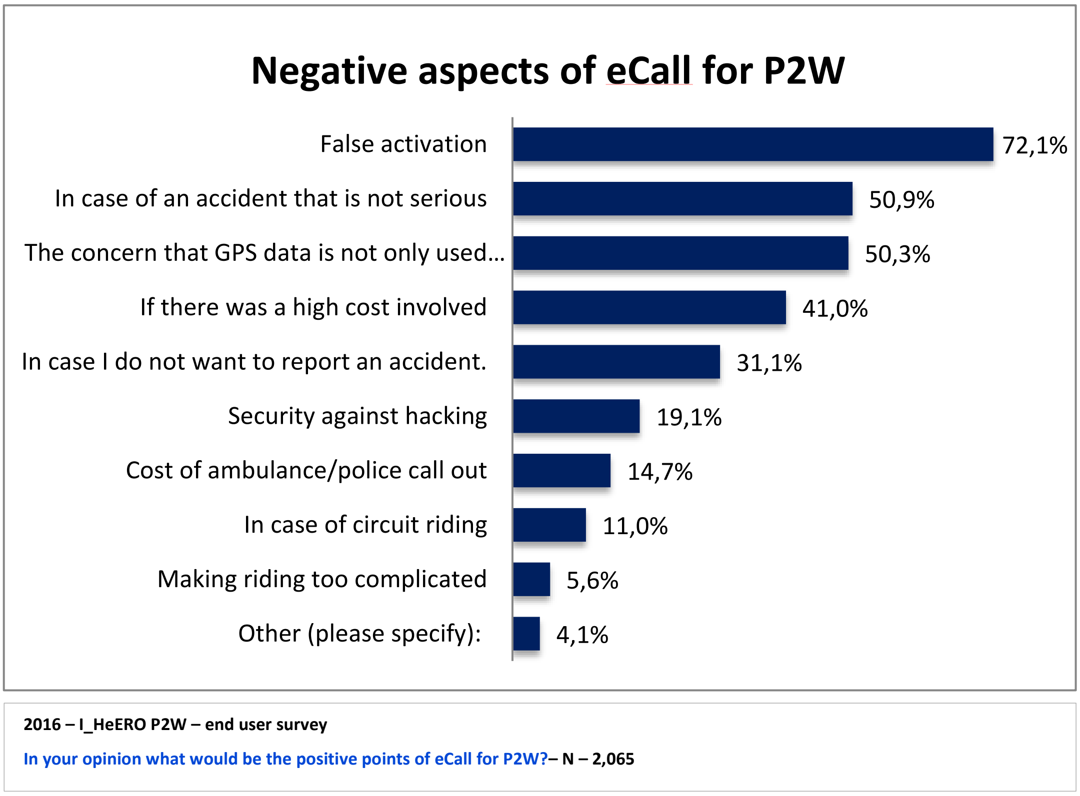


Figure 5 - Negative aspects of a P2W eCall system – I_HeERO user survey

For the above reasons, the I_HeERO Activity 3 experts concluded that a pre-warning time of 20 to 30s will be helpful to both end user and PSAP to avoid unnecessary false eCalls. While the precise pre-warning time definition is left to each implementation, our recommendation is not less than 20s. Further studies can be carried out to adjust the pre-warning time in accordance to the severity of the accident. Thus, a really sever case could result in an immediate eCall trigger without pre-warning.

How does it work?

The pre-warning is always activated when an accident condition potentially requiring an eCall is detected by the sensors and elaborated by the triggering algorithm. During this pre-warning phase, the rider is notified with visual and auditory indications that an eCall is ready to be launched. The rider can then decide to suppress the eCall by pressing the dedicated button (within the pre-warning phase) if he realizes that rescue from the emergency services is not necessary. However, if injury level is high and rider requires emergency services assistance, he can just wait until the end of pre-warning and the eCall will be automatically launched. The rider will be aware that the call has been launched with another specific visual and auditory feedback (see chapter 2.4 for details).

2.2 Macro-functions

This section presents the main functions – known as macro-functions – that a P2W eCall IVS must perform.

The main functional reference is the current standard EN 16072:2015 [27] and the 3GPP, ETSI TS 122 003 V8.0.0 (2009-02) [28] for the communications functions. These have been defined by the I_HeERO P2W experts to meet the usage requirements for the P2W vehicle.

Based on the explanation presented in the previous chapter, the macro-functions description does not include the voice connection and the manual trigger. However, it covers the pre-warning concept as well as a specific HMI (see chapter 2.4).

Figure 6 identifies the so-called "Minimum Requirements", which represent the minimum set of functions necessary to guarantee an eCall for a P2W vehicle.

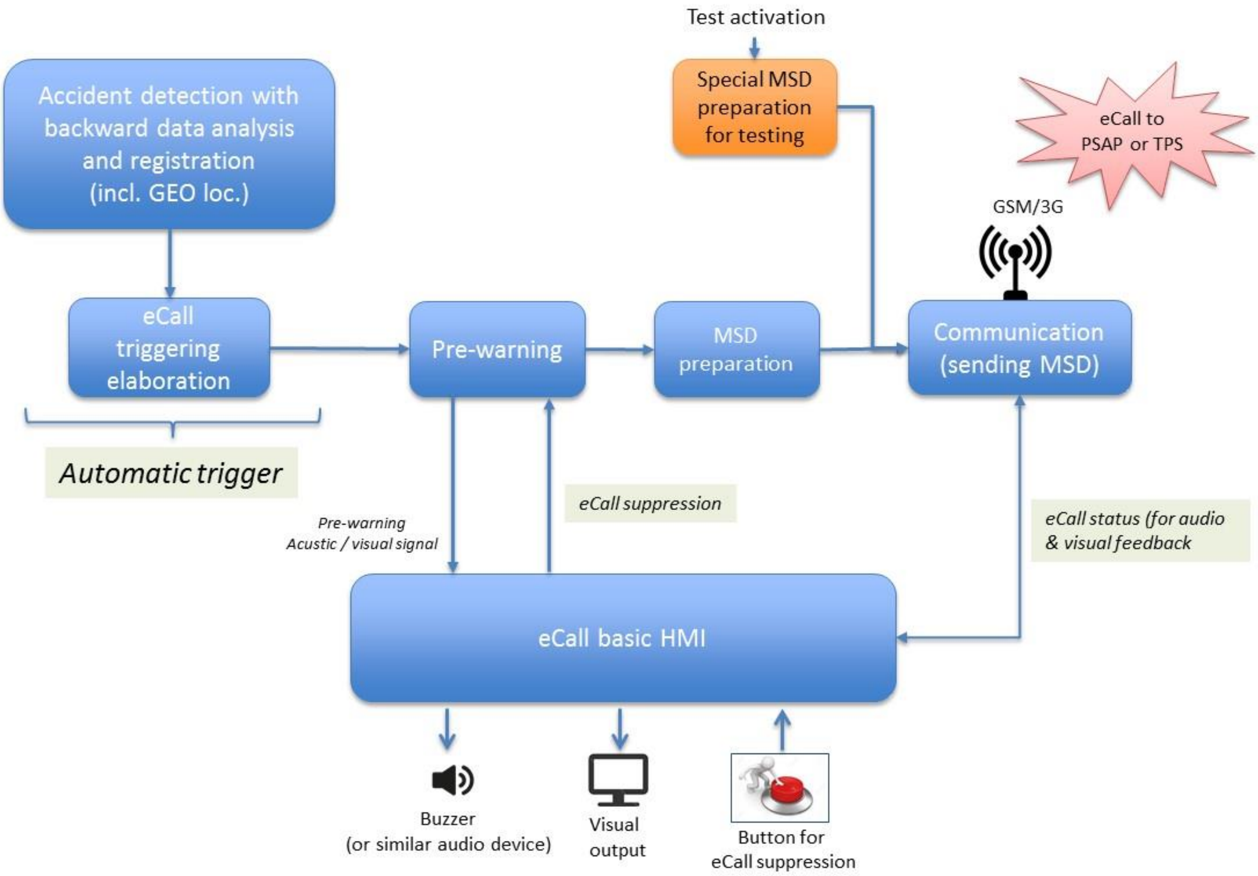


Figure 6 - Macro-function of the P2W eCall

Based on Figure 6, the following main steps can be identified in the P2W eCall sequence:

1. Automatic trigger detection - by using IVS and vehicle's sensors detect the conditions for triggering an eCall, the IVS prepares the geo-localization information and gathers information for the MSD.
2. Pre-warning – before launching the eCall, the IVS waits for a period between 20 to 30s. During that time, the rider can choose to suppress the call sequence if he/she feels the injury level does not require rescue.
3. eCall launch, Communication – after pre-warning time has elapsed, the eCall is generated - starting with the data communication with the PSAP or a TPS. The call progress can no longer be interrupted by the rider.

For all the three steps, a specific HMI is activated as described in chapter 2.4.

2.3 SysML modelling

2.3.1 Introduction

The Systems Modelling Language (SysML) is a general-purpose modelling language for engineering systems. SysML supports the analysis, design and verification of complex systems including hardware, software, information, personnel, procedures, and facilities in a graphical notation. SysML provides graphical representations based on a semantic foundation for modelling system behavior, requirements, structure, and parametrical elements which are used to integrate with other engineering analysis models using the OML XML Metadata Interchange.

It has been chosen for the purposes of this document due to its clarity in presenting functional descriptions which include block diagrams, activity diagrams, state machine diagrams, etc.

2.3.2 Model and description chart-by-chart

The Figure 7 shows the main “actors” involved in the eCall process. These actors are mainly the rider (and eventually the passenger, not included in the chart for simplicity), the P2W vehicle and the PSAP (or TPS) operator. When an accident occurs, the actors interact in a pre-defined pattern based on the current eCall standards adapted by I_HeERO Act. 3 to P2W specificities.

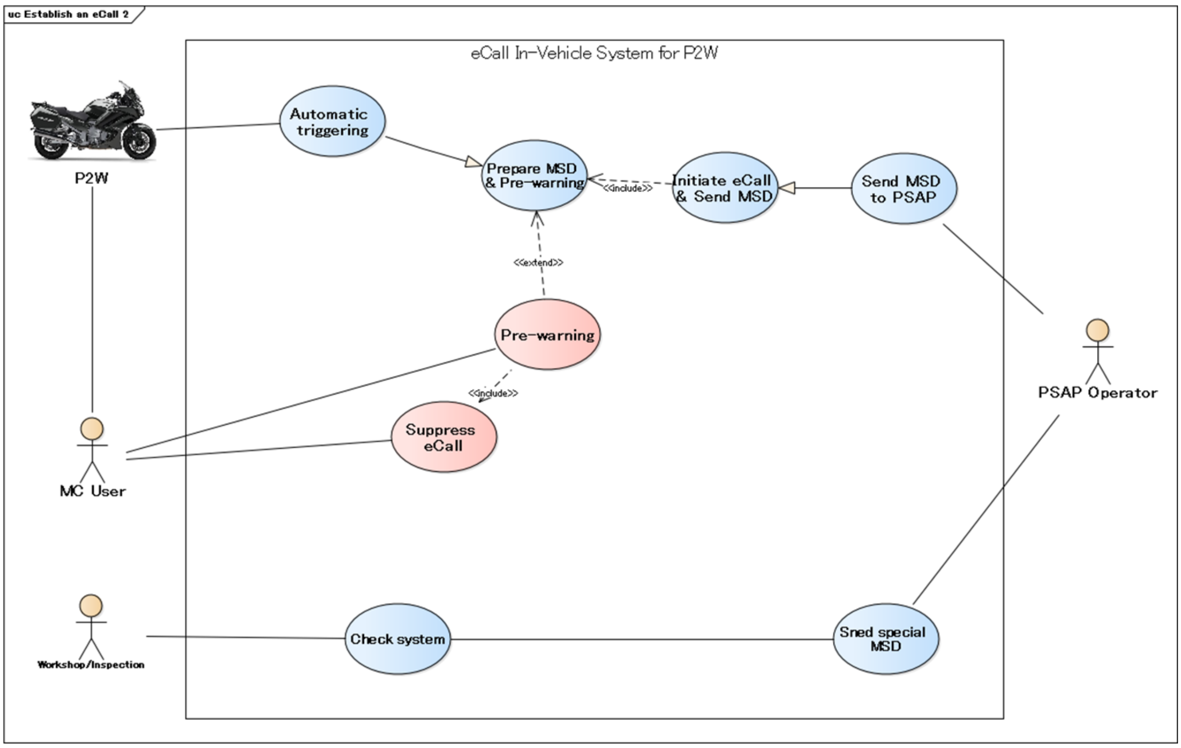


Figure 7 - Usecase diagram of eCall IVS

The diagram in Figure 8 shows the Top State Machine describing the top-level system behavior.

The eCall system is activated by the Main Switch (Key status). Only when it is in “ON” position the system is active while when it is switched in “OFF” position the system becomes inactive unless an eCall is in progress.

The system has two main states: an “Idle Mode” state in which it monitors the sensors to check if an accident has occurred and the “Initiating eCall and Sending MSD” state which is entered when an accident has been detected.

The system can return to “Idle Mode” only if the eCall process is completed (terminated by PSAP) or if the suppression has been requested by rider.

When in “Idle Mode” state, the system can be requested to enter a “Test” state to execute a test sequence for diagnostic purposes (not described in this document).

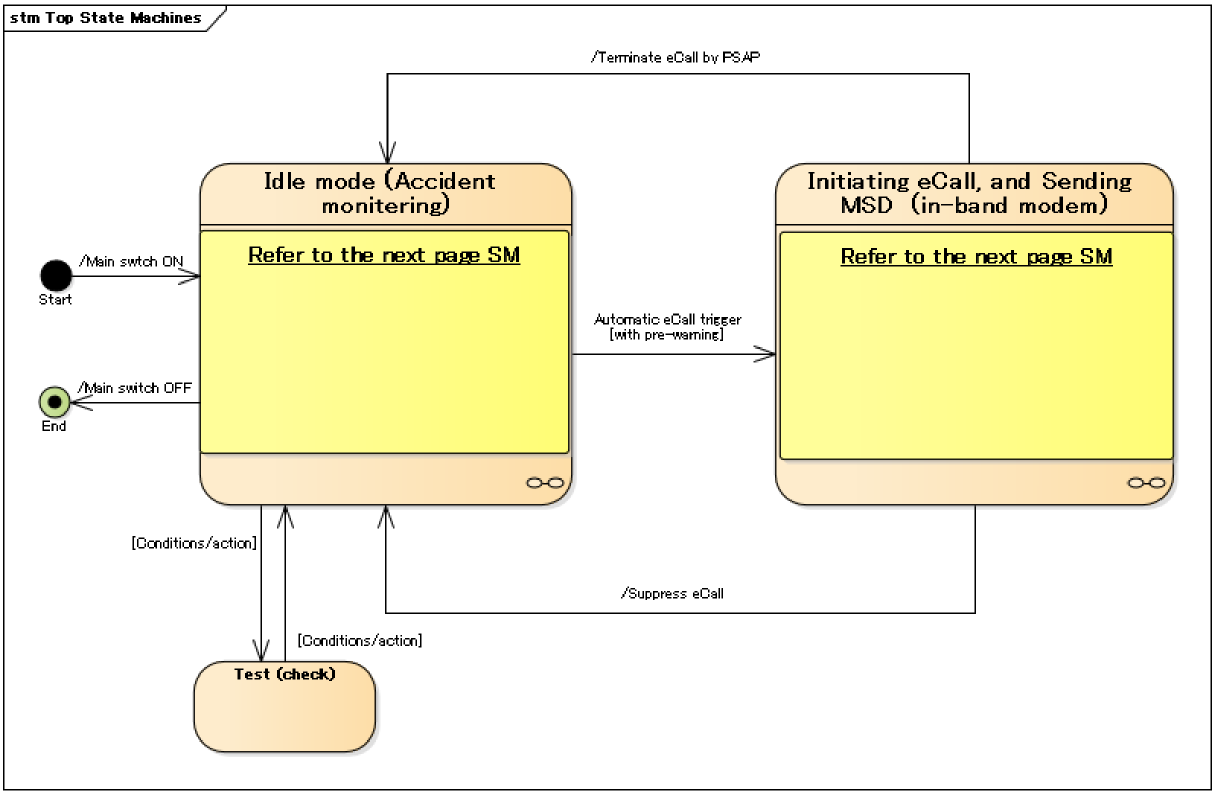


Figure 8 - Top state machine of IVS function description

Figure 9 shows the “Idle Mode” state including the accident monitoring which “decides” if an automatic eCall should be triggered or not. The accident detection is performed by the triggering algorithm as shown in Figure 10. The diagram in Figure 10 refers to the “meta-algorithm” explained in detail in chapter 4.

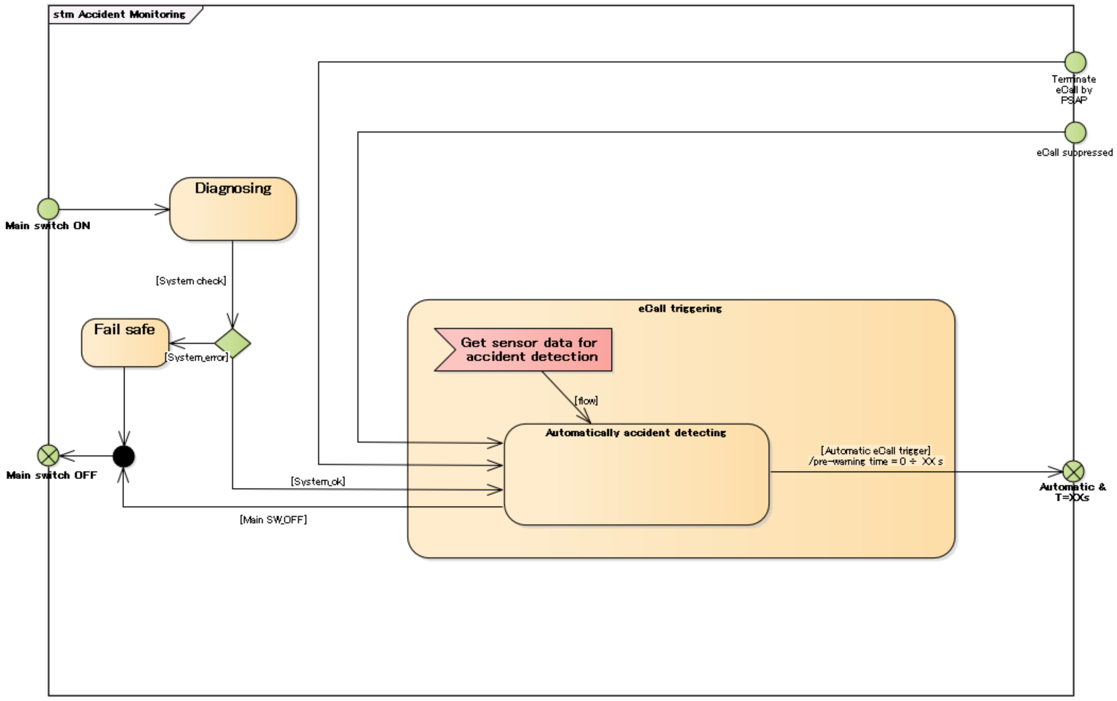


Figure 9 - Idle mode state machine

The "Idle Mode" includes a "Diagnosing" state: after the main switch is set in the "ON" position, the system performs a self-check and proceeds to the "triggering" (monitoring) mode if there are no failures detected. If a failure is encountered, the system enters a "Fail Safe" state whereby the eCall function is disabled and the warning light is turned ON to inform the user that the eCall function/service is not working.

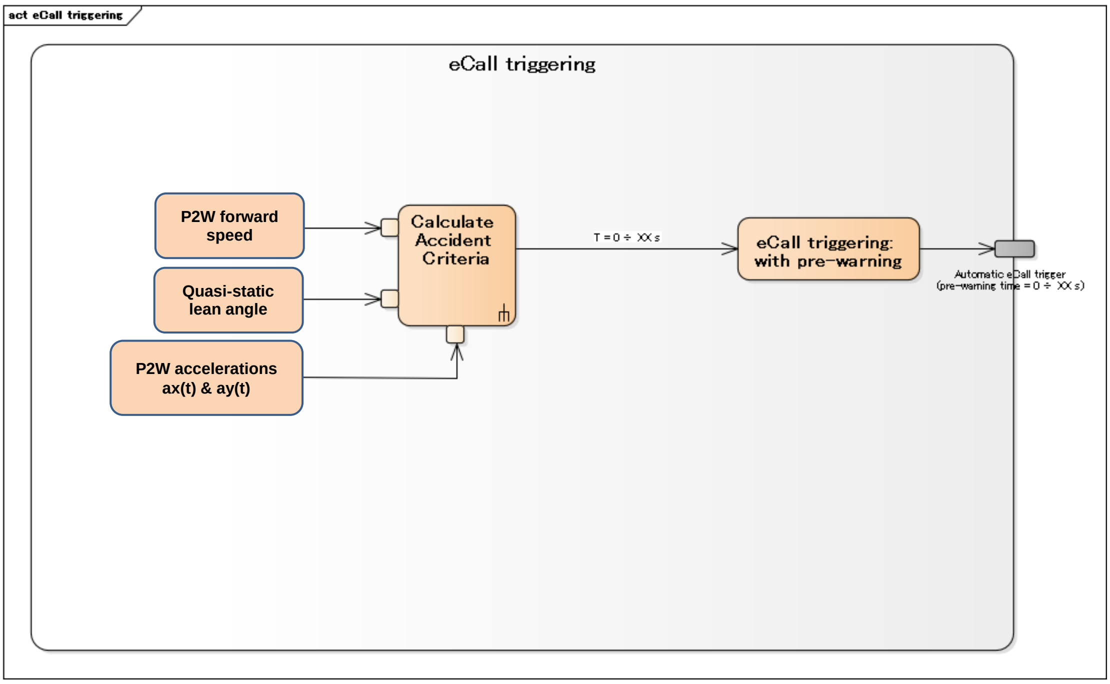


Figure 10 - Automatic accident detecting

Figure 11 shows the second main state of the system. In this state, an automatic eCall trigger has been generated by the meta-algorithm and the system has entered the “pre-warning” state where the user has the opportunity to suppress the call.

The duration of the pre-warning phase is left free to each implementation (in the model indicated 0÷XXs). However, the recommendation of I_HeERO Act. 3 experts is to set this time in a range from a minimum of 20 to a maximum of 30s. This time has been evaluated to be sufficient to determine the injury level by rider itself and decide to proceed with suppression or not.

If the pre-warning time expires and no suppression is requested by the rider, the MSD is prepared and sent to PSAP (or TPS) following existing standard.

When the communication sequence with the PSAP is completed, the eCall is terminated and the system can revert back to its “Idle Mode” state.

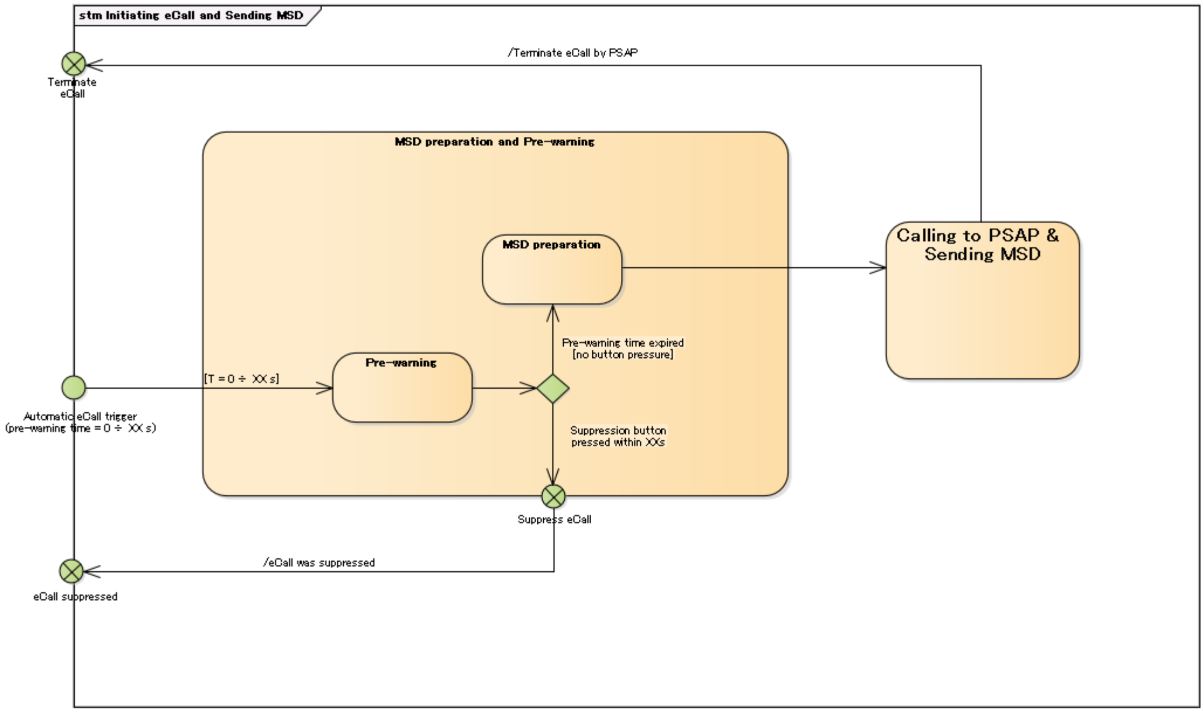


Figure 11 - Initiating eCall & Sending MSD State Machine

2.4 eCall HMI

The efficiency of the eCall for P2W (in its minimum requirements configuration) is strongly linked to the HMI defined by I_HeERO Act. 3 experts. The HMI provides clear audible and visual information to the rider regarding the status of the system. For example, by considering the probable separation of rider and bike, it is important that the rider on the ground with serious injuries is assured that an eCall is in progress by an audible and simple sound.

The purpose of this document is not to define with extreme detail how the audio and visual feedback must be provided.

However, as a minimum requirement, the experts consider the use of a simple audio generator (i.e. a buzzer) and a simple indicator (i.e. a LED tell-tale) as shown in Figure 12 to be adequate.

#	STATUS	Audio and visual feedback	
		Audio (i.e., buzzer)	Visual (i.e., LED telltale) eCall
1	IDLE (Accident Monitoring) & eCall system diagnosis = OK	Nothing	OFF
2	IDLE (Accident Monitoring) & eCall system diagnosis = NG	Long noise (ex. 3s or more)	ON
3	Accident Detected → pre-warning	High rate sound (synchro with blinking)	High rate blinking
4	Accident Detected → Automatic eCall launched	Double long sound	Low rate blinking
5	Suppression by pushing button	Single long sound (feedback on button pushing, less than 3s)	OFF
6	Termination by PSAP	Nothing	OFF

Figure 12 - eCall HMI (audio and visual) recommendation

Alternatively, similar audio and visual feedbacks can be provided through a more sophisticated UI (i.e., a TFT display for visual). However, I_HeERO Act. 3 experts recommend that the same logic is used to achieve harmonisation between different eCall HMIs from different OEMs.

There are no specific recommendations for suppression button. However, it should be ensured through careful implementation to minimise the risk that the button is pressed accidentally and that only an intentional action from the user leads to the suppression.

3 Criteria for triggering

3.1 Toward the P2W eCall

According to the European Standard (ref – EN16072) an eCall is "an emergency call generated either automatically via activation of in-vehicle sensors or manually by the vehicle occupants". The automatic IVS triggering method is not specified within the standard, however an example given (6.10.1) could be the signal generated by an airbag control module.

Studies into the triggering of an airbag have been published in 1998 [4] and later in 2005 [5] prior to the first motorcycle airbag introduction to market in 2006.

This first series production motorcycle airbag was applied to the Honda GL1800. However at the time of writing this is the only model with an optional airbag fitment – the vast majority of P2W's do not have airbags fitted.

While the triggering system employed for motorcycle airbag was focused specifically to frontal impacts it is clear that motorcycle eCall would also require detection of accidents where the motorcycle might not have a direct frontal impact at all (eg. a lateral or rear end collision or detection of a "run off"/"low side" accident).

This creates complexities in assessing the suitable triggering criteria. Consider the following scenarios:

- A crash with a concrete wall versus a low side crash (the former accident is a hard-physical impact whereas the latter can be a "slide-away" of the wheels).
- Vehicle dynamics in high-speed accidents versus low speed accidents can be very different.
- The separation of the rider from the motorcycle.
- There can also be significant injuries to riders in low speed accidents.

Furthermore, if the system makes an eCall in a situation where it is not required, this could lead to reduced trust in the system itself. Therefore, it was considered most important that the target for the eCall triggering should be the satisfaction of the system for both user and PSAP. The target for motorcycle eCall should be to detect accidents for users that require urgent medical assistance, i.e. those that have life-threatening injuries.

In order to realise the benefits of a motorcycle eCall for all stakeholders within a reasonable timeframe and effort, it was considered that it would be better to propose a system that could reach the market faster while achieving the key objectives of a P2W eCall system. For this reason, a simplistic solution was considered based on key variables within an in-depth accident database.

3.2 Statistical criteria for development of P2W accident detection

One of the issues is the use of new technologies for detecting accidents. At this time of writing, high precision sensor technologies are still in development despite wide spread adoption of sensors via popular apparatus. It is still very difficult to detect accident and injury with a high degree of accuracy. For the purpose, of this study it was decided to target a level of accuracy for accident detection similar to that in automotive AACN application [6].

Conceptually, the criteria for triggering the eCall requirement can be expressed as in Figure 13, below.

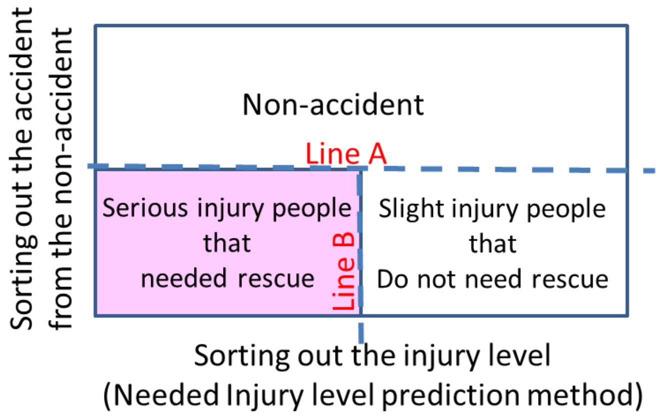


Figure 13 - Defining the Accident and Injury requirement

Additionally, there are two kinds of errors that exist in Injury Prediction. Figure 14 below shows the prediction matrix.

		Actual injury	
		Serious	Slight
Prediction result	Serious	True Positive	Over Triage**
	Slight	Under Triage*	True Negative

*Person needing triage does not get it
**Person not needing triage gets it.

Figure 14 - Confusion matrix for injury prediction.

The axes from Figure 14 compare the prediction result with the actual injury. This then shows values where the injury is accurately predicted compared with values where it is falsely predicted. Accurate prediction is indicated by the True Positive and True Negative cell results. Alternatively, the other two cells indicate "Under Triage" and "Over Triage" (see 3.4). Under Triage cells indicates where "Slight" injury is predicted but the actual injury is "Serious". In concrete terms, this would be where medical assistance is needed but not provided (due to lack of triggering), a “missed call”. On the other hand, there is the case where a “Serious” injury is predicted but a “Slight” injury actually occurs. This cell condition is described as “Over Triage” which, again in concrete terms, refers to the case where medical assistance is provided but not required. A” false call”.

As a starting point, it was proposed to follow the DGU guidebook on Triage rates [7]. These are 10% for “Under Triage” and 50% for “Over Triage”. Similar results are shown in the Toyota/Nihon University injury prediction study for automotive AACN [4] as shown by the chart below (Figure 15).

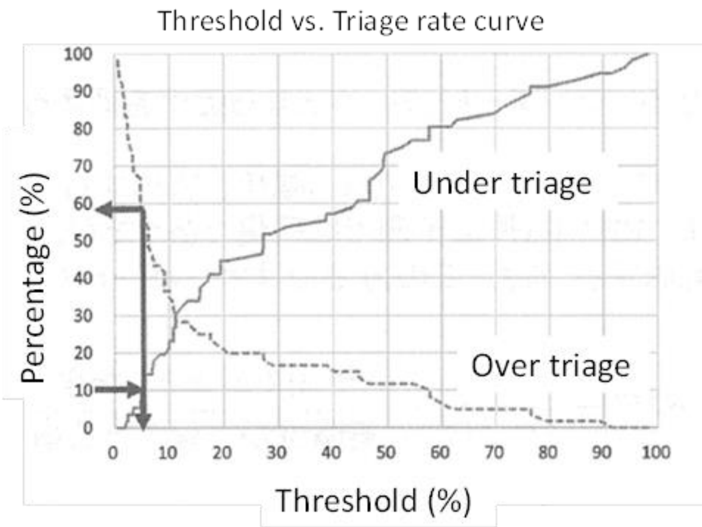


Figure 15 - Toyota Nihon University Triage rate curves

3.3 Method and Data used to evaluate hypothetical triggering algorithm.

Figure 16 (below) describes the workflow input and output process to create the triggering algorithm. This is based on inputs from tasks in sub-activities A3.1 (Use cases) and A3.2 (Misuse cases).

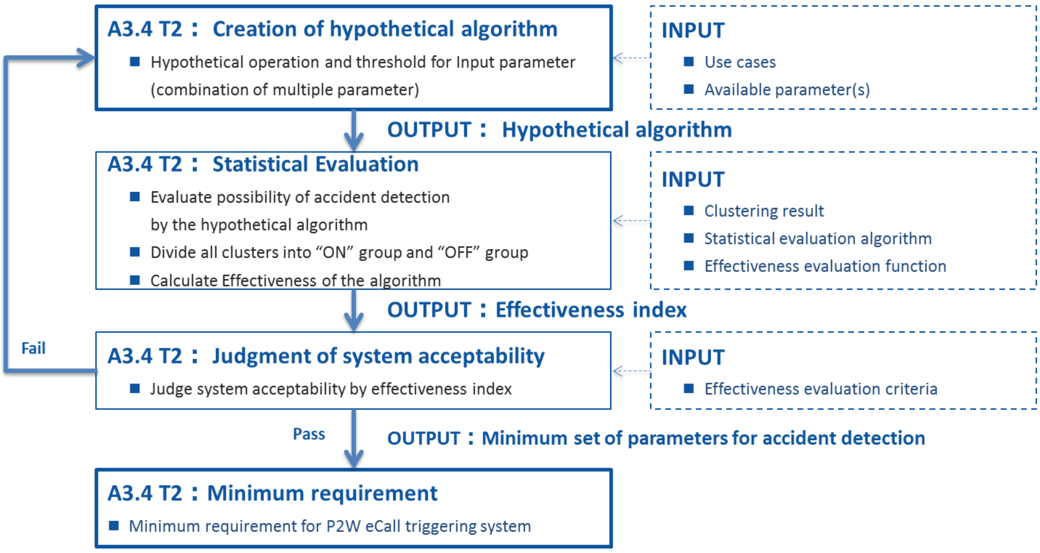


Figure 16 - Proposal for sub activity A3.4 T2 evaluation method.

The target for the evaluation method was to create a hypothetical triggering criteria and evaluate this by statistical analysis of the accident database. An iterative process would then be applied to investigate alternative hypotheses. The GIDAS database (German In-Depth Accident Study) was determined to give the most relevant and suitably detailed level of parameters required to carry out the analysis. The details of the database comparisons can be found in the M23 deliverable (chapter 3.2).

GIDAS is a cooperative project between the Federal Road Research Institute (BAST) and the German Association for Research in Automotive Technology (FAT). The GIDAS database represents an in-depth collection of 2000 accidents annually with approximately 2700 parameters for each recorded accident involving personal injuries in and around Dresden and Hannover, Germany. The University of Technology of Dresden have been collecting in-depth accident data since 1999. The data represents 2062 cases involving P2W users with an over 50cc engine capacity since 2005.

The Figure 16 shows the distribution of the P2W accidents according to key parameters collected at Pre-Crash and Collision point.

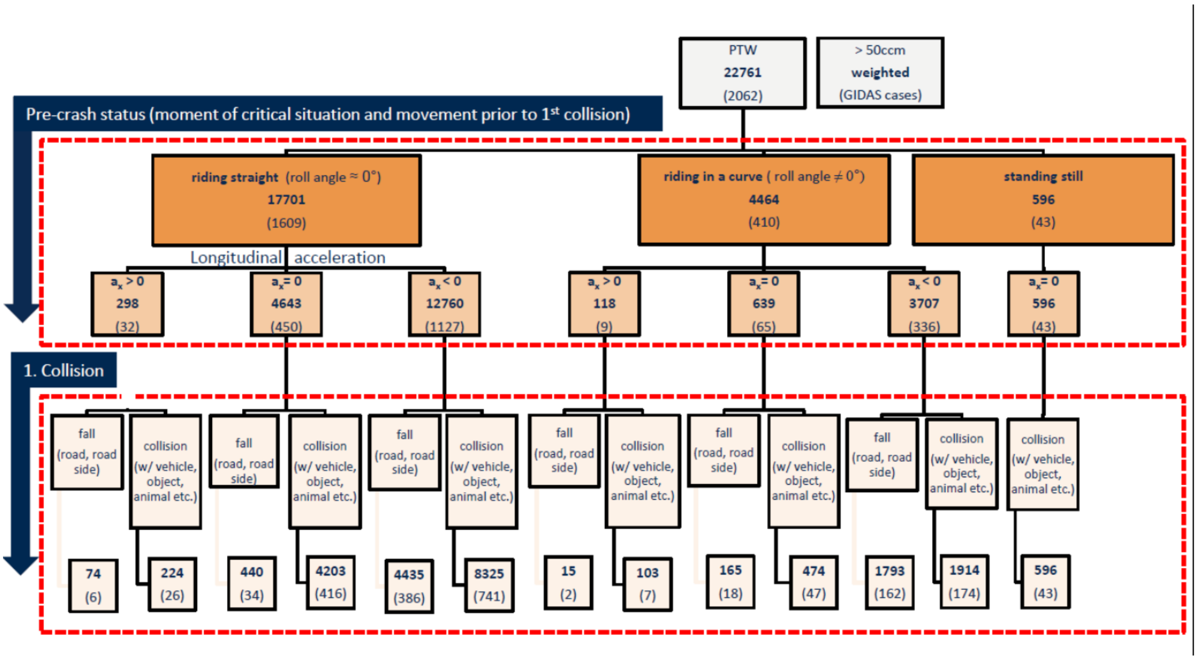


Figure 17 - Distribution of P2W accidents at Pre-Crash and Collision point [8].

The figure shows bold and bracketed counts at each point of the distribution tree. Bracketed figures indicate the real accident database cases. Bold figures indicate weighting according to the German national statistics database (DESTATIS) which represents the total amount of relevant accidents involving P2W in 2015 in Germany. Weighting is defined by accident location, severity and main accident type. Important to note is that the weighting is based on ALL Accidents in DESTATIS and not motorcycle only accidents.

The detailed definitions of the cell labels are given in the figure below:

label	definition
riding straight	roll angle ≈ 0° initial speed ≠ 0 kph Includes: - riding straight in a curve - braking to standstill
riding in a curve	roll angle ≠ 0° initial speed ≠ 0 kph Includes: - turning off / into a road / crossroads area - braking to standstill no restriction of curve radius
standing still	initial speed = collision speed = longitudinal acceleration = 0
longitudinal acceleration	$a_x > 0 \rightarrow$ acceleration $a_x < 0 \rightarrow$ deceleration $a_x = 0 \rightarrow$ no acceleration or deceleration
fall	Isolated fall on the road surface or in the road side area
collision	with vehicle, object, animal etc.

Figure 18 - Definitions of parameters used for accident breakdown.

To carry out the statistical analysis the following parameters from the GIDAS database were studied initially:

- Delta-V
- Collision Speed
- Impact configuration defined in ISO13232
- Relative Speed
- Throwing Distance (of Motorcycle from collision point)
- Throwing Distance (of Rider from collision point)
- Injury Severity (based on MAIS)
- Final Position (Left side, Right side, Upright, Upside-down)
- Opposing Vehicle Collision Speed
- Initial Riding situation (Straight, Curve, Standing Still)

Characteristic Parameters for evaluating accident conditions.

To clearly define the necessity of eCall triggering it was decided to focus on the Injury Severity parameter. Figure 19 (right) shows the Injury Severity distribution (weighted to DESTASIS German national accident statistics). 3% are IS0 (No injuries), 17% are IS1 (slight injuries), 45% IS2 (slight injury with less than 24 hours' hospitalisation), 33% IS3 (severe injuries with more than 24 hours' hospitalisation) and 2% IS4 (Fatal, died within 30 days). As explained in [8], relevant categories for eCall are IS2, IS3 and IS4.

Based on the Injury Severity (IS) definitions, it was concluded in sub-activity 3.1 to assume that IS0 & IS1 (No injuries & Slight Injuries but without hospitalisation) would not require urgent medical treatment, therefore should represent the key cut off point of the Injury Severity dimension. IS2 (up to 24h hospitalisation) and above were defined as necessary to warrant urgent medical treatment and, therefore, eCall triggering.

It is important to note that the GIDAS database contains only accidents where personal injury is reported and should not be considered representative of P2W accidents in their entirety.

Injury Severity	Description	Hospitalization
IS=4	Fatal (died within 30 days)	-
IS=3	Severe	> 24h
IS=2	Slight	< 24h
IS=1	Slight	No
IS=0	No injuries	No

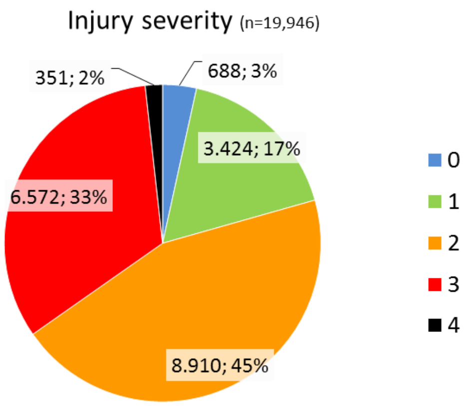


Figure 19 - Definitions/distribution of Injury Severity from GIDAS P2W accident dbase

For evaluating the riding crash conditions, the following parameters were considered most relevant from the GIDAS database. See table below:

Parameter	Description	Parameter code
Collision speed	collision speed of the biker before 1st collision	(VKZW1)
Delta-V	delta-v of the biker before 1st collision	(DVZW1)
Final Position	Final position after crash	(FZGENDL)

Table 1 - Parameters for evaluating accident conditions.

The choice of the above parameters was based on 2 factors; that the data should be reliable with regards to accuracy within the database; and that the data would be measurable on the P2W with existing sensors. The reason for the 2nd factor is to allow, ultimately, the easiest future uptake and market penetration of a newly proposed P2W eCall system.

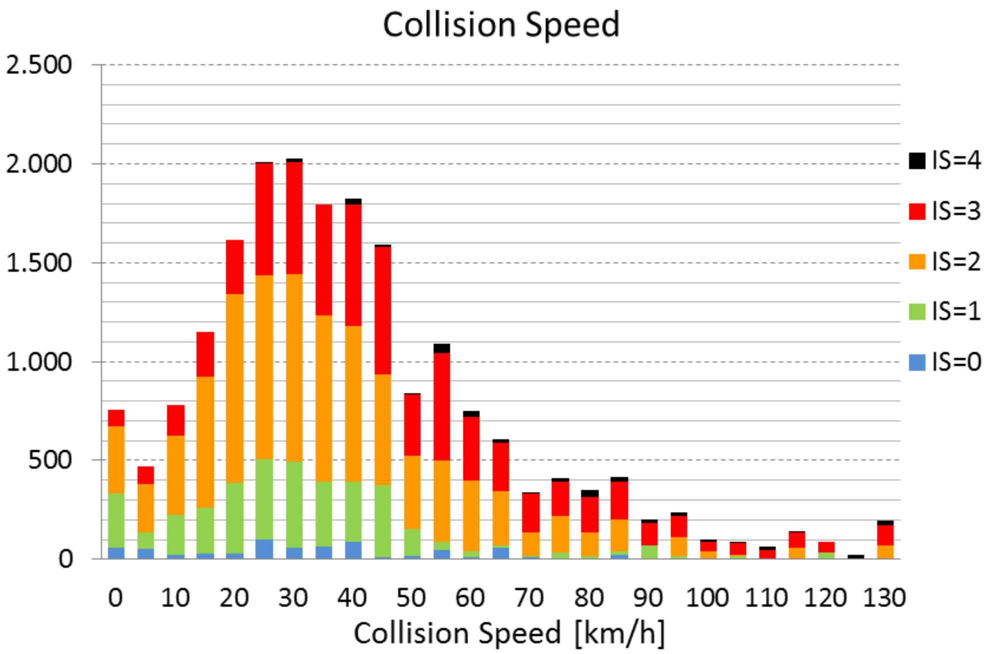


Figure 20 - Distribution of the P2W collision speed by Injury severity.

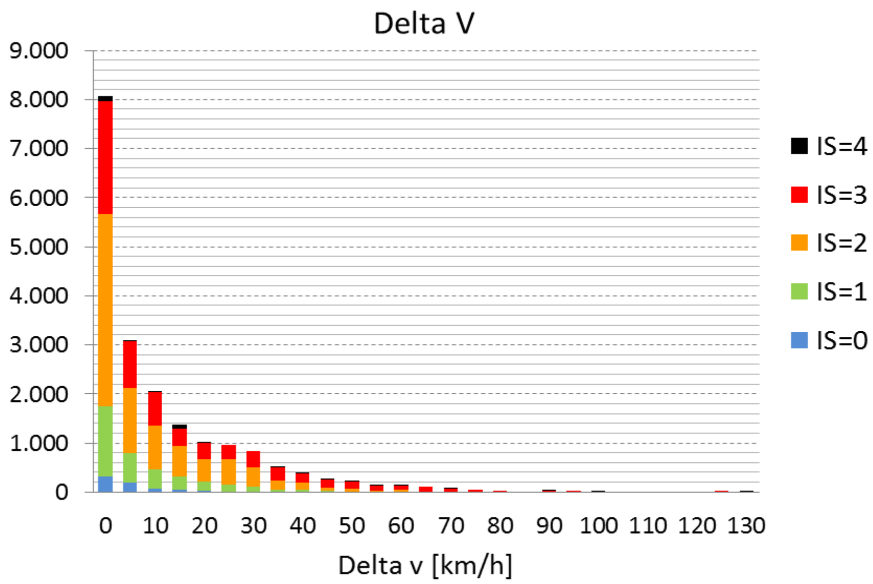


Figure 21 - Distribution of the P2W Delta V by Injury severity.

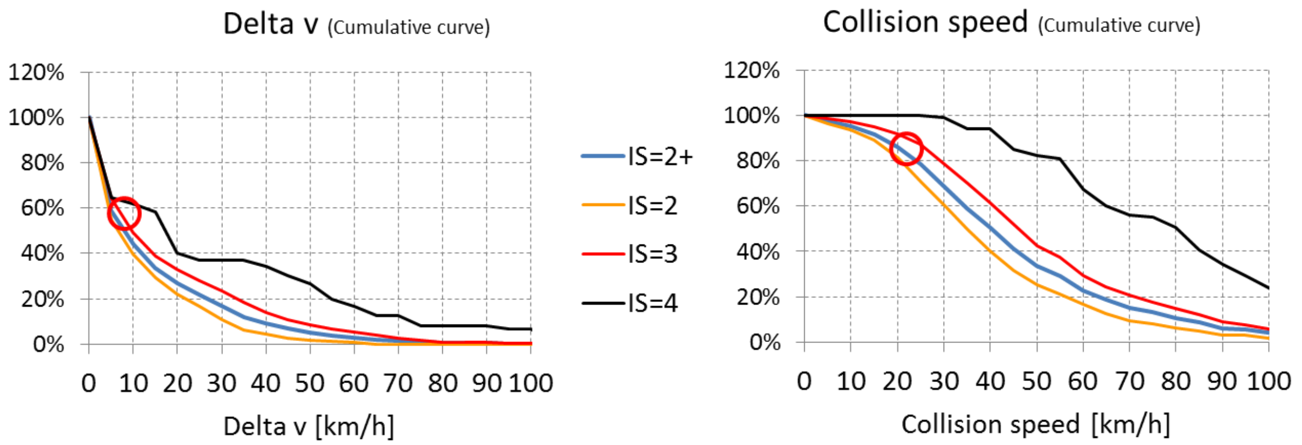


Figure 22 - IS vs. Delta V and Collision speed for P2W

Result of Collision speed vs Delta-V

The data shows that 80% of eCall relevant accidents (IS2,3,4) (see [8]) have a collision speed over 20km/h. Furthermore 60% of eCall relevant accidents are over 5km/h, in other words, **40% are in case of Delta v = 0.**

Therefore, Collision speed has a higher correlation to eCall relevant accidents than Delta V.

Result of Final Position

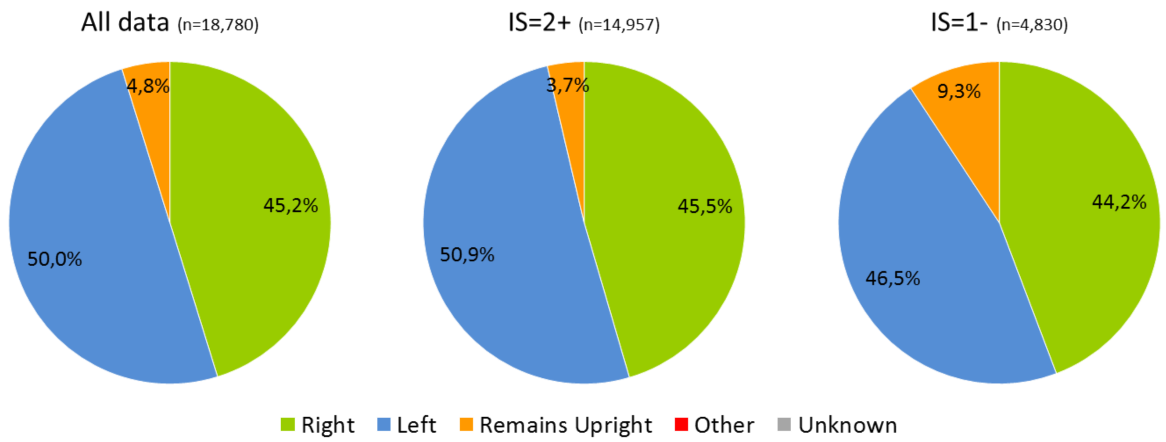


Figure 23 - Final vehicle position after crash (GIDAS "FZGENDL“)

Figure 23 (above) shows that over 96% vehicles fall down to the right or left after accident. The IS1 chart indicates a much higher percentage of “remains upright” P2W’s. During the study, it was considered that this is likely an effect of the data collection process. In other words, the vehicle could have been moved by first attenders during the post-crash situation. However, despite this it was concluded that the final position of the vehicle immediately after the crash can be used as variable of accident detection. Ultimately, a motorcycle lying on its side is not in a typical situation and would indicate that some kind of accident has occurred.

Additional data for evaluating accident conditions – I_HeERO accident survey.

Because of the sampling method of the GIDAS database it was considered necessary to gather additional data on accident experiences that currently isn't available. I_HeERO carried out a quantitative accident experience survey within spring and summer 2016 to gather this information. Key items to be identified: True number of accidents (to understand how many eCalls may actually occur, therefore to control/monitor false call rate); throwing distance of the rider from the P2W which is not included in GIDAS but would be extremely relevant to P2W eCall; and finally, the P2W riders' ability to walk and speak after the accident event.

The survey was completed anonymously online with 78% of respondents from Germany, Italy, and Austria. A total of 1041 respondents reported they had experience of an accident with a P2W in some form in the past. Figure 24 shows the total number of accidents with P2W's and the corresponding numbers which were attended by ambulance or police responders.

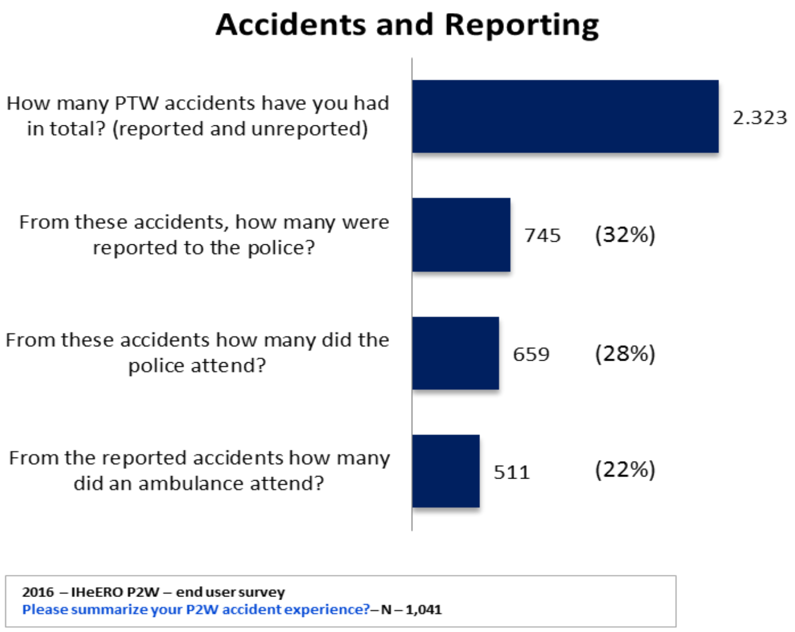


Figure 24 - Accidents reported and attendance by ambulance or police.

Figure 24 shows that, of the total 2,323 accidents experienced, 32% were actually reported to the police with 22% attended by ambulance services. This indicates that many may not have required support from the emergency services. This is an important consideration in terms of an automatic eCall function being applied to P2W's. Further data from the survey is presented in the analysis below.

Limitations of the data

Following the Accident Case study result from sub-activity 3.1 using the GIDAS data (Reference – M23_D3_2 – Para 3.4, Figure 17) [8] it was clear that all accidents needed to be considered to avoid missing any cases that would be critical for developing a triggering algorithm. The defined accident cases account for 90.6% of the total accident database. For the purpose of this task, it was considered that all available accident data should be analysed.

Limitations of the I_HeERO survey are that these data obviously do not include any information on fatal accidents. This is not considered too limiting as fatal accidents are included in national and GIDAS statistics. Additionally, it can be unclear that "reporting" of accidents refers only to the need of an emergency call. Participants could have considered that a simple "falling down" of the P2W does not warrant any call out if no 3rd party damage occurs. Respondents often noted that no damage was done to property and injuries were sufficiently light and therefore felt no need to refer to emergency services.

3.4 Evaluation and Results of analysis

As mentioned above in 3.3 it was first necessary to define what would be the Injury severity limit requiring a "must have" eCall. IS level 2 was set as the minimum limit because of the need for hospitalisation.

The second assumption used in the example cases below show the "Collision Speed" dimension at either 20kmh (case 1) or 25kmh (case 2).

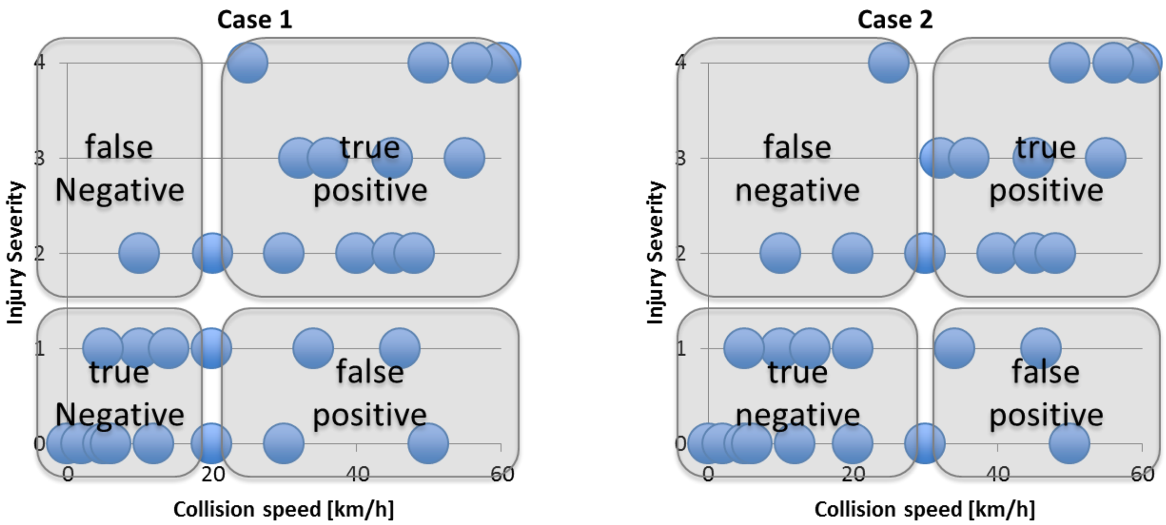


Figure 25 - Representation of Statistical Evaluation.

From Figure 25 the division of true positive, false positive, true negative and false negative can be categorized. Based on the confusion matrix in Figure 25 (Above) the false negative cluster indicates "Under Triage" while the false positive cluster represents "Over Triage".

Expressed in % terms the calculations are as follows:

Over triage rate$= \frac{FP}{TN+FP}$ **Under triage rate** $= \frac{FN}{TP+FN}$

The target should be to achieve an Under-Triage rate of not more than 10% [5]

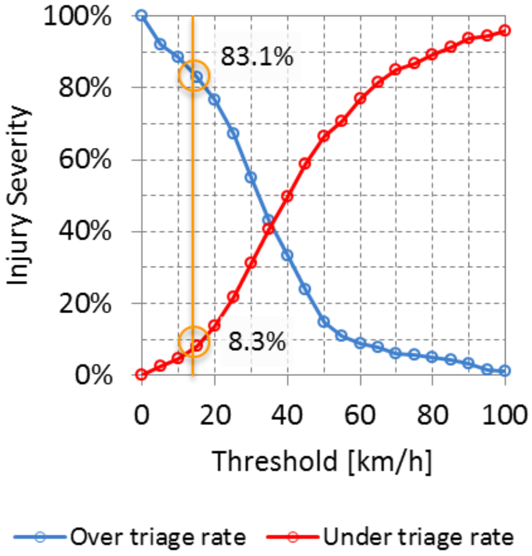
Results of the first analysis

Evaluation of triggering by collision speed resulted in an Under Triage (UT) rate of 8.3% with a threshold of 15kmh applied. At the same time, the Over Triage (OT) rate of 83% is considered very high. These results are shown in Figure 26.

The chart to the right shows the result of triggering by delta-V.

Evaluation of the triggering by delta-V at the 15kmh threshold indicates that the eCall will not be activated in 66.2% of eCall relevant cases. Clearly very far from the 10% UT rate guide from the DGU.

While the result of the "Collision speed" calculation shows a workable UT, alone, it cannot be used to define a triggering condition. The results of the first pass show that, independently, the parameters of "Collision speed" and "delta-V" are not characteristic.



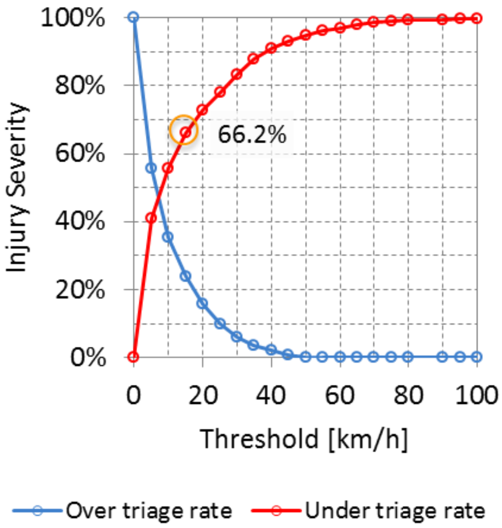


Figure 26 - Collision speed and Delta-V distributions by injury severity.

Results of the second analysis

Figure 27 shows the flow diagram based on the relevant parameters selected for crash detection. The schematic illustrates if the active P2W has fallen over or not, if yes, the system would evaluate whether the collision speed threshold has been exceeded in a given time prior to the fall down detection. The fall down can be detected by existing sensors on board the P2W such as those used for the fuel supply cutoff.

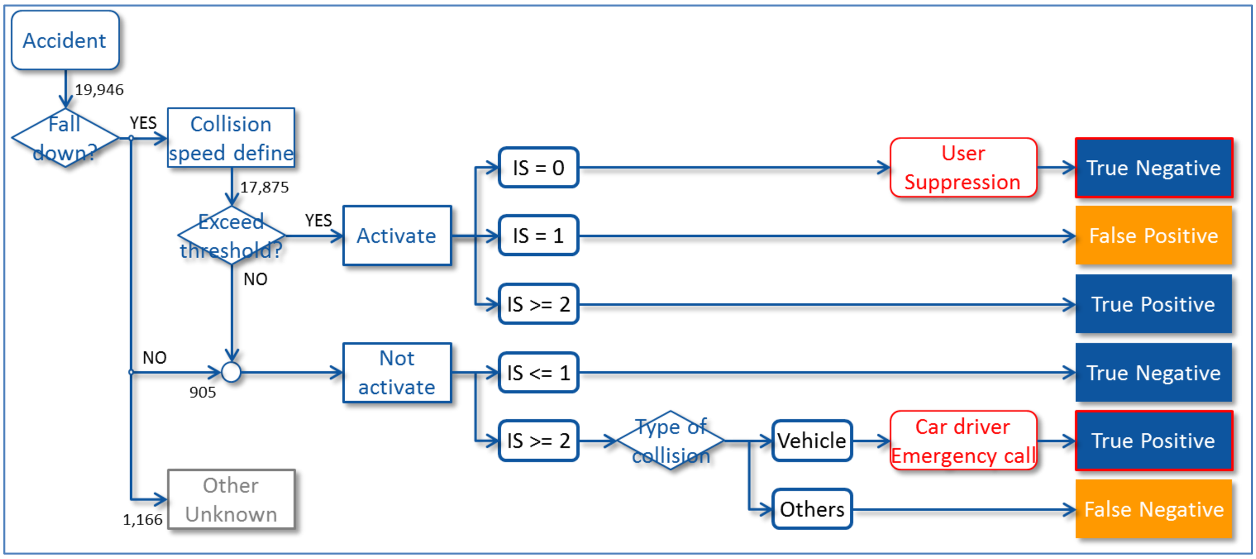


Figure 27 - Flow Diagram – Relevant Parameters

The next part of the system would detect if the travelling speed of the motorcycle has exceeded the pre-defined threshold at the time of the collision. If fall down and speed thresholds are reached, the system will then “Activate” the eCall. These can be referred to as the “crash detection” conditions. From here the IS classifications indicate the clustering (True Negative, False Positive, True Positive and False Negative).

The Scenario diagram then shows some assumptions used for reducing Over Triage and Under Triage.

Assumption #1 applies when the **crash detection** conditions have been reached. It assumes that the rider without injuries (IS0) is able to return to the P2W within a few moments where they can then “suppress” the eCall before it is sent from the vehicle. The chapter on functional and architecture recommendations explains the HMI and eCall pre-warning process in more detail.

From the user survey, data was provided to indicate the proportion of reported accidents by the injury severity levels. Figure 28 below, shows 84% of IS0 injury level accidents go unreported by the rider.

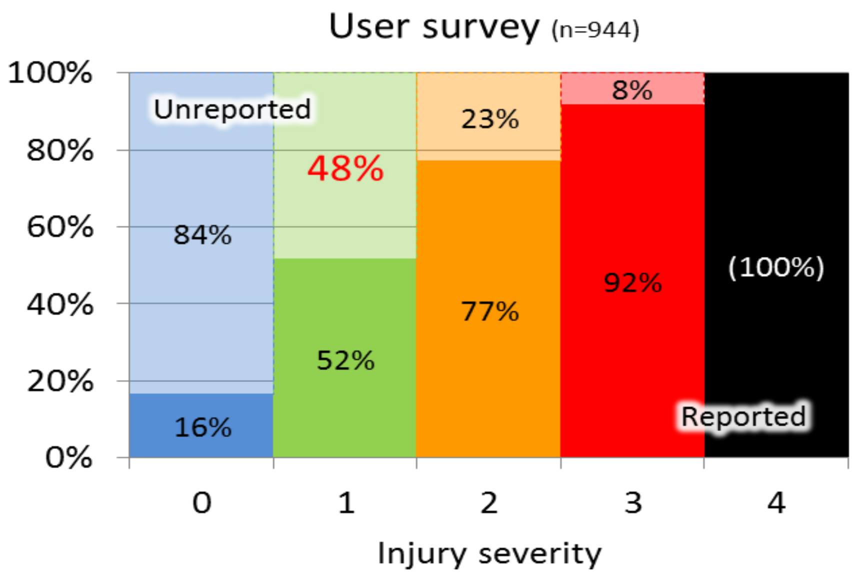


Figure 28 - Reported and unreported accidents by Injury Severity level (Fatal IS4 assumed).

Assumption #2 applies when the **crash detection** conditions have **not** been reached in the crash situation and account for 4.5% of the accidents in the GIDAS database. The assumption applies in accidents with an “Other Vehicle (OV)”, typically a car, and that the P2W rider has IS2 and above level injuries. In this case the OV driver is deemed able to make an emergency call.

As can be seen from the data below (Figure 29), almost 60% of accidents involving another vehicle are reported by another person (assumption, this is the OV driver/participant). Based on this data the assumption of OV driver being able to make the emergency call is considered reasonable.

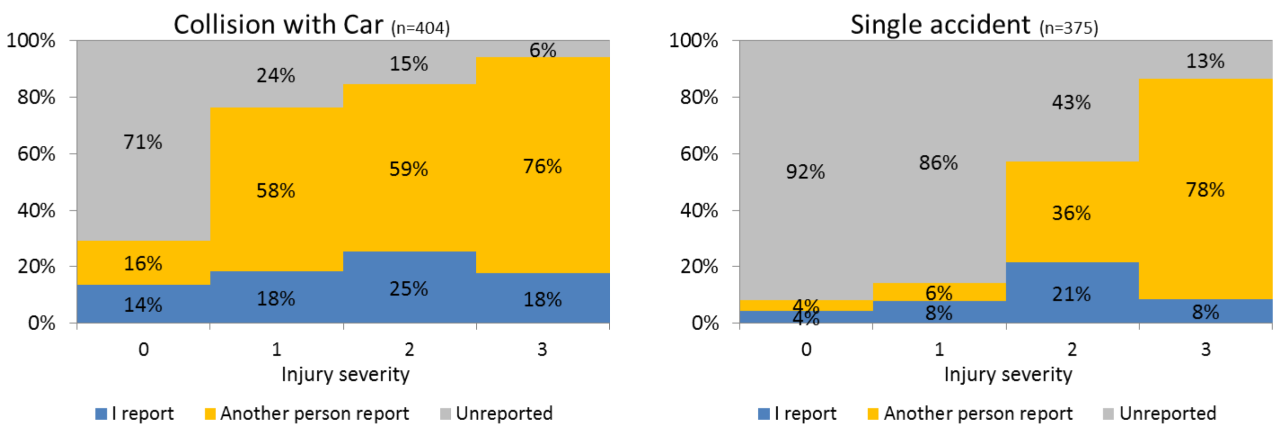


Figure 29 - Who reported accidents by Injury Severity (OV and Solo).

With the assumptions applied to the data, the following result was produced. The Over / Under triage rate reaches a more acceptable level with a collision speed threshold set to 25km/h. An Over triage rate of 52.2% was considered somewhat acceptable in relation to the DGU 50% recommendation. The Under-Triage rate of 8.2% falls below the DGU recommendation of 10%.

Threshold [km/h]	False Positive	True Positive *1	True Negative *2	False Negative	Under Triage rate	Over Triage Rate
0	2,999	14,840	825	117	0.8%	78.4%
10	2,702	14,768	1,121	188	1.3%	70.7%
20	2,294	14,261	1,529	696	4.7%	60.0%
25	1,995	13,730	1,828	1,226	**8.2%**	**52.2%**
30	1,618	13,114	2,205	1,843	12.3%	42.3%
40	935	11,736	2,888	3,220	21.5%	24.5%

Figure 30 - Triage rates according to assumptions of eCall suppression and OV driver call.

*1 : includes “eCall not activate but other vehicle driver can call emergency”

*2 : includes “eCall activate but can be suppressed”

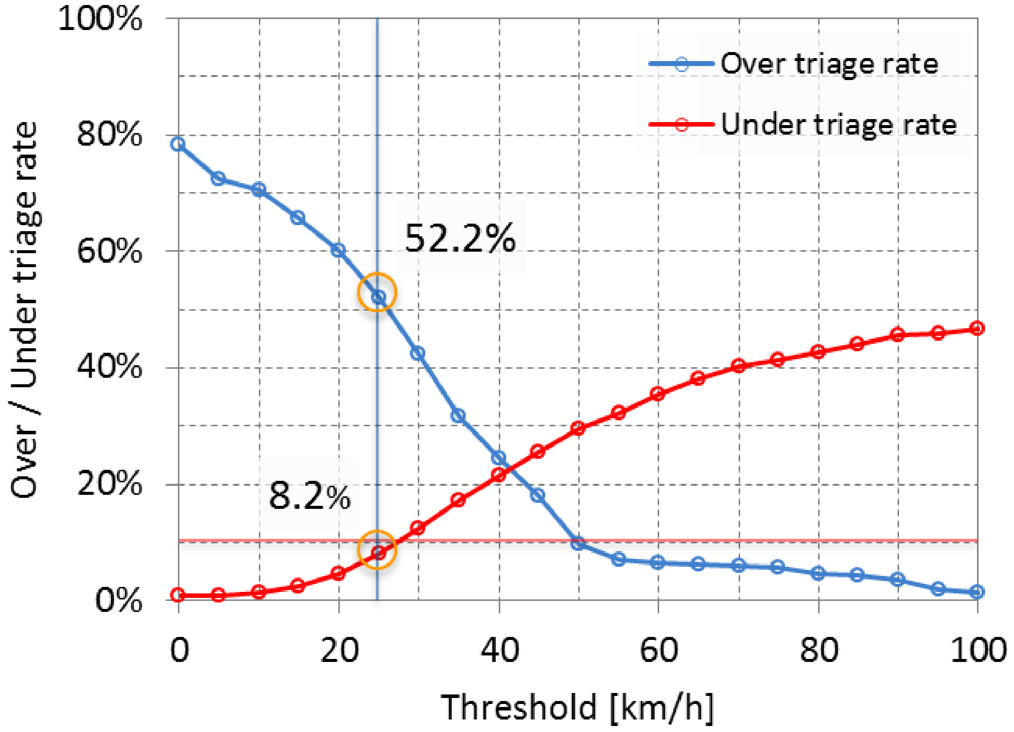


Figure 31 - Triage rates according to assumptions of eCall suppression and OV driver call.

3.5 Final Result

After further consideration assumption #1 was reviewed once more on the grounds that the GIDAS data is effectively already "filtered" due to the fact all of the accidents have been reported and, therefore, representative of the 52% shown in Figure 31.

The distribution table below shows the final data described at 5kmh levels. From this result, it is considered reasonable to maintain the 25kmh threshold for the eCall triggering in order to ensure a suitable balance between UT and OT rates. OT increases with threshold reduction. It is recommended that a decrease in speed threshold is avoided to prevent an increase in the OT rate.

Threshold [km/h]	False Positive	True Positive	True Negative	False Negative	Under Triage rate	Over Triage Rate
0	2,999	14,840	825	117	0.8%	78.4%
5	2,765	14,825	1,058	131	0.9%	72.3%
10	2,702	14,768	1,121	188	1.3%	70.7%
15	2,508	14,607	1,315	350	2.3%	65.6%
20	2,294	14,261	1,529	696	4.7%	60.0%
25	1,995	13,730	1,828	1,226	8.2%	52.2%
30	1,618	13,114	2,205	1,843	12.3%	42.3%

Table 1 – Final triage rates shown in 5km/h increments

<u>Expression of Triggering Criteria</u>

Based on the data studied, it was concluded that the collision speed parameter and detection of a fall down condition would be sufficient to determine triggering of a motorcycle eCall.

This is the recommendation for the minimum requirement of the Triggering Criteria:

1. The falling down of the motorcycle shall be detected.
2. The vehicle speed shall be estimated prior to the fall down detection.
3. An eCall shall be activated when the vehicle falling down is detected and the accident speed exceeds 25km/h.

The falling down of a motorcycle is a clear indication of the vehicle being in an unusual condition that warrants attention of some kind. Typically, a vehicle in this condition will be returned to an upright condition and placed on its supporting stand.

For the vehicle speed estimation, it is recommended to review at 3 seconds before the fall down detection. This is defined in ISO13232, the crash event for a motorcycle accident ends within 3 seconds after first impact.

If the fall down and speed conditions are met, the system should trigger the pre-warning of the eCall according to the description in chapter 2.1.3. At this point if the rider is OK and wants to suppress the eCall before it is sent to the PSAP they can activate the suppression function within the HMI. In case the rider considers an eCall warranted or is unable to suppress the eCall, the eCall itself will be triggered after the pre-warning time has elapsed.

The scientific expression of the triggering meta algorithm is shown below.

- **Example of algorithm**
  - eCall trigger : $Firecall(t) = 1$

    If
    - $\theta_{fall} = 1$

      and
    - $V_0(t) < V_{deadzone}$

      And
    - $V_S(t) > V_{min}$

      And
    - $k(t - T_s) = 1$

    ELSE
  - $Firecall(t) = 0$

- $\theta_{fall}(t)$:fall down status at time=t
- $k(t)$:key status at time=t
- $V(t)$:Vehicle speed at time=t

- $V_0(T) = \max_{T-T_0}^{T} V(t)$
- $T_0 = (1.0)[\mathrm{sec}]$
- $V_{deadzone} = (1.0)[\mathrm{m/s}]$
- $V_S(T) = \max_{T-T_S}^{T} V(t)$
- $T_S = (3.0)[\mathrm{sec}]$
- $V_{min} = 6.9\ [\mathrm{m/s}](25[\mathrm{km/h}])$

<u>DeltaV analysis for stand still condition</u>

The P2W I_HeERO members decided it would be useful to re-consider the stand still collision use cases in order to see if some relationships could be found within the GIDAS data and the measure of acceleration. It was proposed to analyze this using the Delta-V parameter, as this was available within the working dataset and might reflect a given acceleration. A schematic for the analysis is shown in Figure 32 below.

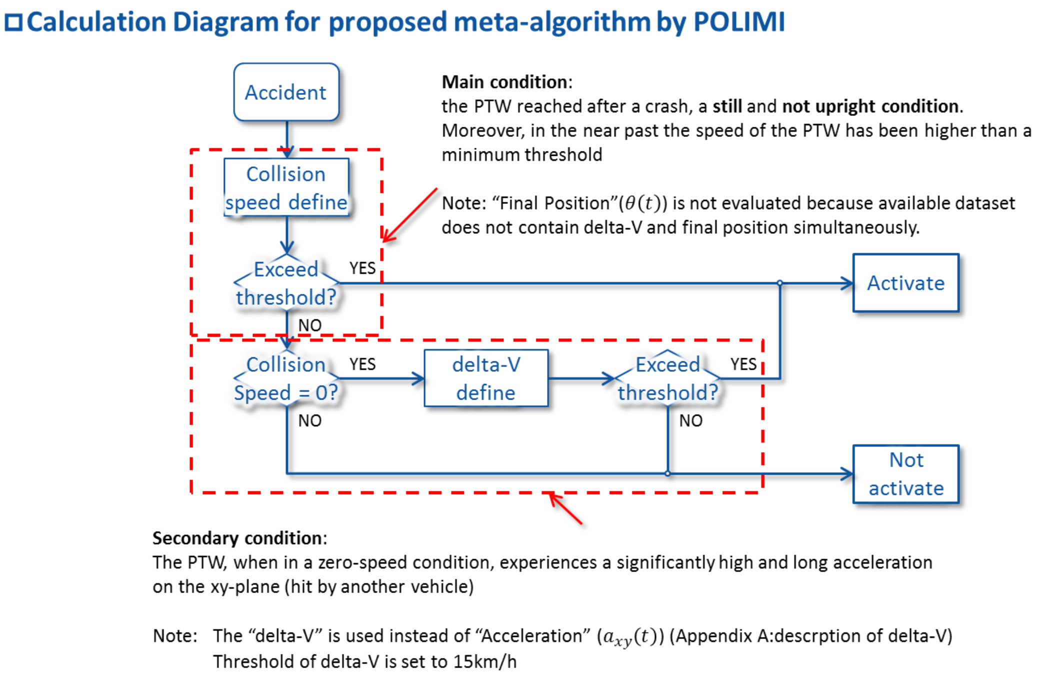


Figure 32 - schematic diagram for analysing the stand still accident condition.

As it was not possible to analyse the database keyed to the final position the data was analysed purely to understand the benefit of the Delta-V measure compared with the "Main Condition". The figures below show the comparison of the two algorithms.

"Main condition" only

Collision speed Threshold [km/h]	False Positive	True Positive	True Negative	False Negative	Under Triage rate	Over Triage Rate
5	3,145	15,411	967	423	2.7%	76.5%
10	3,065	15,075	1,046	759	4.8%	74.6%
15	2,864	14,524	1,248	1,311	8.3%	69.7%
20	2,631	13,637	1,480	2,198	13.9%	64.0%
25	2,271	12,411	1,841	3,423	21.6%	55.2%
30	1,869	10,912	2,243	4,923	31.1%	45.5%

Meta-algorithm

Collision speed Threshold [km/h]	False Positive	True Positive	True Negative	False Negative	Under Triage rate	Over Triage Rate
5	3,294	15,623	818	212	1.3%	80.1%
10	3,215	15,287	897	547	3.5%	78.2%
15	3,013	14,735	1,099	1,099	6.9%	73.3%
20	2,780	13,848	1,331	1,986	12.5%	67.6%
25	2,420	12,623	1,692	3,212	20.3%	58.9%
30	2,018	11,123	2,094	4,711	29.8%	49.1%

Notes
- For comparison, "final position" is not considered in these tables.
- Only IS=0 cancellation assumption is applied.

Figure 33 - benefit of the Delta-V measure compared with the "Main Condition"

The results show an improvement in the UT rate, which is however, coupled with an increasing OT rate indicating an increasing number of false positives. The chart below shows that the overall performance of the alternative algorithm (OT-UT balance) is not offering any benefit. This suggests either inaccurate data or an over sensitivity which might, in the real world, lead to false triggering of an eCall under normal dynamic conditions.

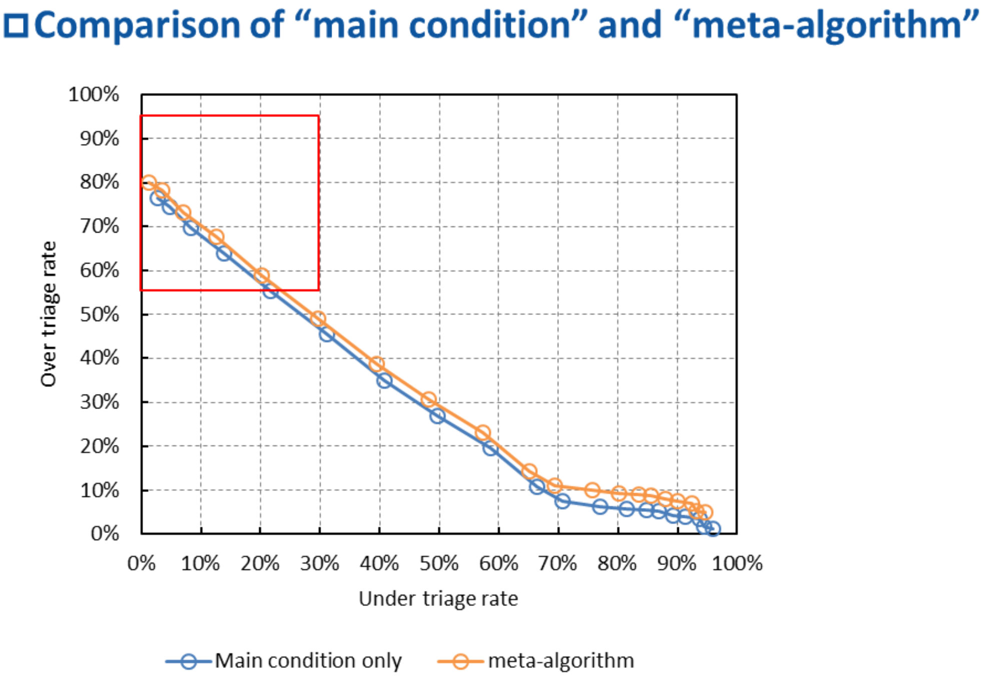


Figure 34 - comparison of main condition and "meta-algorithm" including Delta-V

3.6 Summary and conclusions

Motorcycle eCall differs from a motorcycle airbag trigger because of the need to more than purely frontal impacts.

Collision speed and Delta-V were evaluated. Collision speed was shown to be a better predictor for eCall triggering. It is, however, important to consider that the accident database is not providing objective measures but rather observer estimates. Therefore, it may be that DeltaV may be able to improve the performance of motorcycle eCall but further analysis and verification is required.

It was concluded that the fall down detection and collision speed were most relevant for the motorcycle eCall triggering criteria. The Under Triage rate of 8.2% and Over Triage rate of 52.2% can be considered satisfactory from the point of view of a motorcycle IVS required to meet the minimum requirement.

With such a system, it is considered suitable to differentiate a minor fall from a more serious accident where the injury level could require medical assistance.

4 Meta-algorithm for “minimum requirement”

4.1 Main variables

In order to define a triggering criterion, it is necessary to identify:

- A minimum-requirement set of measured variables
- A minimum-requirement e-call triggering (meta)algorithm

It is worth noting that the algorithm has been designed to be SIMPLE and robust, and that in this document the algorithm is described at high-level only (without low-level signal processing details); similarly, no details on the management of sensors faults and the corresponding risk mitigation actions are provided in this chapter (for ISO26262 risk analysis results please refer to chapter 7).

4.1.1 The definition of the variables

The variables used by the meta-algorithms are here described (in a formal and in a pictorial way) and briefly discussed.

Variable **k(t)**: Vehicle-Enabled-status [adimensional]; can take only two values (Boolean variable): 0=not enabled; 1=enabled.

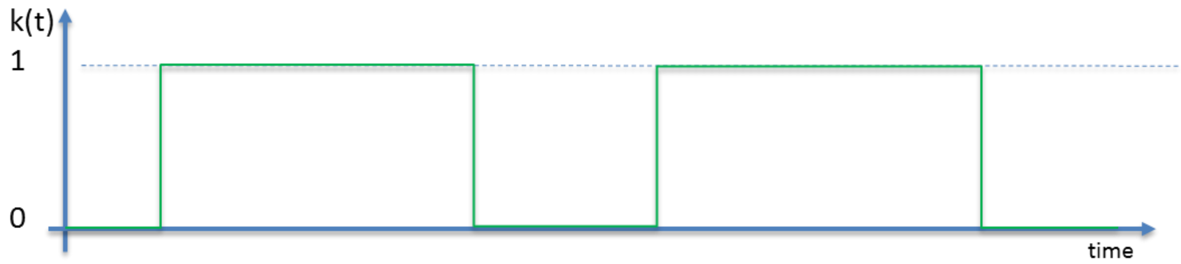


Figure 35 - A pictorial example of variable k(t)

Remark on variable k(t). It can be a “key-on” signal in case of a classical mechanical key; it is representative (regardless the technology used to do it) of the status of the vehicle (enabled or not enabled by the rider). In after-market or retrofit products can be replaced with a «virtual-key» or “virtual enabling signal” if a direct connection of the P2W enable status signal is not available (the virtual enabling signal makes an estimation of the vehicle status by monitoring its movements via accelerometers or similar sensors)

Variable **v(t)**: P2W forward speed [m/s].

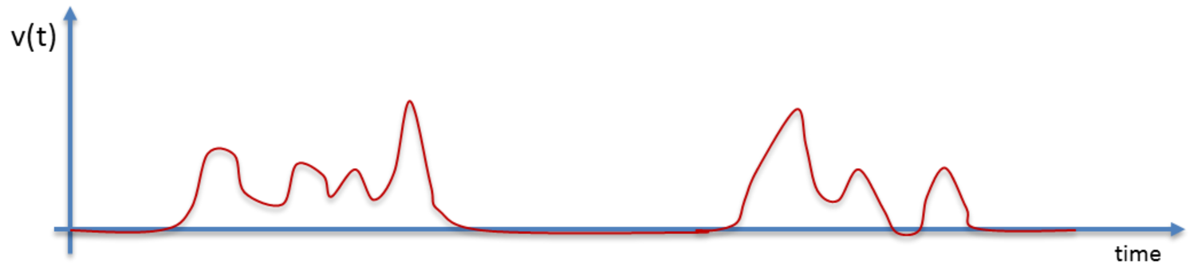


Figure 36 - A pictorial example of variable v(t)

Remark on variable v(t). Any sensor providing the measure of this variable can be used. As an example, wheel-speed signals, or GPS-based speed, or a combination of both, can be used.

The management of the availability of this signal (example: tunnels or “canyoning” situations for a GPS sensor) and the corresponding risk-mitigation is out of the scope of this description, and depends on specific implementations.

Variable **ax(t)**: P2W acceleration measured on the x direction of the motorcycle [m/s^2].

Variable **ay(t)**: P2W acceleration measured on the y direction of the motorcycle [m/s^2].

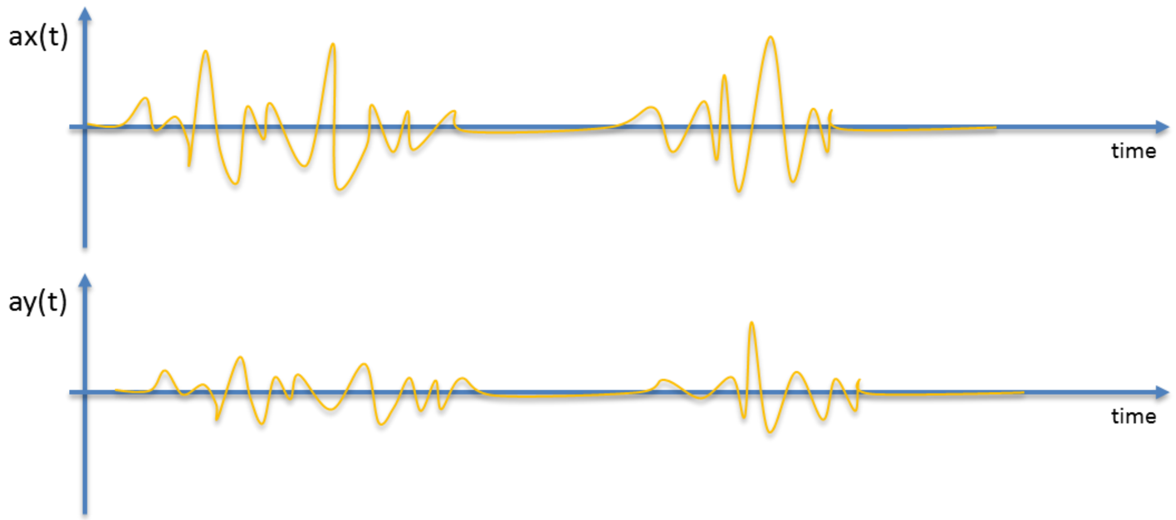


Figure 37 - A pictorial example of variables ax(t) and ay(t)

Remark on variables ax(t) and ay(t). The x-y plane is a P2W body-fixed plane defined by the longitudinal (forward direction, x) and lateral (transversal direction, y) directions.

Variable **Rollstatus(t)**: status of the absolute value of quasi-static lean angle θ(t) of the P2W, with respect to a pre-define threshold θmax [adimensional]; can take only two values (Boolean variable): 0=below the threshold; 1=beyond (or equal) the threshold.

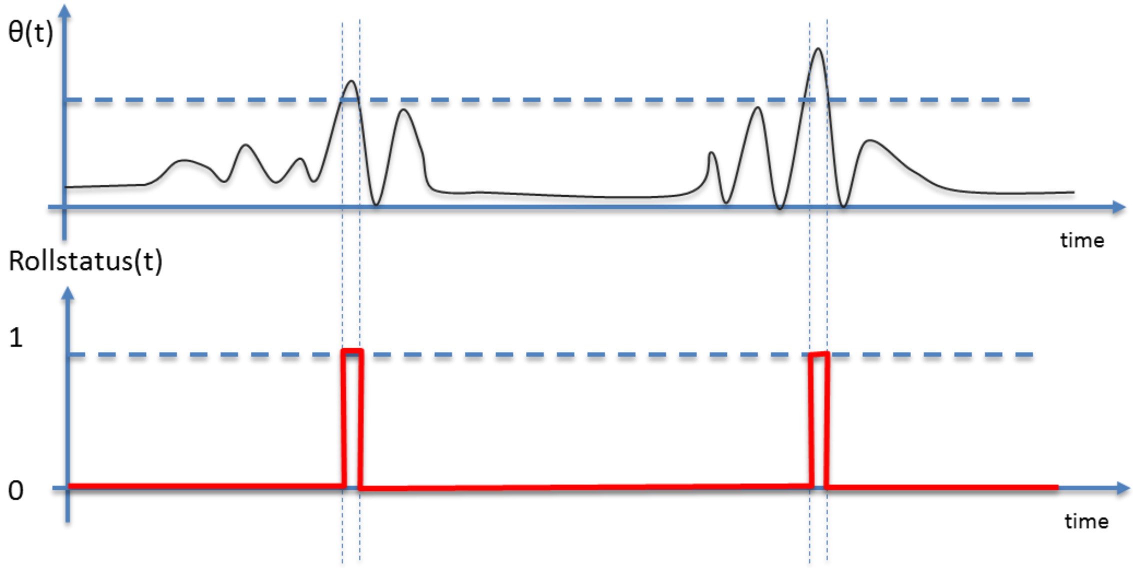


Figure 38 - A pictorial example of variable Rollstatus(t) and its background variable θ(t)

Remarks on variable θ(t), to which Rollstatus(t) is linked.

- θ(t) is the ABSOLUTE VALUE (no difference between a right or left lean) of the QUASI-STATIC lean angle of the P2W referred to the gravity direction (motorcycle upright =0°). See next remarks for more details. Note that the direct availability of the measurement of the variable θ(t) is not mandatory for the availability of Rollstatus(t) (example: an engine cut-off sensor does not provide at its output the value of the lean angle, but only the overshoot of a pre-defined lean angle threshold);
- A quasi-static lean-angle sensing technology is assumed. See next pages for more details
- The angle used in the definition of the variable Rollstatus(t) is the lean angle of the P2W referred to the gravity direction (motorcycle upright =0°). It is NOT referred to the road-surface
- A restricted range 0-90° is used (the angle is 0° also when the motorcycle is upright but upside-down)

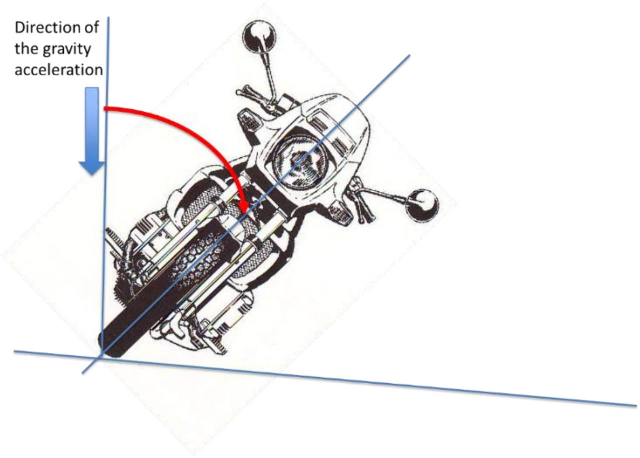


Figure 39 - Geometrical definition of the background variable θ(t)

Remarks on the “quasi-static” feature of the lean angle θ(t).

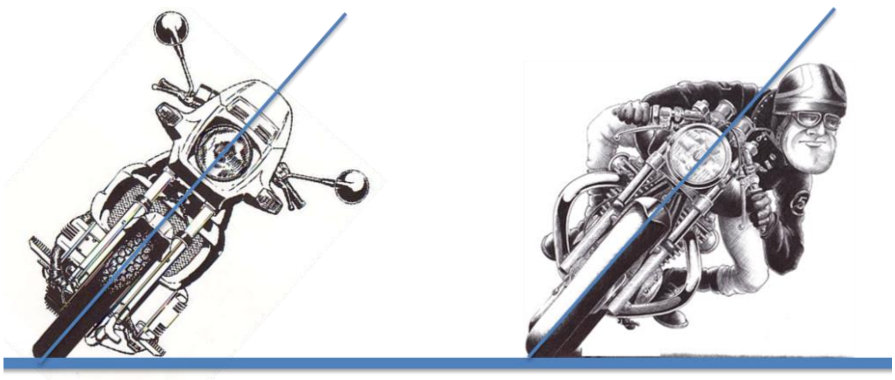


Figure 40 - A pictorial illustration of the quasi-static (left) and the dynamic (right) variable θ(t)

Lean angle in a «quasi-static condition» means that the P2W is still or has very small speed or movements; the equilibrium is due to the rider or to the leaning of the P2W onto the road or onto a static object. The same lean angle can be due to completely different type of forces acting on the P2W.

Notice that the more general variable “Lean angle in a dynamic condition” is more difficult to be obtained.

For the e-call purpose it is assumed that the measured angle used by the definition of Rollstatus is based on the assumption of quasi-static conditions.

See in the below picture an example (real data): under the quasi-static condition, in a dynamic working condition the output does not correctly represent the P2W lean angle. A standard inclinometer (e.g.

based on a 1-axial accelerometer, or on a mass + spring device) can correctly measure the quasi-static lean-angle; not the dynamic lean angle.

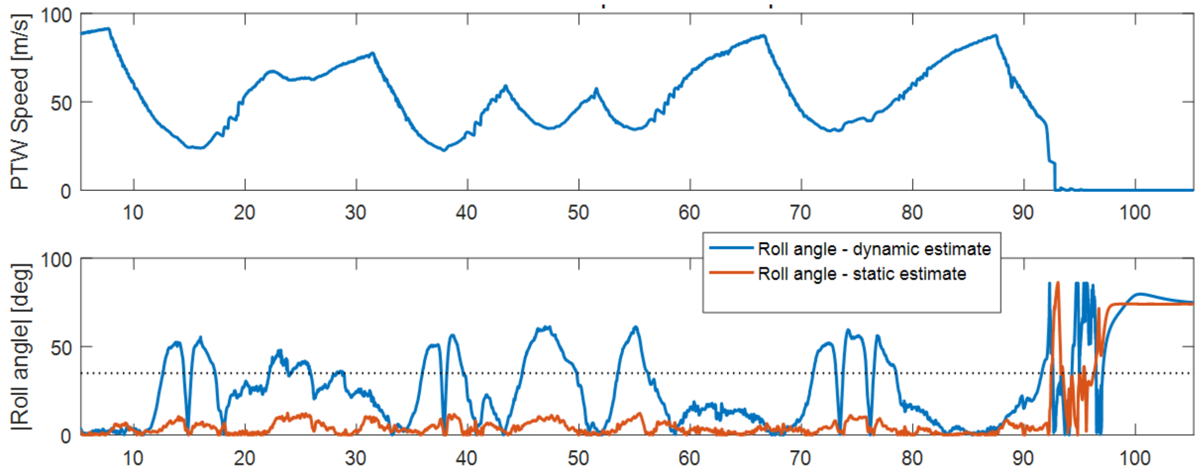


Figure 41 - A real example of static and dynamic estimate of the roll angle θ(t)

4.1.2 The definition of the internally-computed variables

At each (discrete) time t, the algorithm computes the following internal variables:

- $\boldsymbol{V_0(t)}$
- $\boldsymbol{V_s(t)}$
- VHPx(t)
- VHPy(t)

These internally-computed variables are now defined and briefly discussed.

$\boldsymbol{V_0(t)} = \max_{[t-\boldsymbol{To},\boldsymbol{t}]} v(t)$ Is the maximum value of the forward speed of the P2W, in the restricted monitoring time-window [t-To,t]).

$\boldsymbol{V_s(t)} = \max_{[t-\boldsymbol{Ts},\boldsymbol{t}]} v(t)$ is the maximum value of the forward speed of the P2W, in the full monitoring time-window [t-Ts,t]

Notice that the algorithm internally keeps in a volatile memory buffer the last Ts seconds of data; no log of this memory stack is kept after a crash for privacy reasons

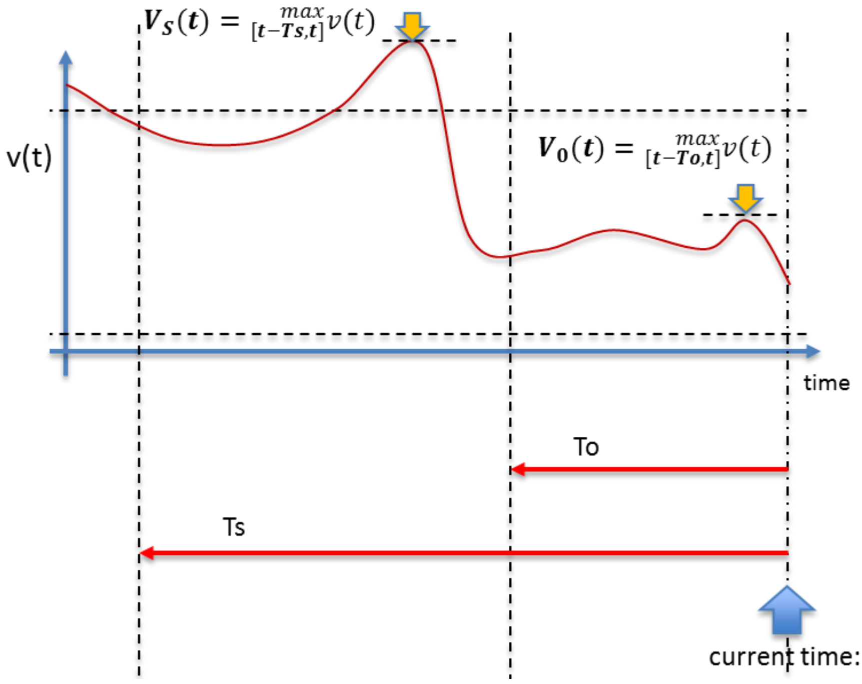


Figure 42 - Pictorial description of internally computed variables $V_0(t)$ and $V_s(t)$

VHPx(t) is an estimation of the longitudinal speed obtained by numerical integration AND High-Pass filtering of the longitudinal acceleration (High-Pass filtering is needed to avoid drifting; High-Pass filtering emphasizes only fast and strong events).

Similarly, VHPy(t) is an estimation of the lateral speed obtained by numerical integration AND High-Pass filtering of the lateral acceleration.

Note that in both cases “a” is a key parameter of the algorithm since it defines the cut-off frequency of the high-pass filter (see signal-processing block scheme in Figure 44 and Figure 46).

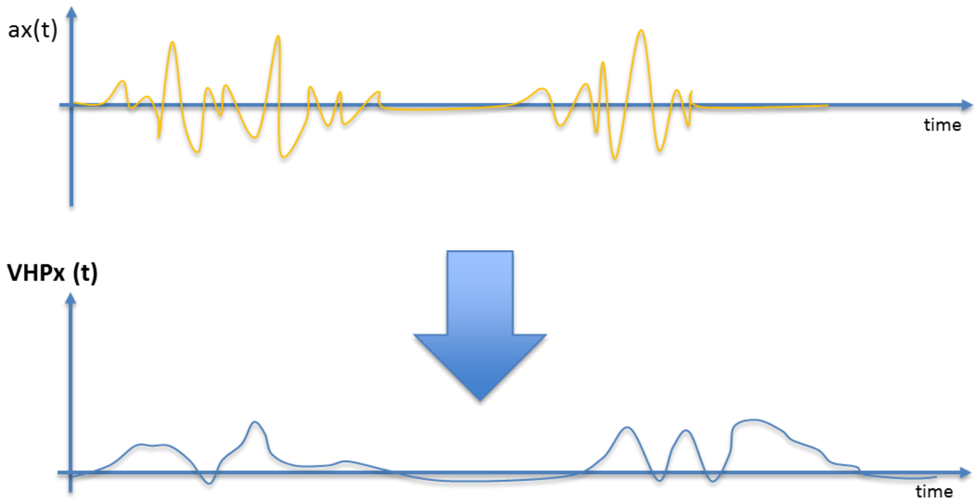


Figure 43 - Pictorial description of internally-computed variable VHPx(t)

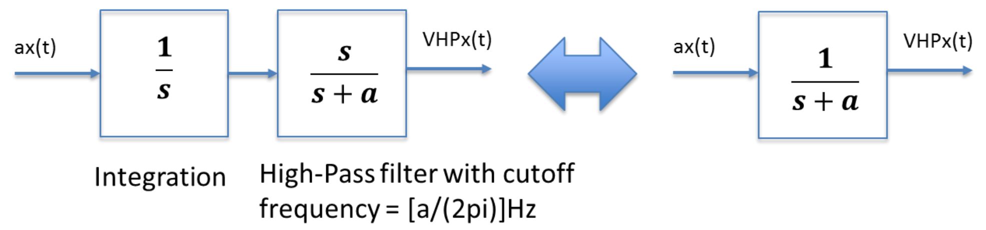


Figure 44 - Block-scheme representation of the signal-processing chain to obtain VHPx(t)

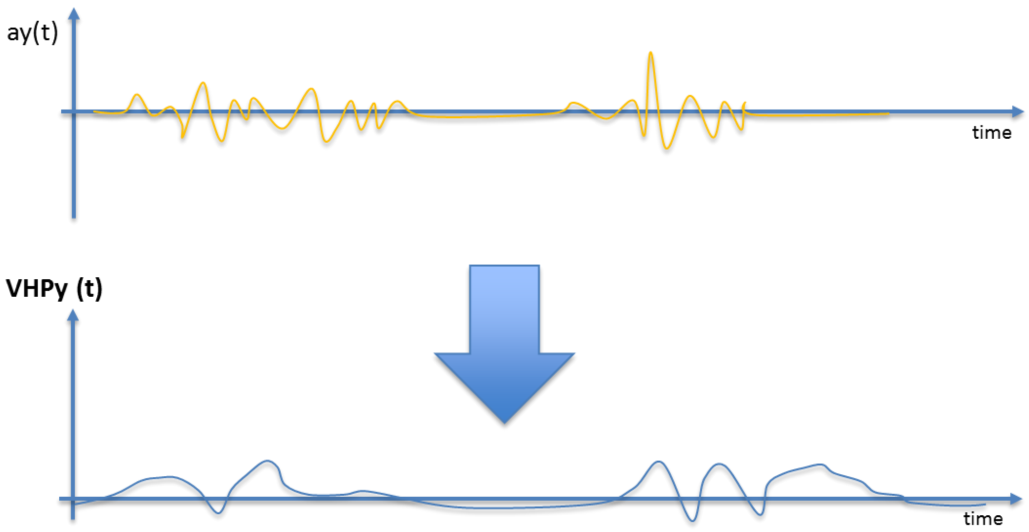


Figure 45 - Pictorial description of internally-computed variable VHPy(t)

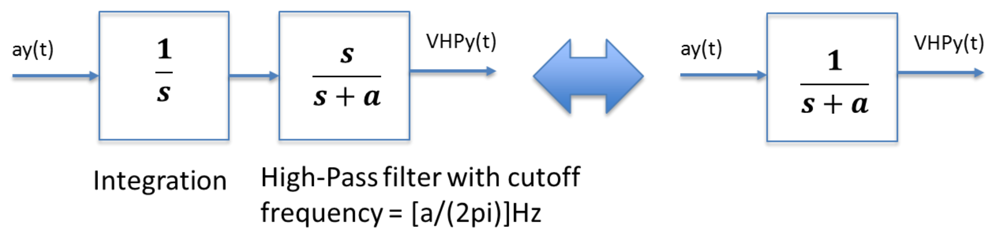


Figure 46 - Block-scheme representation of the signal-processing chain to obtain VHPy(t)

Remark on VHPx (and/or VHPy) (from a real example of a „mini-crash“).

In Figure 47 an example (using real data) of VHPx(t) computation is shown. Notice that VHPx(t) is correctly computed, and results in a much smoother variable than ax(t), without drift phenomena. A value of a=0.5 has been used in this example. This value of a is a good compromise between a precise computation of the integrated speed and the removal of drifting phenomena.

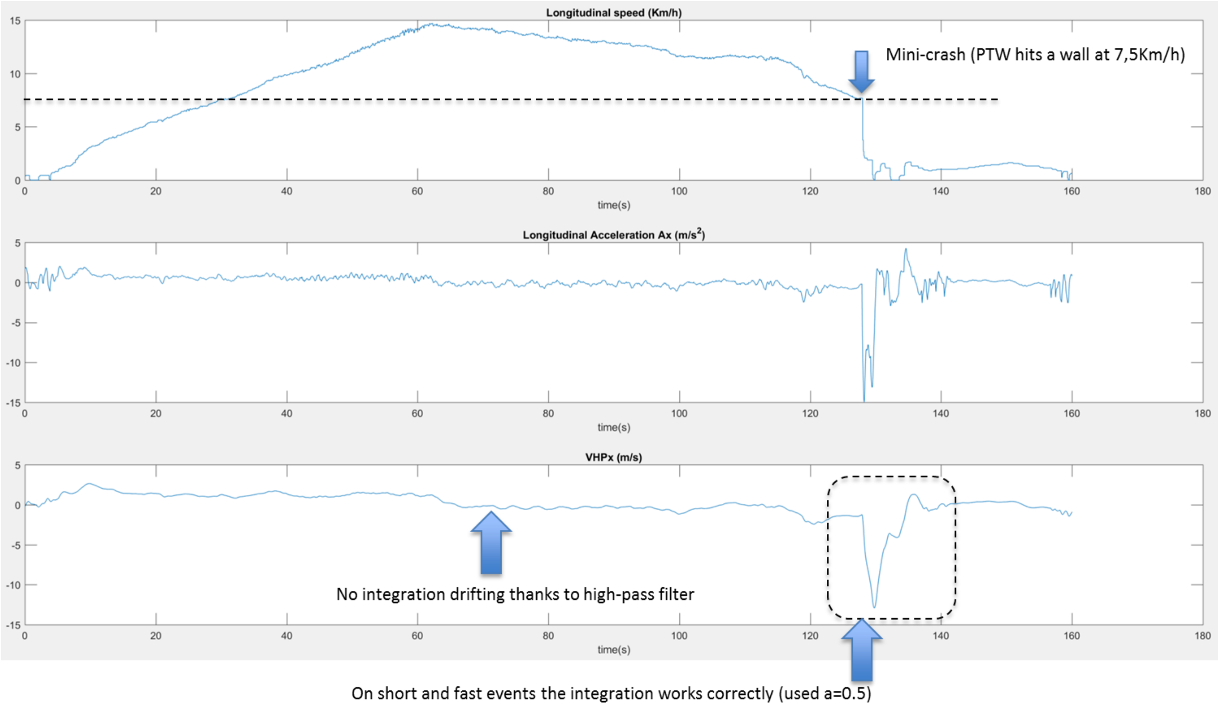


Figure 47 - Real example of VHPx(t) computation from a low-speed "mini-crash" into a wall.

4.1.3 The definition of the main parameters of the meta-algorithm

The algorithm is characterized by a set of parameters (tuning or calibration parameters). These parameters are now recalled and briefly discussed.

- **Ts** [s]: defines the size of the FULL monitoring time-window [t-Ts,t] (sliding window).
- **To** [s]: defines the size of the RESTRICTED monitoring time-window [t-To,t] (sliding window).
- **Vmin** [m/s]: defines the minimum threshold speed that the vehicle must have within the full monitoring window (see meta algorithm)
- **Vdeadzone** [m/s]: defines the near-zero speed range (near-zero-speed dead zone). This parameter is motivated by the fact that a speed sensors can be subject to some noise and can provide a small non-zero value of the speed even when the motorcycle is perfectly still (see. e.g. a GPS-based speed measurement)
- **θmax** [deg]: defines the maximum threshold lean angle of the P2W in order to be considered «upright» (parameter used internally for the definition of the Boolean variable Rollstatus(t))
- **VHPxmin** [m/s]: defines the minimum threshold speed on VHPx that can create a shock-detection on the x plane (must be used ONLY when the motorcycle is still)

- **VHPymin** [m/s]: defines the minimum threshold speed on VHPy that can create a shock-detection on the y plane (must be used ONLY when the motorcycle is still)
- **a** [rad/s]: defines the cut-off frequency of the High-Pass filter in cascade to the integrator, used to reconstruct the speed from ax(t) and ay(t)

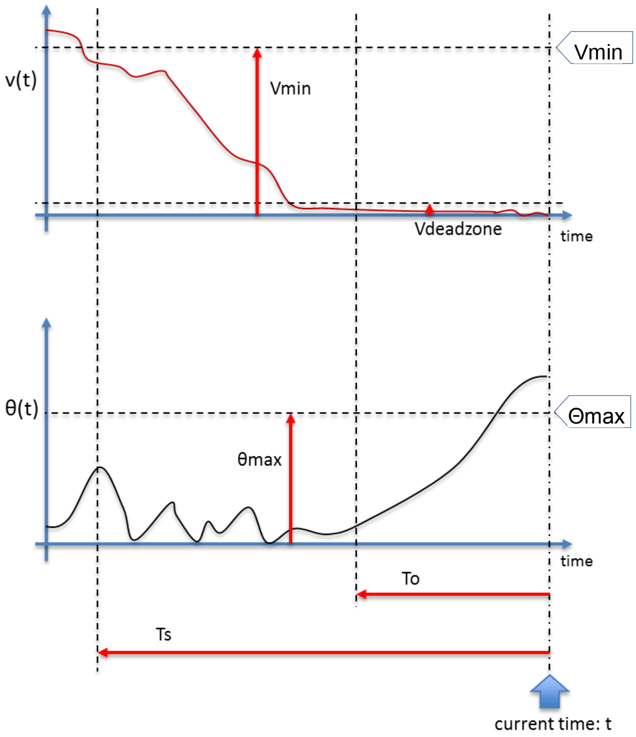


Figure 48 - Pictorial description of parameters Ts, To, Vmin, Vdeadzone, θmax.

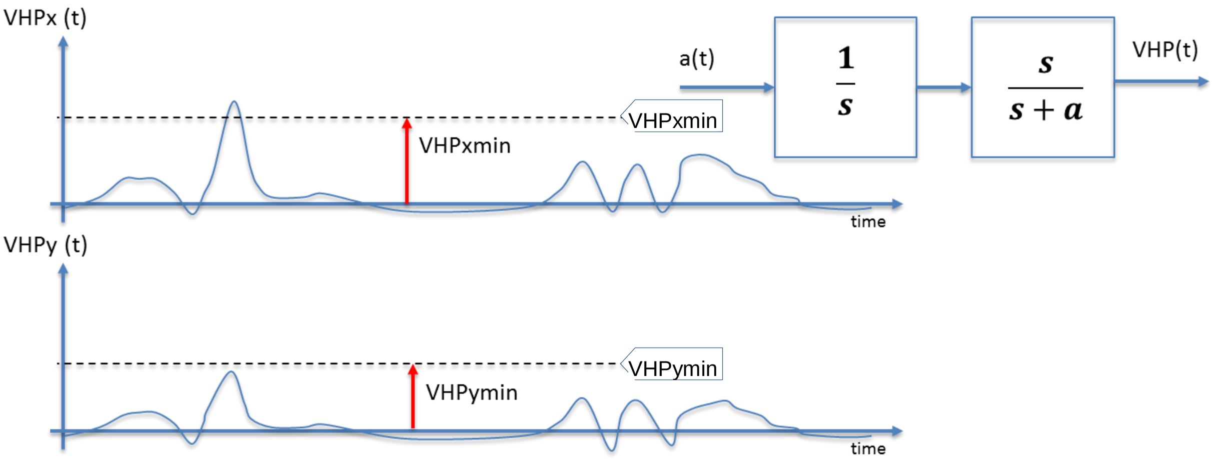


Figure 49 - Pictorial description of parameters VHPxmin, VHPymin, a.

4.1.4 Suggested values of the parameters of the meta-algorithm

The algorithm is characterized by a set of parameters (tuning or calibration parameters). The suggested values of these parameters are now briefly discussed.

To [s]. Tradeoffs:

- Small value: triggering more reactive
- Large value: algorithm less reactive but more robust
- Suggested value: not larger than 10s

Ts [s]. Tradeoffs:

- Small value: more false negatives (some events are discarded)
- Large value: more false positives
- Suggested value: open, OEM definition

Vmin [m/s]. Tradeoffs:

- Small value: low-speed events are included in the triggering algorithm (more false positives)
- Large value: low-speed events discarded (more false negatives)
- Suggested value: not smaller than 15Km/h

Vdeadzone [m/s]. Tradeoffs:

- Small value: risk of non-triggering [critical condition]
- Large value: vehicle still slowly-moving
- Suggested value: no smaller than 1m/s (3,6Km/h)

θmax [deg]. Tradeoffs:

- Small value: more final positions are considered as potential crashes (more false positives)
- Large value: less final positions are considered as crashes (more false negatives)
- Suggested value: OEM definition (depends on the shape of the vehicle; must be more than the lean angle when on the side-stand, and less than the lean angle when on the ground – see Figure 50)

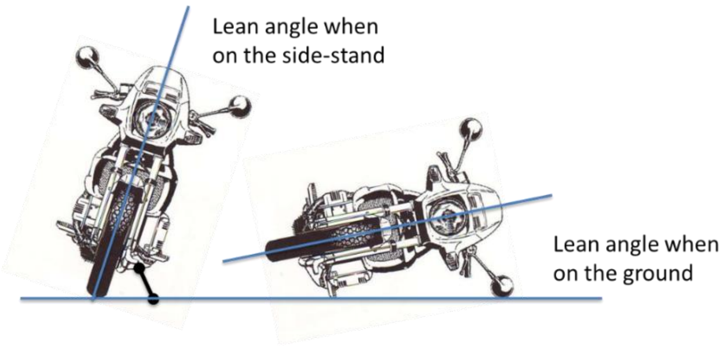


Figure 50 - Pictorial description of the limits of θmax.

VHPxmin and **VHPymin** [m/s]. Tradeoffs.

- Small value: more events could be classified as shocks (more false positives)
- Large value: less events could be classified as shocks (more false negatives)
- Suggested value: OEM definition; depends on the normal vibration levels induced by the engine

a [rad/s]. Tradeoffs.

- Small value: more events could be classified as shocks (slow removal of drift)
- Large value: less events could be classified as shocks (fast removal of drift)
- Suggested value: OEM definition; depends on the normal vibration levels induced by the engine (a tentative value can be 2rad/s - Using a=2 corresponds to a transient time of 5 time-constants, namely 2,5s. Can be a good compromise between a correct integration and drifting removal - see Figure 51)

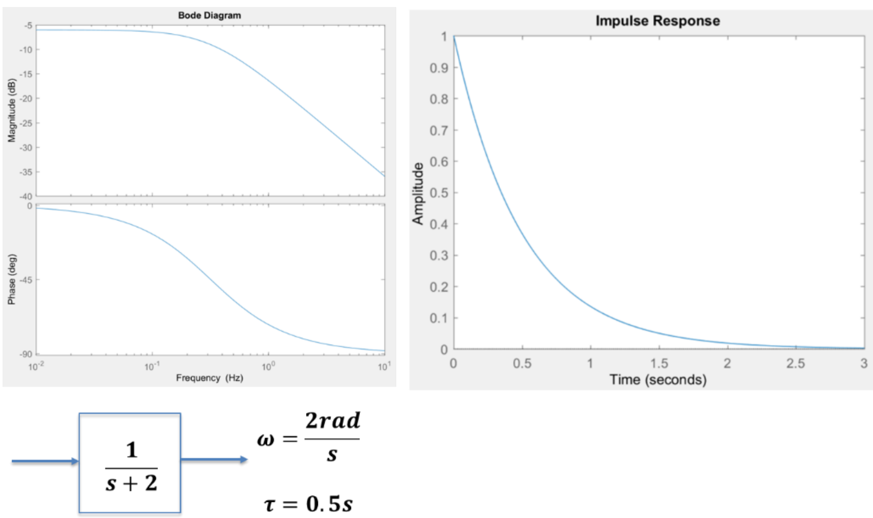


Figure 51 - Example (Bode plots and transfer function) of the cascade of integrator and low-pass filter for the computation of VHPx and VHPy

4.2 Meta-algorithm proposal

The meta-algorithm for eCall triggering is defined as follows (minimum-requirement only):

The triggering variable Firecall(t) takes the following values:

Firecall(t) =1

IF

$\{\theta(t) > \theta max \text{ AND } Vo(t) < Vdeadzone \text{ AND } Vs(t) > Vmin \text{ AND } k(t-Ts)=1\}$

OR

$\{V(t) < Vdeadzone \text{ AND } V(t+To) < Vdeadzone \text{ AND } (|VHPx(t)| > VHPxmin \text{ or } |VHPy(t)| > VHPymin)$
$\text{AND } k(t-Ts)=1\}$

ELSE

Firecall(t)=0

The general idea of the above minimum-requirement meta-algorithm is the following: the e-call is triggered when:

- **Main condition**: the P2W reached, after a crash, a still and not upright condition. Moreover, in the near past the speed of the P2W has been higher than a minimum threshold (with this additional condition low-speeds events are discarded)

  OR

- **Secondary condition**: The P2W, when in a zero-speed condition, experiences a significantly high and long acceleration on the xy-plane (namely it is hit by another vehicle)

In both conditions, it assumed that the P2W is enabled («key-on» or similar) to avoid false positives when the P2W is in parking mode (remark on the “enable” variable: during the crash the key signal could be interrupted; this is why such variable is checked at t-Ts and not at t).

Remark on the secondary triggering condition

Notice that in the secondary triggering condition, namely:

$\{V(t) < Vdeadzone \text{ AND } V(t+To) < Vdeadzone \text{ AND } (|VHPx(t)| > VHPxmin \text{ or } |VHPy(t)| > VHPymin)$
$\text{AND } k(t-Ts)=1\}$

There is a NON-Causal condition (V(t+To) is in the «future» with respect to t). This condition is suggested to avoid false positives in case of very fast accelerations from stand-still. Instead of T0 a fixed number (e.g. 2s or 3 s) can be used)

An illustrative time-domain example (main triggering condition) - (pictorial description)

In Figure 52 a pictorial example of activation of the main triggering condition is proposed.

Remarks:

- the Firecall(t) signal can be subject to some chattering and bouncing; a robustifying condition (e.g. 3 consecutive values at value =1) can be added
- once triggered, the variable Firecall is reset only with enable=off or PSAP terminates the procedure

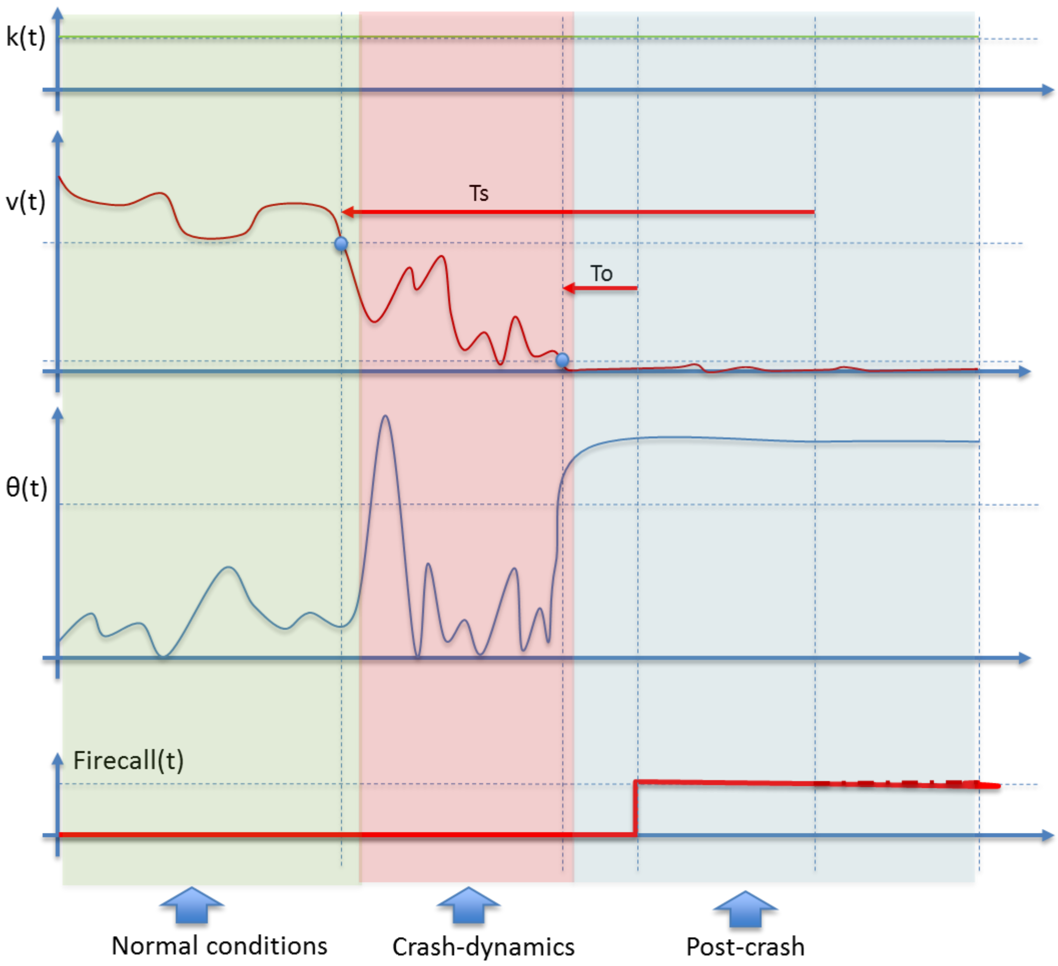


Figure 52 - A pictorial illustration of the main triggering condition.

A real example (main triggering condition)

In Figure 53 an example of activation of the main triggering condition is proposed, using real data recorded during a real crash.

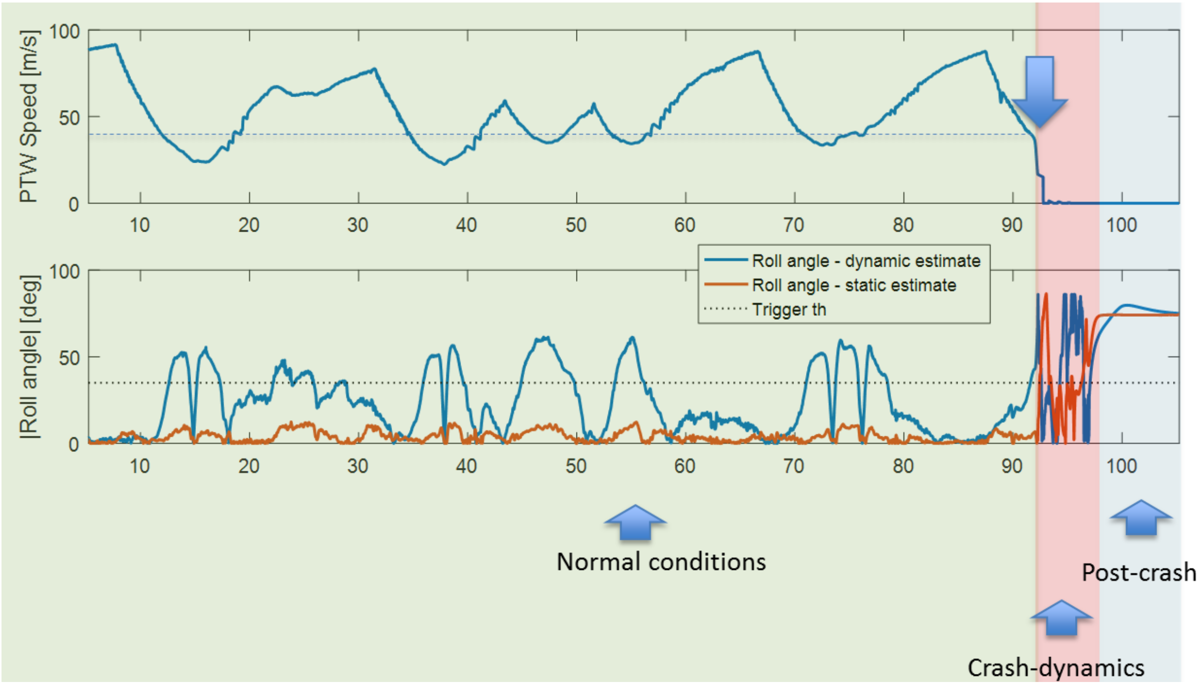


Figure 53 - A practical illustration of the main triggering condition on real data

5 Basic Architecture Recommendations

5.1 Inputs

Referring to Figure 1, there are two tasks providing the main part of inputs for task 3, which deals with basic architecture recommendations. One is task 1 providing the functional description of the in-vehicle system for Powered Two-Wheeler (see chapter 2 - Functional Description). The other studied the criteria for triggering and derived its minimum requirements (see chapter 3 - Criteria for triggering). Other sub-activities focused on these aspects and the results of the studies has been considered as inputs for the architectural recommendations.

The results of the study of existing eCall systems and eCall standards, the results from the patent research as well as conclusions for the adapted MSD recommended for the specific Powered Two-Wheeler eCall are considered as well.

Interfaces to rider and/or passenger (pillion) are not part of the minimum requirement study and thus not considered in the basic architecture recommendation. Bluetooth equipment such as in-helmet microphone / speaker or wirelessly connected sensors are personal fit items and not part of the vehicle.

Additional recommendations from the I_HeERO activity 5 dealing with next generation 112 (packet switched network) could not be considered within this study because of the project timing and thus the missing final results at the time as this document have been issued.

The following two chapters focus on the functional description and the triggering criteria's main inputs characteristics.

5.1.1 Function description

The functional description represents the minimum set of requirements, an in-vehicle system for Powered Two-Wheelers should consist of [24].

Since rider and vehicle are likely to be separated following an accident, the rider can be out-of-range for an acceptable voice quality. In addition, the helmet would impact the clarity of a voice connection. Thus, the i_HeERO Act. 3 experts recommend an eCall without a voice connection as minimum requirement.

As a consequence of the absence of the voice connection, there are two concerns to be addressed. The first concern is the missed opportunity for the PSAP to identify a false call by means of a so called silent call, where the voice connection is used by the PSAP to listen into the scene to get as much as possible information about the actual situation. To address this, the pre-warning time and eCall suppression mechanism has been proposed as a simple and effective countermeasure.

The second concern is that of the manual trigger, which has the same importance as the automatic trigger in the existing standards for M1 and N1 class vehicles. The manual trigger, however, can only be effective if there is a possibility to communicate with the PSAP thereafter to explain the reason of triggering.

In order to make use of the pre-warning phase and to supress the eCall when it is not needed, audio and visual feedback of the ongoing actions and current eCall status must be provided to the rider. As part of the minimum requirements a proposal for a human machine interface has been defined as explained in chapter 2.4.

5.1.2 Criteria for triggering

In this task, the two main results have been produced as inputs for the basic architecture for an in-vehicle system for P2W. These are the minimum set of variables to be measured to detect an accident situation and the meta-algorithm to trigger an eCall itself.

The I_HeERO Act. 3 experts spend a considerable amount of time to define a meta-algorithm for emergency incident (see chapter4 – Meta-algorithm for “minimum requirement”). This basic algorithm is necessary to conclude which vehicular variables to be measured and to then define the verification requirements for conformity assessment.

The triggering algorithm described represents the minimum requirement for an emergency incident evaluation. Each manufacturer shall be responsible to choose the most suitable design assuring the eCall functionality and a number of false calls as low as possible. These can be false positives, where the in-vehicle system for P2W launches a call even it was not necessary, but also false negatives, where no call has been triggered despite the necessity to do so. This usually leads to much more complex designs, involving even more input parameters than described above and would result in differentiating intellectual property of the manufacturer.

The responsibility of the intended functionality of the triggering algorithm shall lie with the manufacturer and/or designer of the system. The I_HeERO Act. 3 experts recommend that, this does not become part of the standard.

The algorithm is described at high-level only without low-level signal processing details. No detail on the management of sensors or system faults (and corresponding risk mitigation) is provided (out of the scope of this document).

The table 2 is a list summarising the relevant measured variables. An extensive explanation of these measured variables is given in section 3.4.1

Name	Variable	Unit	Description
Vehicle-Enabled-Status	$k(t)$	BOOLEAN	Key-on signal
Forward speed	$v(t)$ in $\frac{m}{s}$	INTEGER	
Acceleration in x direction	a_x(t) in $\frac{m}{s^2}$	INTEGER	Acceleration in longitudinal (forward) direction x
Acceleration in y direction	a_y(t) in $\frac{m}{s^2}$	INTEGER	Acceleration in lateral (transversal) direction y
Roll-Status	$\theta(t)$	BOOLEAN	With respect to a pre-defined threshold θ_{max}: 0= below threshold, 1= beyond or equal the threshold

Table 2 - List of measured variables

5.2 System Boundary

The system boundary represents the interface between the system and its environment or between the system and its neighbour system (Figure 54).

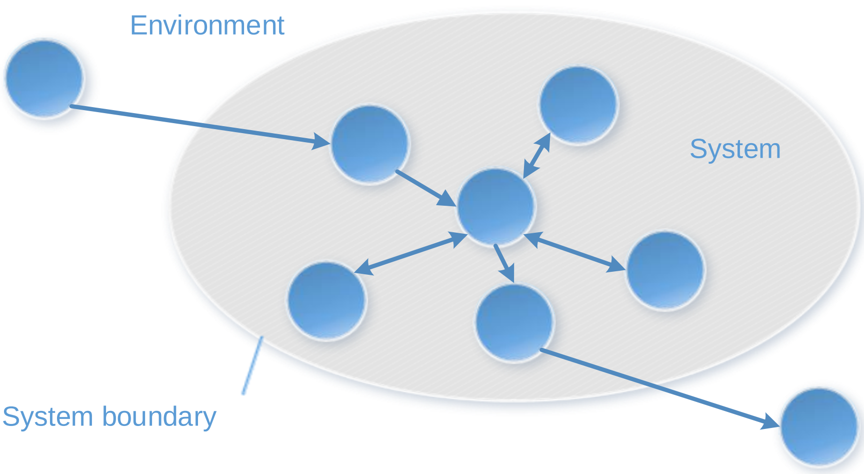


Figure 54 - Elements of a system

In case of the P2W eCall system this includes the following functional elements:

- Apparatus for measuring different variables.
- Processing unit for analysis and evaluation of above variables.

- Triggering logic able to automatically trigger an eCall based on the result provided by the processing unit.
- HMI for visualization of operation status as well as call cancelling in case of misuse or false alarm.
- Transmit device able to setup a cellular network link between in-vehicle system for Powered Two-Wheeler and PSAP and transmit the MSD via this link. Furthermore, the device allows for call-back functionality.

Outside the system and thus out of scope for the definition of a basic architecture are:

- The cellular network infrastructure and the PSAP, TPSP infrastructure
- Devices and logic not physically related to motorcycle like Bluetooth headsets and microphone, remote controls etc.

Interfaces to neighbour systems and actors are:

- PSAP
- Cellular network
- Motorcycle
- Human

Figure 55 illustrates the system in standard UML.

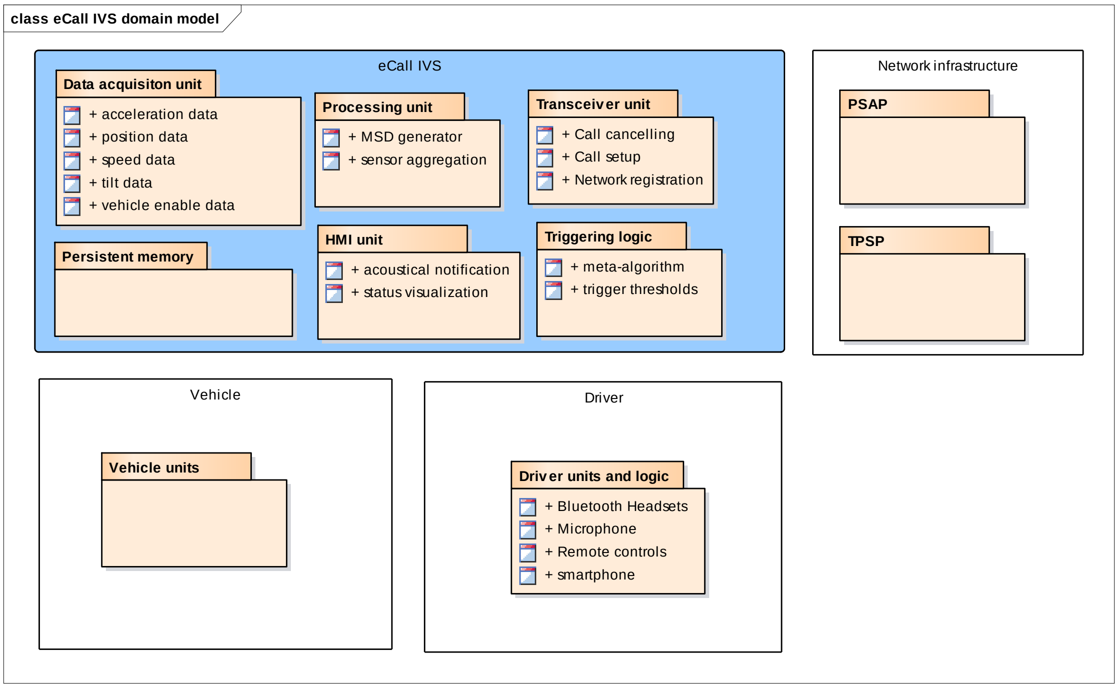


Figure 55 - UML view of the in-vehicle system for P2W

5.3 Architectural recommendations

5.3.1 State-of-the-art

A comprehensive state-of-the-art analysis has been carried out by the I_HeERO Act. 3 experts. The results are summarized in milestone report M22 [2].

In reference to EN 16072 (Pan-European operating requirements) [27] the high-level requirements of an in-vehicle system are:

- the eCall in-Vehicle System shall include a Network Access Device (NAD, e.g. PLMN (such as GSM), module);
- the eCall in-Vehicle System shall detect when an eCall trigger has been initiated;
- in the event of an accident the eCall system shall automatically determine whether or not to trigger an eCall and where appropriate make such an eCall automatically;
- an eCall shall also be able to be triggered manually;
- upon triggering an eCall
  - an emergency call with service identification eCall (TS12 according to ETSI/TS 122 003 [28]) is signalled manually or automatically to the mobile radio network.
  - a Minimum Set of Data (MSD) to any system operated by a given Mobile Network Operator (MNO) with the European pre-assigned TS12 destination address (112) is sent;
- the eCall system shall also try to establish a voice connection between the vehicle and that pre-assigned destination address (preferably a Public Safety Answering Point (PSAP) with TS12);
- the eCall system shall provide clear visual and/or audible information regarding the status of the connection when the eCall system is automatically or manually activated (HMI)

There is a requirement prescribed in EN 15722 [29] to provide data. This results in additional functional elements of an in-vehicle eCall system.

- Actual (at the time of triggering) vehicle's location and direction determination system based on GNSS or other means fulfilling the accuracy and confidence information requirements.
- Timestamp of the initial data generation within the current eCall incident event
- Memory to persistently store:
  - vehicleType

- VIN number (according to ISO3779)
- vehiclePropulsionStorageType

Optional other information can be transmitted in the MSD as well. This can lead to extended in-vehicle system architectures, which are not considered in this document.

In the European Standards for Pan-European eCall [27], the generation of the automatic triggering signal is declared as a signal from one or more sensors or processors within the vehicle and thus not considered as part of the in-vehicle eCall system. A reference to other sensor data, for example used within an airbag control module is being made. The existence of an appropriate triggering mechanism was the reason for the application of the mandate to M1/N1 class vehicles only in the first step.

Furthermore, according to the European Standard, the in-vehicle system is deemed to:

- be capable of supporting eCall;
- be robust and to normally survive a crash;
- meet the specification of the operating requirements of the ETSI communications standards, in the case of GSM/UMTS circuit switched networks, (ETSI/TS 122 101, ETSI/TS 124 008, ETSI/TS 126 267, ETSI/TS 126 268, ETSI/TS 126 269 [Release 8 or later]) under which it operates and the quality of service requirements defined in this document;
- use an ETSI prime medium when transmitting the MSD message

A high level generic eCall architecture is described in Figure 56.

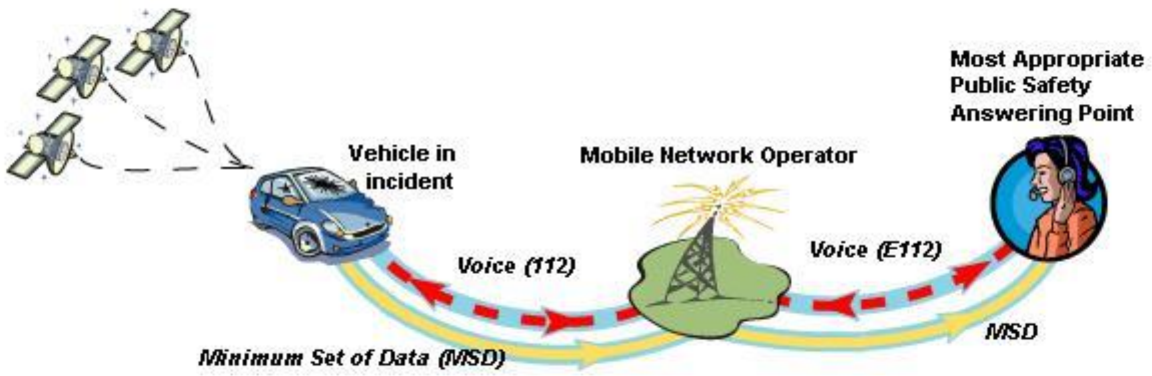


Figure 56 - State-of-the-art eCall operation sequence

Derived from these requirements, a state-of-the-art in-vehicle eCall system would comprise of the following functional blocks:

- Cellular Network connectivity (GSM)
- In-band modem for MSD transmission
- Embedded SIM
- GNSS (GPS, Galileo)
- Antenna for GNSS and GSM
- Power supply
- Vehicle connectivity (e.g. CAN)
- Analogue-to-Digital and Digital-to-Analogue coder/decoder (Microphone, speaker)
- eCall application

5.3.2 Basic architecture recommendation for in-vehicle system for Powered Two-Wheeler

In this chapter the differences of a state-of-the-art in-vehicle eCall system to an IVS for P2W are focused on.

5.3.2.1 Voice connection

As described in sub-section 5.1.1 “Function description”, it is recommended that the voice connection should only be optional (see Figure 57).

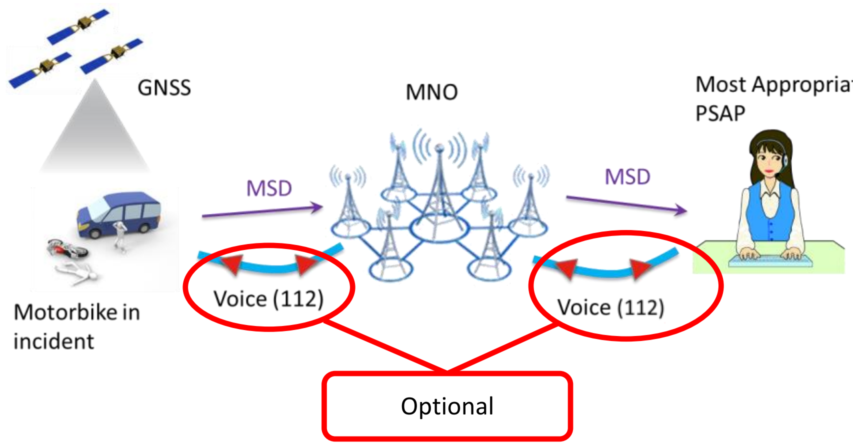


Figure 57 - main parts of eCall for P2W

The eCall connection (TS12), in this case, is used for the message transfer according to ETSI/TS 126 267 and ETSI/TS 126 268, such as “SEND-MSD”, “INITIATION” message and “ACK” messages only. The PSAP can also push a MSD “Resend-REQ” request via this call. However according to the minimum requirement proposal, the voice path of the IVS for P2W is disabled. In Figure 58 the audio path within the in-band modem and also the corresponding functional blocks for ADC and DAC as well as the amplifier to connect a loudspeaker are shown as disabled.

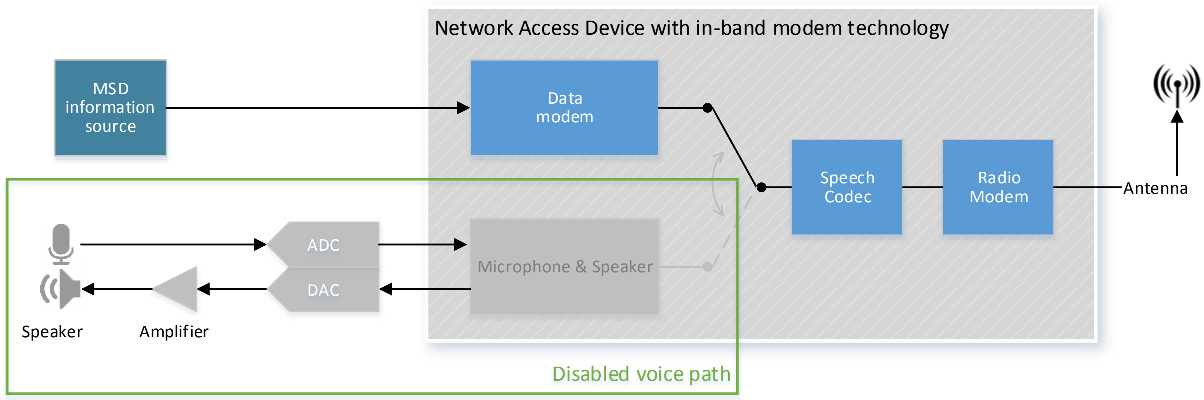


Figure 58 - In-band modem within Network Access Device [30]

5.3.2.2 eCall button for manual triggering

The I_HeERO Act. 3 experts for eCall for P2W see a need of a voice connection if the in-vehicle system has the manual trigger capability to allow the user to justify the triggering to the PSAP. Thus, there is a direct link between the need for the audio connection and the manual triggering. Since the recommendation is that voice connection for an IVS for P2W should be optional, it follows that the manual triggering feature should also be optional. The basic architectural recommendation will therefore not consider the manual triggering button.

The test procedures for the EC type-approval with respect to 112-based eCall in-vehicle systems [30] assumes the availability of a manual trigger via the in-vehicle HMI. The testability need to be ensured by other means, such as via a diagnostics command.

5.3.2.3 Human Interface

Special consideration to the HMI (Human Machine Interface) and how it should be implemented within the “Minimum Requirements” are described in section 2.4. It is recommended that the HMI provides an indication about the eCall status, such as pre-warning, eCall launched, eCall not launched or system fault through a combination of acoustic warning and visual warning.

With reference to section 2.4, the recommendations for a minimum requirements HMI are:

- Audio feedback by means of a buzzer or similar acoustic device
- Visual feedback by means of an LED indicator specific for eCall function
- Button for eCall suppression during the pre-warning period

Within the architecture for an IVS for P2W, the output driver for the visual (e.g. LED) and audio feedback (e.g. buzzer) need to be considered.

5.3.2.4 Automatic triggering

One of the main differences of an IVS for P2W compared to for M1/N1 class vehicles IVS is the absence of an automatic triggering signal (such as an airbag ECU). In case of a P2W, this triggering signal need to be processed and generated by using certain defined variables and an automatic triggering algorithm as described in chapter 4.

Even though the design of the triggering algorithm itself shall be at the discretion of the vehicle manufacturer or the equipment supplier, its robustness, reliability and moreover its effectiveness need to be ensured. It is recommended that the triggering demonstrates conformity against the verification standard [32] during the EC type-approval procedure. The automatic triggering application thus becomes part of the IVS for P2W. The provision of the minimum set of variables for trigger calculation (Vehicle Enable Status, Speed, Roll Status and Acceleration in x- and y-direction) and the methods shall be under the responsibility of the manufacturer.

5.3.2.5 Basic architectural recommendation at a glance

In conclusion of the aspects described in the chapters above an IVS for P2W would follow the proposal as shown in Figure 59 (high level architectural view). Starting from the functional blocks of an eCall IVS for M1/N1 class vehicles (highlighted in blue) there are additions (highlighted in green) and removals (marked w/ a red cross) recommended for a P2W application.

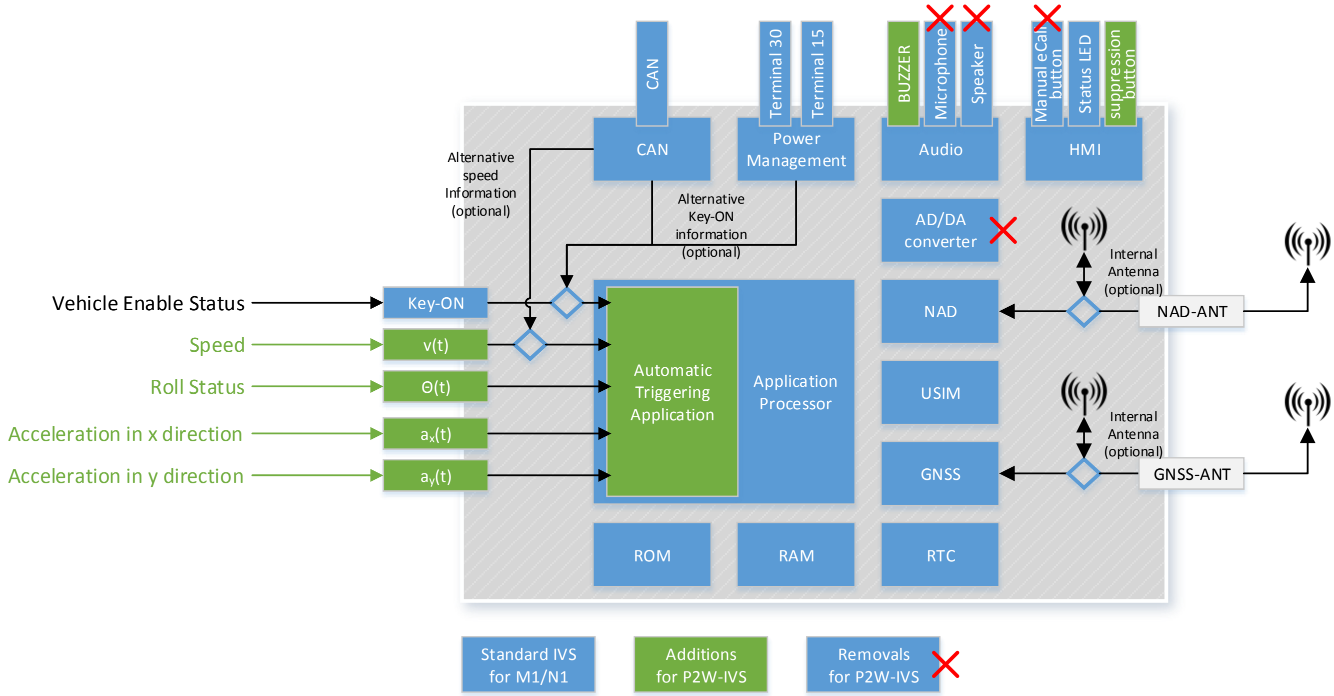


Figure 59 - Functional blocks of an in-vehicle system for P2W

In the following the functional blocks are described in more detail.

CAN Interface

The IVS for P2W shall gather information through the vehicle's CAN (Controller Area Network) if available, with low latency. These can be vehicle status information (Key-ON), vehicle speed information but also information from an external acceleration sensor. Also, information required for the MSD message compilation shall be partly retrieved from another ECU via CAN such as VIN, vehiclePropulsionStorageType or numberOfPassenger according to EN 15722 [29].

In line with the current eCall standards for M1/N1 class vehicles, the implementation of the CAN interface for P2W IVS shall be at the discretion of the vehicle manufacturer / equipment supplier.

Power Management

The block "Power Management" ensures a stable power supplier to all components of the IVS for P2W in their defined voltage and current ranges. It manages overvoltage situations (long-term or transient), jump starts, alternating voltages, interruptions, reverse polarities, short circuits and others. It also manages the power modes in case the IVS is controlled via terminal 15 and will generate a virtual Vehicle Enable Status information.

It is assumed that the IVS for P2W is supplied with sufficient power to fulfil the requirements, such as the necessity to remain registered on the serving network for 60min to allow PSAP and/or rescue workers to call back.

Audio Interface

According to chapter 2, the voice connection should not be mandatory but only optional. The basic architecture recommendation for an IVS for P2W would therefore be without interfaces for the speaker, the microphone and the corresponding drivers (AD, DA converter, amplifier etc.).

It is assumed that the P2W IVS will provide an interface to a buzzer or similar acoustic device for audio feedback. Unlike the M1/N1 eCall IVS, the rider must be provided with an audio indication as to whether an eCall has been launched or not.

HMI

The functional block of the Human Machine Interface (HMI) manages the interfaces to the status LED's for visual feedback and the suppression button. A button is included in the HMI for the suppression during the pre-warning state following the recommendations described in chapter 2.4.

The HMI will alert the rider about the results of the self-test as well as the status of the eCall launch sequence.

Network Access Device (NAD)

The Network Access Device connects the IVS for P2W to the most appropriate PLMN. It contains the in-band modem capability and is usually controlled using AT-commands. The NAD must comply with the eCall recommendations defined by ETSI:

- NAD (Network Access services) and USIM eCall extensions according to ETSI/3GPP Release 10: 3GPP TS 51.010-1, 3GPP TS 24.008, 3GPP TS 31.102 and ETSI TS 127.007
- In-Band Modem solution according to 3GPP Release 10: 3GPP TS 26.267, 3GPP TS 26.268 and 3GPP TS 26.269

The basic architecture recommendation is aligned with the established eCall standards for M1/N1 class vehicles and thus supports circuit switched networks. The I_HeERO Act 3 experts has no specific recommendations about the type of connection to the network. An extension to support packet switch networks based on IMS is considered outside the scope of this report.

Following the current eCall standards for M1/N1 class vehicles there are no additional recommendations for IVS for P2W.

Universal Subscriber Identity Module (USIM)

A USIM is connected to the NAD to enable authenticated call set-up. It stores user subscriber information, authentication information and provides storage space for text messages and phone book contacts. The USIM can be configured only for eCall (in this European Standard referred to as "eCall only"), or a combination of eCall and commercial service provision.

Following the current eCall standards for M1/N1 class vehicles there are no additional recommendations for in-vehicle systems for powered Two-Wheeler.

Antennas

The IVS for P2W consists of an antenna for cellular network connectivity and for GNSS signal reception. Both antennas shall be designed to ensure maximum power radiation and signal reception sensitivity to compensate signal losses due to the installation inside the IVS, which again might be packaged in a safe zone on the motorcycle, resulting in signal attenuation.

Following the current eCall standards for M1/N1 class vehicles there are no additional recommendations for in-vehicle systems for powered Two-Wheeler.

Global Navigation Satellite System (GNSS)

The GNSS provides a location information to be used within the MSD. It also indicated with a confidence bit, whether the position can be trusted as defined in EN 15722 [6].

In accordance to the delegated regulation 2017/79 [31] the GNSS shall be capable of receiving and processing individual signals in L1/E1 band from at least two global navigation satellite systems, including Galileo and GPS.

Following the current eCall standards for M1/N1 class vehicles there are no additional recommendations for in-vehicle systems for powered Two-Wheeler.

Real Time Clock (RTC)

The RTC is a real-time clock (or physical clock), which measures the physical time and ensures the update of the time even when the in-vehicle system is OFF.

Thanks to the RTC, a GNSS receiver can shorten its start-up time by comparing the current time with the time at which it last had a valid signal. If it has been less than a few hours, then the previous ephemeris is still usable.

The time stamp information is part of the MSD.

Following the current eCall standards for M1/N1 class vehicles there are no additional recommendations for in-vehicle systems for P2W.

5.3.3 Design recommendations for an IVS for P2W

During the design of an IVS for P2W there are different aspects to be considered. This section lists some focus areas and provides some recommendations. These are:

Cost

In order to successfully achieve a wide deployment of the pan-European eCall-service, especially if the installation of an IVS for P2W is on voluntary basis, the cost of the system will be the most significant criteria. Efficiency in design, bill of material, production and operation of service are key to keep costs down

A lower bill of material can be achieved through a high degree of integration by encapsulating as many functional blocks (GSM and in-band modem, GNSS, CAN interface) and applications (eCall, network management, diagnostics) as possible into one module which shares a single CPU and its connected peripherals, such as crystal and memory. On the other hand, the high degree of integration requires a robust security concept which may drive the design to a more decentralized one.

The number of connectors should be reduced to an absolute minimum. All components should fit onto one PCB to avoid connections between multiple boards. Also, the suitable connectors for external devices need to be considered.

Radiated power and radiated reception sensitivity

In case of a severe accident, the IVS for P2W shall reliably receive position information based on GNSS and establish a stable connection to a PLMN. This requires the IVS-design to be robust against mechanical impacts. But also, the connected peripherals need to be designed in a way, that they can withstand these impacts. As far as the antennas are concerned, preference shall be given to internal ones. As mentioned in the cost focus, connectors to external antennas are not only costly but in terms of robustness during an accident, these antennas and the corresponding connectors are critical. In M1/N1 class vehicles this circumstance can be mitigated by choosing a crash-proven location such as the centre console or underneath the seats, however on a motorcycle those protected areas are rare.

Internal antennas increase the robustness of the overall system against mechanical forces, but impose draw backs in terms of radiated power transmission and radiated reception sensitivity. Thus special focus shall be placed on the design of the antennas and their performance parameters such as antenna gain and radiation pattern. Also, the mounting position on the motorcycle is essential for an optimal antenna performance and should be taken into account during the design. A good antenna design and its integration into the IVS for P2W including less interference to electromagnetic radiated and conducted emissions results in a fast eCall establishment, a reliable transmission of MSD, a low bit error rate and a reduced probability of a call failure.

Power consumption

The IVS for P2W should be designed in a way to consume the least amount of power during standby. To avoid draining the battery in case of long immobilization, specific measures should be adopted to reduce the consumption (dark current) at the minimum possible level. This minimal power consumption state can be achieved by a design which can disable as many as possible components inside the IVS.

A low power consumption is also necessary during the run time operation of the IVS for P2W. Especially after a severe crash resulting in loss of connection to the vehicle's battery charging circuitry, it is important to ensure that power is available to meet the minimum call and standby time.

Maintainability

Software is today a key factor for many IVS, because it is often optimised to implement improvements and to meet evolving needs, manufacturers must regularly perform software updates on installed IVS. It is therefore important this process is managed efficiently and securely over the entire life cycle of the vehicle.

An update with functional improvements can be installed into the IVS at the dealership with state-of-the-art wired diagnostics interface during a routine vehicle maintenance inspection.

Connected devices can only support the state-of-the-art security standards and technologies available at the time of system design. As the technologies, the knowhow and methods further evolves over time, it might become necessary to address upcoming security issues through the release of a security patch.

Sensor performance

It is recommended that the application to generate the automatic trigger shall be part of the IVS for P2W. It is understood that the following variables are the minimum required inputs for the underlying algorithm:

- Vehicle-Enabled-Status

- Forward speed
- Acceleration in x direction
- Acceleration in y direction
- Roll-Status

The provision of these variables and the methods shall be under the responsibility of the manufacturer.

Vehicle-Enable-Status, Speed and the Roll-Status based on the definition above are available on today's L3-category vehicles. However special focus shall be placed on the sensor(s) providing the measured acceleration values in x- and y-direction.

Based on the technical recommendations, there are quality requirements that need to be met by the acceleration sensor. Depending on the use cases, an automatic eCall should be triggered, these are:

- Crash while motorcycle stands still (v = 0km/h)
    - General requirements
        - Vibration resistance
        - Drift resistance
        - Sensor monitoring
        - High sampling rate, otherwise the crash itself cannot be detected
        - Sensor range must be sufficiently large to be able to distinguish use from misuse cases
        - Signals must be available at least for the crash event itself
        - Crash resistance (sensor, installation)
    - Special requirement for the acceleration sensor
        - Measurement range in x and y plane
- Crash while riding (v > 0km/h)
    - General requirements
        - Vibration resistance
        - Drift resistance
        - Sensor monitoring
        - Sensor must provide signals also after the crash, minimum the time T_0 after reaching the final position

      - Low sampling allowed since not time-critical
      - Crash resistance (sensor, installation)
  - Special requirement for the acceleration sensor
      - Installation location (static lean angle must be measurable)
      - Sensor range can be above 1g for the detection of the final position of the motorcycle

Moreover, according to the meta-algorithm recommendation, the acceleration sensor can be used for speed determination as well. With this a higher sensitivity for speed changes together with GNSS can be achieved. However, this can lead to different requirements for the sensors in terms of range and sampling rate. Also, the dynamic lean angle could have an increased influence.

Self-test capabilities

On power-up, according to EN 16062 [34] the eCall IVS shall perform a self-test without attempting to connect to the cellular network. Any critical system failure, which would result in an inability to execute an eCall shall generate a warning signal for the rider. The nature of such warning is a feature of the product design and not standardized.

However, as described in chapter 2.4, a minimum of standardized HMI is recommended to visualize the system status and system failures. This will allow an easy recognition of and fast familiarization with the eCall conditions even in case of frequent change of P2W model and brand.

Automotive qualification

The IVS is intended to be mounted on/in a motorcycle. Special design requirements might be imposed by the national regulations and/or by the vehicle manufacture such as Ingress Protection (IP rating), climate characteristics (temperature ranges), humidity, vibration characteristics, chemical characteristics or flammability characteristics, which may result in an automotive grade design and component selection.

- AEC-Q100 qualification for integrated circuits
- Manufactured at ISO/TS 16949 certified production sites
- Compliance with ISO 16750 – “Environmental conditions and electrical testing for electrical and electronic equipment for road vehicles”.
- Automotive temperature range, typically –40 to +85 °C

- Qualified and experienced automotive electronics manufacturers

EC declaration of conformity

Radio products and products with integrated radio components must abide to specific national requirements in order to receive legally prescribed type approval in the respective country (e.g. EMC directive (2004/108/EC) and R&TTE directive (99/5/EG)).

The vehicle manufacturer / equipment supplier is responsible for all duties under the respective national requirements (e.g. proper display of warning notes and/or of the CE declaration, re-certifications due to new directives or due to time limited country approvals, …).

6 Prototype

In order to demonstrate the functionality of a complete P2WeCall system two demonstrators were built. For testing the system adaptability, the chosen bikes were of different type, a travel bike (KTM 1290 Super Adventure R) and a sports bike (Aprilia Tuono 1100). The riding tests included some types of accidents where an eCall should be triggered and also non-trigger manoeuvres with high excitation of the bike. In the following all technical components and test scenarios are described in more detail.

6.1 eCall prototype system overview

The architecture for the prototypical eCall system is sketched in Figure 60. An inertial sensor unit measures the accelerations in three dimensions, wheel speed sensors detect the velocities of the front and rear wheel. These sensor data are sent to the ABS-ECU by CAN signals. The ABS-ECU software also includes the accident detection algorithm. If the algorithm detects an accident a CAN-trigger-signal is sent to the Central Communication Unit (CCU) which is also connected with the vehicle CAN. On the handle bar a HMI-device is mounted with status LEDs and an eCall suppression button. The audio interface activates an acoustic signal (buzzer). These components were installed on two test bikes as described below, all components are further described in the following chapters.

It must be pointed out that this setup is only an example of a complete eCall system. Other configurations with a more compact design are also possible for instance by integrating the accident detection algorithm into the CCU.

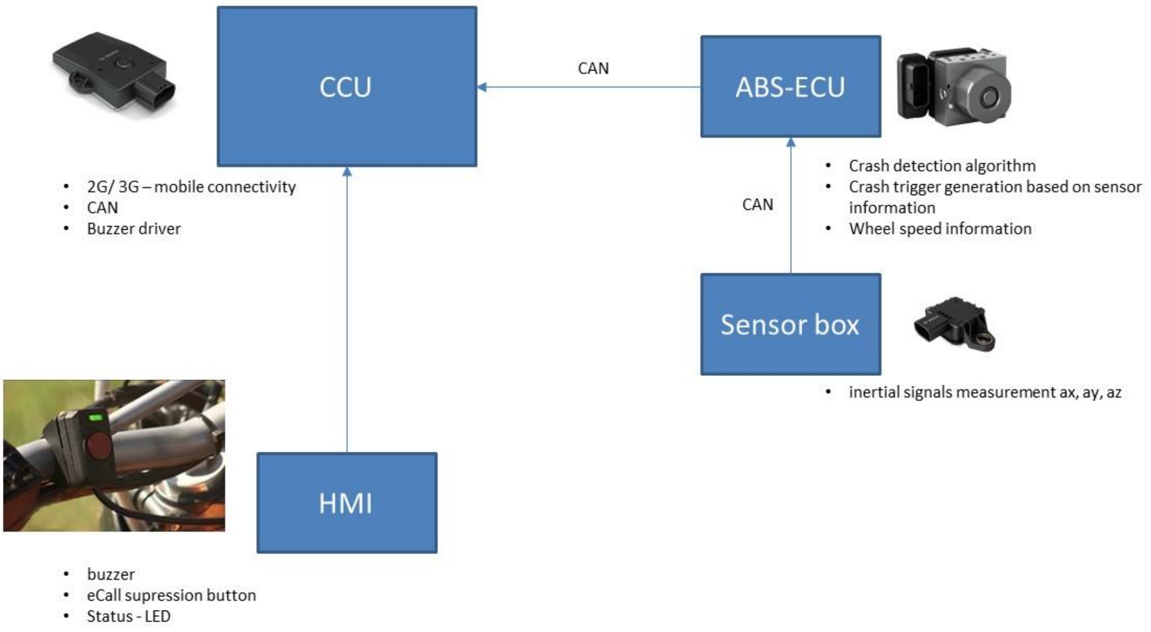


Figure 60 – eCall architecture for prototype proposal

6.2 Test bikes

Piaggio provided the sport bike Aprilia Tuono 1100 (model year 2015) as shown in Figure 61. Some technical data can be found in Figure 62. The bike was already equipped with an inertial sensor box but for the current ABS software including the accident detection algorithm it was necessary to exchange the ABS unit with an ABS 9MP aggregate.

Figure 61 - Aprilia Tuono 1100

CAPACITY	1077 cc
POWER	175 hp at 11000 rpm
WEIGHT	184 kg
HEIGHT	825 mm
LENGTH	2.070 mm

FUEL	Unleaded petrol
FRONT TYRE	120/70 ZR 17"
REAR TYRE	200/55 ZR 17"

Figure 62 - Main technical characteristics of the Aprilia Tuono 1100

As a bike from the travel/enduro segment KTM provided the current 1290 Super Adventure R [see 37]. This bike is already equipped with the latest ABS aggregate and inertial sensor unit suitable for demonstration purposes. The bike is shown in Figure 63, some technical data can be found in Figure 64.

Figure 63 - KTM Super Adventure 1290 R

CAPACITY	1301 cc	**FUEL**	Unleaded petrol
POWER	118kw	**FRONT TYRE**	90/90 ZR 21"
WEIGHT	217 kg	**REAR TYRE**	150/70 ZR 18"
HEIGHT	890 mm		
WHEEL STAND	1580 mm		

Figure 64 - Main technical characteristics of the KTM 1290 Super Adventure R

6.3 Inertial sensor box

In both bikes the BOSCH inertial sensor box MM5.10 was used. It offers acceleration data in three dimensions and angular velocity data in two dimensions. Within the current accident detection algorithm only the acceleration data was used. In the Aprilia Tuono the sensor is mounted below the seat bench, in the KTM Super Adventure the sensor is mounted between tank and engine.

6.4 ABS-ECU including accident detection algorithm

Before the bike integration the accident detection algorithm was tested with simulative methods and the usage of an extensive manoeuvre catalogue including about 700 sets with sensor data of riding situations. The data base contains several accident types (collisions, low/high sider, capsizes) as well as accident-free rides with high excitation (off-road, bad roads, caught near accidents).

The accident detection algorithm was directly integrated into the software components of the vehicle state estimation as used for the lean angle dependent ABS functionality. The KTM 1290 Super Adventure R already used the current ECU and software, only the accident detection algorithm was added to the original software. The Aprilia Tuono (model year 2015) was updated with a new ABS aggregate and current ECU software for lean angle dependent ABS functionality where the accident detection algorithm could be integrated in the same way as in the KTM bike. In both ECUs the standard ABS-CAN interface was modified offering an additional message for sending a trigger signal in case of a detected accident.

In both bikes the ABS unit is mounted in a central and well protected position between seat bench and engine, so in most cases no immediate damage in case of an accident is expected.

6.5 Central Communication Unit (CCU)

The CCU as the central communication device is shown in Figure 65. It is connected to the vehicle CAN for receiving the accident detection trigger signal from the ABS-ECU in the current setup. It also is connected to the HMI as described in the next chapter and to a buzzer for acoustic indication of a detected accident.

Figure 65 - Housing of CCU

For the optimum functionality of the CCU regarding crash safety and connectivity there are some recommendations for finding a convenient mounting position. The CCU should be covered under a plastic shield near the outer shell of the motorbike and not behind any part of the rider.

At the test bikes, the CCU was prototypically integrated into the pillion rider seat (Aprilia Tuono; the tests as described below were done without pillion rider) respectively in the rear area under the complete seat bench (KTM Super Adventure).

Current CCU has a size of 62x95x24 mm. Future studies are required for determining the most suitable position, regarding also the most robust CAN-connection so that CAN communication is ensured also in case of a severe collision.

6.6 HMI interface

On both bikes a handle bar module from Digades were mounted (see Figure 66) and connected with the CCU. Beside the Buzzer connected with the CCU an eCall pre-trigger is now visible by LEDs and the eCall can be suppressed by pushing a button between a defined time span (20s for demonstration) in case of an unharmed or slightly injured rider.

Figure 66 – Example of HMI with LED and eCall suppress button

6.7 Riding tests

The riding tests were done on the test track of the BOSCH corporate research campus in Renningen. An air photograph is shown in Figure 67.

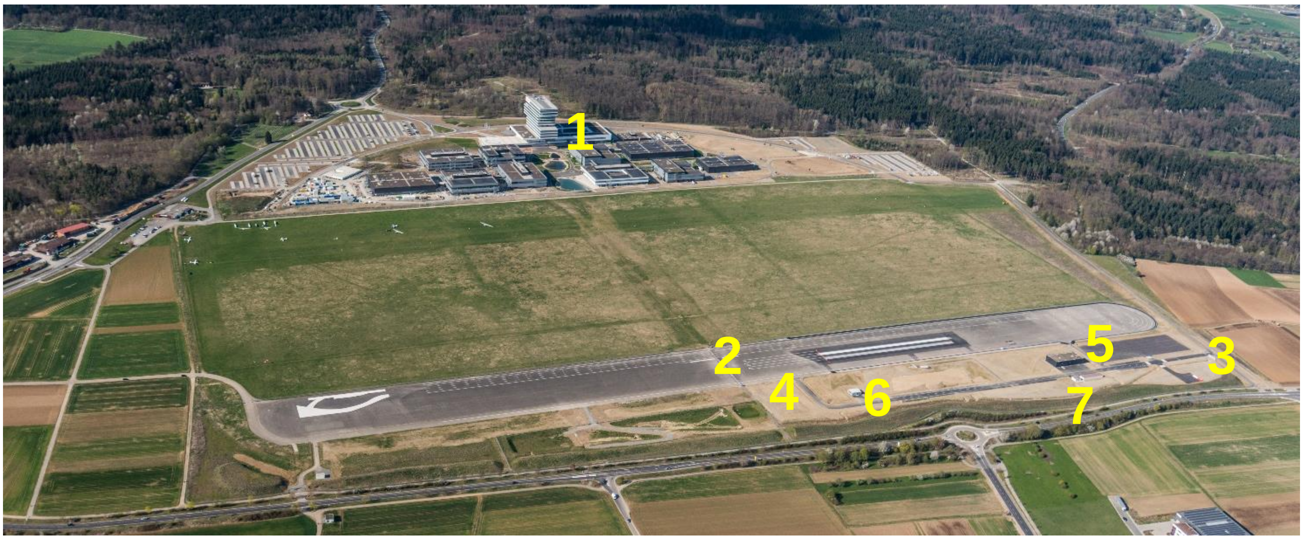


Figure 67 - BOSCH corporate research campus with test track

Description of the areas:

1. Bosch research campus
2. Bosch test track
3. Test track main entrance
4. Inner entrance
5. Inner exit
6. Office
7. Garage

The riding tests were planned in a way to comply the basic requirement as defined in previous work packages (e.g. verification proposal WP3.2).

<u>Non-trigger events:</u>

- Extreme riding maneuver
    - A professional stunt rider was hired to conduct both bikes accident-free riding with unusual excitations of the sensor set, i.e. wheelies, stoppies and drift maneuvers. The aim was to show that even under extreme conditions no eCall is triggered.
- Capsize at stand still
    - To show that capsize in stand still condition does not trigger an eCall, the KTM bike was overturned without a rider sitting on.

Trigger events:

- Low-sider accident
  - Directly after the non-trigger maneuvers with the Aprilia, the stunt rider did intentionally a low-sider accident by strong braking of the front wheel with deactivated curve-ABS while curve riding with a velocity of ~50 km/h to demonstrate eCall triggering under realistic circumstances.
- Rear-end accident
  - A further accident type was a collision with a passenger car while standing still with the bike which corresponds to a typical crossing accident. Due to safety reasons, no rider was sitting on the bike. The KTM bike was equipped with side bags to avoid seizing with the car. The glass windshield of the car was laminated with an adhesive film to avoid fragmentation to safe the car driver and the airbags were disconnected. The stunt rider also drove the car wearing complete motorcycle safety gear and hit the motorcycle at rear-end with a velocity of 40 km/h.

These maneuvers can be regarded as a minimum demonstration set of extreme non-trigger situations and eCall relevant accident types.

For a serial application, a lot of manoeuvres would have to be tested with real crash tests or by simulation including:

- all kinds of bikes (also scooters, light-weight bikes and extreme heavy bikes)
- different types of collision opponents (also pedestrians, bushes, scarps)
- modified bikes, i.e. with large side bags which may damp collision excitations

6.8 MSD setting for eCall demonstration

According to document EN 15722 [29] the MSD setting function is implemented in the CCU device.

For simplifying the activity of testing and development of eCall function an on HostPC tool by CEIT was prepared (see figure below).

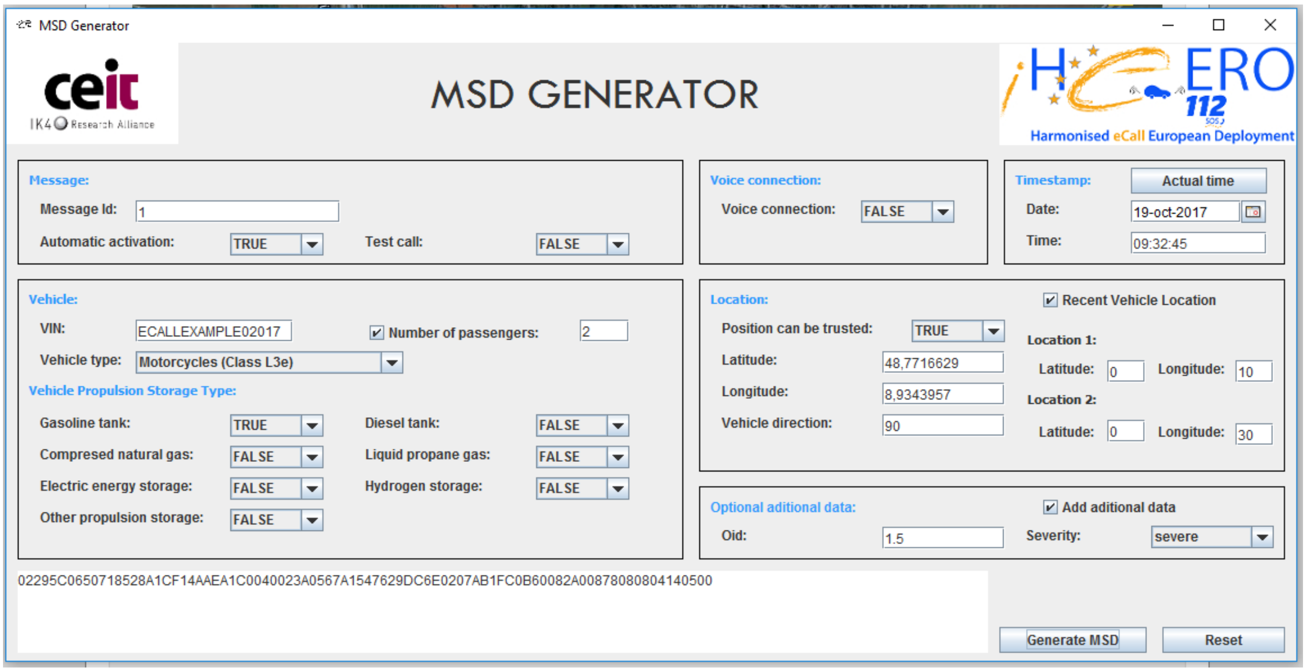


Figure 68 - host PC interface for MSD setting

During the study of I-HeERO P2W cluster some parameters were defined useful for PSAP and rescue efficiency (see [26]):

- **Voice connection** present (true) or not present (false)
- **Number of passengers** (for P2W 1 or 2)
- **Medical history** defined in the national insurance number.
- **Biomedical data** if present some biomedical sensors
- **Severity level** as defined in the sub-Activity 3.5.

The comparison of setting parameters, via Host-PC tool, and the parameters received, from the vehicle as MSD format, was proof that the eCall function worked correctly in all its parts.

6.9 Results achieved in demonstration event in Bosch (Renningen)

The I_HeERO final event with demonstration of functional prototypes has been successfully done on October 20th in Bosch corporate research campus with test track.

The demonstration was preceded by the presentation of results achieved activity-by-activity. Such an explanation has been propaedeutic to a proper understanding of the eCall function's demonstration.

The demonstration has been conducted by using the two prototypes prepared as explained in previous chapters and by following the sequence shown in Table 3.

Manoeuvre	Description	M24	Bike
	- Stage 1 - Standard Riding -- Situations you will have in daily riding		
Cornering	Cornering with lean angle		(Aprilia)
Braking & Acceleration	Braking & Acceleration "close to ABS intervention"		(Aprilia)
	- Stage 2 - Rider goes to the Limits / Critical Situation Situations you will have in critical situations and above		
Wheelie	Non-experienced rider: too much acceleration => front wheel lifts (wheelie) => hard break resulting in hard touch down of front wheel		(Aprilia)
	Experienced rider: more extreme lifting angles, speeds		(Aprilia)
	Demonstration of verification proposal: up to 45° followed by braking	X	(Aprilia)
Stoppie	Non-experienced rider: Strong braking in emergency case => rear wheel lifts (stoppie) => sudden break release resulting in hard touch down of rear wheel		(Aprilia)
	Experienced rider: more extreme lifting angles, speeds		(Aprilia)
	Demonstration of verification proposal: up to 30°	X	(Aprilia)
Drifting	Demonstrate system's robustness => go to the limits to the low sider		(Aprilia)
Low Sider	"Rider goes above the limits" → **eCall activation expected**	X	(Aprilia)
	- Stage 3 - Difference between Use & Misuse		
Short warmup	Warmup for the KTM and to show that system also work for riding manoeuvre		(KTM)
Pro-Wheelie	show that system is activated & robust		(KTM)
Pro-Stoppie	show that system is activated & robust		(KTM)
Drifting	show that system is activated & robust		(KTM)
Falling Over	Situation at tank stop or parking	X	(KTM)
Rear Impact (50kph)	comparable to situations at traffic light etc., but also rear end crash with traffic ahead →**eCall activation expected**	X	(KTM)

Table 3 – Demonstration sequence

The item marked with "x" in column M24 show manoeuvres included in the validation test sequence described in deliverable M24 [33]. Two specific manoeuvres have been selected to demonstrate the eCall activation, while all others are representative of normal use or misuse where the eCall system must not be triggered. For safety reasons, all manoeuvres have been executed by a professional stuntman.

The eCall activation was monitored during the event though three monitors connected with OECON server and development centre for eCall system as shown in Figure 69.

Figure 69 – Monitors showing the reception of an eCall MSD

Figure 70 shows a couple of misuse where eCall was properly not triggered.

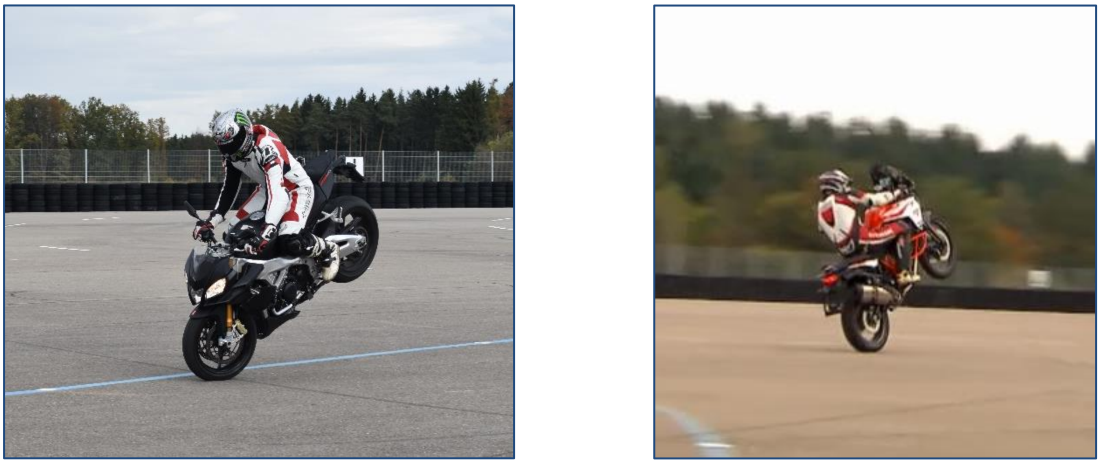


Figure 70 – Typical limit situation (Stoppie & Wheelie) – no triggering done

Figure 71 shows the first condition used to demonstrate an eCall triggering. The rider pushed the bike at the limit producing a Low Sider condition that trigger the eCall. It is worthwhile noticing the distance between the rider and the bike reached after the accident of ≈19m which make impossible any kind of voice connection.

Figure 71 – Low sider accident that produced the eCall triggering

Figure 72 shows the second condition used to demonstrate an eCall triggering. The bike was standing still at 0 km/h with a dummy rider of 75 kg and received a rear collision from a passenger car running at 50kph. In this case the eCall has been properly activated without problems. Also in this case, the voice connection was impossible considering the final position of the rider, behind the car, vs. the final position of the bike, some meters in front of the car.

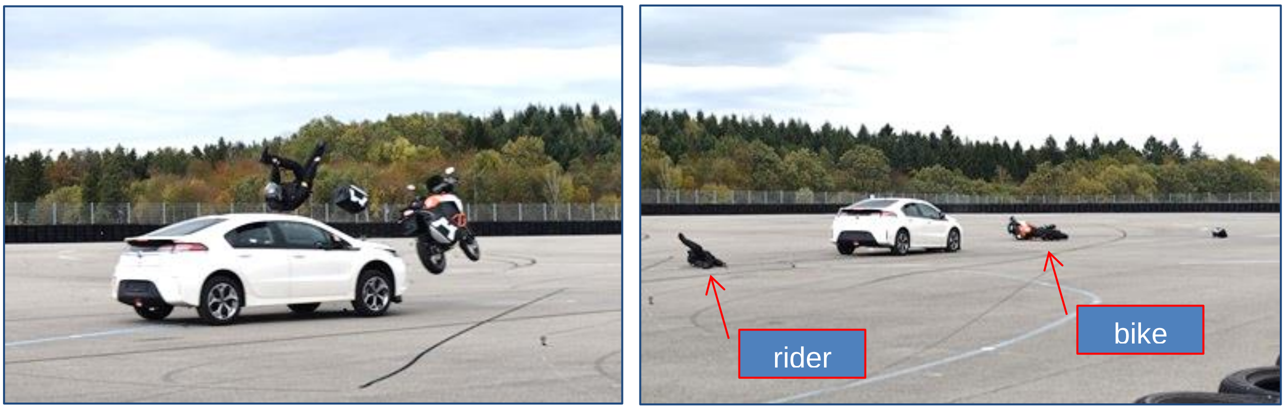


Figure 72 – Rear impact (50 kph)

The demonstration event has successfully shown the proper working of the eCall for P2W defined in I_HeERO Activity 3. The “minimum requirement” functions implemented in the prototype (meta-algorithm) have been demonstrated with live accidents reproducing typical situation occurring every day on the road.

7 ISO 26262 – Hazard analysis and risk assessment (HARA)

7.1 Objective and general information

In order to investigate necessity of safety measures for the eCall system with minimum requirement from the viewpoint of functional safety, Hazard Analysis and Risk Assessment (HARA) for the system was conducted according to ISO 26262 functional safety standard.

According to ISO 26262 the objectives of the HARA are:

a) to identify and to categorize the hazardous events caused by malfunctioning behaviour of the item and

b) to formulate the safety goals related to the prevention or mitigation of the hazardous events, in order to avoid unreasonable risk.

For motorcycles, the hazardous events will be categorized by MSIL depending on their class of severity, probability of exposure and controllability according to Figure 73. For hazardous events assigned with MSIL, safety goals have to be formulated and classified as ASIL that has been converted from MSIL according to Figure 73. However, hazardous events with class QM (quality management) do not lead to safety goals and denote no requirements to comply with ISO 26262.

Severity class	Probability class	Controllability class		
		C1	C2	C3
S1	E1	QM	QM	QM
	E2	QM	QM	QM
	E3	QM	QM	A
	E4	QM	A	B
S2	E1	QM	QM	QM
	E2	QM	QM	A
	E3	QM	A	B
	E4	A	B	C
S3	E1	QM	QM	A
	E2	QM	A	B
	E3	A	B	C
	E4	B	C	D

MSIL (hazardous event)	ASIL (safety goals)
D	C
C	B
B	A
A	QM
QM	

Figure 73 - Determination of MSIL and conversion to ASIL

7.2 Definition of functions

The following functions at vehicle level (perceptible for the customer) were derived from the functional description above and reworked with the expert team.

- Automatically triggering of eCall
- Sending MSD (incl. flag for audio connection, geo localization) and notification about sending status
- Pre-warning (delay and notification)
- Suppress eCall and notification
- Check system (at workshop)

7.3 Technical assumptions relevant for MSIL classification

- Any telecommunication issues are not considered.
- For classification of severity the Delta-S-approach according to 6.4.3.3 in ISO DIS 26262-03.1 (2Ed) BL04 is used:
  "There are operational situations that result in harm (e.g. an accident). A subsequent malfunctioning behaviour of an item in such an operational situation may increase the resulting harm.
  In this case the classification of the severity shall be limited to the difference between the severity caused by the initial operational situation (e.g. the accident) and the malfunctioning behaviour of the item."

7.4 Identification of malfunctions

The following malfunctions (M01-M18) were derived from the functions and checked for safety relevance (possibility of harm or additional harm) according to ISO 26262. Malfunctions with the same expected consequences were summarized because it would lead to the identical risk assessment later.

ID	Possible Malfunction	Expected Consequences	Possibility of harm or additional harm (acc. to ISO 26262)? (if no, rational has to be given)	
Function:	**Automatically triggering of eCall**			
M01	no automatically triggering	false negative – no rescue	Yes	
M02	undemanded triggering	false positive – unwanted rescue	No	S0 - no injuries for the rider or other persons
M03	continuously triggering	false positive – unwanted rescue	No	S0 - no injuries for the rider or other persons
Function:	**Sending MSD (incl. flag for audio connection, geo localization) and notification about sending status**			
M04	no sending MSD	no rescue	Yes	covered by M01 – same consequences
M05	wrong MSD (flag for audio connection)	no consequences	No	S0 - no additional injuries for the rider or other persons
M06	wrong MSD (geo localization)	no rescue	Yes	covered by M01 – same consequences
M07	wrong MSD (test MSD instead of correct MSD)	no rescue, rider believes eCall has been launched	Yes	
M08	no notification about correct sending	no consequences	No	S0 - no additional injuries for the rider or other persons
M09	wrong notification about incorrect sending	no rescue, rider believes eCall has been launched	Yes	covered by M07 – same consequences
M10	undemanded sending of MSD	unwanted rescue	No	S0 - no injuries for the rider or other persons

ID	Possible Malfunction	Expected Consequences	Possibility of harm or additional harm (acc. to ISO 26262)? (if no, rational has to be given)	
Function:	**Pre-warning (delay and notification)**			
M11	no pre-warning (no delay)	unwanted rescue	No	S0 - no additional injuries for the rider or other persons
M12	no pre-warning (no notification)	unwanted rescue	No	S0 - no additional injuries for the rider or other persons
M13	undemanded pre-warning (time exceeding define amount)	slightly delayed rescue	No	S0 - no additional injuries for the rider or other persons
Function:	**Suppress eCall and notification**			
M14	no possible suppression	unwanted rescue	No	S0 - no injuries for the rider or other persons
M15	undemanded suppression	no rescue	Yes	covered by M01 – same consequences
M16	wrong notification about suppression	no rescue, rider believes eCall has been launched	Yes	covered by M07 – same consequences
Function:	**Check system (at workshop)**			
M17	system check continuously on	no rescue	Yes	covered by M01 – same consequences
M18	wrong check of MSD	unwanted rescue (to the workshop)	No	S0 - no injuries for the rider or other persons

Table 4 – Identification of malfunctions and related possibility of harm

7.5 Identification of hazardous events

A hazardous event is described by a malfunction in an operational situation.

The following operational situations were identified and assigned to malfunctions:

ID	Description of the operational situation	Relevant for?	
		M01	M07
S01	Accident with severe / life-threatening injuries	X	X
S02	Accident with light / moderate injuries	X	X
S03	Accident with severe / life-threatening injuries, no other people around	X	X

Table 5 – Hazardous events

7.6 Risk assessment - classification of hazardous events

All hazardous events were classified using the exposure of the operational situation, the severity of the consequences and their controllability.

The delta-S-approach mentioned in 7.3 means that the severity is evaluated without the malfunction and with deterioration by the malfunction. For the severity classification, the difference in severity classes (delta S) was used.

Hazardous event:	**M01S01**
Malfunction:	no automatically triggering
Operational Situation:	Accident with severe / life-threatening injuries
Exposure of the operational situation:	**E1 –** occurs less than once a year
Consequences of hazardous event:	no rescue
Severity of the consequences:	**delta S1** – in worst cases severe / life-threatening injuries (S2) can result in fatal injuries (S3) caused by the malfunction
Controllability:	**C2** – the rider gets notified about no triggering, but may not be able to call for help because of severe injuries but other people around can call
Resulting MSIL:	**QM**
Safety goal (in case of MSIL A-D):	-
Safe state (in case of MSIL A-D):	-

Hazardous event:	**M01S02**
Malfunction:	no automatically triggering
Operational Situation:	Accident with light / moderate injuries
Exposure of the operational situation:	**E1** – occurs less than once a year
Consequences of hazardous event:	no rescue
Severity of the consequences:	**delta S2** – in worst cases light /moderate injuries (S1) can result in fatal injuries (S3) caused by the malfunction
Controllability:	**C1** – the rider gets notified about no triggering and calls for help (easily because of light /moderate injuries), or other people around can call
Resulting MSIL:	**QM**
Safety goal (in case of MSIL A-D):	-
Safe state (in case of MSIL A-D):	-

Hazardous event:	**M01S03**
Malfunction:	no automatically triggering
Operational Situation:	Accident with severe / life-threatening injuries, no other people around
Exposure of the operational situation:	**E1** – occurs less than once a year
Consequences of hazardous event:	no rescue
Severity of the consequences:	**delta S1** – in worst cases severe / life-threatening injuries (S2) can result in fatal injuries (S3) caused by the malfunction
Controllability:	**C3** – the rider gets notified about no triggering, but may not be able to call for help because of severe injuries.
Resulting MSIL:	**QM**

Safety goal (in case of MSIL A-D):	-
Safe state (in case of MSIL A-D):	-

Hazardous event:	**M07S01**
Malfunction:	wrong MSD (test MSD instead of correct MSD)
Operational Situation:	Accident with severe / life-threatening injuries
Exposure of the operational situation:	**E1 –** occurs less than once a year
Consequences of hazardous event:	no rescue, rider believes eCall has been launched
Severity of the consequences:	**delta S1 –** in worst cases severe / life-threatening injuries (S2) can result in fatal injuries (S3) caused by the malfunction
Controllability:	**C3 –** the rider waits for help and realises too late, that no eCall has been launched
Resulting MSIL:	**QM**
Safety goal (in case of MSIL A-D):	-
Safe state (in case of MSIL A-D):	-

Hazardous event:	**M07S02**
Malfunction:	wrong MSD (test MSD instead of correct MSD)
Operational Situation:	Accident with light / moderate injuries
Exposure of the operational situation:	**E1 –** occurs less than once a year
Consequences of hazardous event:	no rescue, rider believes eCall has been launched

Severity of the consequences:	**delta S2 –** in worst cases light /moderate injuries (S1) can result in fatal injuries (S3) caused by the malfunction
Controllability:	**C3 –** the rider waits for help and realises too late, that no eCall has been launched
Resulting MSIL:	**QM**
Safety goal (in case of MSIL A-D):	-
Safe state (in case of MSIL A-D):	-

Hazardous event:	**M07S03**
Malfunction:	wrong MSD (test MSD instead of correct MSD)
Operational Situation:	Accident with severe / life-threatening injuries, no other people around
Exposure of the operational situation:	**E1** – occurs less than once a year
Consequences of hazardous event:	no rescue, rider believes eCall has been launched
Severity of the consequences:	**delta S1 –** in worst cases severe / life-threatening injuries (S2) can result in fatal injuries (S3) caused by the malfunction
Controllability:	**C3 –** the rider waits for help and realises too late, that no eCall has been launched
Resulting MSIL:	**QM**
Safety goal (in case of MSIL A-D):	-
Safe state (in case of MSIL A-D):	-

7.7 Result of HARA

QM is assigned for all possible hazardous events derived from an assumed system shown in functional description (minimum requirements). Therefore, no safety measure is required for this assumed system from the viewpoint of functional safety according to ISO26262 analysis.

8 Conclusions

The document "M26 – Basic Architecture Recommendations" summarizes the results achieved in the sub-activity A3.4 "Architecture and Validation" in full compliance with GRANT AGREEMENT [36]. Tasks performed inside the sub-activity as shown in Figure 1, provide the study of the minimum set of functionalities (also called "minimum requirements") an eCall system for P2W must have. Based on the results achieved in term of functionalities description, criteria for triggering, meta-algorithm and basic architecture, the hazard analysis and risk assessment has been done following ISO26262 standard by I_HeERO Act. 3 experts.

Two prototypes have also been studied and prepared for the final event in Bosch Test track in Renningen (Germany) where the defined eCall for P2W will be demonstrated.

Finally, all the studies and recommendations provided in this document have been provided to CEN TC278/WG15 to support the on-going preparation of draft Technical Standard document for the extension of eCall from M1/N1 vehicle categories to other categories including P2W.

It is worthwhile to underline the importance of I_HeERO studies to explain and made aware WG15 experts of the most relevant differences occurring between passenger cars (M1/N1) and P2W (reference for I_HeERO studies was L3 category) in order to assure their consideration during the new standard preparation.

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5.7. M27 – Classification of severity

M27 – Classification of severity

Harmonised eCall European Deployment

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Main author:	Alexander Skiera
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Lead contractor:	Bosch
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CONTROL SHEET

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2.0	08/09/2017	A. Skiera (Bosch)	Several adjustments and corrections after Internal Review
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	Name		**Date**
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I_HeERO Steering Group	
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TABLE OF CONTENTS

ABBREVIATIONS

GIDAS .... *German in depth accident study*
Moped .... *Powered Two-Wheeler w/ engine displacement ≤50ccm*
Motorcycle .... *Powered Two-Wheeler w/ engine displacement >50ccm*
MSD .... *Minimum Set of DATA within eCALL message*
P2W .... *Powered Two-Wheeler including Mopeds and Motorcycles*
PPE .... *Personal Protective Equipment*
PSAP .... *Public-safety Answering Point*
Slightly injured .... *less than 24 hours of hospitalization*
Seriously injured .... *more than 24 hours of hospitalization*
Fataly injured .... *died within 30 days after the accident*

FIGURES

TABLES

1 Introduction

1.1 Purpose of Document

The purpose of this deliverable document “M27 – Classification of severity” is to summarize the results achieved in the sub-activity A3.5.

This sub-activity addresses three key topics relevant to P2W:

- Potential impact of eCall systems on P2W safety (Tasks 1&2)
- Necessity of eCall activation for P2W (Task 3)
- Predictability of the expected injury severity of an incident (Task 4).

Through the tasks within this sub-activity, the study attempts to provide a critical analysis of these topics and identify challenges as well as opportunities. As a result, some initial ideas about suitable approaches have also been formulated and presented in this report, which could form the basis for further development and implementation projects.

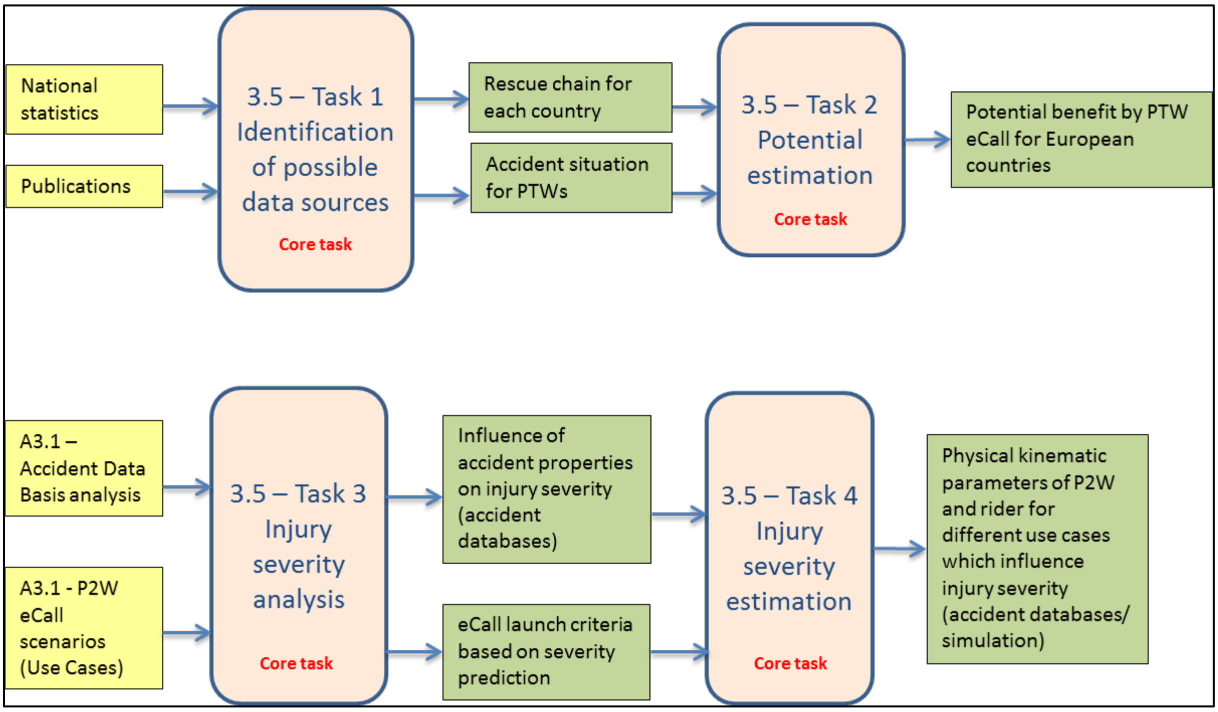

Figure 1 Sub-activity task structure

Chapter 2 presents a general overview of the P2W accidents worldwide (with particular focus on Europe). Next chapter 3 presents the basic concepts of rescue chains in Europe. Using example accident cases, the potential impact of an eCall system is assessed. Before estimating the eCall potential for seven European countries within (4.2), an overview of the results of existing eCall benefit studies is presented in (4.1).

The second part of this report starts with Chapter 5 with the analysis of the results on the need for an eCall using statistical methods and whether the accuracy of the meta-algorithm described in the I_HeERO Milestone report M26 can be improved. Finally the feasibility of injury prediction for P2W rider is presented in Chapter 6 along with recommendations on how the information can be further exploited..

1.2 I_HeERO Contractual References

I_HeERO stands for Infrastructure Harmonised eCall European Pilot.

I_HeERO is an action under the Grant Agreement number INEA/CEF/TRAN/A2014/103743 and the project duration is 36 months, effective from 01 January 2015 until 31 December 2017. It is a contract with the Innovation and Networks Executive Agency (INEA), under the powers delegated by the European Commission.

Communication details of the Agency:

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2 Overview of P2W accidents

This chapter starts with a general introduction of the current worldwide accident situation for all road users (Section 2.1), before looking more closely at P2W only (Section 2.2). In Section 2.3, the accident situation for P2W for Europe is analysed. Finally national statistics for accidents from seven European countries are analysed (Subsection 2.3.1).

2.1 Road accidents - a major threat in our world

According to the latest WHO report on the global status of road safety from 2015 (WHO, 2015) traffic injuries claim more than 1.2 million lives each year. In addition, it is the leading cause of death for young people between 15 and 29 years. Furthermore, the economic costs are approximately about 3% of GDP. These are all very good reasons to increase the effort to reduce road traffic fatalities significantly.

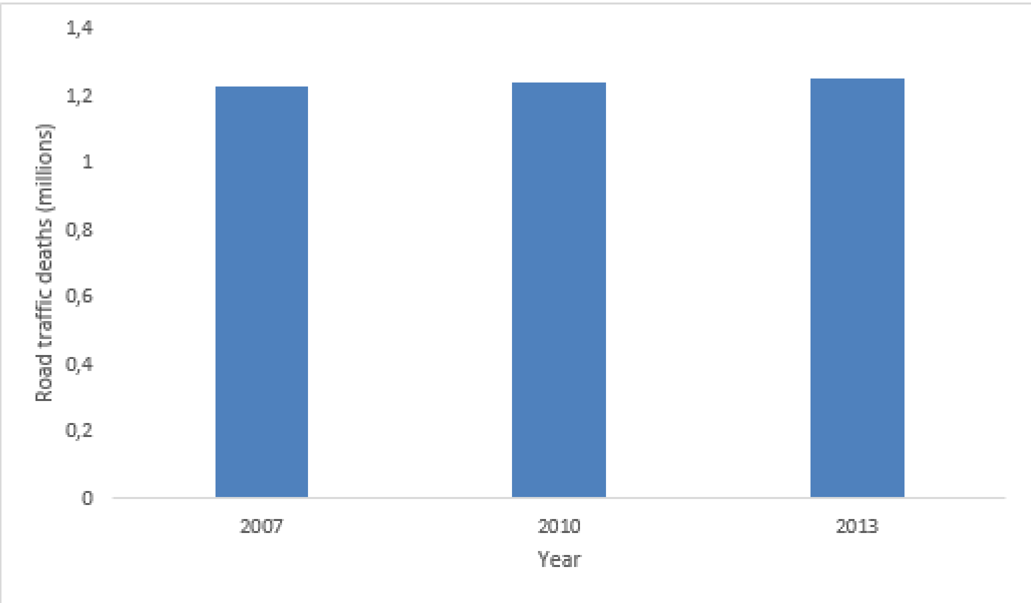


Figure 2: Number of road traffic fatalities, worldwide, 2013 (WHO, 2015)

Looking at the trends of worldwide road traffic deaths over the years 2007 to 2013, a slight increase can be observed for the total number of road traffic fatalities. The latest WHO report states that in 2013 more than 1.2 million lives were claimed by traffic injuries. Considering the growing number of vehicles especially in low- and middle-income countries, without any intervention it is expected that the number of fatalities is likely to increase over the next years.

From the breakdown of the road traffic fatalities, nearly half of all road traffic fatalities worldwide are among vulnerable road users (VRU). Motorized 2-3 wheeler, Cyclists and Pedestrian have very limited protection systems to mitigate the impact of collisions. As a result, these groups tend to be most affected by the accident.

For car occupants, which account for 30% of all road traffic fatalities, many systems have been developed to avoid or mitigate the impact of accidents. On one hand, the passive aspect of vehicle safety was strongly increased by the introduction of seat belts, airbags, enforced vehicle structure or more recently the eCall system. On the other hand, also many new active safety functions like ABS, ESP or recently AEB have significantly enhanced the overall vehicle safety of car occupants.

In comparison, such improvements did not happen for P2Ws. During the last decades the passive safety of P2Ws was mainly enhanced by the introduction of helmets and protection clothing. On the active safety side, there have been the introduction of ABS and recently of MSC. Passive systems like airbag on the bike or on the jacket are very rare. Therefore, there is still a huge potential to increase the safety for P2Ws.

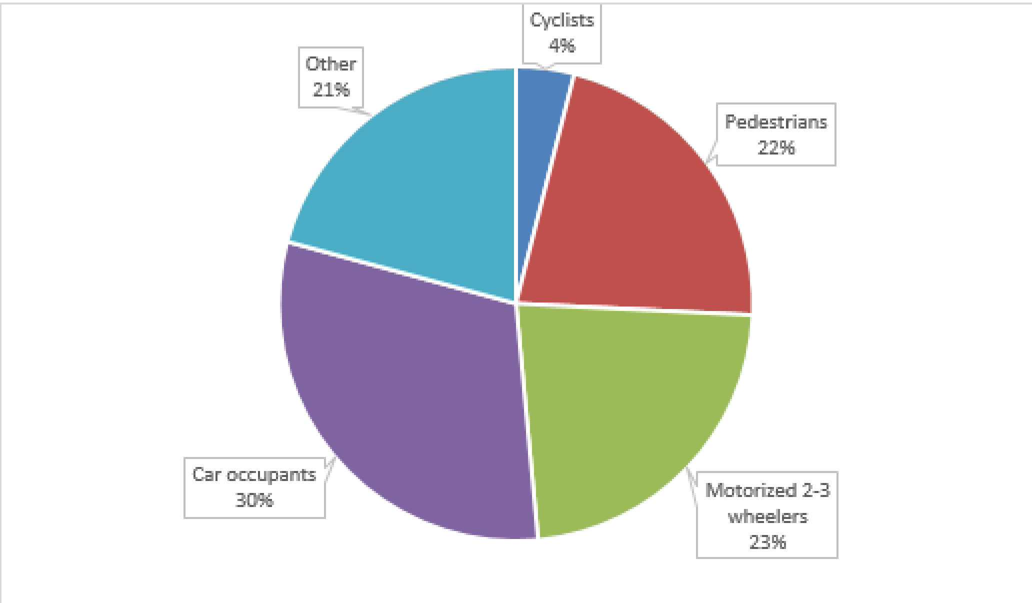


Figure 3: Road traffic fatalities by type of road user, by WHO (WHO, 2015)

2.2 Regional differences of road accidents fatalities for P2W

Approximately 49% of all road traffic fatalities occur within the vulnerable road users (VRU) like pedestrians, bicyclists and riders. P2W account for 23% of all road traffic fatalities worldwide and therefore are the largest share among the VRUs.

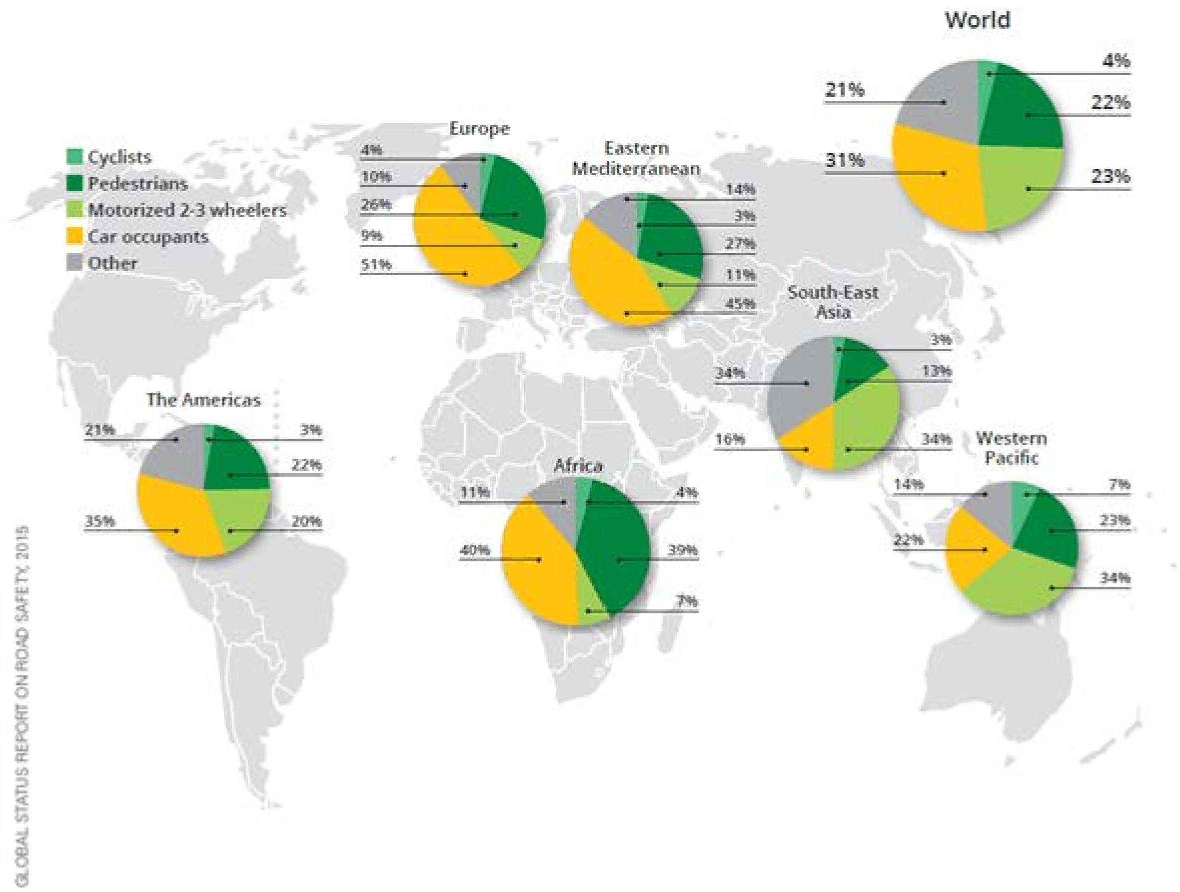


Figure 4: Road traffic fatalities by type of road user, by WHO region (WHO, 2015)

As can be seen in Figure 4, the road fatality distribution varies significantly across different regions. In regions with a high proportion of P2Ws, like the Asian region, the share in fatalities is also very high.

Depending on the region, P2Ws account for between 7 and 34 percent of road fatalities. Improvement in P2W safety can potentially reduce road fatalities significantly.

In Europe, road fatalities for P2W account for 9% of all road traffic fatalities. This appears small, however if the total number of registered P2Ws and their average ridden distance is taken into account, their fatality rate is between 16 and 30 times higher that of a passenger car (Department of Transport, 2004) (NHTSA, 2007).

2.3 European accident situation for P2W

In the European Union 25,938 fatalities arising from 1,054,744 accidents w/ injuries were reported in 2013. During the last decade a steady decrease in road accidents and fatalities can be observed. The main reason for this decrease can be attributed to the increased vehicle and infrastructure safety. A key enabler for the increase in vehicle safety has been the higher legislative requirements of vehicle safety equipment and the safety assessment of the European NCAP program.

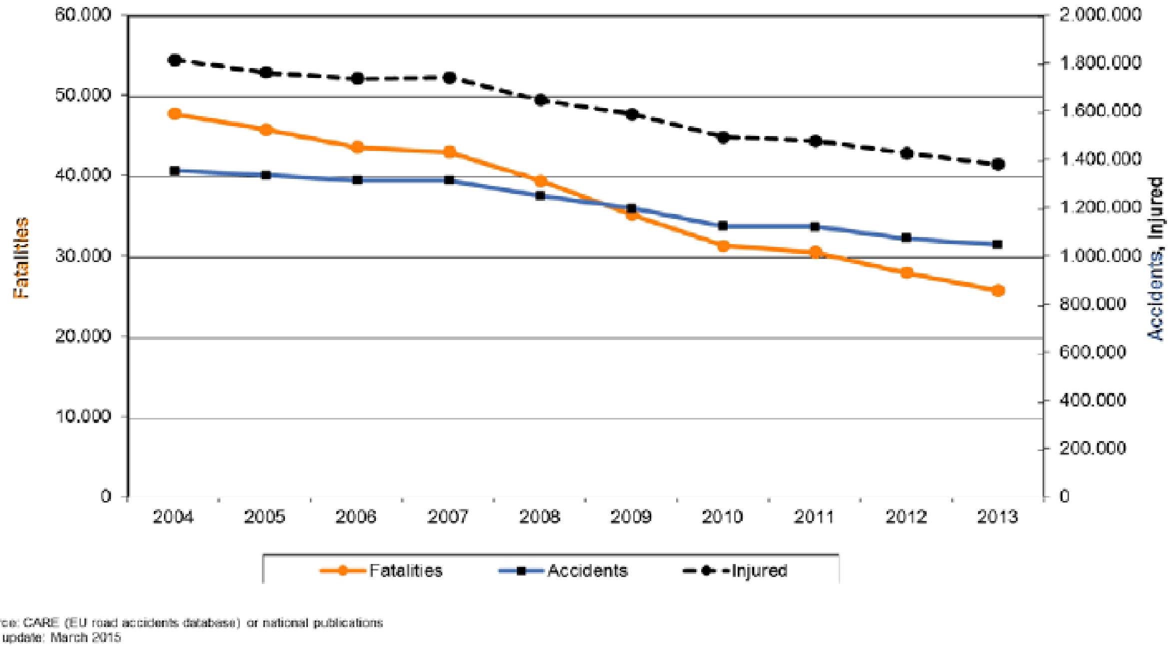


Figure 5: Annual number of fatalities, injury accidents and injured people in the EU, 2004-2013 (European Comission, 2015)

However, looking at relative fatality reduction it can be seen, that these measures do not affect all modes of transport equally. Whereas the total fatality number decreased by 45%, the number of fatally injured motorcyclists only decreased by 30%. During the same period the fatalities for passenger cars decreased by 51%. This indicates that the development of P2W safety is lagging behind that of passenger cars and therefore needs concerted effort to drive improvements.

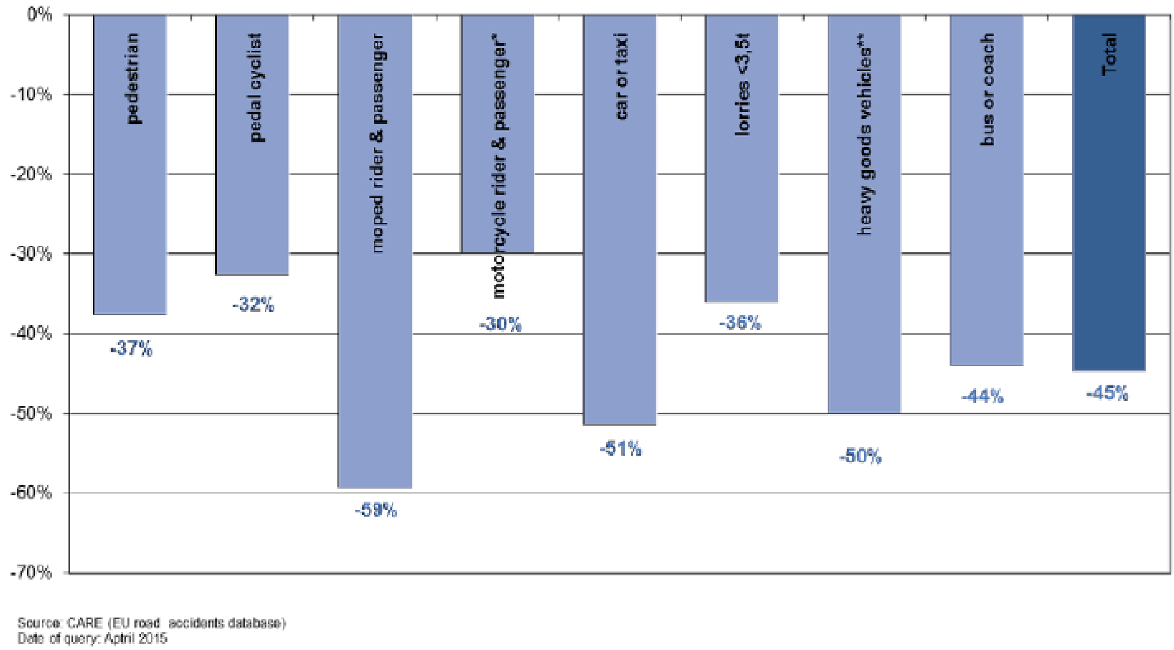


Figure 6: Percentage change in number of fatalities by mode of transport in the EU, 2013 and 2004 (European Comission, 2015)

According to the annual accident report from the European Commission (European Comission, 2015) 4,603 users of P2Ws (which represents 17%[1] of all road traffic fatalities in Europe) died in accidents in 2013. This number is nearly twice as high as the numbers estimated within the WHO report (WHO, 2015) and therefore shows the importance to use local data for accident analysis. These numbers also show, that P2W safety is a larger issue for Europe than indicated by the WHO report.

Looking closer at the accident characteristics in Figure 8 it can be observed that about 60% of all fatally injured motorcycle users died outside urban areas.

Summarizing these initial observations it can be concluded that:

1. P2W safety is and should be a major issue in Europe as P2W user are accounting for 17% of all road traffic fatalities in Europe.
2. The P2W safety development lags behind that of passenger cars which can be observed in smaller fatality reduction for P2W during the last decade.

[1] In Figure 7 the fatality numbers are rounded: 17% fatalities of P2W users = ~15% motorcyclist + ~3% moped users.

3. The majority of fatal motorcycle accidents happens in rural areas, therefore safety development should focus on these areas.

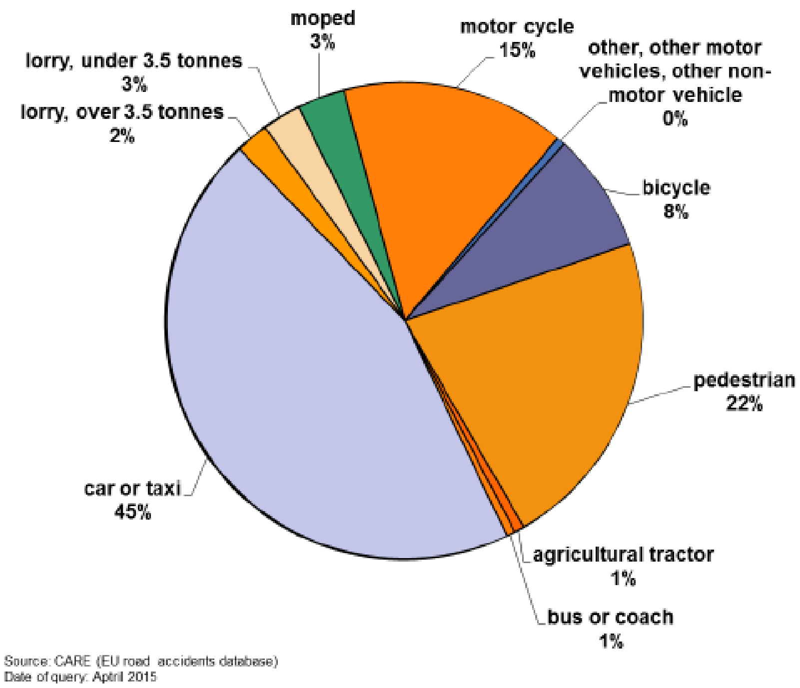


Figure 7: Distribution of fatalities by mode of transport in the EU, 2013 (European Comission, 2015)

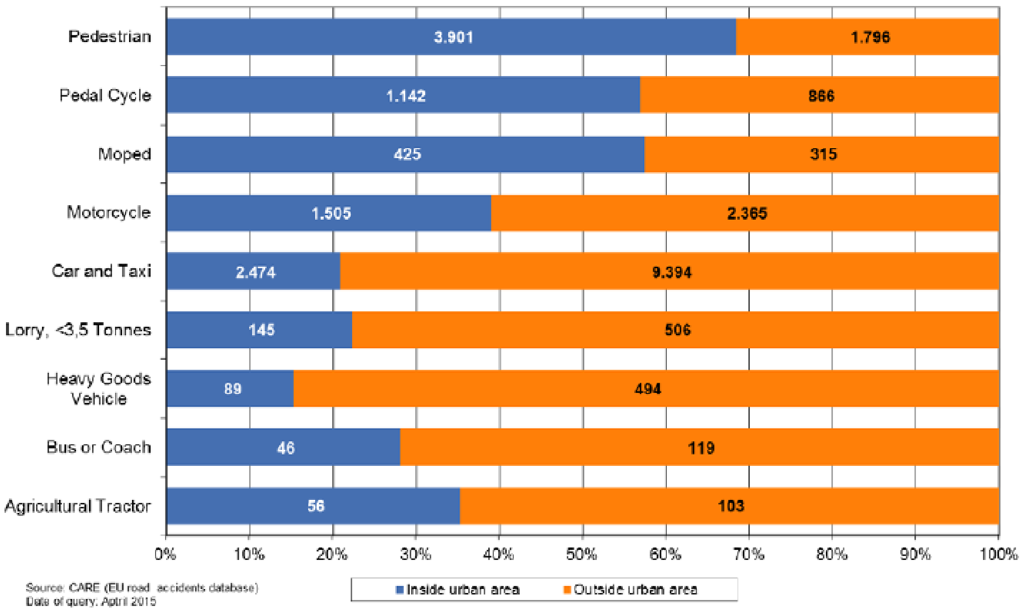


Figure 8: Fatalities by type of area and mode of transport in the EU, 2013 (European Comission, 2015)

2.3.1 Accident situation for P2W in seven European countries

The official European statistics provide accident data to a limited depth. For a closer look into the accident situation for P2W the national accident statistics of seven European countries were analyzed. The criteria of injury severity, accident location (urban and rural), single vehicle accident and time of the accident (day and night) were considered relevant to assess the potential benefits of eCall.

The following countries were selected because of the good data availability and deemed representative of the rest of European countries: Germany, France, Italy, Spain, Great Britain, Sweden and Hungary. The official national statistics from those countries were analyzed with particular focus on the accident situation for P2W.

The P2W are separated into two categories: motorcycles (MC) (>50ccm) and mopeds (≤50ccm). Given that in most country statistics, the number of casualties rather than the number of accidents and their severity is available, all analysis is based on the numbers of casualty. Also due to limited availability of information, the casualty numbers are only those linked to the P2W and excludes any other injured person within these accidents

If any information were missing within the national statistics, they were calculated by using the casualty distributions of a similar country. For example, if for Italy data were missing about the casualties at darkness, the Spanish distributions for casualties at darkness were extrapolated to Italy. Any estimated numbers are always written in bold letters.

Looking at Table 1 it can be seen, that the relevance of injured P2W users differs quite a lot between different European countries. While in Germany, Great Britain, Hungary and Sweden P2W users only contribute about 9% - 13% to all casualties, they contribute about 27% - 45% in France, Italy and Spain. This difference between the countries is not present for P2W fatalities. Here, P2W fatalities have a share of 12% - 29% for all countries. Seriously injured P2W users have a share of 15% - 31% in all seriously injured persons. Within the slightly injured P2W users, there are significant differences between the countries. As with lower severity the share of unreported accident strongly increases, it is assumed, that the observed differences are strongly corrupted by these effects.

Country	Year	Road user	Casualties of road user	Fatalities of road users	Seriously injured road users	Slightly injured road users
Germany	**2015**	All	396,891	3,459	67,706	325,726
		Moped	15,612	62	3,058	12,492
		MC	30,434	639	9,986	19,809
		All P2W	46,046	701	13,044	32,301
France	**2014**	All	76,429	3,384	26,632	46,413
		Moped	7,916	165	2,738	5,013
		MC	14,209	625	5,419	8,165
		All P2W	22,125	790	8,157	13,178
Great Britain	**2014**	All	194,477	1,775	22,807	169,895
		Moped	2,330	6	405	1,919
		MC	18,036	333	4,884	12,819
		All P2W	20,366	339	5,289	14,738
Hungary	**2014**	All	20,750	626	5,331	14,793
		Moped	1,317	17	528	772
		MC	1,311	58	584	669
		All P2W	2,628	75	1,112	1,441
Italy[2]	**2008**	All	310,739	4,731	**24,747**	**281,261**
		Moped	28,216	294	**1,470**	**26,452**
		MC	55,086	1,086	**3,311**	**50,689**
		All P2W	83,302	1,380	**4,781**	**77,141**
Spain	**2013**	All	126,400	1,680	10,086	114,634
		Moped	15,596	54	818	14,724
		MC	41,273	301	2,512	38,460
		P2W	56,869	355	3,330	53,184
Sweden	**2014**	All	18,933	270	2,347	16,316
		Moped	814	8	121	685
		MC	890	36	240	614
		P2W	1,704	44	361	1,299

Table 1 Casualties of road users for seven European countries

[2] Missing Italian data were estimated based on Spanish distributions.

According to Table 2, the share of P2W casualties in rural areas is between 12% - 53%. The large margin is caused by data from Sweden with 53% and Italy with 12%. Looking at fatalities only, the share of fatally injured P2W users in rural areas ranges between 48% (Italy) - 76% (Germany). For seriously injured P2W users the share in rural areas ranges between 28% (Italy) – 57% (Sweden). Slightly injured P2W users majorly occurred in the city 73% - 89%, only in Sweden the share is equally distributed between rural and urban area.

Country	Year	Road user	Rural				Urban			
			Casualties of road user	Fatalities	Seriously injured	Slightly injured	Casualties of road user	Fatalities	Seriously injured	Slightly injured
Germany	**2015**	Moped	2,469	31	729	1,709	13,143	31	2,329	10,783
		MC	12,997	501	5,609	6,887	17,437	138	4,377	12,922
		All P2W	15,466	532	6,338	8,596	30,580	169	6,706	23,705
France	**2014**	Moped	1,006	88	620	298	6,910	77	2,118	4,715
		MC	4,413	412	2,460	1,541	9,796	213	2,959	6,624
		All P2W	5,419	500	3,080	1,839	16,706	290	5,077	11,339
Great Britain	**2014**	Moped	231	4	53	174	2,099	2	352	1,745
		MC	4,432	211	1,841	2,380	13,604	122	3,043	10,439
		All P2W	4,663	215	1,894	2,554	15,703	124	3,395	12,184
Hungary[3]	**2014**	Moped	**167**	**9**	**120**	**46**	**1,150**	**8**	**408**	**726**
		MC	**407**	**38**	**265**	**126**	**904**	**20**	**319**	**543**
		All P2W	**574**	**47**	**385**	**172**	**2,054**	**28**	**727**	**1,269**
Italy[4]	**2008**	Moped	**2,346**	**130**	**272**	**2,022**	**25,870**	**164**	**1,198**	**24,430**
		MC	**7,801**	**535**	**940**	**6,612**	**47,285**	**551**	**2,371**	**44,077**
		All P2W	**10,147**	**665**	**1,212**	**8,634**	**73,155**	**715**	**3,569**	**68,507**
Spain	**2013**	Moped	2,720	34	267	2,419	12,876	20	551	12,305
		MC	11,457	203	1,152	10,102	29,816	98	1,360	28,358
		All P2W	14,177	237	1,419	12,521	42,692	118	1,911	40,663
Sweden[5]	2014	Moped	311	5	46	260	503	3	75	425
		MC	590	28	**158**	**404**	300	8	**82**	**210**
		All P2W	902	33	**204**	**665**	802	11	**157**	**634**

Table 2 Casualties of P2W user vs. accident area for seven European countries

Considering the light condition during P2W accidents of Table 3 it can be seen that in Germany, Great Britain and Italy only a small portion (11% - 15%) of P2W casualties occur at darkness.

[3] Missing Hungary data were estimated based on France distributions.
[4] Missing Italian data were estimated based on Spanish distributions.
[5] Missing Swedish data were estimated based on total casualties.

Within the other countries the share of P2W users injured in darkness range between 25% (Spain) - 31% (Hungary). Regarding fatalities, Germany and Great Britain are again very similar. Between 12% - 15% of all fatalities died in the night. In all other countries the share is between 25% - 33%.

Country	Year	Road user	Darkness				Daylight			
			Casualties of road user	Fatalities	Seriously injured	Slightly injured	Casualties of road user	Fatalities	Seriously injured	Slightly injured
Germany	**2015**	Moped	2.927	16	694	2.217	12.685	46	2.364	10.275
		MC	3.302	69	1.045	2.188	27.132	570	8.941	17.621
		All P2W	6.229	85	1.739	4.405	39.817	616	11.305	27.896
France	**2014**	Moped	2.884	85	1.022	1.777	5.032	80	1.716	3.236
		MC	3.710	169	1.296	2.245	10.499	456	4.123	5.920
		All P2W	6.594	254	2.318	4.022	15.531	536	5.839	9.156
Great Britain	**2014**	Moped	**249**	**1**	**49**	**193**	**2.081**	**5**	**356**	**1.726**
		MC	**1.924**	**49**	**588**	**1.293**	**16.112**	**284**	**4.296**	**11.526**
		All P2W	2.173	50	637	1.486	18.193	289	4.652	13.252
Hungary[6]	**2014**	Moped	**480**	**9**	**197**	**274**	**837**	**8**	**331**	**498**
		MC	**342**	**16**	**140**	**184**	**969**	**42**	**444**	**485**
		All P2W	**822**	**25**	**337**	**458**	**1.806**	**50**	**775**	**983**
Italy[7]	**2008**	Moped	4.261	75	297	3.830	23.955	219	1.173	22.622
		MC	**8.318**	**276**	**668**	**7.339**	**46.768**	**810**	**2.643**	**43.350**
		All P2W	**12.579**	**351**	**965**	**11.169**	**70.723**	**1.029**	**3.816**	**65.972**
Spain[8]	**2013**	Moped	**3.941**	**17**	**210**	**3.701**	**11.655**	**37**	**608**	**11.023**
		MC	**10.430**	**96**	**646**	**9.668**	**30.843**	**205**	**1.866**	**28.792**
		All P2W	**14.372**	**113**	**856**	**13.369**	**42.497**	**242**	**2.474**	**39.815**
Sweden[9]	**2014**	Moped	**214**	**2**	**31**	**181**	**600**	**6**	**90**	**504**
		MC	**235**	**11**	**62**	**162**	**655**	**25**	**178**	**452**
		All P2W	**449**	**13**	**93**	**343**	**1.255**	**31**	**268**	**956**

Table 3 Casualties of P2W user vs. light condition for seven European countries

Summary of some observations:

[6] Missing Hungary data were estimated based on France distributions.
[7] Missing Italian data were estimated based on Spanish distributions or on total casualties.
[8] Missing Spanish data were estimated based on total casualties.
[9] Missing Swedish data were estimated based on total casualties.

- Share of P2W user casualties in all casualties differs in Germany, Great Britain, Hungary and Sweden between 9% - 13%, in France, Italy and Spain about 27% - 45%.
- Share of P2W user fatalities in all fatalities between 12% - 29%.
- Share of fatally injured P2W users in rural areas ranges between 48% (Italy) - 76% (Germany).

2.3.2 Accident situation for P2W in European Union

Based on the seven analyzed European countries an extrapolation for the Europe Union as a whole has been done. For the extrapolation the number of fatalities of road users were used. It was assumed that the calculated distributions of the seven European countries are representatively for Europe.

According to the extrapolations in Table 4, in 2016 there were 1.86 million casualties caused by traffic accident in Europe with 259.379 persons seriously injured. Injured P2W users account for 15% in all casualties, 18% in all fatalities and 17% in all seriously injured road users.

Country	Year	Road user	Casualties of road user	Fatalities of road users	Seriously injured road users	Slightly injured road users
7 Europe[10]	**2008-2015**	All	1.144.619	15.925	**159.656**	**969.038**
		Moped	71.801	606	**9.138**	**62.057**
		MC	161.239	3.078	**26.936**	**131.225**
		P2W	233.040	3.684	**36.074**	**193.282**
Europe[11]	**2014**	All	**1.859.563**	25.872	**259.379**	**1.574.312**
		Moped	**85.663**	723	**10.902**	**74.038**
		MC	**201.208**	3.841	**33.613**	**163.754**
		P2W	**286.871**	4.564	**44.515**	**237.792**

Table 4 Summary of casualties of road user for seven European countries and Europe

[10] 7 Europe: Germany, France, Great Britain, Hungary, Italy, Spain & Sweden. Missing data were estimated for each country individually.
[11] Missing European numbers were extrapolated based on the fatalities and the distributions from the seven European countries.

Looking at the accident location in Table 5 it can be seen, that the majority of P2W casualties occurred in urban areas (78%). However, considering only severe casualties, the picture looks quite differently. In this case, there are 61% of all fatalities and 40% of all seriously injured P2W users in rural areas.

Country	Year	Road user	Rural				Urban			
7 Europe[12]	**2008-2015**		Casualties of road user	Fatalities	Seriously injured	Slightly injured	Casualties of road user	Fatalities	Seriously injured	Slightly injured
		Moped	**9,250**	**301**	**2,107**	**6,928**	**62,551**	**305**	**7,031**	**55,129**
		MC	**42,097**	**1,928**	**12,425**	**28,052**	**119,142**	**1,150**	**14,511**	**103,173**
		All P2W	**51,348**	**2,229**	**14,532**	**34,981**	**181,692**	**1,455**	**21,542**	**158,301**
Europe[13]	**2014**	Moped	**11,036**	**359**	**2,514**	**8,266**	**74,627**	**364**	**8,388**	**65,772**
		MC	**52,533**	**2,406**	**15,505**	**35,006**	**148,675**	**1,435**	**18,108**	**128,748**
		All P2W	**63,569**	**2,765**	**18,019**	**43,272**	**223,302**	**1,799**	**26,496**	**194,520**

Table 5 Summary of casualties of P2W user vs. accident area for seven European countries and Europe

[12] 7 Europe: Germany, France, Great Britain, Hungary, Italy, Spain & Sweden. Missing data were estimated for each country individually.
[13] Missing European numbers were extrapolated based on the fatalities and the distributions from the seven European countries.

Considering the lighting condition in Table 6, it can be observed that 24% of all P2W fatalities died during the night, whereas only 19% of all P2W casualties occurred at night. For accidents in rural area, an increase in accident severity can be observed with lower lighting (darkness)

Country	Year	Road user	Darkness				Daylight			
			Casualties of road user	Fatalities	Seriously injured	Slightly injured	Casualties of road user	Fatalities	Seriously injured	Slightly injured
7 Europe[14]	**2008-2015**	Moped	**14,956**	**205**	**2,500**	**12,173**	**56,845**	**401**	**6,638**	**49,884**
		MC	**28,261**	**686**	**4,445**	**23,079**	**132,978**	**2,392**	**22,491**	**108,146**
		All P2W	**43,218**	**891**	**6,945**	**35,252**	**189,822**	**2,793**	**29,129**	**158,030**
Europe[15]	**2014**	Moped	**17,843**	**245**	**2,983**	**14,523**	**67,820**	**478**	**7,919**	**59,515**
		MC	**35,267**	**856**	**5,547**	**28,800**	**165,941**	**2,985**	**28,066**	**134,954**
		All P2W	**53,110**	**1,101**	**8,530**	**43,323**	**233,761**	**3,463**	**35,985**	**194,469**

Table 6 Summary of casualties of P2W user vs. light condition for seven European countries and Europe

<u>Summary of some observations:</u>

- In 2014, there were 1.86 million casualties caused by traffic accident in Europe. Thereof 259.379 persons were seriously injured.
- Injured P2W users account for 15% in all casualties, 18% in all fatalities and 17% in all seriously injured road users.
- Majority of P2W casualties occurred in urban areas (78%), but 61% of all fatalities in rural areas.
- 24% of all P2W fatalities happend during the night

[14] 7 Europe: Germany, France, Great Britain, Hungary, Italy, Spain & Sweden. Missing data were estimated for each country individually.
[15] Missing European numbers were extrapolated based on the fatalities and the distributions from the seven European countries.

2.4 Summary

In 2013, there were 1.2 million traffic fatalities worldwide, of which23% were users of P2Ws. In Europe, there were about 25,872 traffic fatalities in 2014. Thereof 18% (4,564) were users of P2Ws. As no further official information about traffic casualties were available at the time of the study, several national statistics were analyzed and missing numbers were estimated. Taking the analyzed countries as representative for Europe, the traffic casualty numbers were extrapolated. The results were used as an input for the eCall potential estimation in 4.2. According to the estimations of 2.2 and 2.3 following observations can be made:

<u>Observation worldwide:</u>

- 1.2 million traffic fatalities worldwide
- 23% were P2W users

<u>Observation for seven European countries:</u>

- Share of P2W user casualties in all casualties differs in Germany, Great Britain, Hungary and Sweden between 9% - 13%, in France, Italy and Spain about 27% - 45%.
- Share of P2W user fatalities in all fatalities between 12% - 29%.
- Share of fatally injured P2W users in rural areas ranges between 48% (Italy) - 76% (Germany).

<u>Observation for Europe:</u>

- In 2014, there were 1.86 million casualties caused by traffic accident in Europe, of which 259,379 persons were seriously injured.
- Injured P2W users account for 15% in all casualties, 18% in all fatalities and 17% in all seriously injured road users.
- Majority of P2W casualties occurred in urban areas (78%), but 61% of all fatalities in rural areas.
- 24% of all P2W fatalities happened during the night

3 Organization of rescue chains in Europe

In this chapter the general structure of rescue chains in Europe and their basic rescue principles are described. Using example cases, the effect of possible eCall systems on the rescue chain is illustrated and the accident characteristics with largest expected eCall benefit are pointed out.

3.1 Introduction

The current rescue chain (without eCall) and the future rescue chain (with eCall) are compared and explained below. Possible problems and solutions for optimization are considered. In addition, it will be described why a fast rescue can be life-saving, how the current rescue times in European countries are and in which situations eCall can show a benefit and when not. For a better understanding, three made-up stories are used:

Scenario 1:

Peter is traveling to his holiday at 6 a.m. with his vehicle (not home country). A car driver underestimates his speed and causes an accident with him. Peter is seriously injured, but he is conscious. Because of the early time, not too many people are on the road.

Scenario 2:

Sarah drives home with her vehicle after work at 5 p.m. and the streets are crowded because of the evening commute. She is waiting at a red traffic light. An inattentive driver brakes too late and a collision is no longer avoidable. She has a headache and is under shock. An eye-witness immediately alerts the emergency call. The eye-witness is a local, so he / she knows the localization of the accident scene.

Scenario 3:

Jon drives a low-traffic overland route at 8 p.m. His vehicle is slipping, comes off the road and lands in a ditch. Jon is unconscious and is life-threatening injured. His vehicle is not visible from the road.

Comments about these scenarios can be found in the subsection 3.4 Accident Scenarios in comparison (with and without eCall).

3.2 Response and rescue times

In the EU, certain response times are required by law. This means, at which time (starting from the emergency call) the rescue team should arrive at the accident scene at the latest. Table 7 below shows the response times for several European countries.

Country	Response time (time between emergency call and arrival of the rescue team)	Addition
Germany	5 – 17 minutes	Depends on German states and area
Denmark	8.3 minutes	Country average
Finland	6 – 10 minutes	Highest risk classification: 6 minutes Second highest category: 10 minutes
France	10 – 15 minutes	-
Italy	8 – 20 minutes	-
Netherlands	18 – 30 minutes	A1 = Life-threatening: 18 minutes A2 = urgent: 30 minutes B = ordered transport: not determined
Norway	20 minutes	Better: less than 12 minutes
Czech Republic	15 – 20 minutes	Uniform regulation
Hungary	15 minutes	-

Table 7: Response times in Europe (Forplan, 2010) (Zeitzen, 2006) (Jachs, 2014) (Clinic of Anesthesiology-University Hospital, 2012) (Danziger, 2016) (Jansen, 2009) (Schwarzmann, 2016) (Franek, 2017)

In general, the time limit range from 5 - 30 minutes.

When rescuing, 3 pillars must be considered: Immediately, quickly and gently. The fast and gentle rescue are often in conflict, so the rescue has to be done individually. The rescue must always be done immediately. The gentle rescue is preferred if any movement can degrade the patient's health (e.g. injury to the abdominal organs, head injury, limb injuries, spinal injury alone). Rapid rescue must occur if the patient's health may worsen every second (e.g. burning vehicle, resuscitation, unconsciousness, severe uncontrollable bleeding, abdominal injury). (Allinger, 2010)

Thereby, the "Golden Hour of Shock" should be considered. The “Golden Hour of Shock” predicates that patients should be hospitalized within an hour from the time of the accident. For this, 20 minutes should not be exceeded during alarm and approach (accident, emergency call, alarm, approach). Looking at Table 7, 20 minutes are questionable, as in several countries the response time is between 15 and 20 minutes. If you consider that the emergency is not immediately communicated, but possibly after a few minutes, the “Golden Hour of Shock” would have already failed at this point. The rescue of the patients, as well as the supply and the transport to the hospital should also be completed in 20 minutes each. For P2W the advantage is that injured persons are freely accessible in case of an accident in the normal case. So no time is lost for the salvage. However, the rescue team has to be especially careful and gentle when rescuing crashed motorcyclists, since they have an increased risk of injury to the spine. Overall, this list results in a rescue of an hour. (Allinger, 2010)

When looking at Figure 9, the idea behind “Golden Hour of Shock” can be understood along with the importance of a fast rescue. As soon as the heart stops (green line), there is just about 5 minutes left to live. When the respiration stops (blue line), there is up to 15 minutes left and in case of massive bleeding (red line) there is the (golden) hour left.

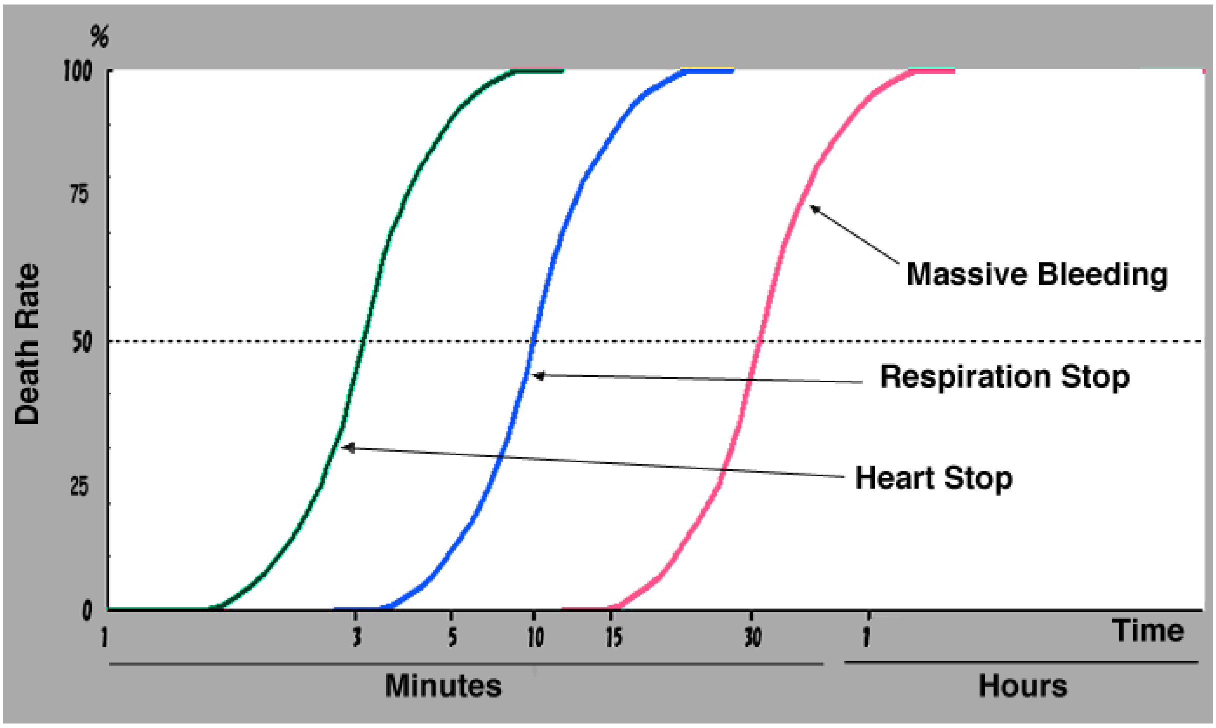


Figure 9: Golden hour principle (Wikipedia, 2017)

Other studies have investigated the impact of the rescue time on survival of severely injured persons in Germany and found out that there's no clear correlation between lethality and the duration of the rescue period. Longer medical procedures were performed at the site of the accident, when the patients were severely injured. This study proposes a "golden period of trauma", which don't consider the length of the rescue period, but its adaptation to the injury pattern, the severity of the injury and the situation at the accident scene. (Kleber, et al., 2013) (Kleber, 2016)

But in one case, both studies are in agreement: the most important factor in a rescue is the rapid arrival of the emergency service, which means that the time to report the accident and the journey to the accident site has to be minimized.

3.3 Rescue chains in Europe

In the following, the current rescue chain (without eCall) and the future rescue chain (with eCall) are presented and explained. Possible problems and solutions are considered.

3.3.1 Current rescue chain (without eCall)

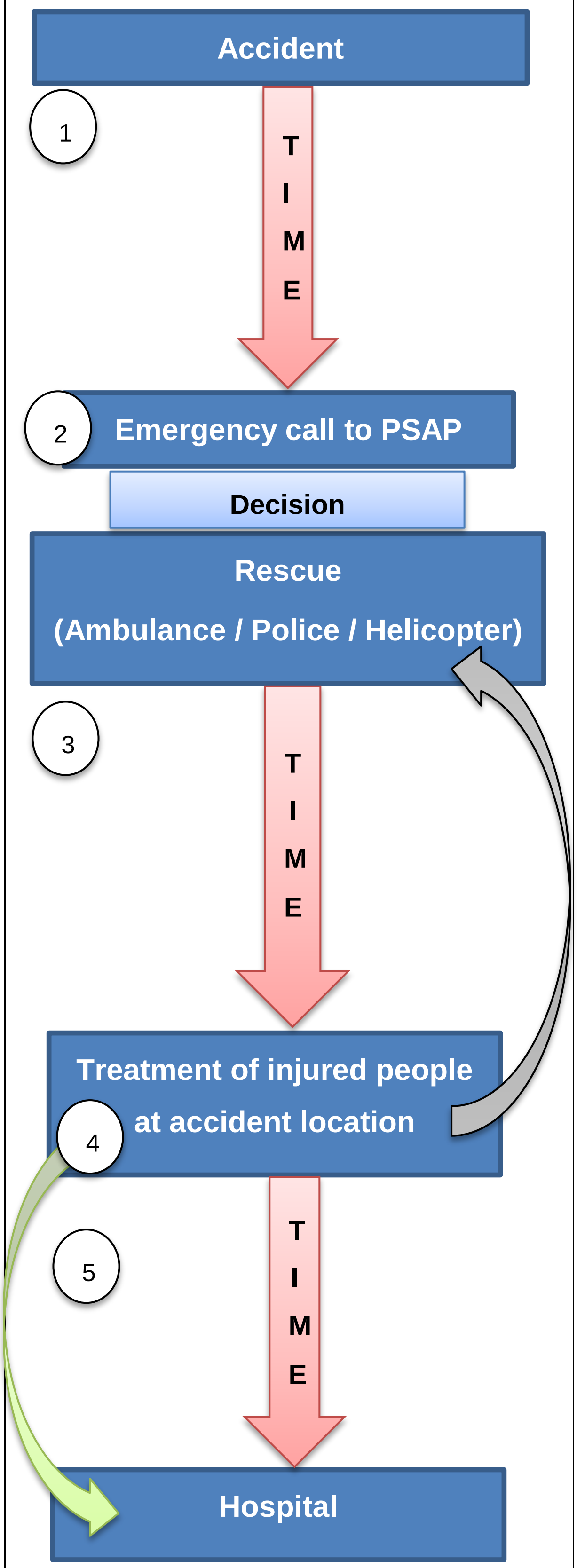
In case of a traffic accident, the rescue chain starts normally by a call to the next PSAP. This call is either from a victim of the accident, an eye witnesses or someone coincidentally detecting the accident. From the call the PSAP operator gathers valuable information about the accident and decides based on these information about the appropriated rescue measures. Rescue teams are then send out to the accident spot. After their arriving the rescue of the victims starts and their medical treatment. As soon as the victims reach a health condition good enough for transportation, they are taken to hospital. By reaching the hospital the rescue chain is completed.

This procedure is quite effective. However it has several potential challenges.

1. Like mentioned in section 3.2, the most important factors in a rescue are the rapid arrival of the emergency service and the first treatment of the victims. But this assumes, that the rescue chain is activated in the first place. The presented rescue chain depends completely that someone reports the accident to the PSAP and provides the relevant information. For certain accident scenarios the time period between the accident occurrence and the report to the PSAP can therefore be very long.
2. The PSAP completely depends on the provided information of the caller. If the caller can't provide the information in the needed quality and quantity, valuable time for the rescue will be lost.

In the following, the above described rescue chain is shown graphically again in Table 8. The blue boxes correspond to an incident. The red arrows represent the time passing by. This time should be minimized for a fast arrival of the rescue team and a fast rescue. The gray arrow indicates a possible reinforcement and thus a time loss. The green arrow stands for the information and decision to the hospital. The numbers in the circle are references to the explanation what happens during this time in the right column of the table.

Rescue chain without eCall



Description

1. Time between accident and emergency call
   - Accident detection, secure the accident scene, overview of the accident
   - Problem: Time can be very long until other road users notice the accident (e.g. in single vehicle accident, rural area, night, vehicle isn't visible from the road), The patient is not able to call the emergency (shock, unconscious), unknown place (can't describe the position / localization of the accident side)
   - Possible solution: eCall

2. Time between emergency call and rescue
   - Decision which rescue team is needed
   - Problem: Accident severity could be different than expected
   - Possible solution: -

3. Time between rescue and treatment of injured people
   - Remember the "Golden Hour of Shock"
   - Rescue team drives to the accident side
   - Problem: Accident scene is possibly hard to find; rescue team can't pass because of congestion, missing corridor for emergency vehicle access, accidents, "watchers", misbehaviors of persons etc.
   - Possible solution: eCall (Accident scene is possibly hard to find); higher punishments for "watchers" and misbehaviors of persons

4. Treatment of injured people
   - Remember the "Golden Hour of Shock"
   - Care of the patient(s)
   - Information and decision to the hospital
   - Problem: possibly reinforcement
   - Possible solution: -

5. Time between treatment of injured people and transport to the hospital
   - Remember the "Golden Hour of Shock"
   - Care of the patient(s)
   - Transport to the hospital
   - Problems: rescue team can't pass because of congestion, missing corridor for emergency vehicle access, accidents, "watchers", misbehaviors of persons
   - Possible solution: eCall (congestion); higher punishments for "watchers" and misbehaviors of persons

Table 8: Rescue chain without eCall

3.3.2 Future rescue chain (with eCall)

For an accident where an eCall system is present, the rescue chain starts with receiving the MSD information by the PSAP. Thereby the operator already has the important information about the exact location of the accident, the involved vehicle type and further one included within the MSD. With these information and possible further information received from calls made by victims of the accident, eye witnesses or someone coincidentally detecting the accident, the PSAP operator can decide about the appropriated rescue measures. Rescue teams are then send out to the accident spot. After their arriving the rescue of the victims starts and their medical treatment. As soon as the victims reach a health condition good enough for transportation, they are taken to hospital. By reaching the hospital the rescue chain is completed.

Main advantages by an eCall system are:

1. By sending out the MSD, the PSAP is directly informed about the accident and thereby the rescue chain is activated immediately.
2. The PSAP is supplied with important information about the accident even if no contact to any victims or eye witnesses is available.
3. By receiving the exact position of the accident location, the rescue team can safe valuable time during their approach.

Considering the mentioned challenges of the current rescue chain presented in subsection 3.3.1 and the advantages of an eCall system, the main benefit accident scenarios can be derived out of that. As a result a high eCall benefit is expected in the following scenarios:

1. In accidents happening during darkness
1. In single vehicle accidents
2. In accidents with severe injuries
3. In accidents In rural areas
4. In accidents abroad
5. Combinations of all these points

In the following, the above described rescue chain is shown graphically again in Table 9.

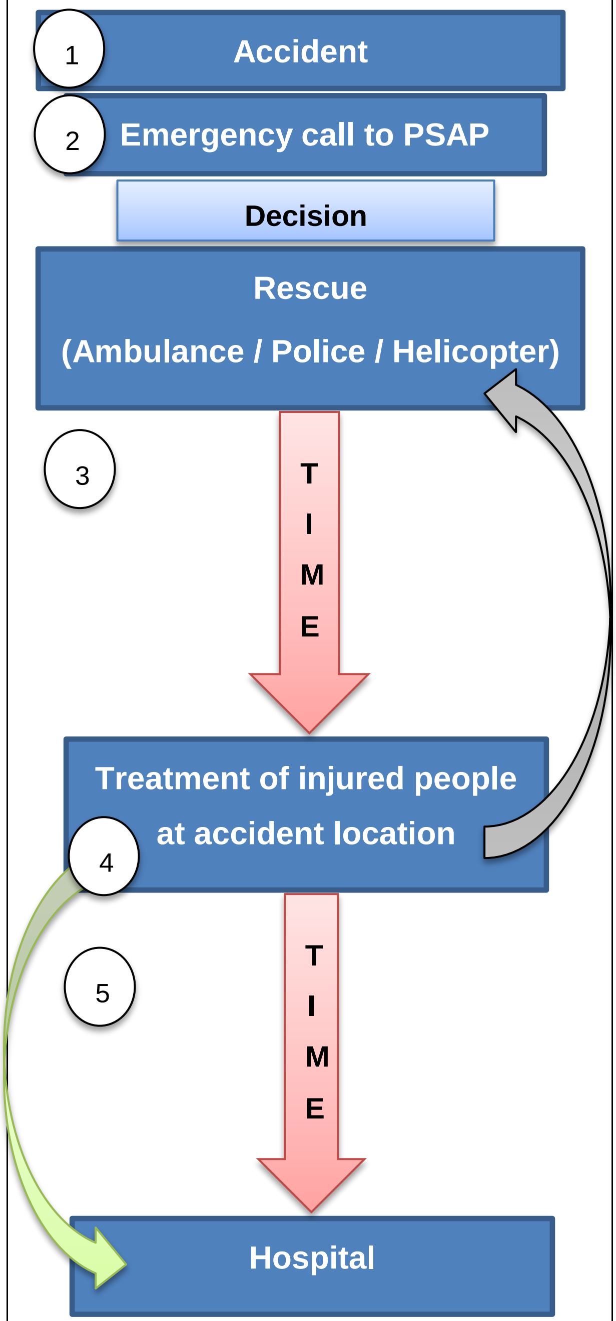
Rescue chain with eCall	Description / Benefit
	1. Time between accident and emergency call • The eCall is triggered during the accident and a voice connection is established to a PSAP. The MSD (Minimum Set of Data) is automatically sent to the PSAP with the following information: accident time and location, vehicle brand, fuel, direction, etc. PSAP connects with the crashed vehicle. 2. Time between emergency call and rescue • In case the driver is conscious, it is possible for the driver to explain the injuries (if he / she has some), so it is easier for PSAP to decide which rescue team is needed 3. Time between rescue and treatment of injured people • The emergency service has the exact GPS position, direction of travel and other data of the crashed vehicle , time for the search of the accident location can be saved 4. Treatment of injured people • At this point, no great benefit is expected 5. Time between treatment of injured people and transport to the hospital • At this point, no great benefit is expected The greatest benefit of eCall in the rescue chain will be in 1. Accident, 2. Emergency call to PSAP and 3. Response time / arrival of the rescue team at the accident site

Table 9: Rescue chain with eCall

3.4 Accident Scenarios in comparison (with and without eCall)

In the following, the scenarios introduced at the beginning of the subsection 3.1 will be reviewed with and without eCall. Furthermore the benefits will be illustrated by using these examples.

Scenario 1:

Peter is traveling to his holiday at 6 a.m. with his vehicle (not home country). A car driver underestimates his speed and causes an accident with him. Peter is seriously injured, but he is conscious. Because of the early time, not too many people are on the road.

Without eCall: Peter and the other driver are under shock and are acting mindless. A noninvolved person drives along the road at 6.02 a.m. He detects the accident, gets an overview of the accident scene and alerts the emergency call by 6.05 a.m.. The rescue team starts at about 6.09 a.m. and arrives at the accident site at 6.25 a.m. (16 minutes). Peter gets his first professional medical treatment 25 minutes after the accident.

With eCall: Peter and the other driver are under shock and are acting mindless. At 6.01 a.m., the PSAP operator receives a MSD about Peter's accident and despatches an ambulance to the accident spot. A noninvolved person drives along the road at 6.02 a.m. He detects the accident, gets an overview of the accident scene and alerts the emergency call by 6.05 a.m.. The rescue team starts at about 6.05 a.m. and arrives at the accident site at 6.20 a.m. (15 minutes, because exact location is known). Peter gets his first professional medical treatment 20 minutes after the accident.

It can be seen, that in this example, the emergency services arrives at the accident site 5 minutes earlier for the eCall case. For Peter this might help to reduce the severity of his injuries and his suffering.

Scenario 2:

Sarah drives home with her vehicle after work at 5 p.m. and the streets are crowded because of the evening commute. She is waiting at a red traffic light. An inattentive driver brakes too late and a collision is no longer avoidable. She has a headache and is under shock. An eye-witness immediately alerts the emergency call. The eye-witness is a local, so he / she knows the localization of the accident scene.

Without eCall: The eyewitness immediately alerts the emergency call (around 5 p.m.) and describes accurately the accident location to the PSAP operator. The emergency team starts at 5.03 p.m. The rescue team is around 5.19 p.m. (16 minutes) at the accident site. Sarah gets her first professional medical treatment 19 minutes after the accident.

With eCall: The eyewitness immediately alerts the emergency call (around 5 p.m.) and describes accurately the accident location to the PSAP operator. At the same time the PSAP operator also receives Sarah's eCall MSD. The emergency team starts at 5.03 p.m. The rescue team is around 5.19 p.m. (16 minutes) at the accident site. Sarah gets her first professional medical treatment 19 minutes after the accident.

In this specific example eCall would increase the information security and the PSAP could compare the information provided by the eCall system with the information by the eye-witness, The rescue time couldn't be shorten by an eCall system in this case, as the eye-witness immediately alarms the emergency and he / she can describe the exact accident location.

Scenario 3:

Jon drives a low-traffic overland route at 8 p.m. His vehicle is slipping, comes off the road and lands in a ditch. Jon is unconscious and is life-threatening injured. His vehicle is not visible from the road.

Without eCall: After an hour, a driver notices Jon in the ditch. The driver immediately calls the emergency (around 9 p.m.). The rescue team arrives at 9.19 p.m. The emergency doctor can only determine Jon's death.

With eCall: The eCall system is triggered during the accident and sends out the MSD to the PSAP at 8.01 p.m.. The PSAP operator despatches an ambulance to the accidents spot and the team arrives at 8.12 p.m. and finds Jon seriously injured. Due to the fast treatment of Jon's injuries he could be saved.

In this example eCall would have a very high benefit, because it minimized the time between the accident occurrence and alert of the rescue service.

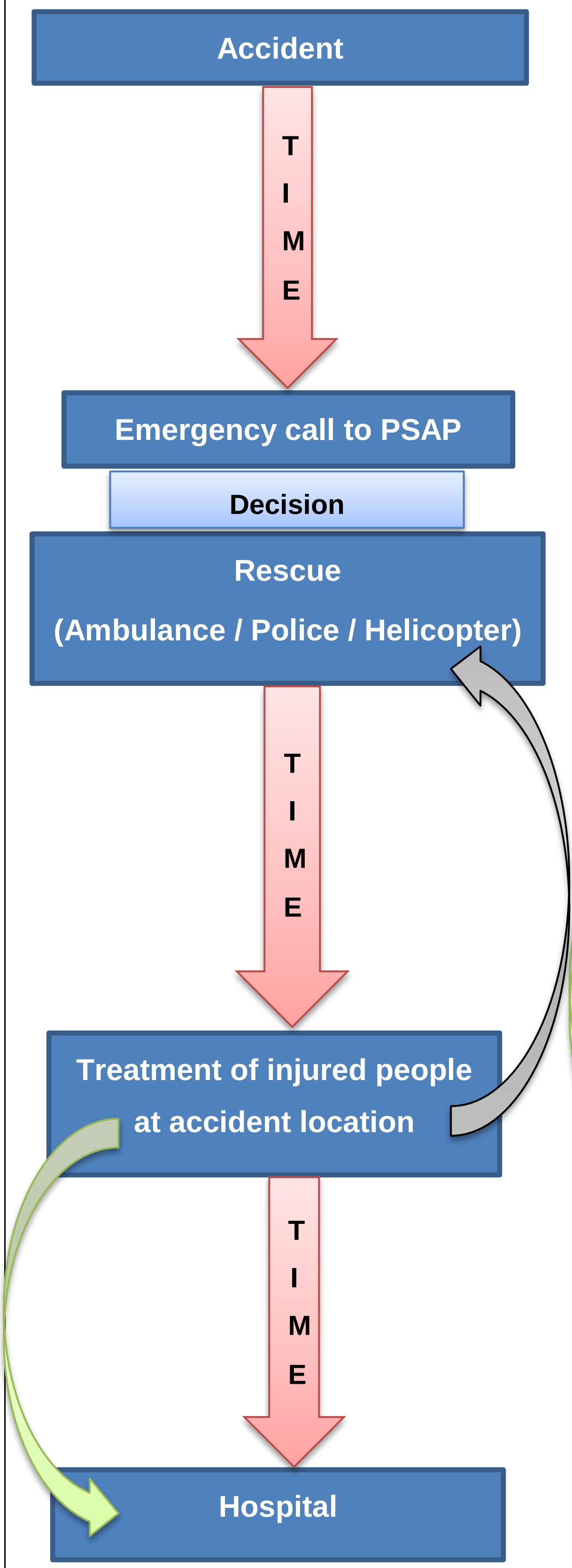
3.5 Summary

All in all, the European rescue chain begins with the emergency call. Then the PSAP makes a decision regarding the selection of the rescue team. Afterwards the rescue begins, which must take place immediately, quickly and gently. After the arrival of the rescue team, they take care of the patients and transport them to the hospital.

Generally, eCall can have a high benefit in the event of serious accidents with severely injured persons. Looking at severe scenarios (e.g. these in 3.1 Introduction) with the accident characteristics "abroad", "night" or "alone", the potential effectiveness of eCall rises.

But also in other cases, time can be saved between the accident and the emergency call with eCall. In addition, the approach time of rescue team might be reduced in a few cases due to eCall sending the exact location. A minimum approach time and a fast rescue are important in order to attend the patient as quickly as possible and thus to be transported to the hospital faster, in order to minimize and prevent worse consequences.

Rescue chain without eCall	Rescue chain with eCall



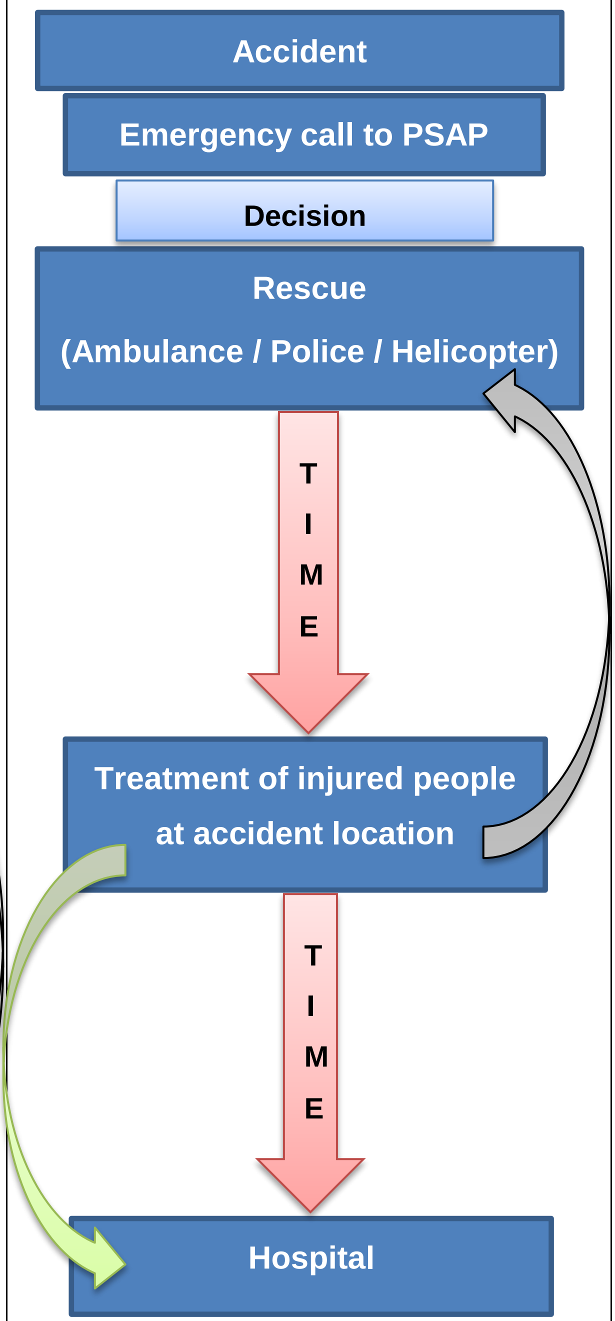


Table 10: Rescue chain with and without eCall in comparison

4 eCall potential estimation

To estimate the eCall potential on road safety and to be able to quantify it, a review of available eCall related studies has been undertaken. Based on these studies, the first steps of an original potential estimation analysis has been done for Germany. As next step, these results were then extrapolated to seven European countries and to the Europe Union in total.

4.1 Available eCall studies

4.1.1 Introduction

This section gives an overview of available eCall studies and their findings. The relation between the studies will be shown and the most relevant ones identified. Most of these studies investigate the potential reduction of fatalities and severely injured in road traffic accidents due to eCall. Some also examine whether the rescue service can reach the accident site more quickly and whether the congestion time can be shortened. Many studies only consider the benefits of eCall in passenger cars (these studies have also been included in this report because there aren't many studies looking only at motorcycles and to get a general indication about the expectable benefit by an eCall system in vehicles).

4.1.2 eCall studies

An online search for studies dealing with eCall effectiveness was conducted. These studies were investigated and their main results are presented in the following form:

Name of the study

Area:	Describes in which region, country, continent etc. the study considered
Basis:	Describes the used data base, e.g. databases, other studies, etc.
Methodology:	Describes the process of the study
Reduction fatalities:	Describes how many fatalities can be reduced (in percent) according to the study result
Reduction severely injured:	Describes how many serious casualties can be reduced (in percent) according to the study result
Reduction congestion:	Describes the extent to which traffic jam can be reduced (in percent or minutes)
Reduction time:	Describes the extent to which rescue time can be reduced (in percent or minutes)

STORM (Stuttgart Transport Operation by Regional Management) (Fraunhofer Institute for Systems and Innovation Research, 1997)

Area:	Stuttgart
Methodology:	Case study, field tests, simulation, estimated assumptions
Reduction time:	10 minutes (50% faster) in rural areas (from 21.2 to 11.7 minutes)

eCall Impact Assessment (European Commission, 2011)

Area:	Europe
Basis:	SEiSS, STORM, E-MERGE, AINO, eIMPACT, Swedish study, SBD, CARE Database
Methodology:	Literary study, summarize and compare the studies
Reduction fatalities:	2% - 15%
Reduction severely injured:	2% - 15%
Reduction congestion:	3% - 17%

E-MERGE (harmonisation of the eCall service chain) (Nielsen, et al., 2004)

Area:	Europe (Spain, Netherlands, UK, Germany, Sweden, Italy)
Basis:	Other studies
Methodology:	Laboratory tests, integration tests, real-life tests in 6 EU countries (see “Area”), Survey for participating PSAPs
Reduction fatalities:	5%
Reduction severely injured:	10%

eIMPACT (socio-economic impact assessment of intelligent vehicle safety systems in Europe) (Malone, et al., 2008)

Area:	Europe
Basis:	AINO, Swedish study, E-MERGE, SEiSS, CARE database
Methodology:	Estimations based on existing studies and statistics
Reduction fatalities:	3,5%

eCall UK 2013 Review and Appraisal UK (Atkins, 2014)

Area:	UK
Basis:	2011 EC Impact, 2009 EC Study (Finland, UK, Netherlands, Hungary)
Methodology:	Literary study, summarize and compare the studies
Reduction fatalities:	1% - 2%
Reduction severely injured:	0,5% - 1,5%
Reduction time:	max. 2 minutes

Impacts of an automatic emergency call system on accident consequences (AINO) (Virtanen, et al., 2006)

Area:	Finland

Basis:	Swedish study, E-MERGE, SEiSS
Methodology:	Evaluation; analysis of empirical data of accidents in Finland 2001 – 2003; data from road accident research teams, rescue service and accident data system, interviews with emergency services and rescue teams, surveys of emergency centers officers
Reduction fatalities:	4% - 8% (all vehicles including motorcycles, mopeds and snowmobiles)
Reduction time:	Emergency call within the first 5 minutes: +5,5% (from 82% to 87,5%) Emergency call within 5 - 30 minutes: -5,4% (from 14% to 8,6%) Emergency call after 30 minutes: -0,2% (from 4% to 3,8%)

eCall System: French a posteriori efficiency evaluation (Chauvel, et al., 2009+)

Area:	France
Basis:	LAB/CEESAAR, PVM2000 database
Methodology:	A posteriori; examination real accidents with eCall equipped cars
Reduction fatalities:	2,8% (assumption: 100% of the vehicles are equipped with eCall)

SEiSS (socio-economic impact of intelligent safety systems) (Abele, et al., 2005)

Area:	Europe
Basis:	E-MERGE, eSafety, etc. (AIDE, ARCOS, CarTALK, CHAMELEON, EDEL, etc.), CARE database
Methodology:	Literary study, summarize the studies; statistical analyzes (official statistics, traffic analyzes)
Reduction fatalities:	5% - 15%
Reduction severely injured:	10% - 15%
Reduction congestion:	10% - 20%

Improving Safety for Motorcycle, Scooter and Moped Riders (OECD, 2015)

Area:	worldwide
Basis:	AINO
Methodology:	Research; literary study, summarize and compare the studies
Reduction fatalities:	10%

Ex-ante evaluation of the eCall System (Riley, et al., 2007)

Area:	Czech Republic
Basis:	AINO, E-MERGE, Swedish study, police statistics database

Methodology:	Analysis of European Studies, empirical data of traffic accidents and rescue operations
Reduction fatalities:	3% - 9%
Reduction severely injured:	5% - 10%
Reduction congestion:	2 min / accident

Automatic emergency calls in France (Chauvel, et al., 2008+)

Area:	France
Basis:	LAB/CEESAR, TRACE, PVM2000 database
Methodology:	A priori; Selection of accident statistics with specific parameters (single accident, at night, in rural areas); Analyze every accident and create an expert opinion.
Reduction fatalities:	5% - 6%

Grundlagen für eCall in der Schweiz (Basic information of eCall in Switzerland) (Rapp, et al., 2009)

Area:	Switzerland
Basis:	SEiSS, E-MERGE, AINO, SMART 2008/0055, CGALIES, GST Rescue, INFRAS, eSafety, Austrian project, Machbarkeitsstudie ADAC
Methodology:	Literary study, summarize and compare the studies
Reduction fatalities:	5% (E-MERGE) (assumption: 100% of the vehicles are equipped with eCall)
Reduction severely injured:	10% (E-MERGE) (assumption: 100% of the vehicles are equipped with eCall)

Europe (EU28) vs. Norway - Assessment of Socio-economic Impact of In-vehicle Emergency Call (eCall) (Brembo, 2016)

Area:	Norway (and Europe)
Basis:	SMART 2008/55, E-MERGE, SEiSS, Swedish Study, AINO, STORM, eIMPACT
Methodology:	Literary study, summarize and compare the studies
Reduction fatalities:	1% - 10%
Reduction severely injured:	2% - 15%
Reduction time:	Reduction of rescue time in urban areas from 13 to 8 minutes (40%) and in rural areas from 21.2 to 11.7 minutes (50%)

SMART 2008/55 (Impact assessment on the introduction of the eCall service in all new type-approved vehicles in Europe, including liability/ legal issues) (Francsics, et al., 2008)

Basis:	SEiSS, E-MERGE, AINO, eIMPACT, Austrian eCall study, Czech eCall study, SBD, Swedish eCall study, Dutch eCall study, Hungarian eCall study, European Commission

Methodology:	Literary study (SBD, Swedish eCall study, Dutch eCall study, Hungarian eCall study below), summarize and compare the studies

SBD

Area:	UK
Reduction fatalities:	3%
Reduction severely injured:	2%
Reduction time:	10 minutes

Swedish eCall study

Area:	Sweden
Basis:	STORM, SEiSS, E-MERGE, eSafety, Driving Group
Reduction fatalities:	2% - 4% (assumption: 100% of the vehicles are equipped with eCall)
Reduction severely injured:	3% - 4% (assumption: 100% of the vehicles are equipped with eCall)

Dutch eCall study

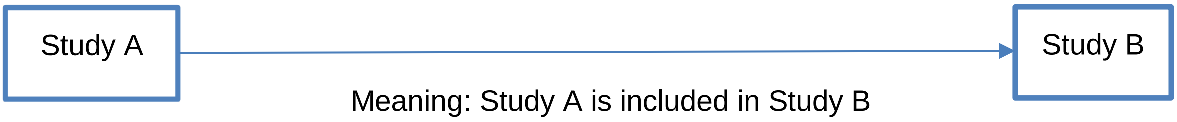
Area:	Netherlands
Reduction fatalities:	1% - 2%
Reduction severely injured:	1%
Reduction congestion:	3.5%
Reduction time:	3 minutes

Hungarian eCall study

Area:	Hungary
Reduction fatalities:	2% - 3%
Reduction congestion:	15% - 20%
Reduction time:	10 – 15 minutes

It can be seen, that the results of the studies are quite similar to one another. One reason for this is that many of the studies did not carry out their own analyzes. Instead they summarize or combine the results of other studies. Because of these dependencies, these results are presented in the first step and in the next to identify the most important ones. In Figure 11 the studies and their dependencies are summarized.

A short explanation how to read the cross references: Each box corresponds to a study. The lines show the relationships. The study on which the arrow points is based on the respective other study (see explanation below).



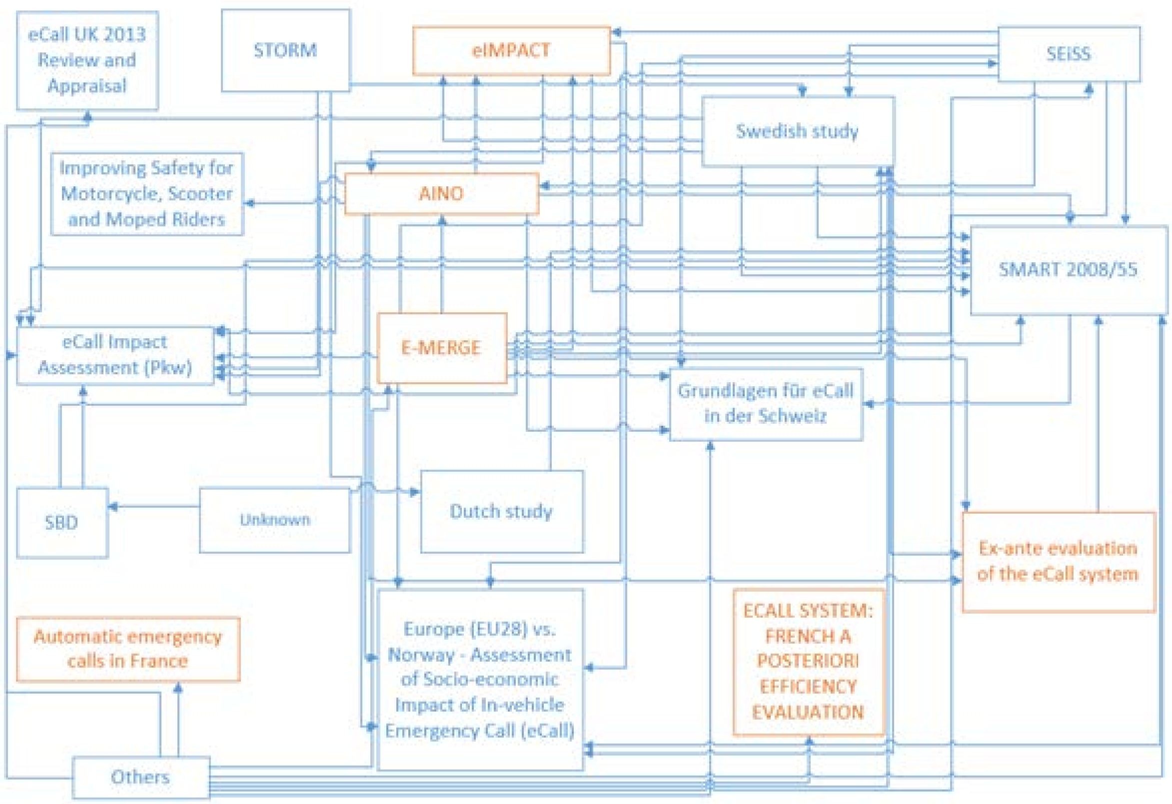


Figure 10: Basis for other studies (cross references)

Figure 11 shows the dependencies between the individual studies. The most relevant studies are orange. The blue studies are summaries or have not been considered in more detail. Now it can be seen for example, that the study SMART 2008/55 is only a summary. On the other hand, the E-MERGE study is for example a central baseline study that is often referenced. The following is a summary of the essential studies which seem to have their own analyses.

Study	Reduction fatalities	Reduction severely injuries	Basis	Vehicles (for which vehicles the study applies)	Area	Date
E-MERGE	5% (saves about 2.000 lives per year)	10%	Other studies	Passenger cars	Europe	2004
eIMPACT	3.5%	-	AINO, Swedish study, E-MERGE, SEiSS	Passenger cars, trucks and buses	Europe	2008
AINO	4% - 8%	-	Swedish study, E-MERGE, SEiSS	all vehicles including motorcycles, mopeds and snowmobiles	Finland	2006
ECALL SYSTEM: FRENCH A POSTERIORI EFFICIENCY EVALUATION	2.8% (3% - 10% interval)	-	LAB / CEESAR	Passenger cars	France	2009+
Ex-ante evaluation of the eCall system	3% - 9%	5% - 10% (based on E-MERGE)	AINO, E-MERGE, Swedish study	Passenger cars	Czech Republic	2007
Automatic emergency calls in France	5.1% (5% - 10% interval)	-	LAB / CEESAR, TRACE	Passenger cars	France	2008+

Table 11: Relevant studies

The “ECALL SYSTEM: FRENCH A POSTERIORI EFFICIENCY EVALUATION” study was especially striking, because it carried out an “a posteriori” analysis. That means, they have evaluated real accidents with eCall equipped vehicles.

All the other studies carried out assessments by analyzing and evaluating databases, statistics, other studies, tests, evaluations and surveys.

4.1.3 Summary

In summary, there are many studies on eCall benefits but only few have original analsysis and these have been identified. Most of these studies estimated the benefits for passenger cars. Their results can not be directly applied to P2Ws. It can be seen that by an eCall system with assumed 100% installation rate, the total number of fatalities could be reduced by up to 3% - 8% and by up to 10% for seriously injured (depending on the country). Because of the lack of eCall benefit analysis for motorcycles or generally old benefit analysis, an original analysis has been conducted to estimate the benefit potential for P2W eCall with current accident data in the following section.

4.2 Benefit potential of eCall in motorcycles

4.2.1 Introduction

As mentioned before, at the time of this study there is no current eCall benefit analysis for P2W available. Hence it is only possible to present an estimate for the benefit potential of eCall for P2W. In order to do this, data from the GIDAS (German In-Depth Accident Study) database and the statistics from (2.3.1) were used. The detailed description of the process can be found in (4.2.2).

4.2.2 Methodology

The basic idea for the benefit potential estimation was to use a very general approach by classifying retrospectively accidents according to their characteristics as benefit levels. As no medical assessment has been performed, it is not possible to provide exact benefit estimations about the reduced fatalities or seriously injured. Instead, benefit potential levels were defined to point out an upper limit of the expected casualties which benefits from an eCall system.

It was assumed that eCall is most beneficial in the case of single accidents (1 participant), at night, in rural areas, or a combinations of those. At night and in rural areas less traffic and therefore longer alarm times are expected. In case of a single accident, there are possibly no eyewitnesses, who could call the emergency, so these cases are of particular importance with regard to eCall. Table 12 shows the distribution.

Area											
1 Participant						> 1 Participant					
Day			Night			Day			Night		
LI	SI	F	LI	SI	F	LI	SI	F	LI	SI	F

Table 12: Categories for eCall benefit potential estimation

Description of Table 12: At the top of the table is the number of traffic accidents with at least one motorcyclist involved by area (urban, rural with highway). This number is divided into the number of participants involved. Of particular importance are single accidents in which only one participant was involved. This number is split into day and night. Especially relevant are the injured at night. The last row of Table 12 shows the maximum injury severity of a person involved in the accident. These are subdivided into light injured (LI), severe injured (SI) and the fatalities (F). Uninjured were not considered, because no eCall benefit is expected.

The following steps were made for the benefit potential estimation:

1. Data from the GIDAS database: The criteria above (single accident, night, and rural area) were collected for P2Ws and the maximum severity injury within the accident. The results were recorded in Table 16 and Table 17.
2. These data are only from Hannover and Dresden (Germany). Since these data are not representative, these figures had to be calculated for nation-wide results for Germany.
3. An assessment scale was introduced (Table 13). Points are awarded and added for each criterion. The higher the score, the higher the benefit potential of eCall. If the value is between 0 and 6, the benefit potential is rather low. If it is 7, 8 or 9 eCall has a medium benefit potential and a high benefit potential for a sum of 10, 11, 12 or 13.

Urban: +1		Rural or Highway: +3
>1 Participant: +1		1 Participant: +3
Day: +1		Night: +3
Light injured: -3	Severe injured: +3	Fatality: +4

Table 13: Assessment scale of eCall potential

Low benefit potential: A low potential will be present if it can be assumed that there are eye-witnesses on the scene. A low potential is also expected in accidents with participants with minor injuries because they aren't dependent on a fast rescue.

Medium benefit potential: A medium benefit potential is achieved if although there are eye-witnesses on the spot, a fast rescue is nevertheless important because of serious or fatal injuries.

High benefit potential: A high benefit potential is expected especially when there is little traffic and therefore there are no eye-witnesses on the scene to call the emergency. Especially in case of serious and fatal injuries, a rapid arrival of the rescue team can be life-saving.

4. The calculated GIDAS data based on accidents were transferred to Germany and based on P2W casualties.
5. On the basis of these figures, an eCall benefit potential was estimated for Europe (assuming that 100% of the P2W are equipped with eCall).

Table 14 and Table 15 show the distribution from Table 13. The points are always added from the previous row, so it is easy to see in the last row if it's a low, medium or high potential benefit. The fields that are of minor benefits according to the scale in Table 13 are marked yellow. A medium potential orange and a high benefit potential green.

Urban:											
1											
1 Participant:						> 1 Participants:					
4						2					
Day:			Night:			Day:			Night:		
5			7			3			5		
LI:	SI:	F:	LI:	SI:	F:	LI:	SI:	F:	LI:	SI:	F:
2	8	9	4	10	11	0	6	7	2	8	9

Table 14: Benefit potential valuation according to the assessment scale (urban)

Rural and highways:											
3											
1 Participant:						> 1 Participants:					
6						4					
Day:			Night:			Day:			Night:		
7			9			5			7		
LI:	SI:	F:	LI:	SI:	F:	LI:	SI:	F:	LI:	SI:	F:
4	10	11	6	12	13	2	8	9	4	10	11

Table 15: Benefit potential valuation according to the assessment scale (rural and highways)

4.2.3 Result

4.2.3.1 eCall benefit potential for Germany

According to these categories in Table 12, special tables with consideration of the severity of injury were created from the GIDAS database. In total, the GIDAS database records 4,052 accidents involving at least one motorcycle.

Table 16 and Table 17 show the number of accidents involving at least one motorcyclist by area, number of participants, daytime and the maximum injury severity of the accident.

No and unknown injuries were excluded, as no eCall benefit potential is expected or not assessable. It must also be noted that unknown light conditions and twilight is included in accidents with injured participants during the day.

As above, LI stands for light injured, SI for severe injured and F for fatalities.

In total, there were 4,052 accidents with at least one P2W, which are divided as follows:

Urban:											
3,273											
1 Participant:						> 1 Participants:					
617						2,656					
Day:			Night:			Day:			Night:		
524			93			2,307			349		
LI:	SI:	F:	LI:	SI:	F:	LI:	SI:	F:	LI:	SI:	F:
356	163	5	53	39	1	1,589	694	24	215	124	10

Table 16: Accidents with at least one P2W in urban areas (GIDAS)

In Table 16 one can see that there are significantly more accidents with more than one participant. During the day, more accidents happen as more traffic prevails.

Rural and highways:											
779											
1 Participant:						> 1 Participants:					
369						410					
Day:			Night:			Day:			Night:		
316			53			372			38		
LI:	SI:	F:	LI:	SI:	F:	LI:	SI:	F:	LI:	SI:	F:
126	178	12	18	34	1	140	190	42	11	22	5

Table 17: Accidents with at least one P2W in rural areas and highways (GIDAS)

In Table 17, the share of one participant and several participants are almost the same. Also here because of more traffic during the day more accidents happened.

Comparing Table 16 and Table 17, there are almost three times as many accidents in urban areas as in rural areas. However the accidents with only one participant in urban areas as well as in rural areas are about the same. It is striking that, in the case of accidents with one participant, there are more severe injured and fatalities in the country, especially during the day.

According to Table 18, 3,302 accidents with at least one involved P2W have a low eCall benefit potential, 558 accidents have a medium eCall benefit potential, and 292 accidents have a high eCall benefit potential.

It should be noted that the GIDAS database contains only 2 cities in Germany: Hannover and Dresden, so these numbers had to be extrapolated to Germany. Each accident is thus given a weighting which can be used to offset accidents for Germany. As not all groups are available within GIDAS the weighting leads to a slightly smaller number than the actual one (44,604 compared to 45,807).

In Germany there were 45,807 accidents with at least one P2W involved in 2015, therein 46,046 P2W users were injured. The GIDAS weighted accidents were mapped to the P2W casualties for the further analysis.

In the next step, the cases according to the evaluation scale of Table 13 were used. A high benefit potential is expected in case of single accidents, at night, in connection with a serious or fatal injury. A low benefit potential is expected in case of an accident in the city, with more than one participant, during the day or minor injuries of the participant(s).

	GIDAS accidents	GIDAS accidents weighted	P2W casualties in Germany (2015)
Low benefit potential	3,202 (79%)	35,368 (80%)	36,619 (80%)
Medium benefit potential	558 (14%)	5,509 (12%)	5,622 (12%)
High benefit potential	292 (7%)	3,543 (8%)	3,805 (8%)
Total	4,052 (100%)	44,604 (100%)	46,046 (100%)

Table 18: Estimated benefit potential of eCall for P2W in P2W accidents in GIDAS and Germany

As can be seen in Table 18, there are 3,805 P2W accidents in Germany, which could have a high benefit potential from eCall.

4.2.3.2 eCall benefit potential for Europe

In order to obtain results for the benefit potential of eCall for Europe, the results from Germany were mapped to seven European countries and then extrapolated to Europe. The researched statistics from 2.3.1 Accident situation for powered two-wheeler in seven European countries were used. Groups were then formed, for example according to Table 4, and the benefit potential distributions gained form the GIDAS analysis were mapped. By using various casualty distributions with different accident characteristics, it was tried to get more accurate estimations.

Country	Year	Benefit potential	Total casualties of P2W users	Fatalities of road users	Seriously injured road users	Slightly injured road users
7 Europe[16]	**2008-2015**	Low	**205,316**	**0**	**12,034**	**193,282**
All P2W		Medium	**16,866**	**2,721**	**14,146**	**0**
		High	**10,858**	**963**	**9,894**	**0**
Europe[17]	**2014**	Low	**252,592**	**0**	**14,800**	**237,792**
All P2W		Medium	**20,818**	**3,366**	**17,452**	**0**
		High	**13,461**	**1,198**	**12,263**	**0**

[16] 7 Europe: Germany, France, Great Britain, Hungary, Italy, Spain & Sweden. Missing data were estimated for each country individually.
[17] Missing European numbers were extrapolated based on the fatalities and the distributions from the seven European countries.

Table 19 Estimated P2W eCall benefit potential for European countries and Europe based on casualty distribution

In Table 19 the P2W eCall benefit potential were estimated using the severity information. Slightly injured P2W users always have a low benefit potential, as there is no significant severity reduction potential for these cases. For serious injured road users the eCall benefit potential is evenly distributed on all levels. For a high benefit potential for seriously injured P2W users at least two eCall benefit criteria have to be fulfilled. For example, these accidents happened in rural area at night. For fatally injured P2W users there is at least a medium benefit potential assumed. Compared to the seriously injured P2W users, there are no low benefit potential cases for fatally injured P2W users, as it is assumed that even a slight faster rescue of the P2W user could be lifesaving.

Country	Year	Benefit potential	Rural				Urban			
			Sum injured road users	Fatalities	Seriously injured	Slightly injured	Sum injured road users	Fatalities	Seriously injured	Slightly injured
7 Europe[18]	**2008-2015**	Low	**34,981**	**0**	**0**	**34,981**	**171,907**	**0**	**13,605**	**158,301**
All P2W		Medium	**8,277**	**1,473**	**6,803**	**0**	**8,330**	**1,423**	**6,907**	**0**
		High	**8,484**	**756**	**7,729**	**0**	**1,062**	**32**	**1,030**	**0**
Total of Europe[19]	**2014**	Low	**43,272**	**0**	**0**	**43,272**	**211,279**	**0**	**16,759**	**194,520**
All P2W		Medium	**10,265**	**1,825**	**8,440**	**0**	**10,229**	**1,759**	**8,469**	**0**
		High	**10,519**	**940**	**9,579**	**0**	**1,308**	**40**	**1,268**	**0**

Table 20 Estimated P2W eCall benefit potential for European countries and Europe based on casualty and accident location distributions

In Table 20 the P2W eCall benefit potential were estimated using the severity information and the accident location. For seriously and fatally injured P2W users in rural areas, it is very likely that there will be no direct eye-witnesses and the first responders will take longer to locate accident spot if a call is made. Hence, it is always assumed to get at least a medium benefit

[18] 7 Europe: Germany, France, Great Britain, Hungary, Italy, Spain & Sweden. Missing data were estimated for each country individually.

[19] Missing European numbers were extrapolated based on the fatalities and the distributions from the seven European countries.

potential by an eCall system. On the other hand in urban areas, there is only a small portion of high benefit cases for seriously and fatally injured P2W users, as here it is very likely that there will be an eye-witnesses who will call the next PSAP and to determine the accident location very fast.

Country	Year	Benefit potential	Darkness				Daylight			
			Sum injured road users	Fatalities	Seriously injured	Slightly injured	Sum injured road users	Fatalities	Seriously injured	Slightly injured
7 Europe[20]	**2008-2015**	Low	**35,252**	**0**	**0**	**35,252**	**169,252**	**0**	**11,222**	**158,030**
All P2W		Medium	**3,416**	**371**	**3,045**	**0**	**13,407**	**2,208**	**11,199**	**0**
		High	**4,420**	**520**	**3,900**	**0**	**7,293**	**585**	**6,708**	**0**
Europe[21]	**2014**	Low	**43,323**	**0**	**0**	**43,323**	**208,273**	**0**	**13,804**	**194,469**
All P2W		Medium	**4,189**	**457**	**3,732**	**0**	**16,572**	**2,733**	**13,839**	**0**
		High	**5,442**	**644**	**4,798**	**0**	**9,072**	**730**	**8,342**	**0**

Table 21 Estimated P2W eCall benefit potential for European countries and Europe based on casualty and light condition distributions

The estimated P2W eCall benefit potentials of Table 21 were calculated by using the benefit potential distributions of casualties by light conditions. The share of high benefit potential compared to medium benefit potential cases for seriously and fatally injured P2W users is much higher in darkness than in daylight cases. There are however fewer total casualties in darkness than in daylight.

A fourth benefit potential estimation has been also performed by using the benefit potential distributions of casualties by accident location and the distinction of single accidents and multiple participant accidents. The results are only shown in an accreted form in Table 22.

In Table 22 the estimated benefit potential for a P2W eCall system assuming 100% installation rate for each used method is given. The results of the different methods are summarized as expected potential range for each level. In Europe, it is expected to have up to 14.500 casualties of P2W users with a high benefit potential by eCall. This correspond to 5% of all

[20] 7 Europe: Germany, France, Great Britain, Hungary, Italy, Spain & Sweden. Missing data were estimated for each country individually.
[21] Missing European numbers were extrapolated based on the fatalities and the distributions from the seven European countries.

casualties of P2W users. For additionally 16.866 P2W users a medium benefit potential is expected, which corresponds to 7% of all P2W casualties.

Country	Year	Benefit potential	Estimation method				
			Severity of injured P2W users	Severity of injured P2W users + accident location	Severity of injured P2W users + light condition	Severity of injured P2W users + accident location + single-/ multiple accidents	Resulting potential range of all P2W casualties
7 Europe[22]	**2008-2015**	Low	**205,316**	**206,887**	**204,504**	**207,859**	**204,504 (88%) - 207,859 (89%)**
All P2W		Medium	**16,866**	**16,607**	**16,823**	**16,772**	**16,607 (7%) - 16,866 (7%)**
		High	**10,858**	**9,546**	**11,713**	**8,410**	**8,410 (4%) - 11,713 (5%)**
Europe[23]	**2014**	Low	**252,592**	**254,551**	**251,596**	**255,740**	**251,596 (88%) - 255,740 (89%)**
All P2W		Medium	**20,818**	**20,494**	**20,761**	**20,721**	**20,494 (7%) - 20,818 (7%)**
		High	**13,461**	**11,826**	**14,514**	**10,411**	**10,411 (4%) - 14,514 (5%)**

Table 22 Comparison of estimated P2W eCall benefit potential for European countries and Europe gained by different methods

Looking at the severity in Table 23, it can be seen that for up to 1,374 fatally injured and for 13,140 seriously injured P2W users a high benefit potential by eCall is expected. This corresponds to 30% of all fatally and seriously injured P2W users. For additionally about 20,000 P2W casualties a medium benefit potential is expected, which correspond to 70% of all fatally and 39% of all seriously injured P2W users.

[22] 7 Europe: Germany, France, Great Britain, Hungary, Italy, Spain & Sweden. Missing data were estimated for each country individually.

[23] Missing European numbers were extrapolated based on the fatalities and the distributions from the seven European countries.

Country	Year	Benefit potential	Resulting potential range within P2W users injury category			
			Fatalities	Seriously injured	Slightly injured	All P2W casualties
7 Europe[24]	2008-2015	Low	0 - 0	11,222 - 14,576	193,282 - 193,282	204,504 (88%) - 207,859 (89%)
All P2W		Medium	2,579 - 2,896	14,146 - 14,244	0 - 0	16,607 (7%) - 16,866 (7%)
		High	788 - 1,105	7,351 - 10,608	0 - 0	8,410 (4%) - 11,713 (5%)
Europe[25]	2014	Low	0 - 0	13,804 - 17,947	237,792 - 237,792	251,596 (88%) - 255,740 (89%)
All P2W		Medium	3,190 - 3,585	16,909 - 17,571	0 - 0	20,494 (7%) - 20,818 (7%)
		High	979 - 1,374	9,104 - 13,140	0 - 0	10,411 (4%) - 14,514 (5%)

Table 23 Estimated P2W eCall benefit potential range for European countries and Europe within each severity group

4.2.4 Summary of eCall benefit potential

ECall's largest benefit is expected for single accidents, at night, in rural areas, or combinations of these criteria. For this reason, an assessment scale was introduced to consider and evaluate such cases. As the GIDAS database does not give a representative statement for Germany, the results had to be calculated with the help of a weighting. Finally the results were extrapolated for several European countries and for Europe as total. Assuming that the eCall equipment rate is 100%, the following result can be stated:

Germany:

- In Germany, 3,805 P2W users (8%) per year could have a high benefit potential by an eCall System.
- Further 5,622 (12%) P2W user could additionally profit with a medium potential from an eCall system.

[24] 7 Europe: Germany, France, Great Britain, Hungary, Italy, Spain & Sweden. Missing data were estimated for each country individually.

[25] Missing European numbers were extrapolated based on the fatalities and the distributions from the seven European countries.

European countries (Germany, Great Britain, Sweden, France, Hungary, Spain, Italy):

- In the seven analyzed European countries, up to 11,713 P2W users (5%) could have a high benefit potential by an eCall System.
- Further 16,866 (7%) P2W user could additionally profit from an eCall system.

Europe:

- In Europe, up to 14,514 P2W users (5%) could have a high benefit potential by an eCall System. This includes 30% of all fatally and seriously injured P2W users.
- Further 20,818 (7%) P2W user could profit additional profit from an eCall system. This includes 70% of all fatally and 39% of all seriously injured P2W users.
- Casualties in rural areas or in darkness profit more by an eCall system.
- For up to 255,740 P2W casualties eCall has only a low or no benefit potential at all. Especially for the 237,792 slightly injured P2W users, eCall can be more seen as a comfort function then an actual emergency case.

4.3 Summary eCall potential estimation

Within this chapter available eCall studies were reviewed and a benefit potential estimation for P2W eCall was conducted. As no medical assessment has been performed, it is not possible to provide exact benefit estimations about the reduced fatalities or seriously injured. Instead, benefit potential levels were defined to point out an upper limit of the expected casualties that profit from an eCall system. Only some general accident characteristics like severity, accident location, light condition and single accidents were taken into account. Other effect which could increase or reduce the eCall potential were not considered. Starting point of the analysis was the GIDAS accident database. The benefit potentials found there were mapped to Germany and other European countries, before finally being extrapolated to Europe. The following observations can be made:

eCall benefit studies:

- Available studies point out that the total number of fatalities could be reduced by up to 3% - 8% and by up to 10% for seriously injured (depending on the country) assuming an eCall system installation rate of 100%.

Germany:

- 3,805 (8%) P2W users could have a high benefit potential by an eCall System.
- 5,622 (12%) P2W user could have a medium benefit potential by an eCall system.

European countries (Germany, Great Britain, Sweden, France, Hungary, Spain, Italy):

- Up to 11,713 (5%) P2W users could have a high benefit potential by an eCall System.
- Up to 16,866 (7%) P2W user have a medium benefit potential from an eCall system.

Europe:

- Up to 14,514 (5%) P2W users could have a high benefit potential by an eCall System. This includes to 30% of all fatally and seriously injured P2W users.
- Up to 20,818 (7%) P2W user could have a medium benefit potential from an eCall system. This includes to 70% of all fatally and 39% of all seriously injured P2W users.
- Casualties in rural areas or in darkness profit more by an eCall system.
- For up to 255,740 P2W casualties eCall has only a low or no benefit potential at all. Especially for the 237,792 slightly injured P2W users, eCall can be more seen as a comfort function then an actual emergency case.

The eCall potential estimation performed here points out a high benefit potential for P2Ws of about 5% for all P2W casualties. Looking at severe casualties only, about 30% of all severely injured P2W users would profit from a high benefit potential. These numbers can not be taken directly as reduction potential of the P2W casualty numbers by a P2W eCall system. They are rather an upper limit and the real numbers will be much smaller. Nevertheless, they provide a first feeling of what could be expected from such a system. At the same time, they make already aware of the problem of unneeded eCall launches. For Europe, there are 237,792 P2W casualties only slightly injured per year. In these cases eCall can be more seen as a comfort function then an actual emergency case and therefore PSAPs and the rescue chain do not have to be burdened by such cases. However, it will be seen in chapter 5 that it is not easy to distinguish cases where eCall should be launched from the one where it is not needed.

5 Determine eCall relevance by statistical methods

5.1 Introduction to the topic

Within the i_HeERO project report M23 (Harnischmacher, et al., 2016) it was defined to classify all accidents where the rider needed treatment in hospital as eCall relevant. Within report M26 (Borin, et al., 2017) the performance of a hypothetical triggering algorithm was assessed which classifies the eCall relevance of an accident using speed information and the final position of the bike. This assessment has shown that there is still a lot of room for improvement in determining the need of an eCall accurately.

In this chapter a different approach to determine the need of an eCall launch was analyzed. The basic idea was to use the information of large accident databases and statistical classification methods to develop prediction models. For Germany the in depth accident study (GIDAS) and the US database FARS and GES were selected. Finally, the differences in performance were compared and assessed.

5.2 Review of existing studies (for each study same approach)

Before starting our own analysis, existing studies were reviewed and several approaches were compared with their advantages and disadvantages. Then it was looked at the methods and the databases used in this study. Four studies were compared with respect to their used databases, approaches and properties.

5.2.1 Analysis of powered two-wheeler crashes in Italy by Classification Trees and Rules Discovery (Montella A., 2012)

The goal of this study is to determine interdependence as well as dissimilarities among crash characteristics and to provide insights for the development of safety improvement strategies focused on P2Ws.

5.2.1.1 Database

P2W accidents in Italy from 2006 to 2008 from Italian National Institute of Statistics (ISTAT)

- 254575 accidents
- Two categories for severity - fatal and injury
- 159 variables (19 chosen for models)
- Mainly for investigation of the drivers' fault

• Lack of relevant information

5.2.1.2 Approach

Association rules

• 20 significant rules identified by an a priori algorithm

• *A*→ *B*: with A antecedent and B consequent (in our case severity)

• Support: the percentage of the entire data set covered by the rule

• Confidence: the proportion of the number of examples which fit the right side among those that fit the left side

• Lift: a measure of the statistical dependence of the rule

Transition

• Choosing 4 parameters from the antecedent with high lift as predictors of the classification tree

Remark: This means that it would only be analyzed the effect of four factors on fatality. Either more parameters for the classification tree should be chosen, or several trees constructed. Both cases would make the interpretation a little bit complicated.

Classification tree

Restriction for the tree growing:

1. Minimum decrease in the impurity equal to 0.001
2. Maximum number of levels of the tree equal to four

Avoiding type I error by splitting the data into two parts:

1. Exploratory sample: generating the classification tree and all the association rules
2. Holdout sample: validating the classification tree & Hypothesis testing

5.2.1.3 Advantages & Disadvantages

Pro:

• No need of any a priori probabilistic knowledge about the data (for example, the data does not have to be normal distributed, which is most of the time necessary because of the tests).

• No assumptions of linearity of the data.

• Easy to implement.

Con:

• There is the question which a priori algorithm should be choosen for the association rules and how complicated it will be.

• How to combine the result of the classification tree with the result of association rules.

• Each split in the tree leads to a reduced dataset under consideration. Hence, the model created at the slit will potentially introduce bias.

• Only four parameters can be analyzed at the same time.

5.2.2 Multivariate analysis of MAIDS fatal accidents (Smith, 2009)

The goal of this study is to quantify the effect of various factors on a P2W rider fatality.

5.2.2.1 Database

P2W & L1 vehicles (mopeds) & L3 vehicles (motorcycles) accidents in 5 EU countries during 3 years from Motorcycle Accidents In-Depth Study (MAIDS)

• 921 accidents

• Two categories for severity - fatal and not fatal

• 2000 variables (19 chosen for model)

• Most comprehensive in-depth data

5.2.2.2 Approach

• The distribution of P2W rider fatalities according to 19 parameters.

• Chi-square test for 19 parameters → 14 of them are significant (all parameters are considered individually).

• Logistic Regression (logistic model)

• Backward elimination analysis

Remark:

• There is also a stepwise regression, which works similarly, but forward.

• One can also add or remove parameters manually to see whether it has a big influence on the odds ratio.

• The fit of the model should be tested after the elimination of each variable in order to ensure that the model still adequately fits the data.

5.2.2.3 Advantages & Disadvantages

Pro:

• The logistic can be directly related to the odd.

• Compared to the tree and association rules, the logistic function contains much more parameters, which possibly makes the result relatively accurate.

• One get a ranking of the influence of parameters on fatality.

Con:

• The dataset needs to be normal distributed, as it is an important assumption for the chi-square test. Normally this should not be a problem, since if the dataset is big enough, the data is normally distributed according to central limit theorem.

5.2.3 Probabilistic models of motorcyclists' injury severities in single- and multi-vehicle crashes (Savolainen P., 2007)

The goal of this study is to provide additional insight into the factors that determine injuries to motorcyclists.

5.2.3.1 Database

Single-vehicle accidents & multi-vehicle accidents involving motorcyclists between 2003 and 2005 from the Indiana State Police crash database with rider training records obtained from the American Bikers Aimed Toward Education (ABATE)

• 2273 Single-vehicle accidents

• 2213 Multi-vehicle accidents

• Four categories for severity: no-injury, non-incapacitating injury, incapacitating injury and fatality

• 21 variables in the paper, no accurate number for the overall variables in the database

5.2.3.2 Approach

For single-vehicle motorcycle accidents:

• Summary statistics: percentage of single parameter in the database

• Nested logistic model for all nesting possibilities

For multi-vehicles accidents involving motorcycles:

• Summary statistics: percentage of single parameter in the database

• Multinomial logistic model

5.2.3.3 Advantages & Disadvantages

Pro:

• The logistic can be directly related to the odd.

• One get a ranking of the influence of parameters on fatality.

Con:

• The dataset should be linear and the dataset needs to be normal distributed. An alternative to avoid these conditions is the mixed logistic model, which is a combination of probity logistic and multinomial logistic model. But normally, if the dataset is big enough, the data is normally distributed according to central limit theorem.

5.2.4 An analysis of motorcycle injury and vehicle damage severity using ordered probit models (Mohammed A. Q., 2002)

The goal of this study is to analyze how variations in the characteristics of the roadway, the rider, environmental factors and the motorcycle can lead to variations in different levels of injury severity and damage to the motorcycle and to examine if factors affecting injury severity and factors affecting vehicle damage severity are identical.

5.2.4.1 Database

Accidents involving motorcycles from1992 to 2000 from the Traffic Police Department (TP)

• 27570 accidents

• Three categories for severity: slight injury, serious injury and fatal accidents

• 70 variables → 20 chosen

5.2.4.2 Approach

• Coded discrete injury severity

• Classification of injury severity by year: number and percent of ordered variables

• The mean and standard variation of the 20 explanatory variables

• Assuming the data as linear
• Ordered probit model

5.2.4.3 Advantages & Disadvantages

Pro:

• The model is appropriate when the discrete outcomes have natural rankings.

Con:

• The data should be linear and the error term should be normal distributed.
• The presence of underreporting in an ordered probability model can result in biased and inconsistent model coefficient estimates.

5.2.5 Summary and interpretation of all studies

Considering the four studies, every method has its own advantages and disadvantages. For the analysis within this project as classification methods the multinomial logistic model and the random forest algorithm were chosen.

5.3 Short Introduction of used methods

In this section the used methods of the study are presented. In the first subsection the multinomial logistic model and in the second subsection the random forest algorithm are introduced.

5.3.1 Multinomial Logistic Regression

The multinomial logistic model is a classification method that provides the probability of occurrence of any number of events, given a set of variables. In our case, the multinomial logistic model gets several crash and environmental variables to estimate the probability for each injury severity level, to decide whether the accident is eCall relevant or not.

Assume to have a linear model

$$\ln\left(\frac{P_n(i)}{P_n(K)}\right) = \beta_i X_n + \epsilon_{in} = \beta_{i1} X_{n1} + \beta_{i2} X_{n2} + \cdots + \beta_{iN} X_{nN} + \epsilon_{in}$$

with

$P_n(i)$: the probability that crash *n* will result in motorcyclist injury outcome *i;*

β_i: a vector of estimable coefficients related to injury outcome *i*;

X_n: a vector of measurable characteristics of the accident n;

ϵ_{in}: an error term accounting for unobserved effects influencing the injury severity of crash *n;*

N: the number of parameters in the model

K: the reference group.

If the error terms ϵ_{in} are generalized extreme value distributed and are independent of each other, then the standard multinomial logistic model results:

$$P_n(i) = \frac{\exp(\beta_i X_n)}{1 + \sum_{\forall I \setminus K} \exp(\beta_I X_n)}$$

$$P_n(K) = \frac{1}{1 + \sum_{\forall I \setminus K} \exp(\beta_I X_n)}$$

with $P_n(K)$, the probability that crash *n* will result in motorcyclist injury outcome of the reference group *K*.

5.3.2 SMOTE

The Synthetic Minority Over-Sampling Technique (SMOTE) (Chawla, 2002) was developed to create new synthetic observations by merging two similar records of the minority class (T). The algorithm proceeds as follows:

A SMOTE percentage is defined (N):

- If N<100%, (N/100)*T instances are randomly selected to create new synthetic observations;
- If N=100%, the algorithm creates a number of synthetic instances which is equal to T;
- If, for instance, N=200%, for each instance of the minority class, the new synthetic instances are created.

The procedure starts by selecting one observation at random from the minority class. Next, k-nearest neighbors are identified. Only one of the selected k-nearest neighbors is selected. The new observation is obtained as the difference between the original observation and the selected neighbor, multiplied by a random number included between 0 and 1. The process is repeated until N=0.

5.3.3 Wrapper approach for feature selection

The Wrapper algorithm (Ron Kohavi, 1997) is deployed to select a subset of features that allow to obtain the highest accuracy when a classification problem is solved. The selection of subset is based on the classification results obtained by running any classification algorithm.

Each state of the search space of parameters represents a subset of features. For *n* features, there are n bits in each state that represent whether the feature is included or not. There are only two possible operations that can be done: either add or delete a feature from a state. The size of the search space for *n* features is $O(2^n)$. The objective is to find the state, in the search space, with the highest accuracy.

For a subset of attributes, the evaluation function is the cross-validation which consists of dividing the number of instances in a dataset in *k* equal size partitions. At each iteration, each partition is trained and the k^{th} partition of the dataset becomes the validation set. The cross-validation is repeated multiple times until there is small variation in the accuracy results (i.e. the standards deviation of accuracies in below a certain level).

The search in the search space, begins with an empty set of features, using a forward selection approach.

In this work, the classification algorithm that is used for feature selection is the Random Tree. In Decision Trees, the leaves of the tree represent class labels and the branches a conjunction of features that lead to the class label. Random tree considers *k* randomly chosen attributes at each node. The reason for having selected the Random Tree instead of Random Forest in the context of wrapper approach is that the former converge much faster.

5.3.4 Random Forest

The Random Forest (Breiman, 2001) is an ensemble approach which consists in the construction of several individual classifiers and in combining them to obtain a final result. More specifically, the Random Forest algorithm builds multiple decision trees and grows them to the largest extent possible. Each decision tree is created by selecting a sample of N observations at random with replacement, where N is the size of the training set. From the classification results of each decision trees, a ranking of classifiers is created based on the number of votes obtained by each class. The individual classification that contain the most votes is selected.

Given an ensemble of classifiers, $h_1(x), h_2(x), \ldots, h_K(x)$, a measure of the extent to which the average number of votes at $\boldsymbol{X}, Y$ for the right class exceeds the average vote for any other class is given by the margin:

$$mg(\boldsymbol{X},Y) = av_K\, I\,(h_K(\boldsymbol{X})=Y) - max\ av_K\, I\,(h_K(\boldsymbol{X})=j)$$

where $I(\cdot)$ is an indicator function.

The generalization error is given by the probability over ***X*** and *Y* as follows:

$$PE^* = P_{X,Y}(mg(\mathbf{X}, Y) < 0)$$

The accuracy of the classification results improves as multiple classifiers are combined together. The dissimilarity between trees is critical in order to achieve higher accuracy.

The procedure consists of three phases:

1. A bootstrap phase during which the subset of observations are randomly selected. Different training set samples can include the same observation. The remaining observations form the out-of-bag (OOB) set that is used to estimate the goodness of fit of the Random Forest.
2. Selection of a random number of attributes for growing each tree.
3. A growing phase during which the decision trees are built by splitting the dataset at each node.

This process is run multiple times to develop multiple individual random tree learners. The OOB observations are used to test the individual trees and the entire forest without the need to involve the test set. The OOB estimate is also called average misclassification error.

The Random Forest provides a measure of the importance of each attribute in predicting the correct classification. The first step to compute variable importance consists of counting the correct classification of the entire forest in the OOB samples. Next, each attribute in the dataset is permuted throughout all nodes in the entire forest. For instance, the table below provides an example of original OOB observation and the modified observation.

Original OOB observation	**Modified OOB observation**
eCall Relevant, Two lanes, Urban, **Night**, No Adverse Weather Conditions, Winter, Non-intersection, No Traffic Controls, Two-Way Not Divided	eCall Relevant, Two lanes, Urban, **Day**, No Adverse Weather Conditions, Winter, Non-intersection, No Traffic Controls, Two-Way Not Divided
eCall Relevant, Two lanes, Urban, Day, **Rain**, Winter, Non-intersection, No Traffic Controls, Two-Way Not Divided	eCall Relevant, Two lanes, Urban, Day, **Sunny**, Winter, Non-intersection, No Traffic Controls, Two-Way Not Divided

Table 24: example of modified OOB

As the database consists of categorical variables, the value is randomly picked from the possible categories of that variable. The information on the modified OOB correct classification is stored. If the variable is important, the number of correct classification counts is different from the original count. The procedure is repeated for each variable in the dataset.

5.4 Introduction to Database

5.4.1 GIDAS

The German In-Depth Accident Study (GIDAS) is the largest accident study project in Germany. The joint venture between the Bundesanstalt für Straßenwesen (BASt) and the Automotive Research Association (FAT) was initiated in 1999. There are two investigation teams, one team of the Medical University of Hannover and one team of the Technical University Dresden, who document all relevant information of approximately 2.000 accidents with personal injury annually. They document all relevant information on involved vehicles, participants, the rescue chain and the accident conditions, so there are up to 3.000 encoded parameters per accident in GIDAS. In this study, a data set of GIDAS with 2.635 motorcycle accidents for which the injury severity level of the motorcyclist is known was used.

5.4.2 FARS/GES

The Fatality Analysis Reporting System (FARS) and the National Automotive Sampling System General Estimate System (NASS GES) are the United States (US) National census regarding injuries suffered in motor vehicle traffic crashes. Data are provided from police crash reports and are standardized. The FARS database provides information on fatal crash data; the NASS GES consists of police reported motor vehicle crashes of all types, from minor to fatal. The accident reports are chosen between 60 representative areas of the US and about 50,000 Police Accidents Reports are collected every year. US GES data collectors visit about 400 Police Departments located in the 60 areas and trained personnel code the information which are checked for consistency. Since 2009, the two database were unified by the National Highway Traffic Safety Administration (NHTSA) in terms of coding.

In this study, the FARS and NASS GES database with 31.385 motorcycle accidents recorded between 2010 and 2015 were used for the random forest model.

5.5 Multinomial Logistic Regression on GIDAS

To predict the injury severity level of motorcyclists, the multinomial logistic model is used as method and several variables of 2.635 accidents with motorcyclists from the GIDAS database were used as data.

5.5.1 Procedure

At first three levels for the injury severity are set: 1 for no injury or slight injury without hospitalization (not eCall relevant), 2 for slight injury with hospitalization (eCall relevant) and 3 for seriously and fatal injury (eCall relevant). By doing this, the exact injury severity can also be forecasted.

After reviewing some studies, several variables which could influence the injury severity of the motorcyclist are selected.

The next step is to perform a chi-square test for every variable individually to identify those variables which have a big influence on the injury severity, this means to test if they are significant.

Based on these considerations, and taking into account the covariance matrix of the significant variables, the relevant variables for the multinomial logistic model are selected.

Then the model is implemented, including the chosen variables as input. To optimize the model, the AIC (Akaike information criterion) is taken. This criterion takes into account both the statistical goodness of fit and the number of variables that have to be estimated to achieve this particular degree of fit, by imposing a penalty for increasing the number of parameters.

It is defined as $2N-2\ln(L)$ with N the number of parameters in the model and L the maximized value of the likelihood function for the model. Stepwise backward and forward calculation is used to minimize the AIC and therefore some variables are ruled out.

To get a realistic validation of the model and to avoid an overfit to the data, the data were split into two parts, the training set (70 %) and the test set (30 %). After that the model is implemented on the training set and in the last step the injury severity level is predicted on the test set. The result, in which the probabilities of motorcyclists' injury severity levels are calculated, is compared to the real injury severity levels of the motorcyclists to obtain the quality of the model.

5.5.2 Results

In this section the results of the multinomial logistic model are presented, according to the proceeding in the section before.

At first several variables which could influence the injury severity of the motorcyclist are chosen from different data tables and tested with Chi-Square-Test with the dependent variable VERL_Beteil_L3 (Motorcyclists' injury severity) if they are significant with significance level 5%. In consideration of the covariance of the significant variables, the variables for the model were selected.

Environmental variables (green: significant, red: significant and chosen):

Variable	Description	Chi.square	Degrees of freedom	p-Value
STFUHO	Type of the location	77.09	6	0.00
UART	Description of the accident	114.88	9	0.00
UTYP_kurz	Type of the accident	68.80	6	0.00
WINDV	Wind force	31.91	3	0.00
ORTSL	Urban, rural	146.57	1	0.00
UMGEB	Area	162.95	8	0.00
VSTUFE	Traffic way flow	26.07	5	0.00
TZEIT	Time of day	14.15	2	0.00
UZEITH	Hour	15.96	3	0.00
WOTAG	Day of the week	18.15	6	0.01
JAHR	Year	20.05	14	0.13
UDATM	Month	15.34	11	0.17
WOLK	Fog	6.06	6	0.42
TEMP	Temperature	1.02	5	0.96

Table 25: Surroundings

Variables of Motorcycle and Motorcyclist (green: significant, red: significant and chosen):

Variable	Description	Chi.square	Degrees of freedom	p-Value
firstv0	Travelling speed	232.31	14	0.00
firstvk	Collision speed	255.73	12	0.00
FZART	P2W mass	36.32	2	0.00
FZGKLASS	P2W legal category	56.87	7	0.00
VZSCH	Max. speed driving license	42.04	11	0.00
LSTG	Engine power in kw	43.66	14	0.00
VZBART	Statutory maximum speed	15.60	4	0.00
VEALLG	Health condition	64.67	2	0.00
GESCHL	Gender	15.98	1	0.00
ALTERG	Age (in groups)	4.50	2	0.11
ALTER1	Age (in year)	51.86	43	0.17
UNFMANG	Technical defects	2.74	3	0.43
KLEIDUNG	Protective clothing	7.69	8	0.46
ZWHELM	Helmet	1.26	2	0.53

Table 26: Motorcycle and Motorcyclist

Variables of the road conditions (green: significant, red: significant and chosen):

Variable	Description	Chi.square	Degrees of freedom	p-Value
NEIGUNGP	Roadway grade	34.20	10	0.00
FSTREIF	Nature of lane	31.22	13	0.00
NEIGUNG	Roadway inclination	11.03	3	0.01
STROB	Wet pavement	5.26	2	0.07
STRDECK	Road surface	9.06	6	0.17
RICHTUE	Driving direction	4.68	3	0.20
RICHTVU	Intended driving direction	5.95	4	0.20
VZUL	Speed limit	7.14	7	0.41
STRART	Type of road	5.06	6	0.54
STRABEL	Road light	2.66	4	0.62
STRKL	Road function	4.38	6	0.63
NEIGFBQ	Cross slope	7.63	13	0.87

Table 27: Road conditions

Variables of the collision (green: significant, red: significant and chosen):

Variable	Description	Chi.square	Degrees of freedom	p-Value
ABKOM	Run-off-road	63.60	2	0.00
KONOBJ	Collision object	54.78	7	0.00
STOSSPX	x-coordinate of crash point	41.65	9	0.00
VDI1	direction of force at collision	57.74	10	0.00
VDI2	most damaged part of P2W	41.29	4	0.00
KONBETEIKONOBJ	Crash opponent	105.19	11	0.00
DWINK	Deflection angle	24.69	4	0.00
SEQART	reaction of the motorcyclist	25.84	5	0.00
KWINK	Crash angle	24.32	5	0.00
KWINKS	Sideslip angle	20.75	5	0.00
IMP	angle between crash and driving direction	25.66	8	0.00
STOSSPY	x-coordinate of crash point	21.60	7	0.00
BRPX	x-coord. of first hitting point	16.94	7	0.02
SEQLENK	Steering maneuver	10.64	4	0.03
ZWUBER	user run over	3.50	2	0.17
BRPZ	z-coord. of first hitting point	3.76	4	0.44
BRPY	y-coord. of first hitting point	6.69	7	0.46
DREHNEU	Yaw angle between pre-crash and after-crash	4.42	6	0.62
STOSSPZ	z-coordinate of crash point	3.48	5	0.63

Table 28: The collision

After selecting the 26 variables for the multinomial logistic model, the model is optimized by minimizing the AIC. The optimized model includes only these 8 variables:

Variable	Description	Degrees of freedom
VSTUFE	Traffic way flow	5
UZEITH	Hour	3
firstvk	Collision speed	12
VZSCH	Maximum speed on the driving license	11
ABKOM	Run-off-road	2
KONBETEIKONOBJ	Crash opponent	11
DWINK	Deflection angle	4
SEQART	The reaction of the motorcyclist	5

Table 29: Selected variables by AIC

The following diagrams illustrate the coefficients of the selected variables for the injury severity levels 2[26] and 3[27] compared to level 1[28] and compared to the first feature characteristic of the considered variable:

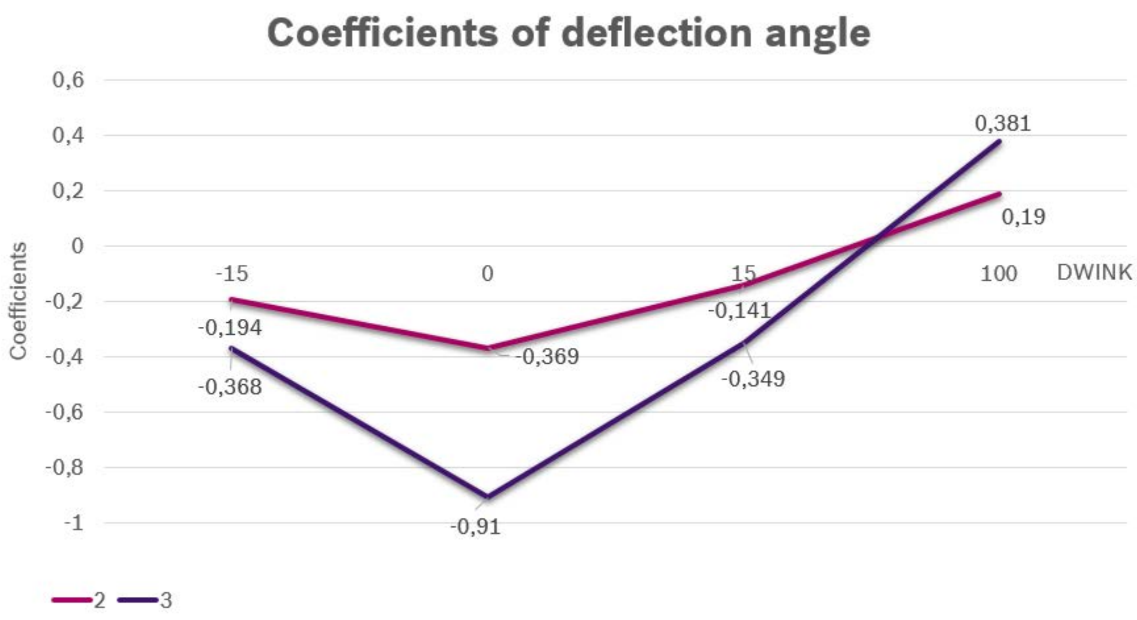


Figure 11: Coefficients of the deflection angle[29] [°]

[26] Includes slightly injured road users with hospitalization less than 24 hours
[27] Includes seriously injured road users or fatalities
[28] Includes uninjured or slightly injured road users without hospitalization
[29] Deflection angle describes the orientation change of the velocity before and after the collision.

For example, in Figure 1, the coefficients of the variable DWINK, which describes the deflection angle, has four coefficients for each injury severity level, although the variable has five feature characteristics in the data. That is because the coefficients of the feature characteristics -15, 0, 15 and 100 are compared to the first feature characteristic -100.

Figure 12: Coefficients of run-off-road[30]

[30] reference characteristic=run off to the right , 2=no run-off-road, 3=run off to the right

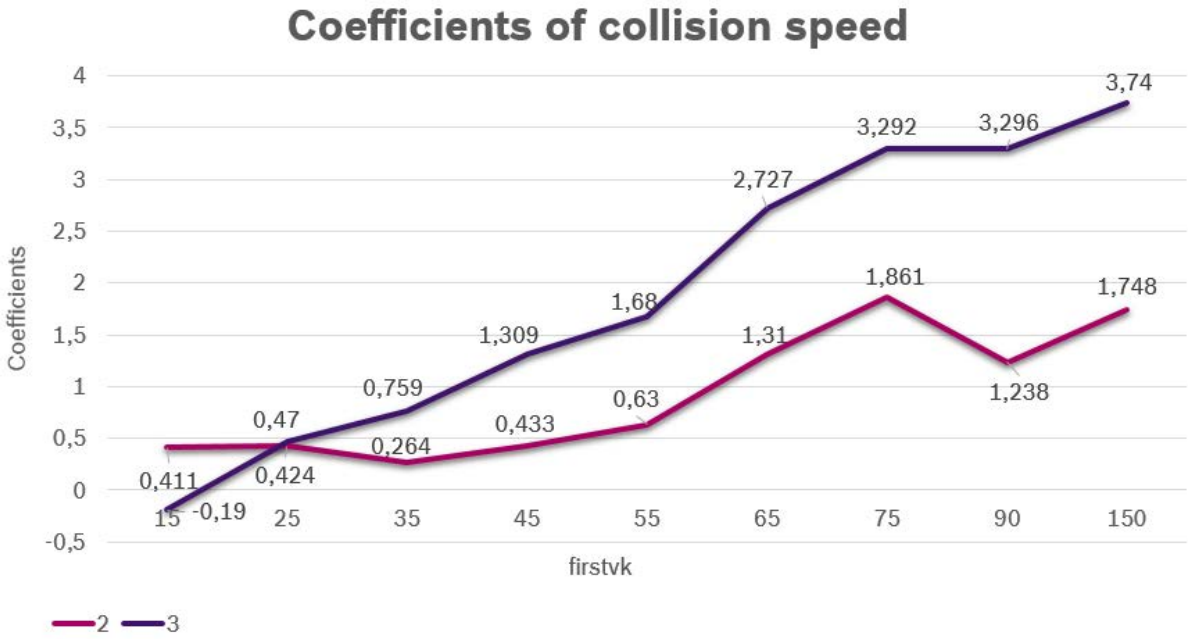


Figure 13: Coefficients of collision speed[31] [kph]

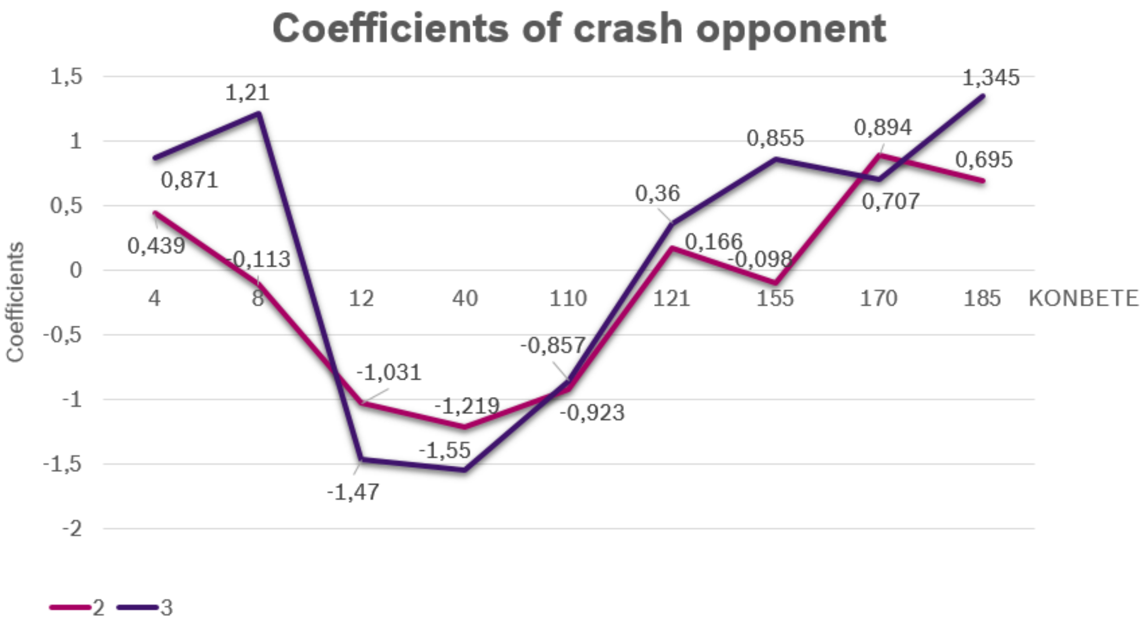


Figure 14: Coefficients of crash opponent[32]

[31] reference characteristic=collision speed of 5kph

[32] reference characteristic=car, 4=truck, 8=other, 12=trams, 40=pedestrian, 110=animals, 121=objects on road, 155=pillar, 170=ditch, 185=wall

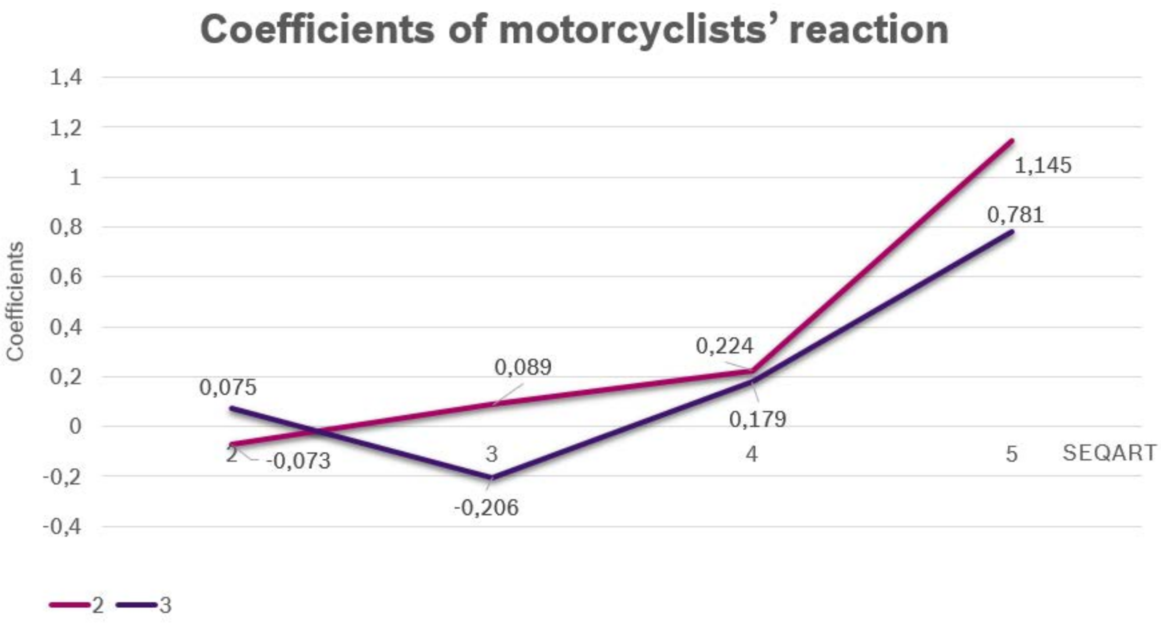


Figure 15: Coefficient of motorcyclists' reaction[33]

Figure 16: Coefficients of accident hour[34]

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[33] reference characteristic=starting to react, 2=no reaction, 3=steering only, 4=braking, 5=accelerating
[34] reference characteristic=0am till 5am, 1=6am till 9am & 4pm till 7pm, 2=10am till 3pm, 3=8pm till 11pm

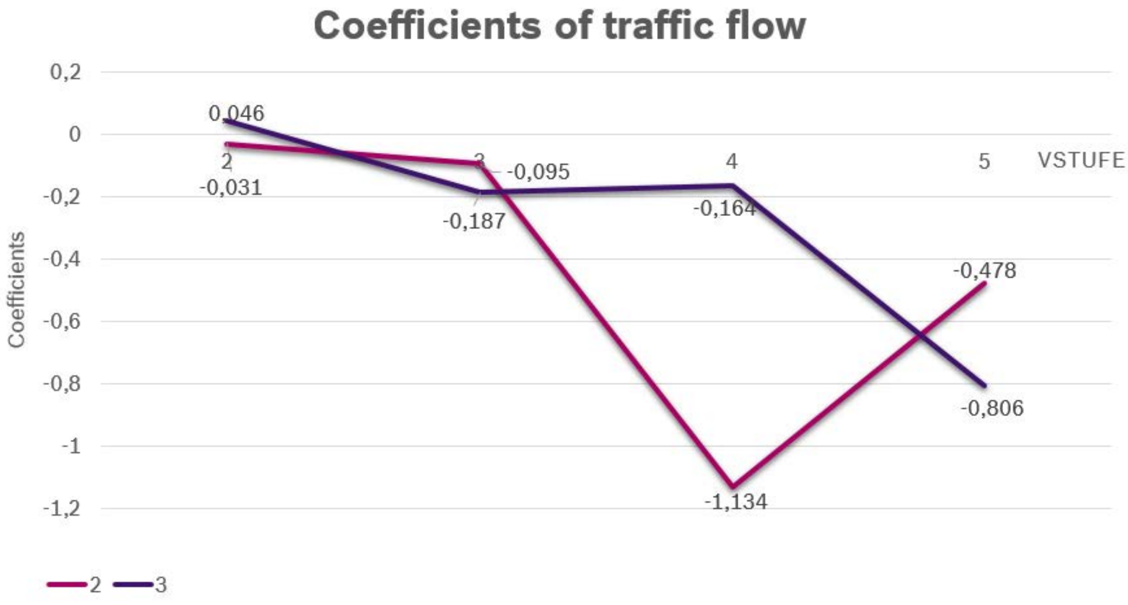

Figure 17: Coefficients of traffic flow[35]

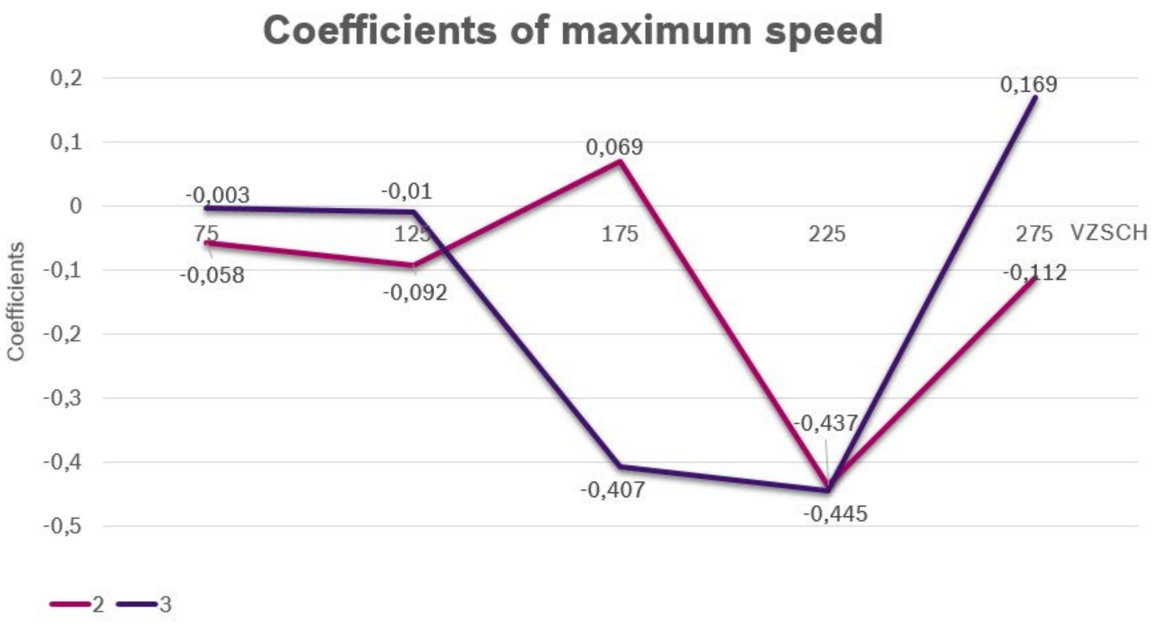

Figure 18: Coefficients of maximum speed according to registration[36] [kph]

[35] reference characteristic=only some other vehicles, 2=slight traffic, 3=medium traffic, 4= thick traffic, 5= traffic jam

[36] reference characteristic=55-99kph, 125=100-149kph, 175=150-199kph, 225=200-249kph, 275=250-320kph

For interpretation of the coefficients the formula of the multinomial logistic model is helpful:

$$\frac{P_n(i)}{P_n(K)} = \exp(\beta_{i1})^{X_{n1}} * \exp(\beta_{i2})^{X_{n2}} * \dots * \exp(\beta_{iN})^{X_{nN}} * \exp(\epsilon_{in})$$

If the feature X_{nj} is increased by 1, the ratio on the left side is multiplied by the so-called effect coefficient $\exp(\beta_{ij})$. That means, the ratio between the probabilities of the two injury severities *i* and *K* changes.

If $\beta_{ij} > 0$, it follows $\exp(\beta_{ij}) > 1$ and the ratio is multiplied by a positive factor, so that the probability of injury severity *i* is increasing. If $\beta_{ij} < 0$, the term $\exp(\beta_{ij})$ is smaller than 1 and the probability of $P_n(i)$ is decreasing, whereas it remains at the same level if $\beta_{ij} = 0$.

To determine how important, the several variables are for each level of the injury severity, the coefficients of the multinomial logistic model have to be considered. The range between the maximum and the minimum of the coefficients of the injury severity level *i* of a variable v_j defines the effect of the variable v_j for the injury severity level *i*.

It can be calculated by $\frac{e^{\max\left(0,\beta_{v_j i}\right)}}{e^{\min\left(0,\beta_{v_j i}\right)}} = e^{\max\left(0,\beta_{v_j i}\right)} * e^{\left|\min\left(0,\beta_{v_j i}\right)\right|}$.

For the chosen variables, the calculated effect is the following:

Variable	Effect for injury severity level 2	Effect for injury severity level 3
firstvk	6.43	50.90
KONBETEIKONOBJ	8.27	18.08
DWINK	1.75	3.64
UZEITH	2.83	3.23
ABKOM	1.90	2.54
SEQART	3.38	2.68
VSTUFE	3.11	2.34
VZSCH	1.66	1.85

Table 30: Effect of the variables

The most relevant variable for injury severity level 3 is the collision speed (firstvk), followed by the variable KONBETEIKONOBJ, which describes the crash opponent. For injury severity level 2, the both most important variables are also first vk and KONBETEIKONOBJ, but in a different order.

The next step is to check how good the prediction model is working. Therefore, the injury severity levels of the test data are predicted and compared to the real injury severity levels.

The result of the prediction with the test data as input:

Accuracy	True	1 level difference	2 levels difference	total
Number	376	374	41	791
Percent	47.53 %	47.28 %	5.18 %	100 %

Table 31: Result with 3 injury severity levels

On the one hand only about 5 % of the predictions have two level difference, but on the other hand only about 48% of the predictions are true. Comparing the accuracy and the data distribution of the three injury severity levels in Table 8, leads to the conclusion that the accuracy depends on the data distribution.

Injury	level 1	level 2	level 3
Accuracy	19.61 %	61.00 %	46.46 %
Data distribution	19.34 %	43.11 %	37.55 %

Table 32: Comparison of accuracy and data distribution (3 levels)

To improve the result, the injury levels 2 and 3 are merged. Because only injury level 1 is not eCall relevant, there are the new resulting levels: not eCall relevant for level 1 and eCall relevant for levels 2 and 3.

If the real injury level is 1 and the prediction is eCall relevant (level 2 or 3), it is called **false positive**.

If the real injury level is 2 or 3 and the prediction is not eCall relevant (level 1), it is called **false negative**.

The result of the prediction with only the two levels eCall-relevant or not eCall-relevant is:

Accuracy	True	false negative	false positive	total
Number	627	41	123	791
Percent	79.27 %	5.18 %	15.55 %	100 %

Table 33: Result eCall relevance

Although at first glance the result looks much better with about 80 % accuracy, considering the data distribution leads to the conclusion that the eCall-System is activated in almost every accident.

Therefore, the accuracy of each injury severity is calculated:

eCall	not relevant	relevant
Accuracy	19.61 %	93.57 %
Data distribution	19.34 %	80.66 %

Table 34: Comparison accuracy and data distribution (2 levels)

To get a better result, the data distribution is modified so that there are the same number of accidents with and without eCall-relevance. The disadvantage of this proceeding is the smaller total number of accidents. The result with the modified data distribution is:

Accuracy	True	false negative	false positive	total
Number	266	34	34	334
Percent	79.64 %	10.18 %	10.18 %	100 %

Table 35: Result eCall relevance with 50:50 data distribution

The prediction of the model is true for 80 % of the test data. The error in both directions, that means false positive and false negative, is about 10 %. Because of that, the error of each injury severity level is also about 20 %.

Further attempts to improve the result were duplicating the data with injury severity level 1 to adjust the data distribution or splitting the data into two parts depending on whether the accident is a single-vehicle-accident or not. However, both approaches didn't improve the result of the prediction.

5.5.3 Conclusion

In this section the steps and the results of using Multinomial Logistic Regression on GIDAS were presented. After defining the three injury severity levels, 26 significant variables were selected by chi-square test in consideration of the covariance. The multinomial logistic model was implemented and optimized by using AIC and the coefficients of the 8 remaining variables of the optimized model were illustrated and analyzed with respect to the relevance for each injury severity level.

The accuracy of the prediction model with three injury severity levels is about 48 %. To improve the result, the injury severity levels 2 and 3 were merged with the new resulting levels eCall relevant (levels 2 and 3) and not eCall relevant (level 1). The accuracy of the new model is about 80 %. But regarding the accuracy for each level individually shows that the accuracy of predicting not eCall relevant accidents is only about 20 %. Therefore, the data set was modified so that there are the same number of accidents with and without eCall relevance. The accuracy of this model is also about 80 %, but has the advantage of the same error in both directions, that means the accuracy of predicting eCall relevant and the accuracy of predicting not eCall relevant accidents are also about 80 %.

5.6 Random Forest on FARS/GES

To predict the accident severity, the Random Forest algorithm was deployed on 13 variables out of 27 that characterize the accidents where a motorcyclist driver is involved. The selection of the variables to be deployed to forecast accident severity, was carried out with the support of the Wrapper for feature subset selection. Moreover, the SMOTE algorithm (Synthetic Minority Over-Sampling Technique) was implemented to balance the dataset with the creation of synthetic data.

5.6.1 Proceeding

The two database, FARS and NASS GES, were merged into a single one, the common variables selected and the car accidents were eliminated from the final database together with the records related to the motorcycle passengers. The new variable “eCall Relevance” was created according to the diagram below:

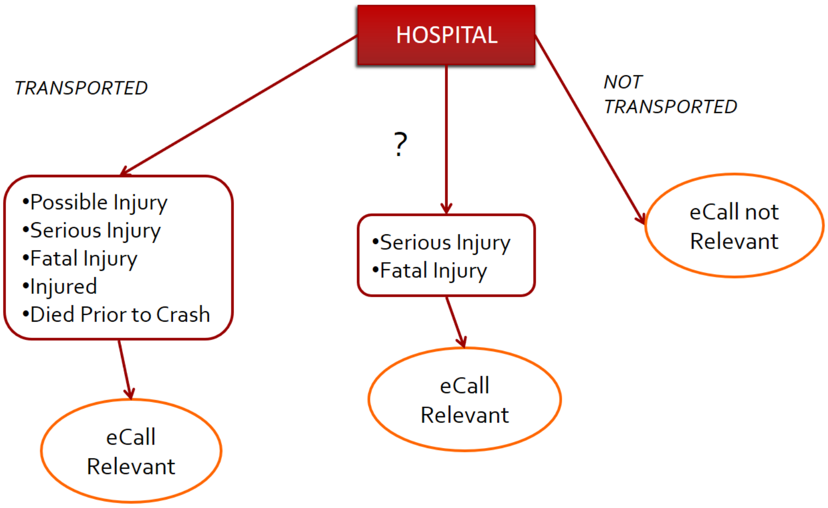

Figure 19: eCall Relevance – variable creation

The diagram shows that a new variable called eCall Relevance was created based on two existing variables: HOSPITAL and SEVERITY. The new variable consists of two modalities: eCall Relevant and eCall not Relevant. The record is classified as eCall not Relevant in all cases in which the motorcycle driver was not transported to the hospital. The accident is eCall Relevant if the variability SEVERITY is classified as Possible, Serious, Fatal Injury and/or the driver involved was transported to the hospital.

The next step of the analysis implied the creation of synthetic data in order to balance the eCall Relevance variable. The Figure below shows the unbalanced dataset in which 40% of the observations are classified as eCall Relevant, while the remaining observations are classified as eCall Not Relevant.

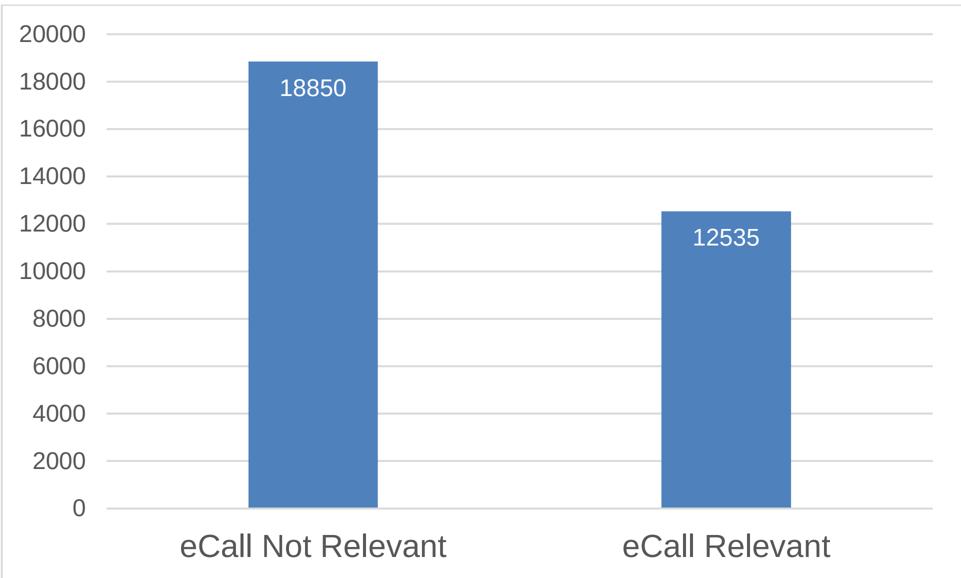

Figure 20: eCall Relevance

The first trials showed that the model results were biased by the size of each class. In our case, the algorithm optimized the results in the direction of the largest group. For this reason, the SMOTE algorithm was applied to create synthetic instances.

The second step of the analysis was focused on feature selection. The most relevant attributes were selected based on the Wrapper approach with the Random Tree classifier as evaluation function. Finally, the Random Forest was implemented for classification and trained on the 70% of the observations.

The results of the classification are evaluated based on the Confusion Matrix:

	Predicted Negative	Predicted Positive
Actual Negative	TN	FP
Actual Positive	FN	TP

Table 36: Confusion Matrix

Where TP (True Positive), TN (True Negative), FP (False Positive) and FN (False Negative) are the number of instances correctly or wrongly classified. In particular, the accuracy is the indicator used to evaluate the classification results. The accuracy is computed as follows:

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

5.6.2 Results

The SMOTE algorithm is applied to the class with the minority of the observations (eCall Relevant). The number of synthetic observations to be created by merging similar existing instances (N) is set to 50%. The number of neighbors (*k*) is set to 5. The Figure below shows the new dataset formed by a number of instances which is similar for both classes of the variable eCall Relevance.

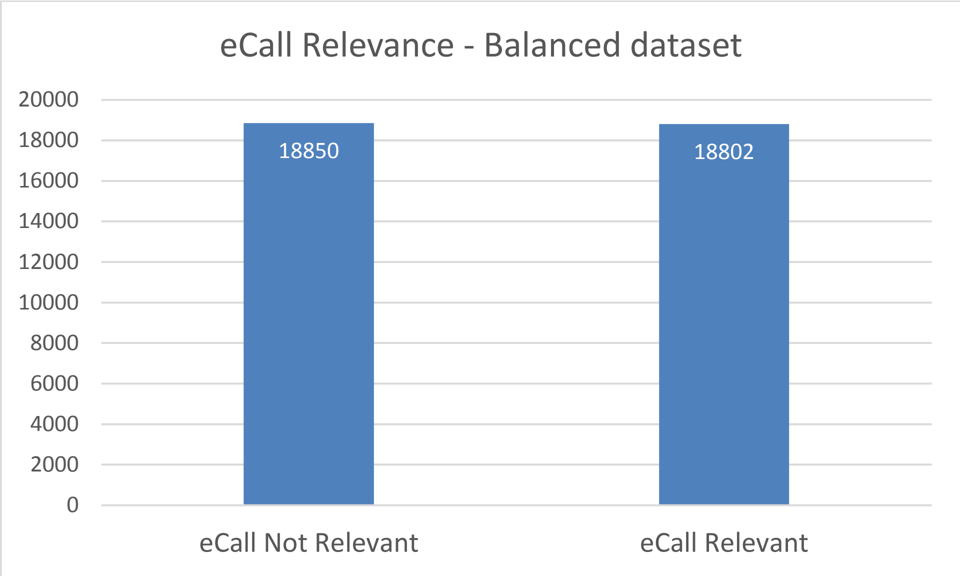

Figure 21: Balanced dataset

Based on the new balanced dataset, the most relevant attributes are selected. The Wrapper approach considers 401 different subsets. The cross-validation for the selection of the subset of attributes in the search space is set to 5 folds. The error rate of the classification results using Random Tree and the selected subset is 12.3%.

The attributes selected by the Wrapper Approach are reported in the Table below:

Table 37: Selected attributes with the Wrapper Approach

Selected variable	Description
day_week	Day of the week.
month	Month of the year.
hour	Time of the accident.
sex	Sex of the driver.
drinking	Indication of whether the legal alcohol limit was exceeded.
make	Motorbike brand.
harm_ev	First harmful event that has caused the accident.
Impact1	Area of the vehicle that has caused or was subjected to the accident.
deformed	Extent of damage (no damage, minor damage, functional damage, disabling damage).
p_crash2	Critical event that has caused the accident.
rest_use	Use of helmet or other safety equipment.
traffic_way	Traffic way flow prior to motorbike critical pre-crash event (i.e. non-traffic way, two-way, one-way, entrance/exit ramp).
curve_roadway	Alignment of the road (straight, curve).

The Random Forest of 100 trees is run by including the 13 selected variables. The accuracy of the model is 89.8% with a total number of 10.141 instances correctly classified. A screenshot of a selection of the Random Tree is reported in Figure 23. The confusion matrix is reported here below:

	Predicted Negative	**Predicted Positive**
Actual Negative	5.191	532
Actual Positive	623	4.950

Table 38: Random Forest Classification Results

```
RandomTree
==========

impact1 = 0
|   rest_use = 5
|   |   make = 34
|   |   |   day_week = 1
|   |   |   |   hour = 8 : 1 (1/0)
|   |   |   |   hour = 10 : 0 (6/0)
|   |   |   |   hour = 12 : 0 (3/0)
|   |   |   day_week = 3 : 1 (4/0)
|   |   |   day_week = 4
|   |   |   |   deformed = 2 : 0 (1/0)
|   |   |   |   deformed = 4 : 1 (7/0)
|   |   |   day_week = 5 : 1 (4/0)
|   |   |   day_week = 7
|   |   |   |   hour = 8 : 1 (2/0)

|   |   |   |   hour = 12 : 0 (1/0)
|   |   |   |   hour = 13 : 0 (3/0)
|   |   |   |   hour = 14 : 0 (1/0)
|   |   |   |   hour = 19 : 0 (1/0)
|   |   make = 37
|   |   |   month = 1 : 1 (15/0)
|   |   |   month = 2
|   |   |   |   traffic_way = 1
|   |   |   |   |   day_week = 2 : 1 (1/0)
|   |   |   |   |   day_week = 3 : 1 (1/0)
|   |   |   |   |   day_week = 7 : 0 (4/0)
|   |   |   |   traffic_way = 2
|   |   |   |   |   harm_ev = 1 : 0 (5/0)
|   |   |   |   |   harm_ev = 26 : 1 (7/0)
|   |   |   |   traffic_way = 3
|   |   |   |   |   curve_roadway = 0
|   |   |   |   |   |   day_week = 5 : 0 (2/0)
|   |   |   |   |   |   day_week = 6 : 1 (2/0)
|   |   |   |   |   |   day_week = 7 : 0 (0/0)
|   |   |   |   |   curve_roadway = 1 : 1 (2/0)
   |   |   p_crash2 = 50 : 0 (0/0)
|   |  |   |   |   |   traffic_way = 8 : 0 (0/0)
|   |   |   |   traffic_way = 9 : 0 (0/0)
```

Figure 22: Random Tree section

The importance of each variable in predicting the correct classification is reported in the Table 39. The day of the week (day_week) and the time of the accident (hour) are the most important variables related to the prediction of crash severity. This is compliant with the official statistics of the U.S. Department of Transportation, National Highway Safety Administration for which the majority of fatal injuries occur during the weekend. In 2015, for instance, the 49% of fatal injuries and 42% of non-fatal injuries occurred during the weekend. There are also specific time ranges during which fatal injuries occurs more frequently such as between 3PM and 9PM (42% of fatal injuries and the 45% of non-fatal injuries).

Table 39: Random Forest Variables Importance

Variable Importance	Number of nodes using the attribute	Attribute / Variable
0.65	32572	day_week
0.63	26768	hour
0.6	25195	month
0.6	18100	deformed
0.6	13138	drinking
0.59	8644	p_crash2
0.59	8569	harm_ev
0.59	20849	make
0.55	14904	rest_use
0.54	11023	impact1
0.49	9136	traffic_way
0.45	8366	curve_roadway
0.43	2725	sex

The importance of the month of the year during which the accident occurred may be a consequence of the higher use of motorcycles during the summer months. According to the Insurance Institute for Highway Safety, Highway Loss Data Institute (IIHS), in 2015, the 71% Motorcyclist fatalities occurred between May and October, with a peak in July.

The importance of the extent of damage of the motorcycle (deformed) in predicting eCall relevant and not relevant injuries could be explained by the fact that more severe accidents usually cause disabling damages. As such, if the motorcycle was disabled because of an injury, that injury might be eCall relevant.

The importance of alcohol use (drinking), type of motorcycle (make) and use of motorbike helmet (rest_use) on predicting accident severity is confirmed by the official statistics. With reference to the alcohol use, the NHTSA 2015 statistics report that the 27% of fatal crashes involved drivers with a blood alcohol concentration above 0.08% or over. The official statistics on the type of vehicles involved in fatal accidents date back to 2007. The IIHS reports that, per 10.000 registered vehicles, rider of sport vehicles had four times higher fatality rate compared to other types of vehicles. Finally, the use of helmet is often not enough to save the driver as, in 2015, the 70% of the drivers involved in fatal crashes wore a helmet.

The remaining variables such as the critical event that has caused the crash (p_crash2), the area of the vehicle that was subjected to the crash (impact1), the type and alignment of the road (curve_roadway) are also ranked in the list of important variables for predicting the accident severity. A more detailed analysis of driver behavior should be carried out on these variables, perhaps, using Naturalistic Driving data.

5.6.3 Conclusion

In this section the proceeding and the results of using Random Forest on FARS/GES were presented. After defining the two injury severity levels, the dataset was balanced so the newly created synthetic data were added to the minority class. Successively, 13 significant variables were selected by the Wrapper Approach. The Random Forest was implemented on the 13 selected variables on the balanced dataset.

The accuracy of the prediction model with two injury severity levels is about 89.8%. The precision of predicting not eCall relevant accidents is about 89.3%, while the precision of predicting the class eCall Relevant is about 90.3%. Therefore, the classification algorithm shows good performance in predicting both classes of the variable eCall Relevance

5.7 Summary

Within this chapter, it was shown that a good distinction between eCall relevant and not relevant cases is possible with the multinomial logistic model and the random forest algorithm.

- ➔ Up to 90% distinction accuracy for the eCall need by statistical methods can be achieved.

The performance of the random forest method is with 90% accuracy better than the one of the multinomial logistic model (80%). The multinomial logistic model however provides an easier interpretation of its parameter. The method in general depends on the availability of large and detail accident databases. As these are only available for some countries, it is not clear if this method could be generally used. To get a better understanding of the effects seen and to assess the usability for industrialization, further studies should be conducted.

6 Severity prediction model

6.1 Introduction

In Europe there is a well established and effective rescue chain in place. Even so, there is still scope for improvements. Currently, the actions taken by the PSAPs in response to a reported traffic accident depends on the information provided by the caller. This directly impacts the efficiency of the rescue chain. Normally, the PSAP attempts to gather as much information about the incident by communicating directly to those involved in the incident. Subsequent actions such as dispatching a medical team by helicopter are taken based on these information and the associated incident handling protocol. These actions are fraught with uncertainty, as one can imagine, especially for cases where no direct communication is possible. These uncertainties can lead to cases where the disproportionate rescue level is provided. Either the level is to low, for example a doctor is not dispatched to the accident spot, or the level is too high, for example a doctor is send out to a spot where the rider has only a superficial injury. The consequences for such non-optimal decisions, beside extra costs and drawing from limited and valuable resources, can be significant as far as the individuals involved is concerned. To mitigate these consequences an advanced eCall system could help by providing additional information like the expected severity of the participants. Assuming the rescue chain will use such information and act accordingly, European road safety could be further enhanced and the severity of casualties could be further reduced.

The goal of the study presented in this chapter is to highlight initial concepts and methods about the determination of such a severity level by an eCall system. Any adjustments to the rescue chain and the expected effect by an injury severity information are outside the scope of this study and could be the subject of analysis in future projects.

The injury severity estimation presented here is based on motorcycle sensor signals for bike to vehicle accidents and based on sensors equipped on the rider's personal protective equipment, e.g. helmet and jacket, for the investigations on single accidents. Starting with an examination of the GIDAS-database, first injury risk curves and the basis for validation cases were developed. For the injury severity estimation on board signals and dummy signal were required. To access these signals, real crash tests and motorcycle accident simulations were undertaken. The multi body simulation delivered 3D data for kinematic analysis including acceleration, velocity, position and angular velocity values of each body segment. In addition to the onboard crash signals, the loads on the sensor equipped dummy were also measured to correlate crash signals and injury risk for these special cases.

6.2 Methods & theoretical principles

6.2.1 Biomechanics & Injury Mechanics

For analyzing the risk for injuries it is necessary to understand the injury mechanism itself. In the following the common keywords and injury mechanisms of the most important body regions will be introduced.

6.2.1.1 Head & Brain Injuries

Head or traumatic brain injuries can be subdivided into different types and injuries dependent on the load and injury mechanism.

Starting with skull fractures which are fractures of the osteal parts of the skull mainly caused by impacts on rigid surfaces. A special case of this injury are fractures of the facial skull which can be ordered by the LeFort criterion 1 to 3. Figure 24 shows the three severity levels. (Schmitt, 2014)

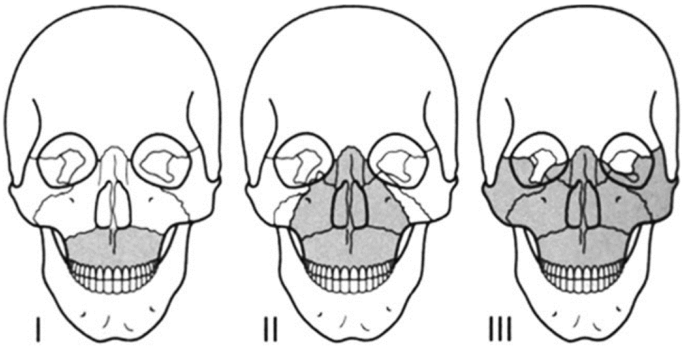

Figure 23: Skull fractures ordered by LeFort levels (Schmitt, 2014)

Injuries of the brain itself are commonly subdivided into diffuse, local and open violations. In addition, specific injuries dependent on the injury mechanism are Coup- and Contre-Coup injuries. Coup injuries are caused by the impact of the brain against the skull on the impact side on which the total head hits an object. On the other hand Contre-Coup injuries are injuries occurring on the opposite side of the actual impact of the head. Figure 25 shows the different injury mechanisms. (Schmitt, 2014)

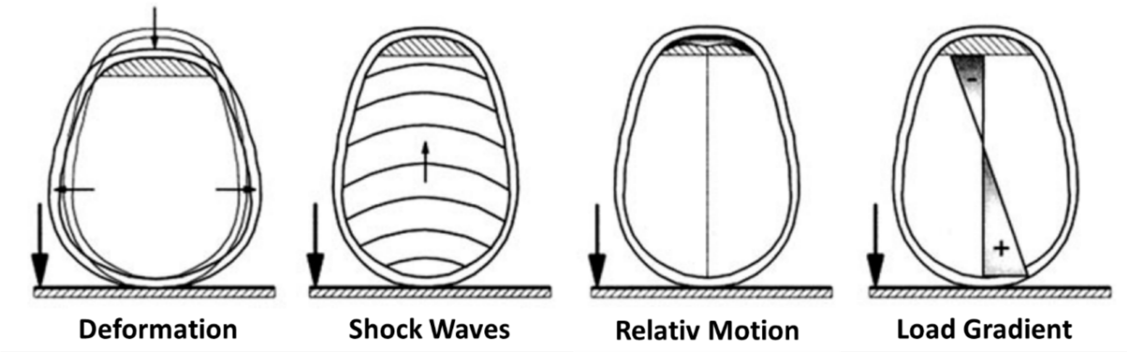

Figure 24: Injury mechanisms of head impacts (Schmitt, 2014)

6.2.1.2 Cervical Spine Injury

Cervical spine injuries can be subdivided into three different types. First, injuries of the osteal parts of the spine like fractures of the vertebral body. Second, injuries of the spinal cord which can result in pain, paralyses or death. And finally, injuries of the soft tissues like ligaments and muscles which are linked to the spine and head. The mechanisms relating to the different injuries are listed in Figure 26. (Schmitt, 2014)

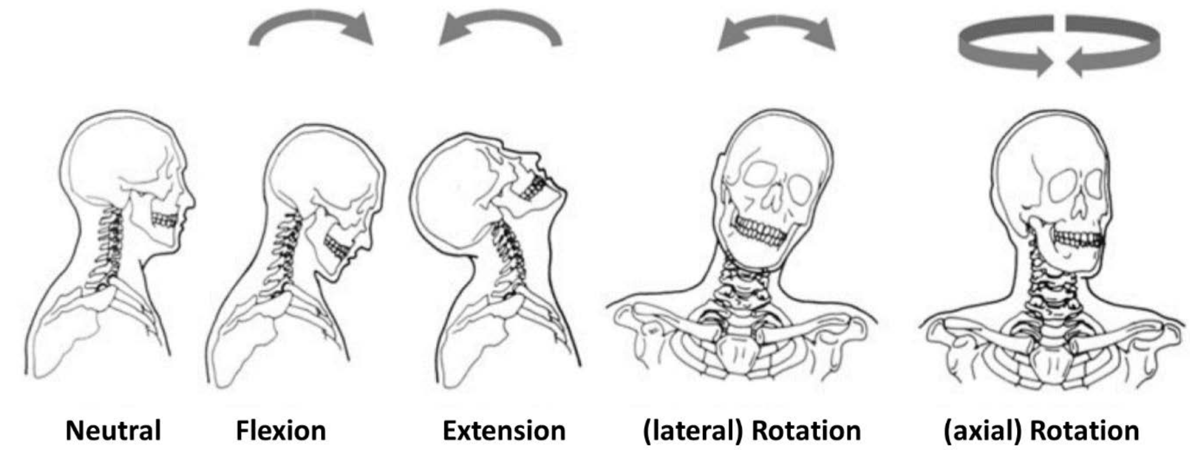

Figure 25: Injury mechanisms of cervical spine injuries (Schmitt, 2014)

6.2.1.3 Thoracic Injuries

The human thorax is composed of the ribcage in which soft tissue organs of the respiratory system and cardiovascular system are located. These are the most critical components for thoracic injuries and are covered by the ribcage. The ribcage combines stiff, soft and flexible components to create a system which fulfills the requirements for protection and flexibility of the thorax. Therefore, skeletal injuries like rib fractures can lead to collapse this system and finally lead to serious injuries. One example could be multiple rib fractures. Figure 27 shows the different mechanisms which lead to fractured ribs.

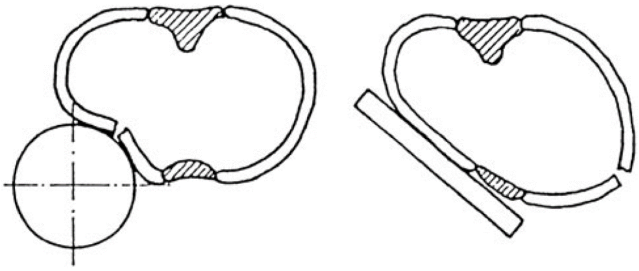

Figure 26: Rip fractures depending on impact body (Kramer, 2006)

Apart from the skeletal injuries the deformation of the ribcage may easily cause injuries of the previous described internal organs. Abrupt acceleration of the thorax due to a blunt impact can cause three different injury mechanisms. Compression, viscous loading and inertial loading of the internal organs which can lead to several injuries. (Kramer, 2006)

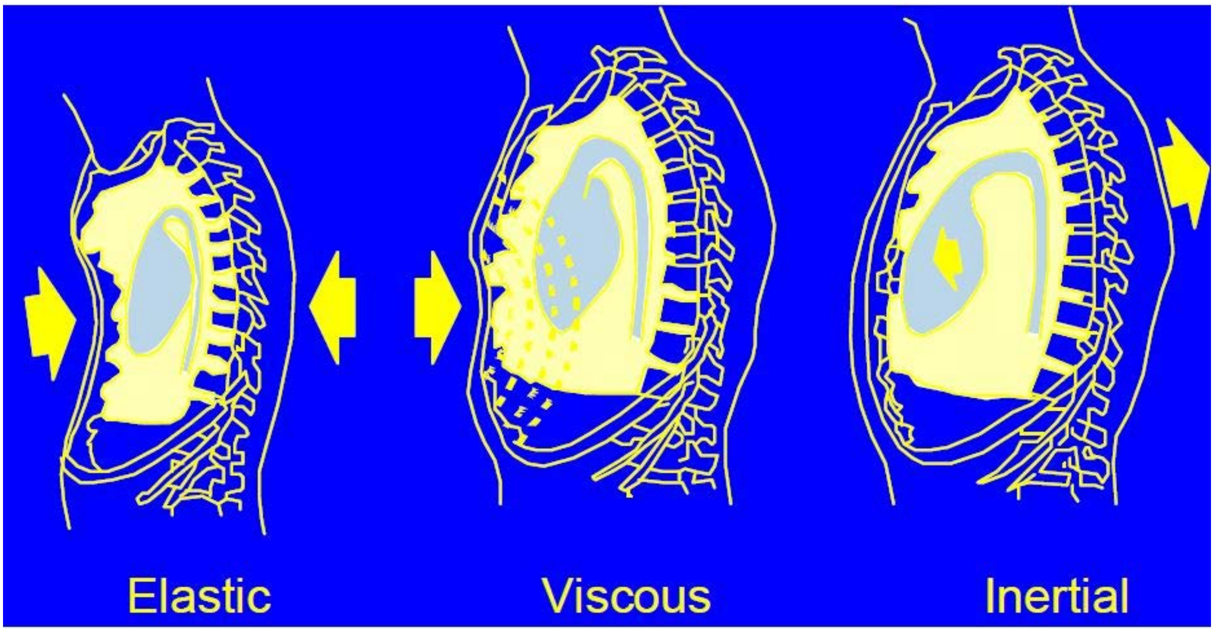

Figure 27: Chest injury mechanisms (Wismans, 2012)

6.2.2 Injury Criteria

To assess the load on a human body the so-called injury criteria was developed. They are physical parameter (e.g. acceleration) which can be measured and related to a specific body region it could cause a specific injury or rather defines a biomechanical limit. There are several injury criteria with different limits for each body region. In the following the injury criteria which are used in this report are described. (Kramer, 2006)

6.2.2.1 *Head Injury Criterion (HIC)*

The Head Injury Criterion (HIC) is the most commonly used injury criteria to describe the load on the head. It is calculated from acceleration value during a defined time interval. For HIC36 the interval has a maximum of 36ms and HIC should not exceed the value of 1000 as a biomechanical limit. Alternatively HIC15 can be used with a time interval of 15ms and a limit of 700. (Schmitt, 2014)

$$HIC = \max\left[\frac{1}{t_2 - t_1}\int_{t_1}^{t_2} a(t)dt\right]^2 \cdot (t_2 - t_1)$$

Where $a(t)$ is the resultant acceleration of the head's centre of gravity (CoG) in g and the time window $t_2 - t_1$ is normally set to $15\ ms$ or $36\ ms$. In order to restrict the use of the HIC to hard head contact impacts this time interval has been proposed to be reduced to $15\ ms$. HIC15 and HIC36 have been implemented using the resultant linear acceleration of the head provided by PC-Crash simulations. The National Highway Traffic Safety Administration (NHTSA) defined in the FMVSS no. 208 occupant crash protection standard limit values of HIC (Table 40).

Section of doc.	Subject	HIC36 Limit	HIC15 Limit
6	Hybrid III test dummy	1000	700
15	5th percentile adult female dummies	X	700
19	Infants in rear facing and convertible child restraints and car beds	X	390
21	3-year-old child dummies	X	570
23	6-year-old child dummies	X	700

Table 40: FMVSS no. 208 standard specifies performance requirements for the protection of vehicle occupants in crashes

6.2.2.2 *Normalized Neck Injury Criterion (Nij)*

The Normalized Neck Injury Criterion (Nij) describes the load on the cervical spine and is calculated from the ratio of applied and critical force and torque on the cervical spine. Where F_Z is the axial load, F_{int} is the critical intercept value of load used for normalization, M_Y is the flexion/extension bending moment, and M_{int} is the critical intercept value for moment used for normalization. (Schmitt, 2014; Eppinger R., 1999)

$$Nij = \frac{F_z}{F_{int}} + \frac{M_y}{M_{int}}$$

6.2.2.3 *Thoracic Spine Acceleration (Ac)*

A simple injury criteria for the thorax is the acceleration of the thoracic spine (Ac). It just defines a biomechanical threshold which is set to $60\ g$ for frontal collisions by FMVSS no. 208.

$$Ac < 60\ [g]$$

6.2.2.4 Contiguous Injury Criterion (CON3MS)

The Contiguous Injury Criterion (CON3MS) is computed by tracing a linear acceleration or joint constraint load signal using a contiguous time window with a width of $3\ ms$. The highest level with a duration of at least $3\ ms$ is called the CONTIGUOUS_3MS injury criterion (MADYMO, 2010). This criterion has been implemented in the present study using the resultant linear acceleration of the torso provided by PC-Crash simulation results.

6.2.2.5 Thoracic Trauma Index (TTI)

To predict the probability of serious injury to the "hard" or bony thorax as a result of blunt lateral impact, the Thoracic Trauma Index (TTI) was proposed in 1984. The TTI is an acceleration criterion based on the accelerations of the lower thoracic spine and the ribs. It also incorporates the weight and the age of the human model. The formulation was derived from a large biomechanical database consisting of 84 cadaver tests. These tests showed that the occurrence of injuries to the hard thorax, including the ribs and the internal organs protected by the ribs, is strongly related to the average of the peak lateral acceleration experienced by the impacted side of the rib cage and the lower thoracic spine. (Eppinger R. H., 1984; Morgan R. M., 1986) The TTI can be used as an indicator for the side impact performance of passenger cars. The specific benefit of the TTI is that it can be used to address the entire population of vehicle occupants because the age and the weight of the cadaver is included. The TTI is defined as:

$$TTI = 1.4AGE + 0.5\left(RIB_g + T12_g\right)\frac{MASS}{MSTD}$$

where AGE is the age of the subject, RIB_g is the maximum absolute value of acceleration in g's of the 4th and 8th rib on struck side, in lateral direction, $T12_g$ is the maximum absolute acceleration value in g's of the 12th thoracic vertebra, in lateral direction, $MASS$ is the mass of the subject and $MSTD$ is the standard reference mass of $75\ kg$. (MADYMO, 2010).

This criterion has been implemented in the present study using the following approximations:

$$RIB_g = T12_g = \left|torsoLatAcc_g\right|$$

where $torsoLatAcc_g$ is the lateral acceleration of the torso calculated from the PC-Crash simulation results as follows:

$$torsoLatAcc = \vec{e}_y \cdot \vec{a}$$

where $\vec{e}_y$ is a unit vector oriented in the lateral direction of the torso and $\vec{a}$ is the acceleration vector of the torso.

6.2.2.6 Abdominal Peak Force (APF)

The Abdominal Peak Force (APF) is a measure of injury to the abdomen. This is a criterion for European and US side impact regulations. APF is the maximum side abdominal strain criterion and is expressed as the highest value of the sum of the three forces [N] measured at each abdominal load cell (front, middle and rear) on the impact side (MADYMO, 2010):

$$APF = \max\left|F_{y,front} + F_{y,middle} + F_{y,rear}\right|$$

This criterion has been implemented in this study with the following approximations:

$$F_{y,front} = F_{y,middle} = F_{y,rear} = F_y$$

where F_y is the lateral component of the contact force on the pelvis:

$$F_y = \vec{e}_y \cdot \vec{F}_p$$

where $\vec{e}_y$ is a unit vector oriented in the lateral direction of the pelvis and $\vec{F}_p$ is the contact force vector on the pelvis.

6.2.2.7 Pelvic Injury Criterion (PIC)

The Pelvic Injury Criterion for the ES-2re dummy is defined as the maximum of the pubic symphysis force of the ES-2re dummy, attained during a side impact experiment (Kuppa S., 2004). In this study, this force has been approximated by the lateral component of the contact force on the pelvis F_y:

$$PIC = F_y$$

6.2.3 The Injury Scale - Estimation of Injury Severity

For this study the widely accepted anatomical scale, the Abbreviated Injury Scale (AIS) from 0 (uninjured) to 6 (not survivable) is used. Originally intended for impact injuries in motor vehicle accidents, the updates of the AIS allow its application also for other injuries such as burns and penetrating injuries (MADYMO, 2010). AIS is worldwide used to encode the type and severity of injuries, but not used in all countries or all hospitals. It classifies the injury severity within a body region defined by a specific injury or for higher scale a combination of injuries. The definition of each AIS level for the different body regions can be access in (AAAM, 2008). Levels or grades of severity are graded as indicated in Table 41.

Level	Explanation
0	No injury
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Maximum injury (causes death)

Table 41: Level of the Abbreviated Injury Scale (AIS)

6.2.3.1 Correlation between HIC & Injury Scale

The correlation between a risk for a defined AIS level and the injury criteria can be described in injury risk curves. One example for the AIS risk progression dependent on an injury criteria is shown in Figure 29.

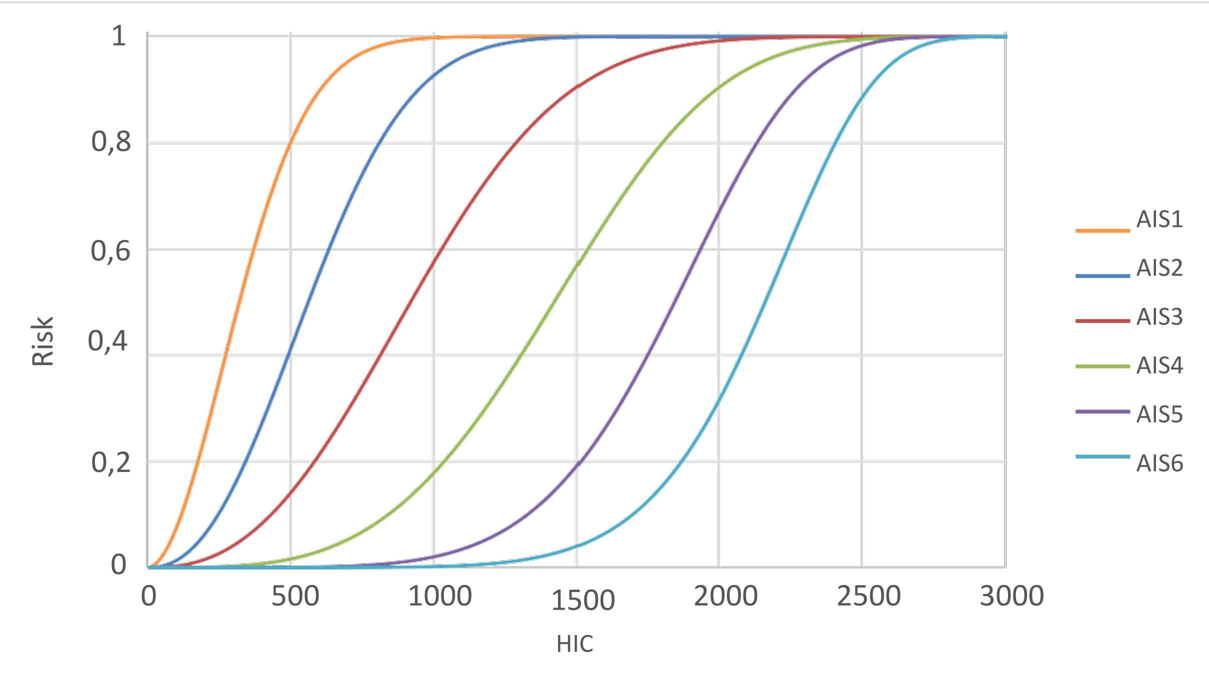

Figure 28: AIS1-6 head injury risk curve over HIC (Wernicke, 2015)

The correlation is calculated as described in the following exemplary for the side impact crash tests. The probabilities associated to HIC36 are governed by lognormal cumulative distribution functions (Figure 30):

$$P(x) = \frac{1}{2}\left[1 + \mathrm{erf}\left(\frac{\ln x - \mu}{\sigma\sqrt{2}}\right)\right]$$

where x is the HIC36 value, $\mathrm{erf}(\,)$ is the Gauss error function, and parameters μ and σ are defined in Table 42. (Eppinger R., 1999; Kuppa S., 2004; Kuchar A.C., 2001)

AIS grade	μ	σ
1+	5.36	1
2+	6.96352	0.84664
3+	7.45231	0.73998
4+	7.65605	0.60580
5+	7.69	0.585
6+	7.735	0.549

Table 42: Parameters of the lognormal probability distributions associated to HIC36 for side impacts ((Kuppa S., 2004) AIS2+, 3+ and 4+, fitted parameters from (Eppinger R., 1999) figure for AIS1+, AIS5+ and AIS6+).

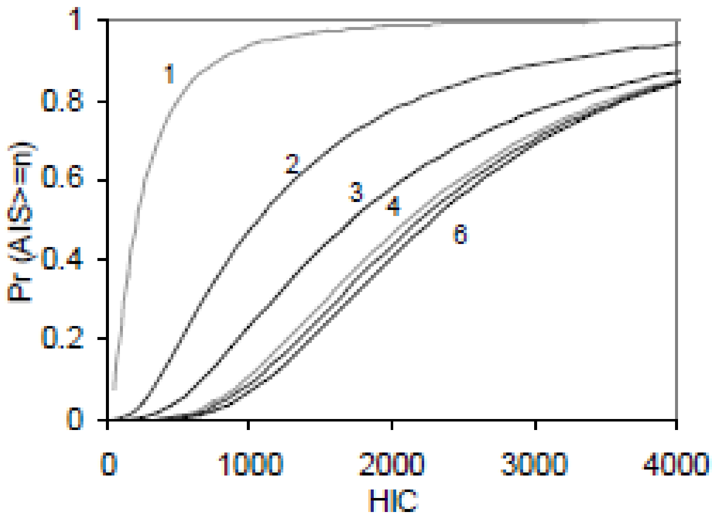

Figure 29: From HIC to AIS probabilities (Kuchar A.C., 2001; Eppinger R., 1999)

More restrictive are the probabilities associated to HIC15, which are governed by the following cumulative distribution function and plotted in Figure 29:

$$P(x) = \frac{1}{1 + e^{a + \frac{200}{x} - bx}}$$

where x is the HIC15 value, and parameters a and b are defined in Table 43. (Prasad P., 1985)

AIS grade	a	b
1+	1.54	0.0065
2+	2.49	0.00483
3+	3.39	0.00372
4+	4.9	0.00351
5+	7.82	0.00429
6+	12.24	0.00565

Table 43: Parameters of the AIS probability distributions associated to HIC15 (FMVSS 214)

6.2.3.2 Correlation between CON3MS & Injury Scale

Probabilities associated to CON3MS are governed by the following cumulative distribution functions (Eppinger R., 1999):

$$P(x) = \frac{1}{1 + e^{a-bx}}$$

where x is the CON3MS value, and parameters μ and σ are defined in Table 44:

AIS grade	a	b
1+	-	-
2+	1.2324	0.0576
3+	3.1493	0.0630
4+	4.3425	0.0630
5+	8.7652	0.0659
6+	-	-

Table 44: Parameters of the lognormal probability distributions associated to CON3MS

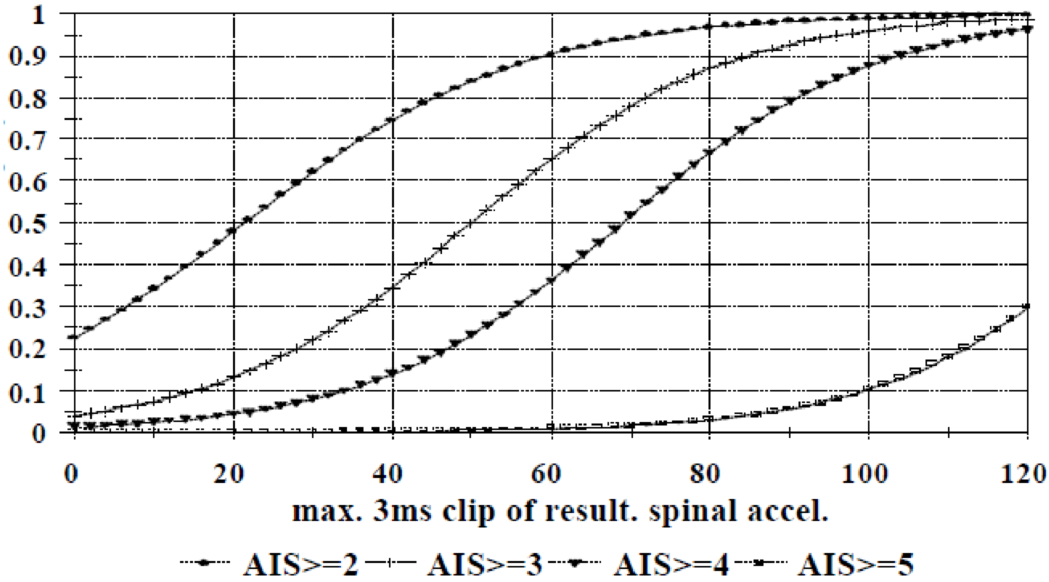

Figure 30: From CON3MS to AIS probabilities (Eppinger R., 1999)

6.2.3.3 Correlation between TTI & Injury Scale

Probabilities associated to TTI are governed by the following cumulative distribution functions (Kuppa S., 2004) (Figure 32):

$$P(x) = \frac{1}{1 + e^{a-bx}}$$

where x is the TTI kernel value, which is calculated as:

$$x = TTI - 1.4AGE$$

and parameters μ and σ are defined in Table 45:

AIS grade	a	b
1+	-	-
2+	-	-
3+	7.2448	0.048657
4+	8.7703	0.048657
5+	-	-
6+	-	-

Table 45: Parameters of the lognormal probability distributions associated to TTI

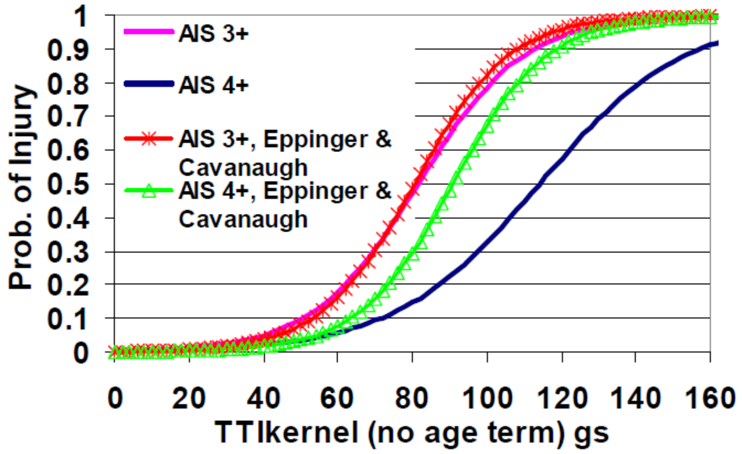

Figure 31: From TTI to AIS probabilities (Kuppa S., 2004; Eppinger R. H., 1984; Cavanaugh J.M., 1993)

6.2.3.4 Correlation between APF & Injury Scale

Probabilities associated to APF are governed by the following cumulative distribution functions (Kuppa S., 2004) (Figure 33):

$$P(F) = \frac{1}{1 + e^{a-bF}}$$

where F is the total abdominal force, which is estimated as:

$$F = \frac{1}{3} APF$$

Parameters μ and σ are defined in Table 46:

AIS grade	a	b
1+	-	-
2+	-	-
3+	6.04044	0.002133
4+	9.282	0.002133
5+	-	-
6+	-	-

Table 46: Parameters of the lognormal probability distributions associated to APF

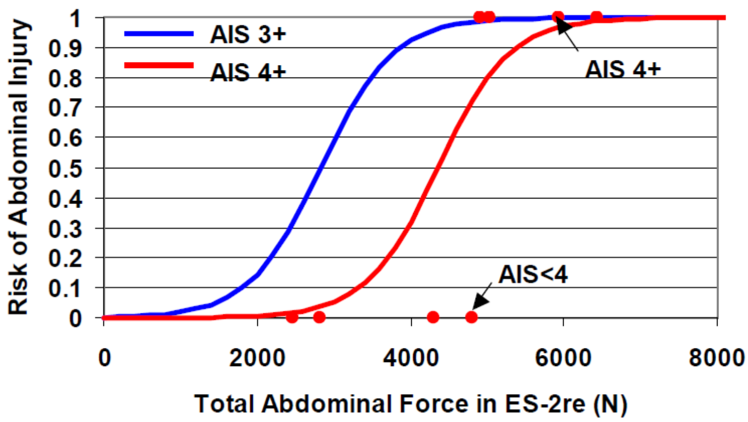

Figure 32: From APF to AIS probabilities (Kuppa S., 2004)

6.2.3.5 Correlation between PIC & Injury Scale

Probabilities associated to PIC are governed by the following cumulative distribution functions (Kuppa S., 2004) (Figure 34):

$$P(F) = \frac{1}{1 + e^{a-bF}}$$

where F is the total pubic force, which is estimated as:

$$F = 0.46\, PIC$$

Parameters μ and σ are defined in (Table 47):

AIS grade	a	b
1+	-	-
2+	6.403	0.00163
3+	7.5969	0.0011
4+	-	-
5+	-	-
6+	-	-

Table 47: Parameters of the lognormal probability distributions associated to PIC

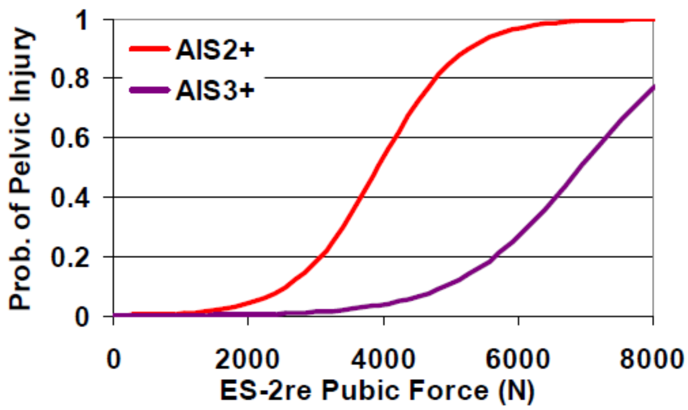

Figure 33: From PIC to AIS probabilities (Kuppa S., 2004)

6.2.4 Introduction to PC Crash & Multi Body Add-on

PC Crash is a simulation environment for reconstruction and analysis of vehicle accidents developed by Dr. Steffan Datentechnik (DSD). It enables the user to reconstruct the scene of accident in detail as well as to simulate the whole course of event to conclude impact speed, velocity of the vehicles, impact angle etc. in 2D and 3D. It can be used to reconstruct and analyze vehicle accidents involving any type of wheeled vehicle and considering also the behavior of human beings (drivers, pedestrians, bike riders, etc.) (Moser A., 1999).

For further analyses it is possible to use different types of models for each participant in the accident simulation. Commonly used for two wheeler analysis is the multi body pedestrian model and the multi body motorcycle model. It enables the user to record crash relevant data respectively the load on each body of the system.

6.3 Case Study Definition & Modelling

For a detailed analysis of different accidents and associate mechanism it was necessary to consider a minimum set of crash or accident data. Due to the fact that the availability of real accident data or crash tests was limited, an alternative method was developed. By establishing a valid simulation environment based on the previously described multi body model it was possible to create such accident data in a controlled environment. In the following section, the individual development steps for vehicle to vehicle as well as single accident simulation are described.

6.3.1 Motorcycle vs. Vehicle Accidents

The focus of this study is the simulation and reconstruction of motorcycle to vehicle accidents to generate synthetic sensor signals. On the one hand to provide bike base sensor signals for potential implementation into a motorcycle sensor set and on the other hand to provide accident related load signals of the multi body dummy model to correlate sensor signals and load signals during a specific accident.

6.3.1.1 Methodology

The base point is the German In-Depth Accident Study (GIDAS) which provides the documentation of several motorcycle to vehicle accidents including the circumstances of the accident and occurred injuries of the rider. Additional crash tests provide the loads and signals of the motorcycle and dummy. As an outcome of this Figure 35 shows the technical methodology on the way to a motorcycle based injury severity estimation, followed by a short description of the individual development steps.

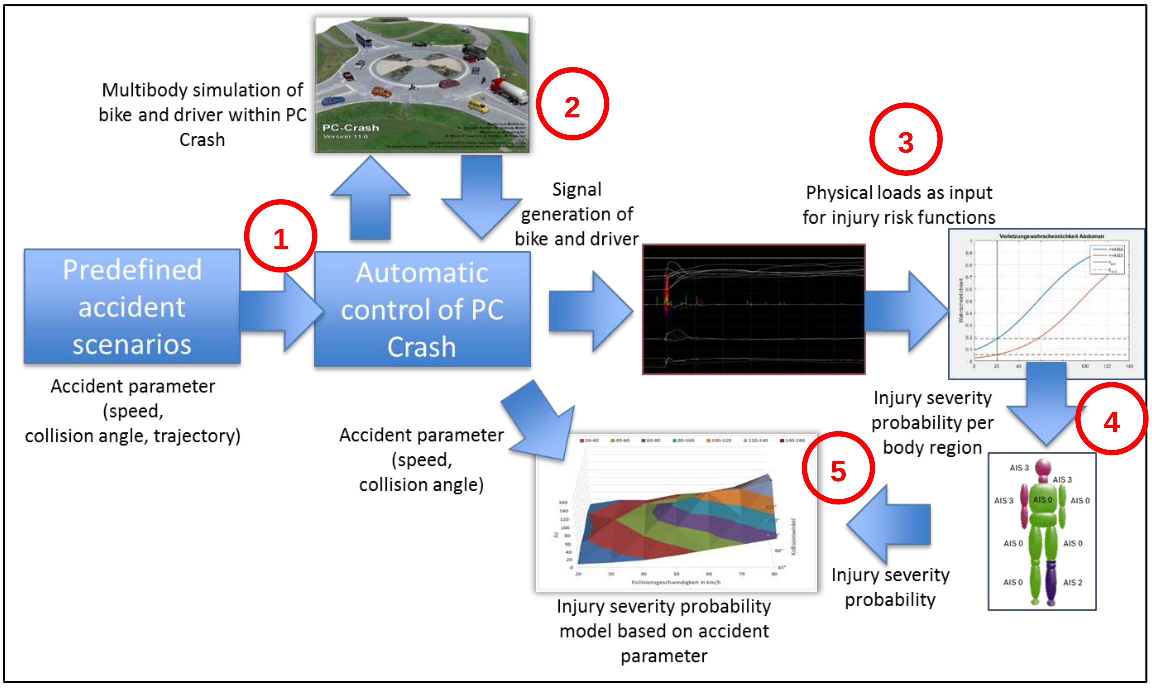

Figure 34: Overview of step by step transfer into simulation environment

Development steps:

1. The analysis of the GIDAS database delivers relevant information about the accidents like configuration, detailed impact angle, speed, vehicle information and injury data for the reconstruction and first correlation between injury risk and real accident data.
2. The accident scenarios described in GIDAS are reconstructed within PC Crash and re-simulated. PC Crash provides the physical loads of the bike and dummy.
3. Using the physical loads of the dummy and injury risk functions, the severity probability of different body region can be calculated. For validation, these results are compared to the actual severity within the GIDAS accident.
4. As a result, a severity probability of the accident can be obtained
5. The injury risk model is transferred into the motorcycle layer to find a correlation between in vehicle sensor signals and injury risk.

6.3.1.2 Case Description

The reconstruction of specific motorcycle crash tests in the simulation environment enables the validation of the motorcycle and dummy model. This is necessary to correlate the multi body dummy load with the measured dummy load and the calculated injury risk.

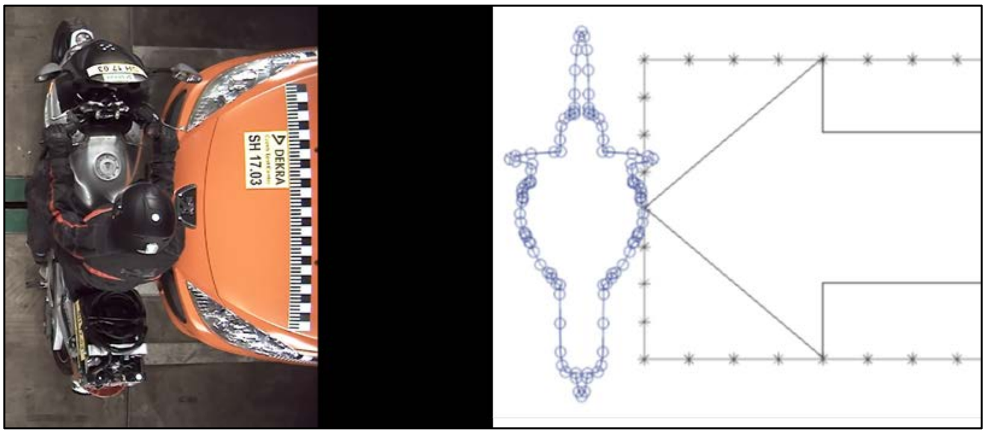

Figure 35: Reconstruction of motorcycle crash tests

To develop suitable models, it is necessary to reduce the complexity of the real accident situation. Therefore, only two types of scenarios were considered - a front crash and a side crash scenario. Further, the focus is on the initial impact of the rider against the car, the assessment of the second impact, e.g. against the road, has not been considered in this study.

ISO-Crash-Code 41X & 101X

The accidents of this crash configurations are characterized by a frontal impact of the motorcycle into the side of the opponent close to the B-pillar. This part of the vehicle is typically surrounded by stiff structural components, e.g. the roof edge, A- and C- pillar, that potentially decelerates the motorcycle and rider drastically. Figure 37 shows a crash test with ISO code 413 and the corresponding reconstruction in the simulation environment.

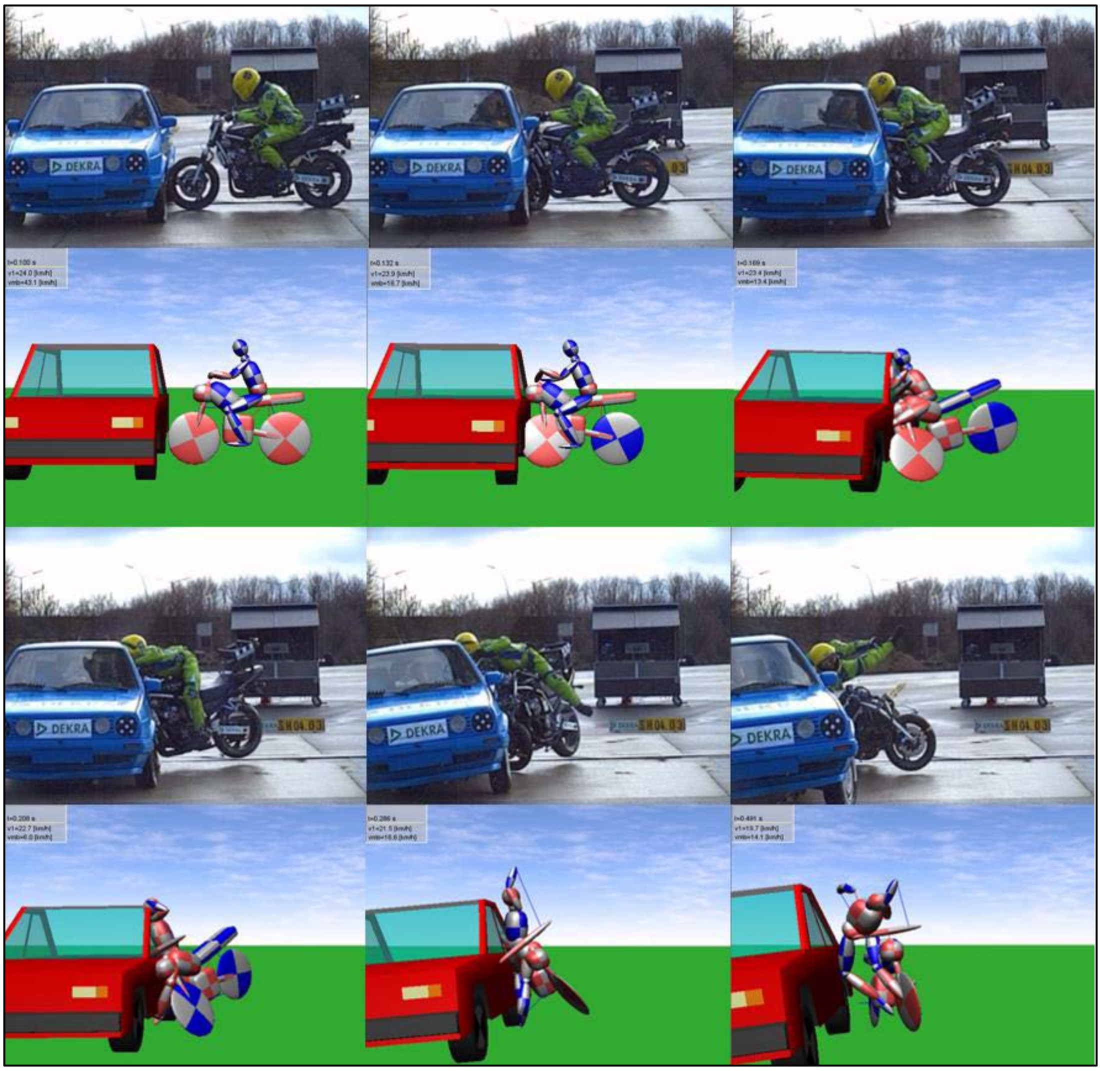

Figure 36: Crash SH0403 & reconstruction in simulation environment

ISO-Crash-Code 31X & 11X

In contrast to the above described impact scenarios, this front crash configurations are located close to the front axle of the vehicle. Therefore, the surroundings of the impact area are less stiff for the motorcycle impact, e.g. the wheelhouse, side sills, excepting the front axle itself. Especially the potential impact points of the rider are less stiff, e.g. the hood or windscreen, excepting the A-pillar. Figure 38 shows exemplarily the crash configuration 313 as ambassador of this crash type.

Figure 37: ISO-13232 crash configuration 313

ISO-Crash-Code 127 & 143

In this crash configuration, the vehicle hits the motorcycle with a full overlap of the front into the motorcycle's side. In this way, the impact impulse of the vehicle can be transferred into the motorcycle directly and into the rider. Therefore, this crash configuration is selected to assess the influence of the vehicle and motorcycle mass on the rider's injury. Figure 39 shows the reconstruction of a crash test with ISO code 127.

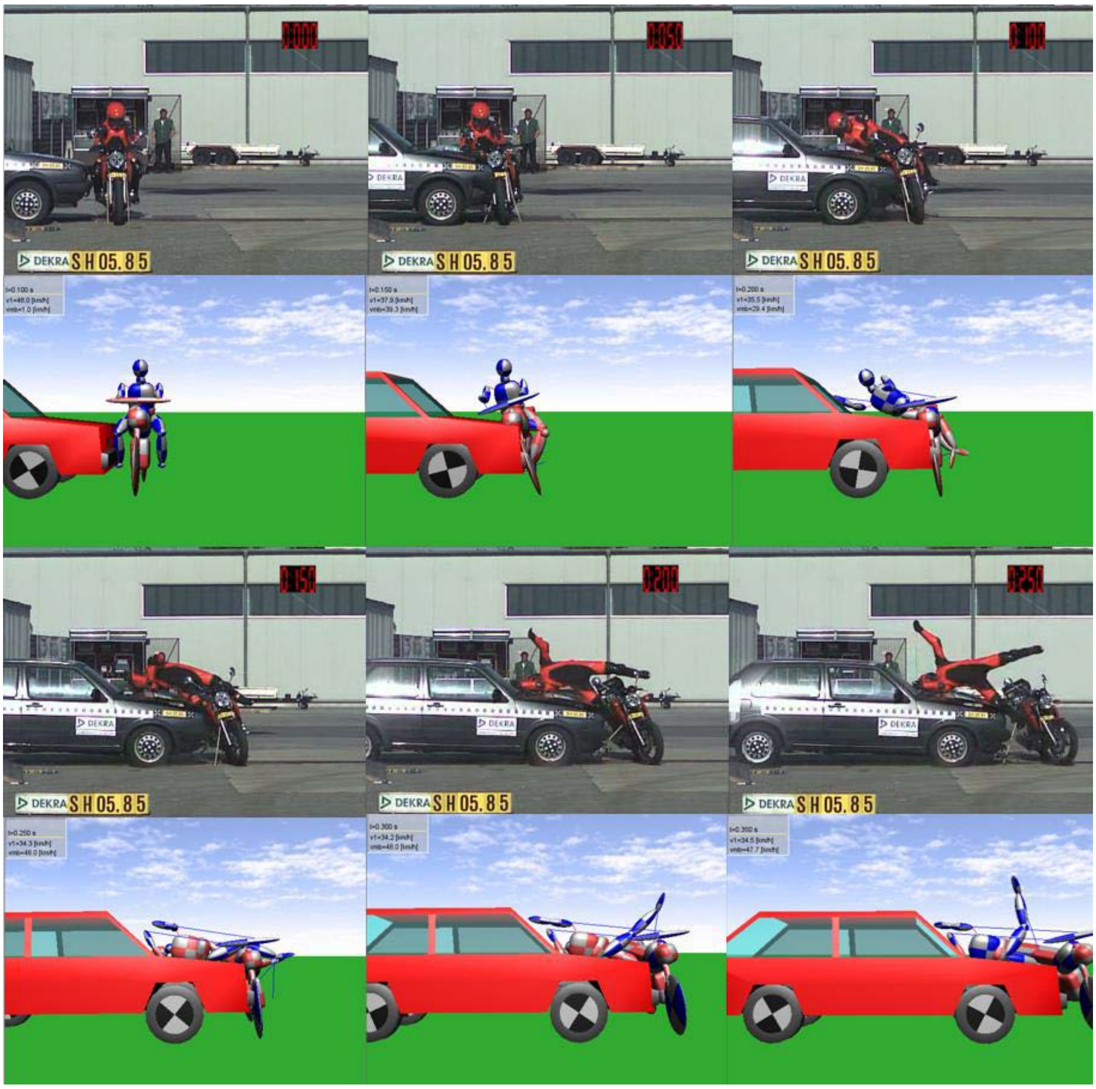

Figure 38: Crash SH0585 & reconstruction in simulation environment (ISO code 127)

6.3.1.3 Rider and bike models

The multi body system used is composed of a rider model and a separate bike model. The rider model is the standard PC Crash pedestrian multi body model repositioned into the seating position on the motorcycle. The model is composed of 20 bodies representing the main body parts e.g. torso, hip, thigh (2x), knee (2x). With 24 cm depth and 1.20 cm extent of the torso, 24 cm shoulder length and 80 cm of hip measurement the multi body model is comparable to a 50th percentile male Hybrid-III crash test dummy. Figure 40 shows the model in the final seating position. The rider model is fixed to the motorcycle by defined retention forces which reach their limits during a crash to realize the release of the rider due to acceleration.

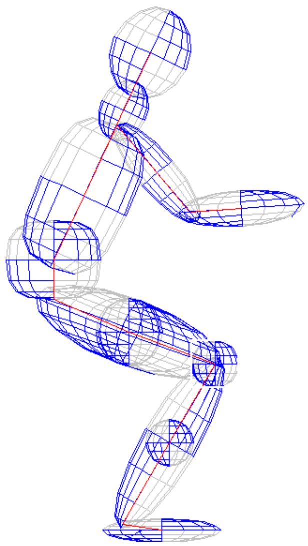

Figure 39: PC Crash multi body rider model

The motorcycle model is a modified multi body model based on the PC Crash motorcycle model to represent an averaged motorcycle. The front fork, joint elements as well as spring elements are modified in this model for an optimized crash kinematic and signal feedback. It is composed of 11 bodies representing the main parts of a motorcycle, e.g. wheels, front and rear fork, engine block. It has a total length of 200 cm, a width of 80 cm and a total height of 105 cm. Figure 41 shows the modified motorcycle model.

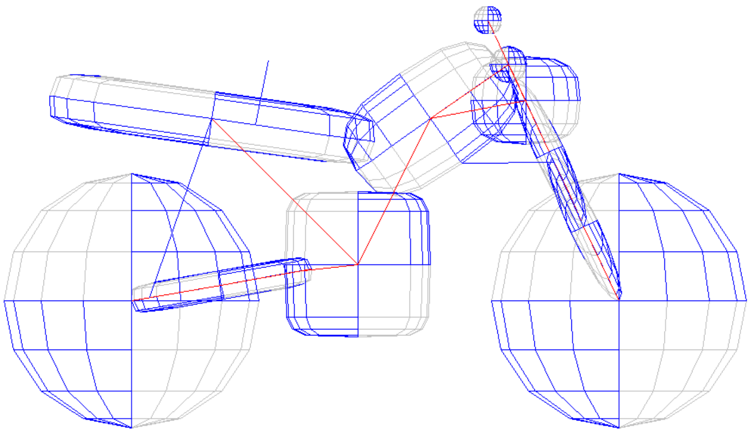

Figure 40: Modified multi body bike model

6.3.1.4 Model parameters to be studied

Various crash parameter can be identified as potential relevant to influence the rider's injuries severity. For the previous describe crash configurations can be noted:

- collision angle α [°]
- collision speed $v\ [\frac{km}{h}]$
- motorcycle weight $m_{bike}[kg]$
- vehicle weight $m_{veh}[kg]$
- crash configuration

For the investigation on potential influence on the injury severity a parameter analysis is required. Varying the various parameters like the collision angle, crash configuration and collision speed, causes a lot of simulation runs that has to be optimized by a Design of Experiment (DoE). Figure 42 shows an example for parameter analysis of different collision points and angles. The main focus for the injury analysis is on the head, neck and thorax assessed by the injury criteria HIC, Nij and Ac. The other extremities are not considered.

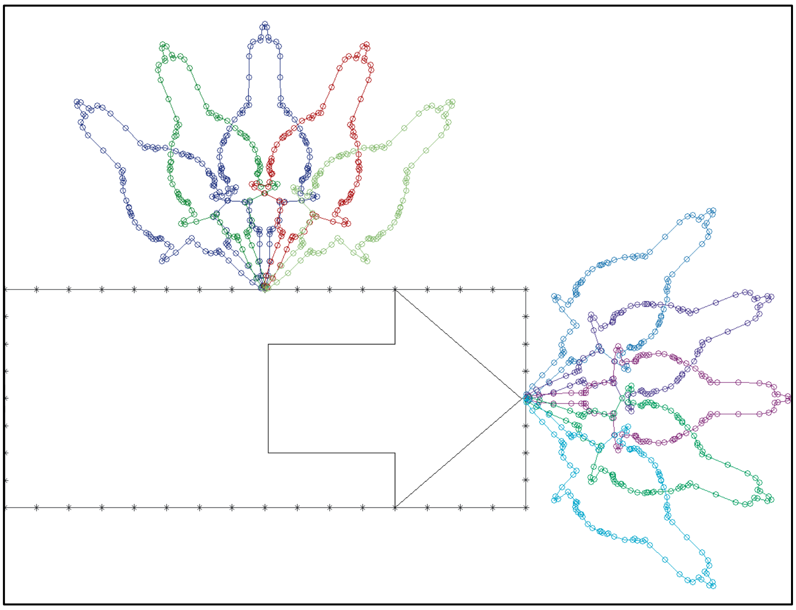

Figure 41: Parameter analysis in different crash configurations

6.3.1.5 Summary of model parameters

The following parameter and their corresponding values could be outpointed to be assessed in the simulation runs. (Table 48)

Parameter	**Value**	**Explanation**
α [°]	45 - 135	collision angle
$v\ [km/h]$	20 - 80	collision speed

Parameter	Value	Explanation
$m_{bike}[kg]$	169	bike weight
$m_{veh}[kg]$	1000 - 2000	vehicle weight
ISO	101X, 31X, 127	crash configuration

Table 48: Selected parameter for parameter analysis motorcycle vs. vehicle

Because of the symmetry of the front crash configurations there is no need to simulate both sides what reduces the total amount of tests. Further the variation of the collision angle and collision speed requires 35 tests per front crash configuration. The investigation on the influence of the motorcycle and vehicle mass requires additional 42 tests. In sum, 112 simulation runs are performed and assessed.

6.3.2 Single accidents

The main goal of the single accident study is to analyze if an injury severity estimator can be developed taking as input data the signals registered by some sensors worn by the rider during a P2W accident. Such sensors would be integrated in the helmet or in other clothes worn by the rider, and would provide information about contact forces, accelerations and other kinematic magnitudes. To this end, a methodology based on accident reconstruction by simulation has been implemented.

6.3.2.1 Methodology

The methodological approach followed in this section is presented schematically in Figure 43.

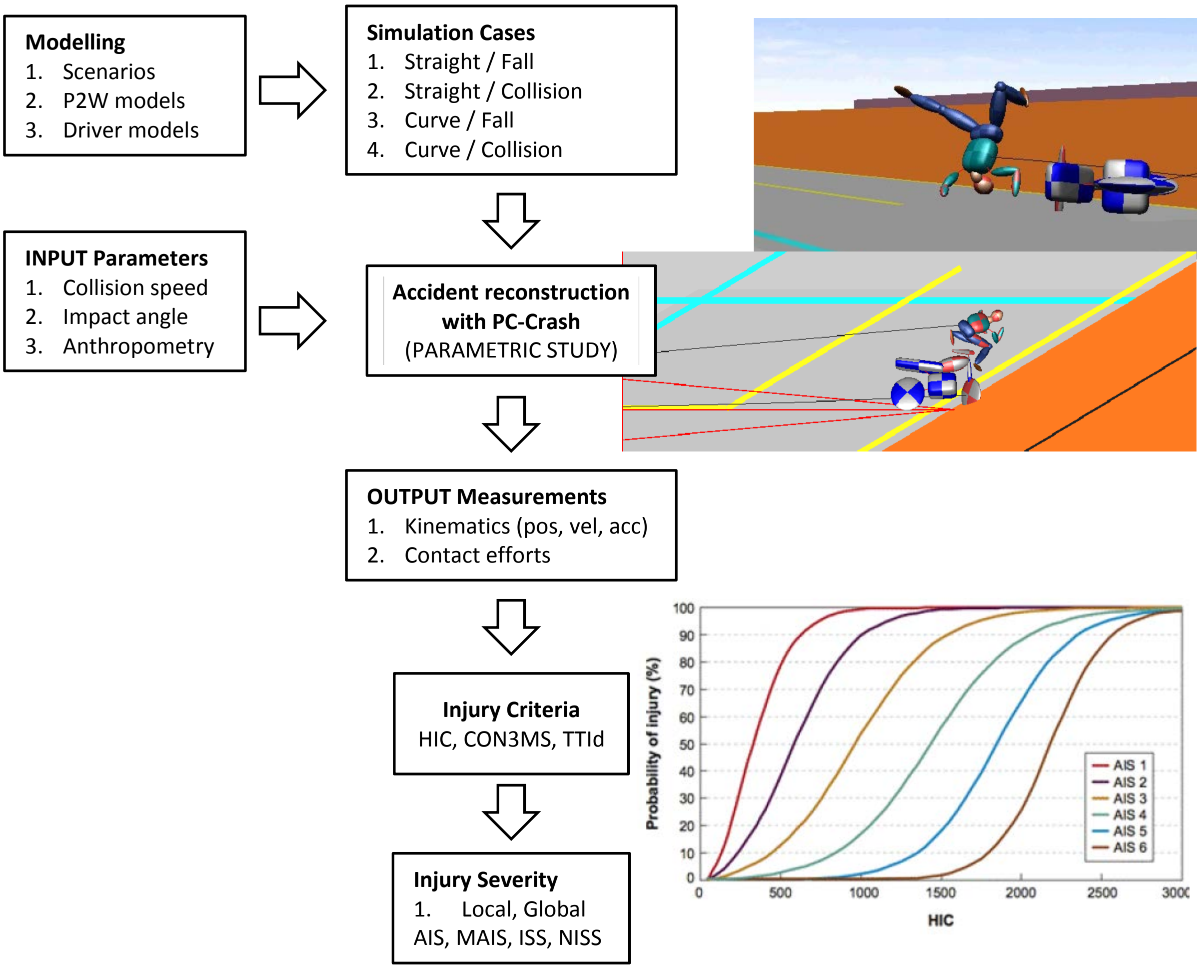

Figure 42: Single accident methodological approach

The central idea is to use PC-Crash simulations to reconstruct P2W accidents and calculate contact forces and accelerations that will serve to evaluate diverse injury criteria. Later, these values of the injury criteria will be used to estimate the injury severity in terms of probability of achieving a particular severity level. The methodology involves the following steps:

- Definition of simulation case studies, including scenarios, rider and bike models, accident conditions, etc. In this study, single P2W accidents involving objects of the road and no other vehicle have been selected. This steps are explained in sections 6.3.2.2 to 6.3.2.5.

- Accident reconstruction with PC-Crash. The use of PC-Crash with such purposes was validated by (Clief W., 1996). More details about this are also described in the following.

- Output measurements. This consists on the registration of signals from the sensors worn by the riders, typically accelerometers and cell forces for the contact forces. This is done straight forward with PC-Crash.

- Evaluation of injury criteria. A selection injury criteria corresponding to the head, thorax and abdomen of the rider are evaluated, as functions of some accelerations and contact forces. The basis is explained in section 6.2.2.
- Estimation of injury severity. There are studies in the scientific literature that correlates the values of the injury criteria with the probability of achieving certain levels of injury severity. These studies propose some formulas to convert injury criteria into severity probability. This is explained in section 6.2.3.

A similar methodology was implemented in (Varvalho, 2013) to select relevant injury criteria to describe P2W accident severity using biomechanical models.

6.3.2.2 Case Description

A lowsider motorcycle accident has been selected as reference accident involving one single P2W. Lowsider situations usually happen in a curve, when one or two wheels slide out due to too much braking, too much acceleration or too much speed with respect to the actual road grip. As a result, rider and bike are separated and, usually, the bike itself does not cause severe injury to the rider, although some impacts against the road should be expected. Bike and rider slide on the road slowing down due to friction until they come to rest or until they collide with objects on the roadside such as barriers, fences, posts or walls. For this study, a wall has been considered to exist along the trajectory of the rider so the rider would get additional damage when crashing against this wall.

The accident has been modelled in PC-Crash as follows. The bike must turn a left curve of radius R whose outer side is limited by a 1 m tall wall. Traffic is right-handed (RHT). The existence of an icy surface at the beginning of the curve causes rider to lose the control of the bike and the rider will be propelled against a wall. To have more control about the impact position against the wall, the curve is not actually modelled in the scenario but modelled as two flat (no bank) straight segments forming an angle of 150º (Figure 44). The impact obstacle is a vertical wall parallel to the second straight segment.

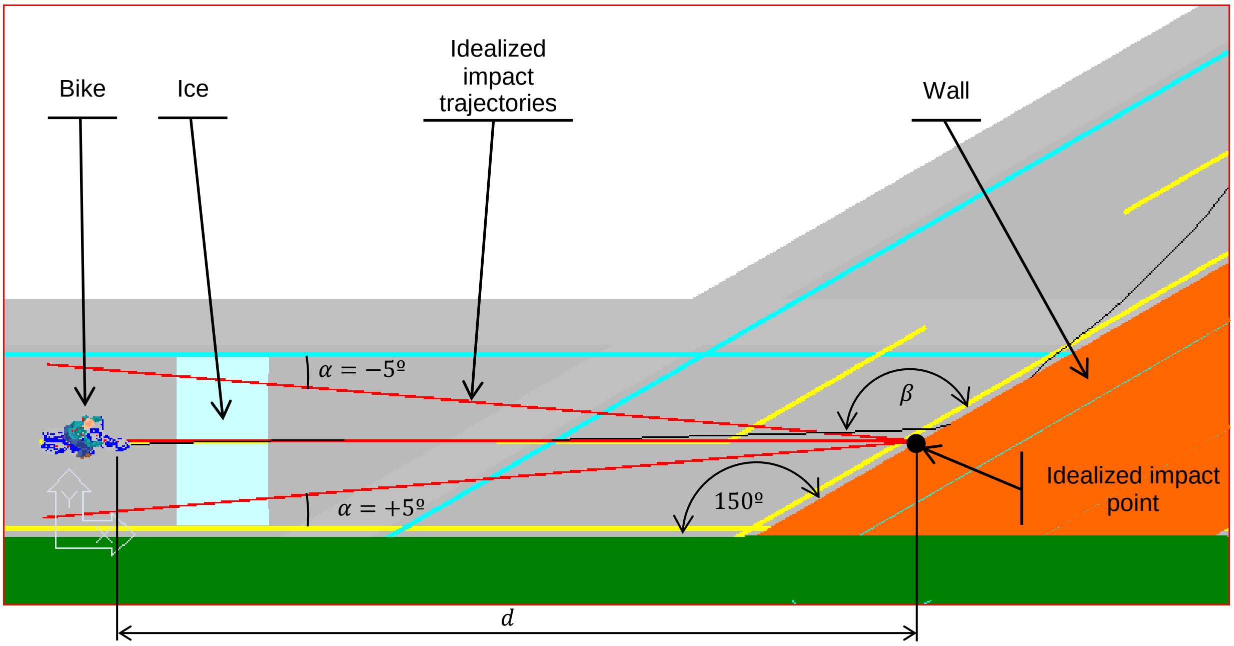

Figure 43: Top view of the accident scenario. Red lines mark the three idealized trajectories investigated in this study.

To simulate the cornering maneuver, the motorcycle is tilted with an angle accordingly to its velocity and to the radius of the curve. Three initial positions have been considered to cope with different impact angles (red lines in Figure 44). The initial state (position and velocity) of the bike is defined by the following parameters:

Parameter	**Explanation**
v	Initial velocity of the bike
α	Angle w.r.t. to X of bike's initial velocity
θ	Initial lean angle of the bike
d	Distance to the impact point

Table 49: Parameters defining the initial state of the bike

Consequently, the accident selected as case study for this work has two phases:

- Lowsider (Figure 45) caused by the existence of an icy surface just at the beginning of the cornering maneuver.
- Impact against a wall (Figure 46 and Figure 47) during rider's excursion after the lowsider incident. Major rider injuries will be originated in this phase.

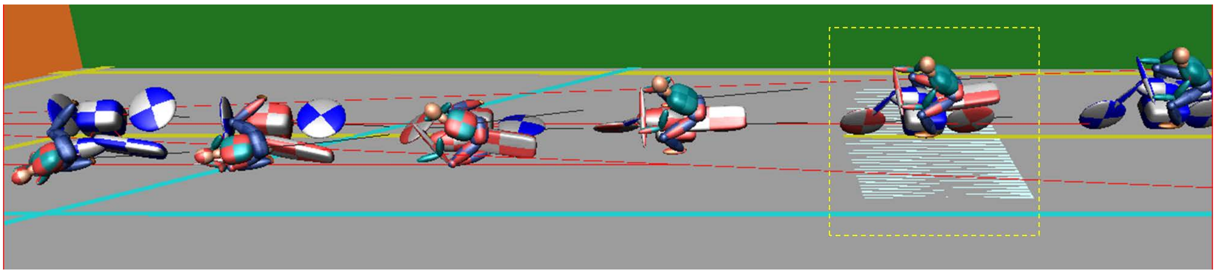

Figure 44: Lowsider phase caused by an icy surface (side view, 6 frames)

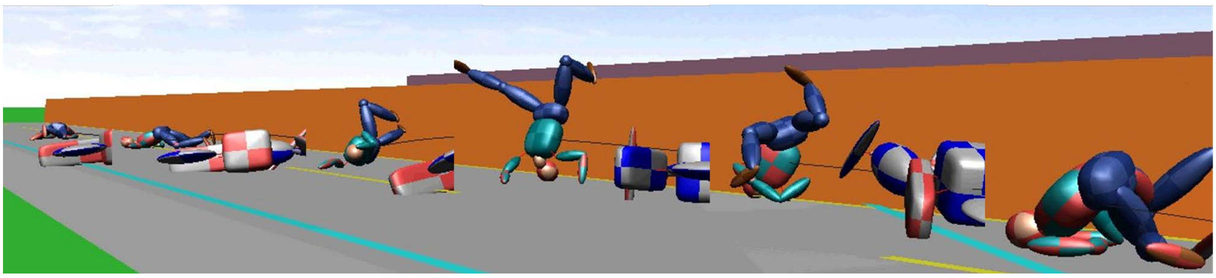

Figure 45: Impact against the wall (front view, 6 frames)

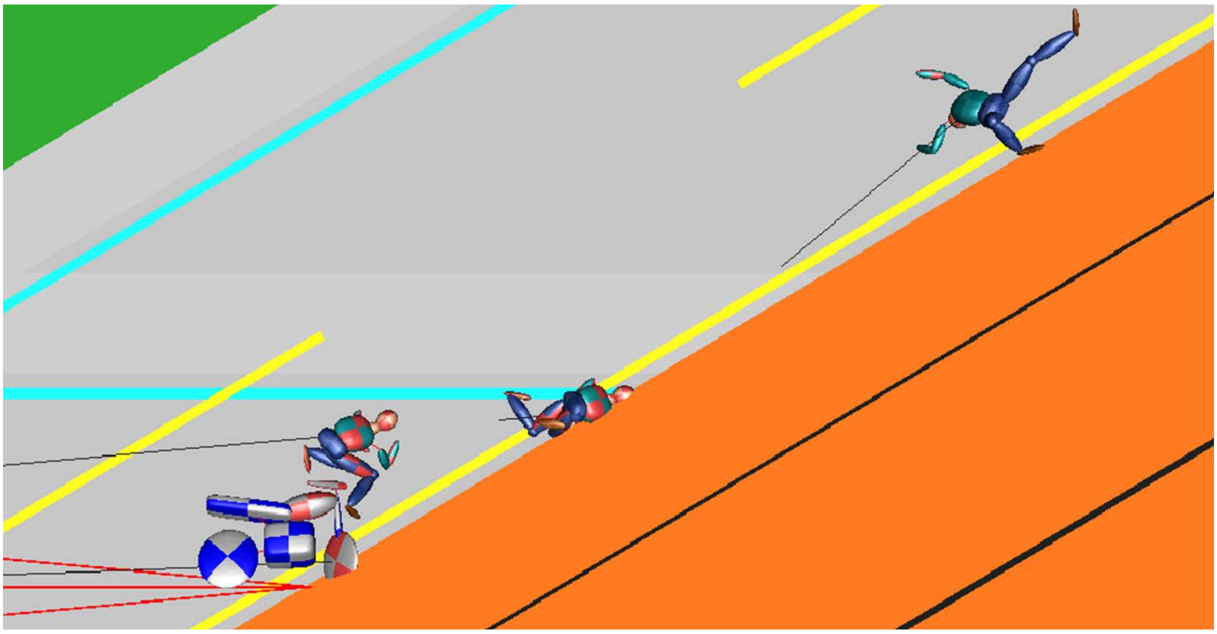

Figure 46: Impact against a wall (top view, 3 frames, bike is shown only in the initial frame)

6.3.2.3 Rider & Bike Models

Studies about injuries and severity of adult male are more readily available than others, so one single rider of this segment has been selected for the analysis. A feature of P2W accidents is that very often, the rider is separated from the bike after the crash. When a separation between rider and bike occurs, which involves large displacements and rotations of the body parts of both rider and bike, the use of biomechanical models is necessary to understand how the accident took place (Bernardo D., 2012).

The combined multibody model “suz gs500e+driver 20140221.mbdef” available in PC-Crash 11 (Figure 48) was selected. This model is composed of two parts:

- Rider: one adult male (18 y.o., 1.835 m tall, 80 kg).
- Bike: Suzuki GS500e (169 kg, wheelbase 1.410 m)

More information about this model can be found in PC-Crash User’s Manual (PC-Crash, 2016).

Figure 47: Rider and Bike

6.3.2.4 Model parameters to be studied

There are many parameters whose influence on rider’s injuries could be investigated. Among others:

- The radius of the curve R
- The initial velocity v of the bike
- The lean angle during cornering θ
- The impact angle of the bike against the ground obstacle.
- Rider’s age and anthropometry (size, mass, etc.)
- Rider physical abilities
- Position and length of the icy surface

Analyzing the impact of the variability of these parameters would need a huge number of simulation runs and hence an unaffordable amount of CPU time. For this reason, it is worth to try to reduce the number of parameters. The main goal of the study is to demonstrate the suitability of the implemented methodology to predict the severity of rider's injuries after an accident. To this end, it was considered that it is not necessary to analyze all of the above mentioned parameters, but a smaller collection.

One idea is removing parameters which are not independent. For example, assuming the initial position of the bike is stable, the initial velocity, the radius of the curve and the bike lean angle are related by a simple equation.

Figure 49 shows a transversal view of the bike from the rear. It was assumed that the bike is in a stationary position while cornering a curve of constant radius R with velocity v. The total mass of rider and bike m is considered to be concentrated at the centre of gravity (CoG), a_N is the normal acceleration, F_c is its corresponding centrifugal force, F_N is the normal reaction force at the contact point and F_r is the lateral friction force between tyre and road. Notice that:

$$a_N = \frac{v^2}{R}$$

Since bike position is stationary, i.e. θ is constant, the equilibrium of momenta at the contact point provides a formula to calculate the lean angle θ:

$$mgh \sin\theta - ma_N h \cos\theta = 0$$

$$g \sin\theta = \frac{v^2}{R}\cos\theta \quad \rightarrow \quad \tan\theta = \frac{v^2}{Rg} \quad \rightarrow \quad \theta = \operatorname{atan}\frac{v^2}{Rg}$$

This formula indicates that only v and R are independent parameters.

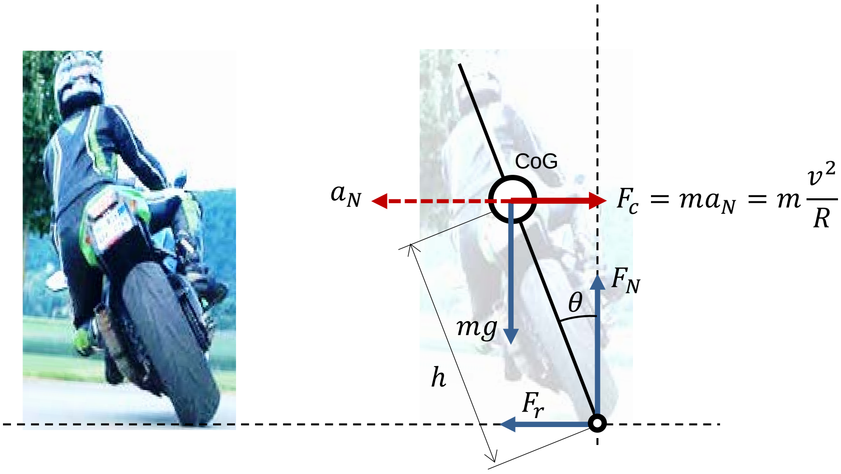

Figure 48: Quasi-static dynamic equilibrium of a rider while cornering: diagram of forces.

Furthermore, this very simple model also provides a threshold for the friction coefficient μ to avoid skidding:

$$F_N = mg$$

$$F_r = -F_c = ma_N = m\frac{v^2}{R}$$

but

$$F_r \le \mu F_N \quad \rightarrow \quad \mu \ge \frac{F_r}{mg} \quad \rightarrow \quad \mu \ge \frac{v^2}{Rg} = \tan\theta$$

Consequently, the friction coefficient μ cannot be exceeded by $\tan\theta$.

Some figures corresponding to curves with radius of 300, 400, 450 and $500\ m$, and cornering velocities of 60, 90 and $120\ km/h$ are presented in Table 50. Notice that in all the cases, $\tan\theta$ does not exceed the most typical road friction coefficient ($0.6 - 0.8$). The friction coefficient of the road is selected to be 0.8.

Conversely, the values of $\tan\theta$ determine the limit value of friction coefficient, below which slip occurs. The analysis of the figures of Table 50 suggests that it is only necessary to select a single value of the radius, for example $R = 400\ \mathrm{m}$, to get differentiated situations that are relevant for the study. Finally radius 400 m was selected for this study.

$v\ \left[\frac{km}{h}\right]$	$R\ [m]$	$\theta\ [deg]$	$\tan\theta\ [\,]$
120	500	12.7636	0.2265
	450	14.1277	0.2517
	400	**15.8199**	**0.2832**
	300	20.6837	0.3775
90	500	7.2616	0.1274
	450	8.0583	0.1416
	400	**9.0498**	**0.1593**
	300	11.9897	0.2124
60	500	3.2413	0.0566
	450	3.6005	0.0629
	400	**4.0492**	**0.0708**
	300	5.3919	0.0944

Table 50: Diverse quasi-static equilibrium positions

Once the radius and cornering velocities have been selected, the friction coefficient of the slippery surface causing the lowsider can be defined, which must be lower than 0.0708. In this way, a minimum value of 0.01 has been selected that PC-Crash permits, which corresponds to ice. And concerning the initial position of the driver and the dimensions of the icy surface, Figure 50 shows the actual figures used in the present study.

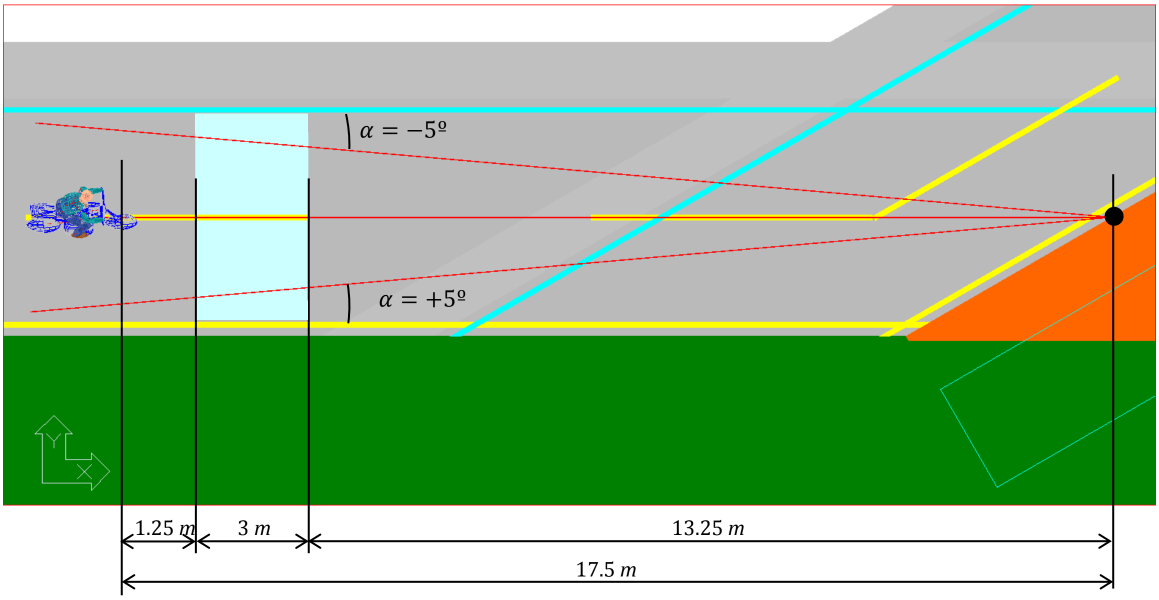

Figure 49: Initial position of the bike and dimensions of the icy surface

6.3.2.5 Summary of model parameters

Finally, the selected parameters and their corresponding values are presented in Table 51.

Parameter	**Figures**				**Explanation**
$R\ [m]$	400				Radius of the curve
$v\ [km/h]$	60	60	90	120	Initial bike velocity
$\theta\ [deg]$	4.05	8.1 (*)	9.05	15.82	Initial lean angle of the bike
$\alpha\ [deg]$	+5	0	-5		Velocity angle w.r.t. axis X (longitudinal)
$\beta\ [deg]$	145	150	155		Impact angle (theoretical trajectory)
$d\ [m]$	17.5				Distance to impact (theoretical trajectory)
$H\ [m]$	1.835				Rider’s height (PC-Crash human model)
$M\ [kg]$	80				Rider’s weight (PC-Crash human model)
$AGE\ [y]$	18				Rider’s age (PC-Crash human model)
$m\ [kg]$	169				Bike mass (PC-Crash bike model)
$Bike$	Suzuki GS500e				PC-Crash model of a Suzuki GS500e
$\mu\ [\,]$	0.8				Friction coefficient of the road
$\mu_s\ [\,]$	0.01				Friction coefficient of the slippery surface

Table 51: Model parameters to be investigated. (*) The lean angle is doubled w.r.t. the theoretical angle.

The total number of distinct simulation runs is finally 12, varying the initial velocity and the impact angle. At 60 km/h with the lean angle θ that corresponds to v and R, rider and motorcycle trajectories differ of the expected lowsider with the motorcycle sliding to the outside of the curve and the rider keeping the inside. Instead, the rider comes off the motorcycle either from its upper part or its right side, and falls to the outside of the curve while the motorcycle takes the inside. The easy way to get a real lowsider to the outside of the curve is to increase the lean angle. Consequently, the cases at 60 km/h have been simulated twice: firstly, with the theoretical lean angle θ, and secondly, with double lean angle, i.e. 2θ.

6.4 Relevant physical parameter & estimated load

The investigations on the different parameters with potential influence on the injury severity identified the following results. The correlation between potential parameters and occurring injuries are assessed via injury criteria for the most important body regions.

6.4.1 P2W vs. vehicle accidents

The parameter analysis in section 6.3.1 identified the potentially relevant parameter and cases for the assessment of variant injury criteria of the head, neck and thorax. Based on that, this section deals with a visual three-dimensional consideration of the features for the injury severity estimation. Each crash constellation is discussed in a separate subsection.

6.4.1.1 ISO-Crash-Code 41X & 101X

Starting with head injury as one of the most critical injuries in bike to vehicle collisions by analyzing the HIC over the collision speed and collision angle. Figure 51 shows this multidimensional distribution for this crash code. In this process a significant link between the resultant HIC and collision speed as well as collision angle. There is a high risk for the rider's head to hit directly the roof edge of the car. Therefore as expected, the faster the bike and the closer to 90° the higher the load on the motorcycle while hitting the vehicle close to the B-pillar respectively the higher the load on the rider's head what causes high HIC values.

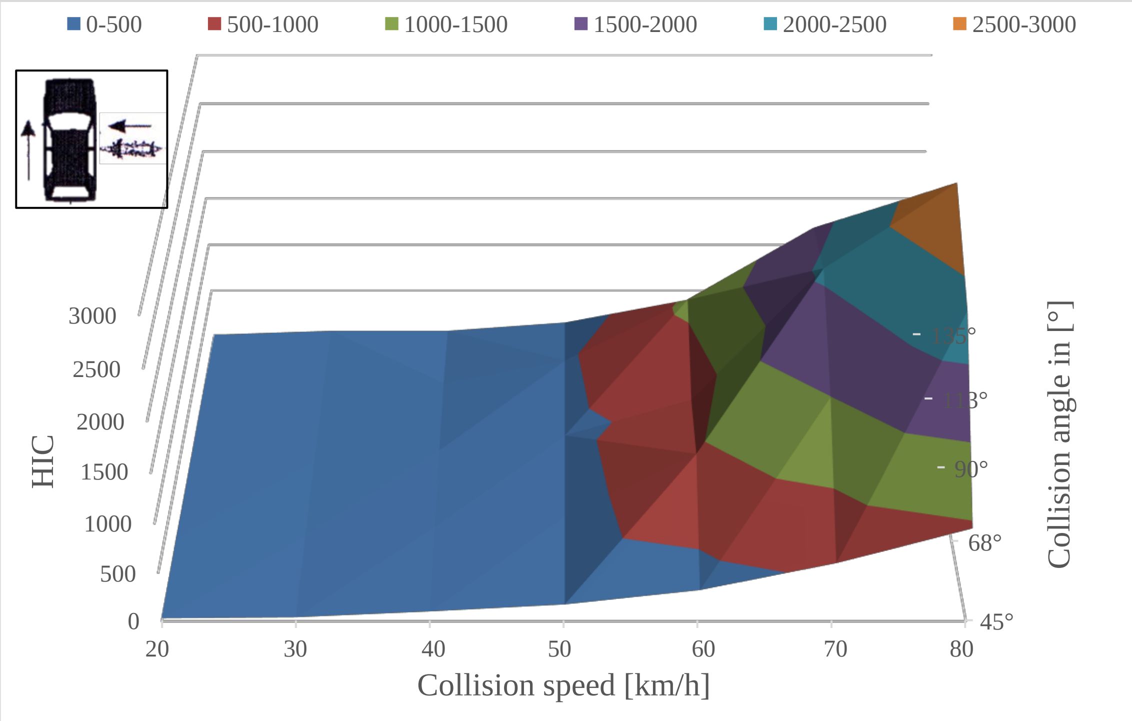

Figure 50: HIC over Impact Angle & Collision Speed for ISO-Crash-Code 41X & 101X

Figure 52 shows the distribution of the Nij within this crash code. For the same reasons as already mentioned for the load on the head there is a significant high correlation between the collision angle and the achieved injury criteria level of the neck. Further the collision speed is nearly linear linked with the Nij level as well.

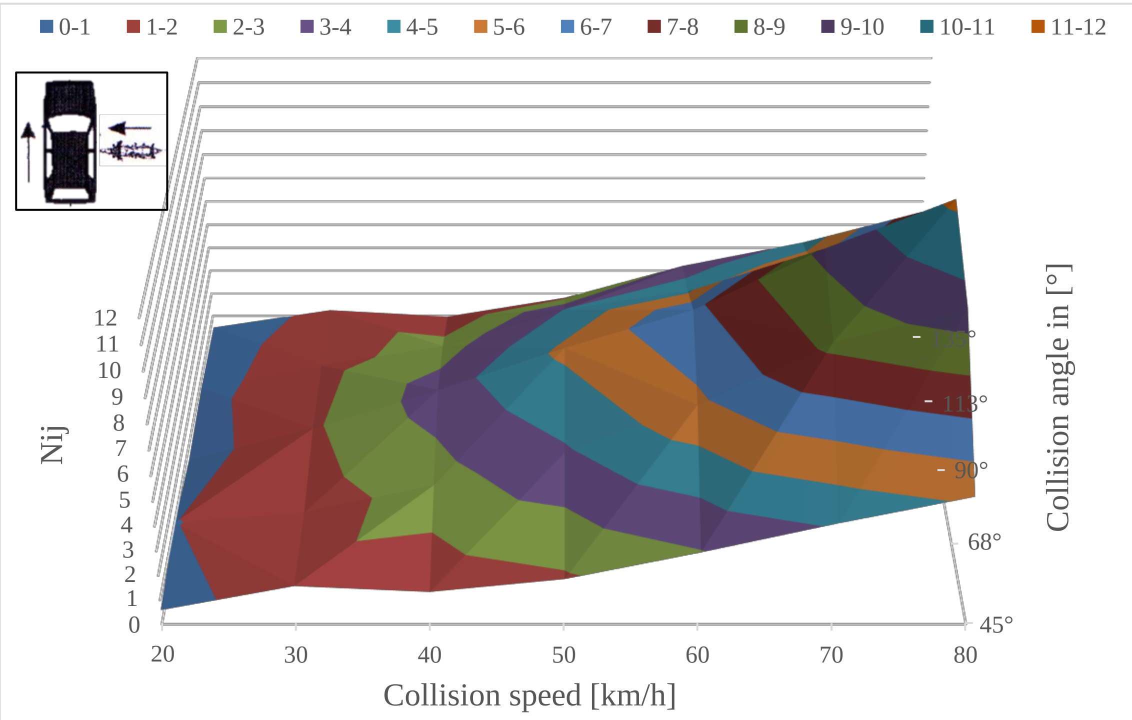

Figure 51: Nij over Impact Angle & Collision Speed for ISO-Crash-Code 41X & 101X

For the assessment of the thoracic load the acceleration of the thoracic spine (Ac) is used. Also Ac correlates with the collision angle and collision speed comparable with the Nij. Figure 53 shows the distribution of the Ac over impact angle and collision speed.

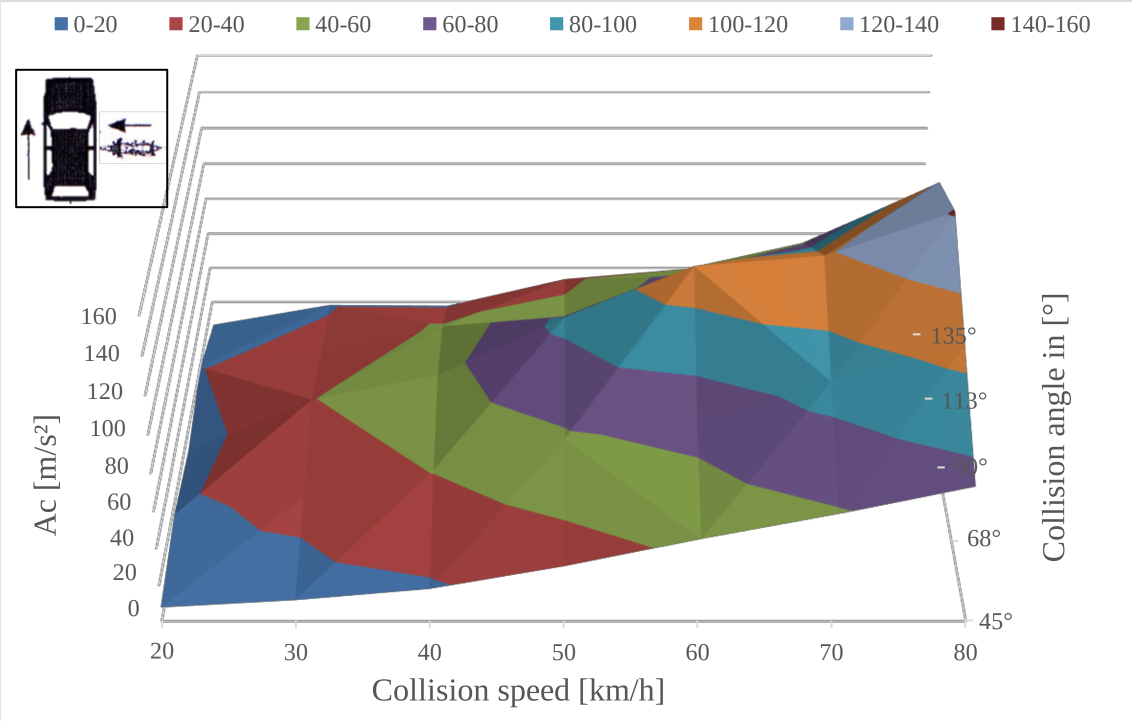

Figure 52: Ac over Impact Angle & Collision Speed for ISO-Crash-Code 41X & 101X

6.4.1.2 ISO-Crash-Code 11X

The results of the investigations on the ISO crash code 11X are presented in the following. Compared to the results of the previous configuration the HIC value is significantly lower. The lower structure in the front part of the vehicle decelerate almost only the motorcycle, therefore the impact is different for the rider and potentially less severe. Therefore the collision configuration itself could be identified as an additional parameter for the injury assessment. Figure 54 shows the distribution of HIC. Beside the already mentioned reduced peak values, a correlation between collision angle and speed can be identified for this configuration too.

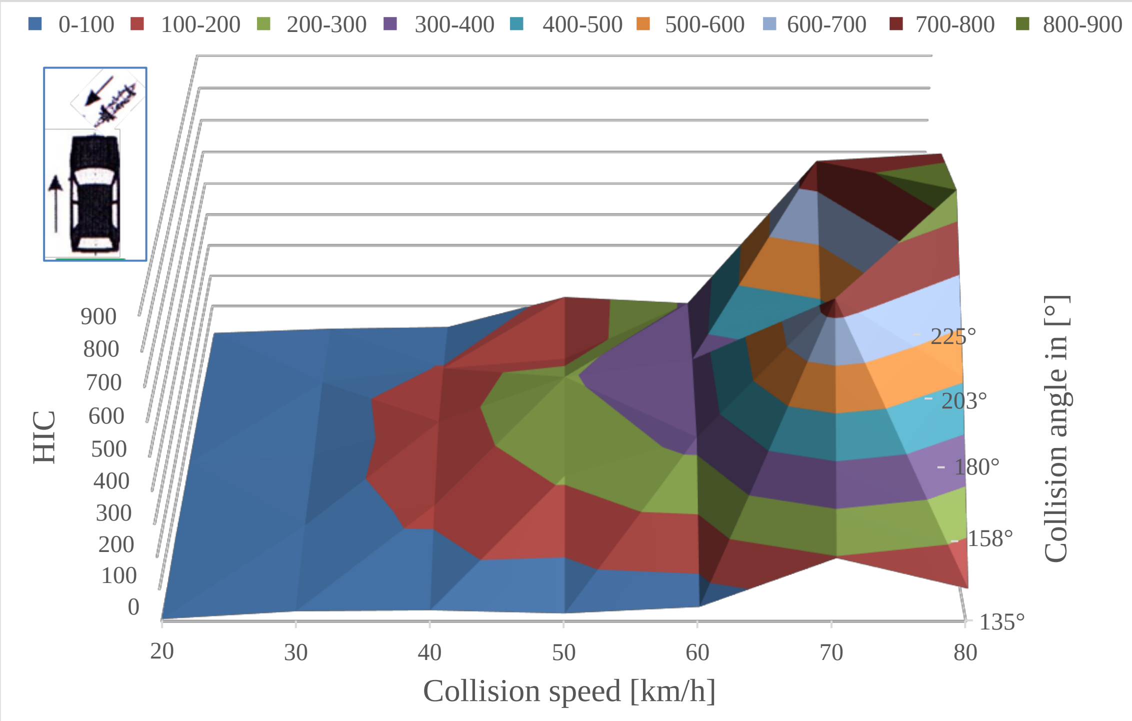

Figure 53: HIC over Impact Angle & Collision Speed for ISO-Crash-Code 11X

The significant correlation between Nij level and the collision angle and particularly for the collision speed can’t be seen for the impact into the front part of the vehicle. (Figure 55)

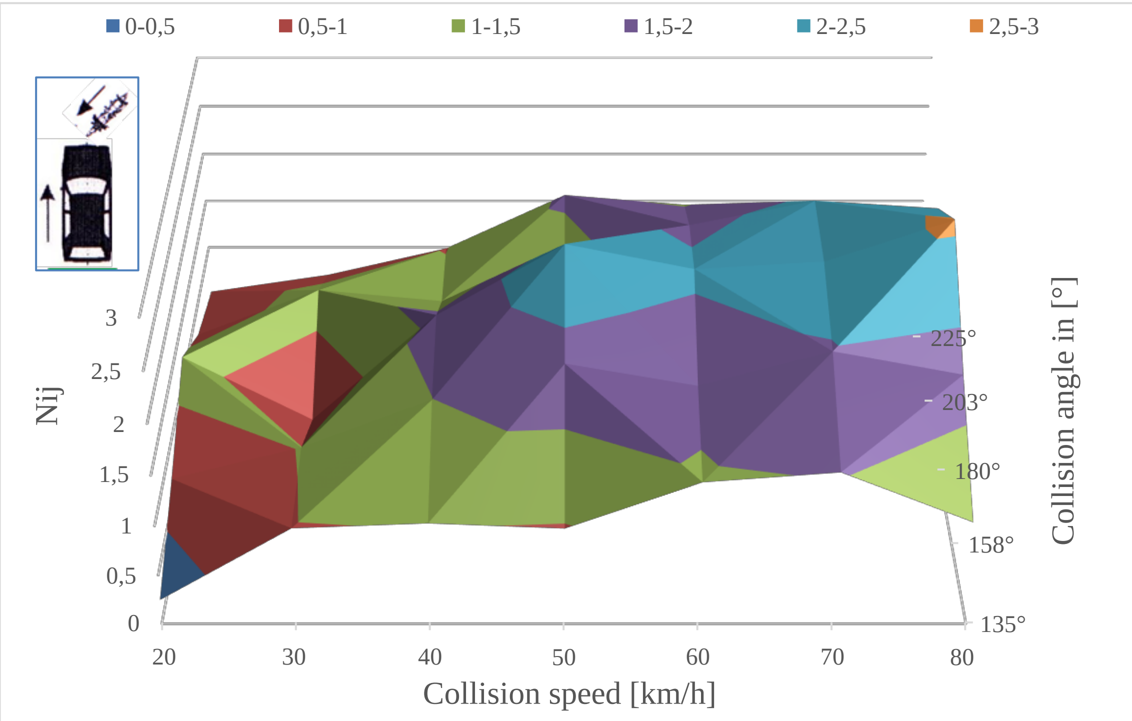

Figure 54: Nij over Impact Angle & Collision Speed for ISO-Crash-Code 11X

Almost the same results can be outlined for the thorax load. The Ac level correlates only roughly with the collision speed and shows almost no correlation with the collision angle.

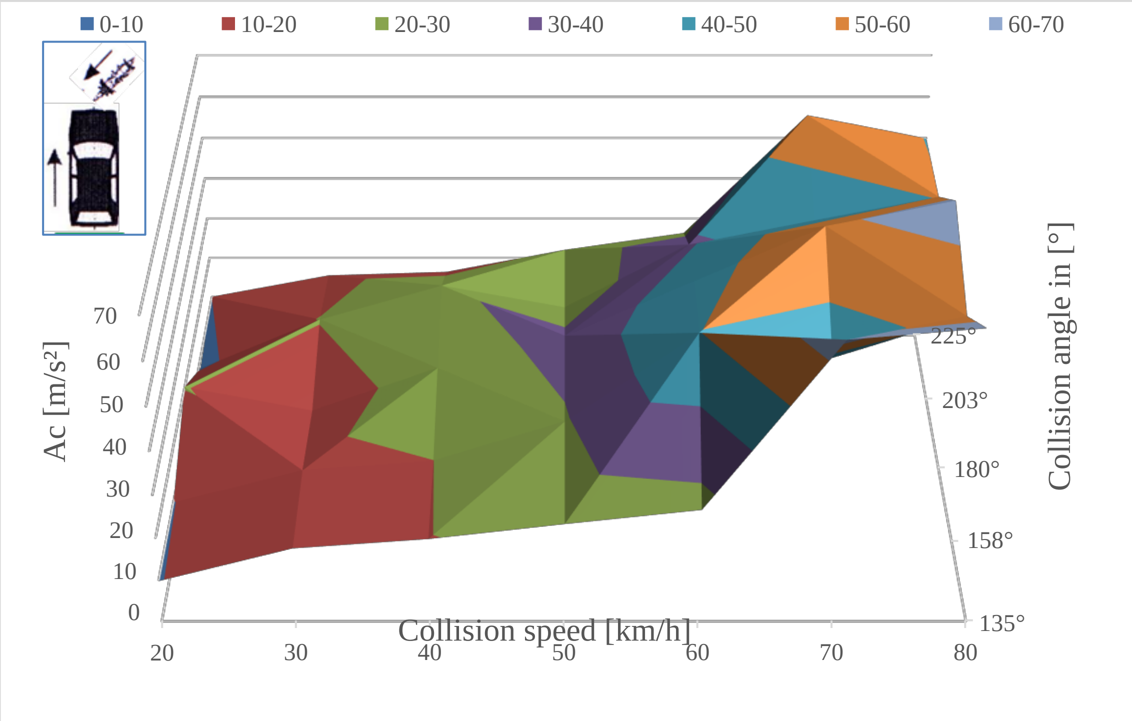

Figure 55: Ac over Impact Angle & Collision Speed for ISO-Crash-Code 11X

6.4.1.3 ISO-Crash-Code 127 & 143

The simulation of the side impact scenarios showed that the main parameter of the injury mechanism is the collision speed. Figure 57 shows that within one speed segment the Ac values remains almost at the same level despite a weight variation of 1000kg. Changes in the motorcycle mass came to the same result.

This may be explained by the fact that the rider isn't directly connected to the bike and in case of a crash the rider is separated from the bike as well as from any other kind of fixed object which would be accelerated by an impact of the vehicle. Therefore, the mass of the bike and the vehicle is negligible.

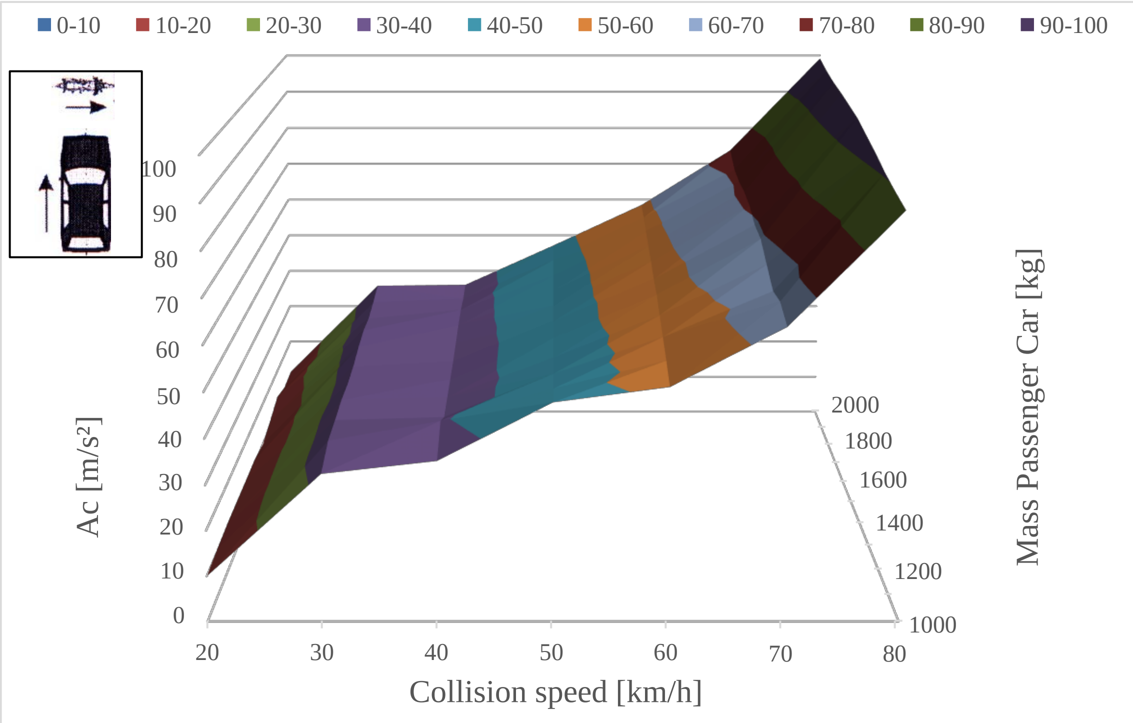

Figure 56: Ac over Collision Angle & Collision Speed for ISO-Crash-Code 127

6.4.1.4 Results

The analysis of bike to vehicle collisions showed a correlation between the collision angle α, – speed v and the load respectively the level of the injury criteria of the head, neck and thorax. However, the grade of correlation depends on the crash configuration itself. While the motorcycle itself hits stiffer or softer parts of the vehicle, the load on the rider depends on the point of its impact. As expected the grade of correlation is higher on accidents in which the rider hits the vehicle directly on stiff parts (e.g. roof edge) comparable to the impact of the bike, than on accidents in which the rider got thrown over or on the vehicle (e.g. hood).

Based on the findings on relevant collision parameter the potential injury risk or respectively risk for injury severity can be calculated by using predefined 2D injury risk curves, e.g. the HIC over AIS shown in Figure 29. The calculated multidimensional injury risk for AIS2 for the head is represented as an example for a realized estimator for ISO Crash Code 41X and 101X in Figure 58.

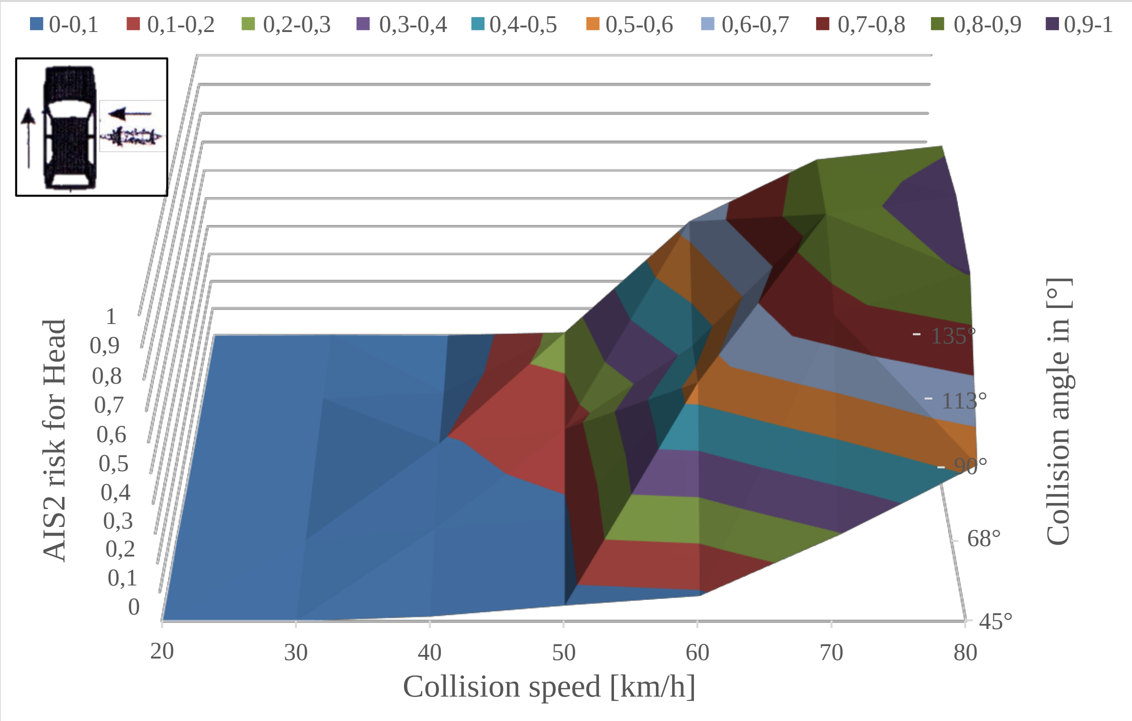

Figure 57: AIS2 risk for the head in ISO-Crash-Code 41X & 101X

This kind of visual representation is possible for all body regions and for each AIS level. The integration of additional injury criteria or AIS level into the diagram isn't convenient for a better understanding. To estimate the overall load of the rider or of each body region a separate injury estimation model for the corresponding body has to be defined.

6.4.2 Single accidents

The potential features influencing the injury severity in a single accident are analyzed within 12 simulated cases. The next tables collect the complete results of the 12 simulations runs including the peak value of each injury criteria and the corresponding risk for AISx.

6.4.2.1 Lowsider at 90 km/h & 120 km/h

Note: β is the theoretical impact angle, θ is the lean angle, VAL is the actual values of the injury criterion and AISx+ is the probability of receiving AIS grade x or bigger.

VEL km/h	*β* [deg]	*θ* [deg]	BODY REGION	INJURY CRITERION	VAL	AIS1+ [%]	AIS2+ [%]	AIS3+ [%]	AIS4+ [%]	AIS5+ [%]	AIS6 [%]
120	155	15,8	HEAD	HIC36	555	83%	22%	7%	1%	1%	0%
120	155	15,8	HEAD	HIC15	535	83%	43%	15%	3%	0%	0%
120	155	15,8	THORAX	CON3MS	40	-	75%	35%	14%	0%	-
120	155	15,8	THORAX	TTId	63	-	-	0%	0%	-	-
120	155	15,8	ABDOMEN	APF	11723	-	-	91%	28%	-	-

120	155	15,8	ABDOMEN	PIC	3908	-	3%	0%	-	-	-
120	150	15,8	HEAD	HIC36	784	90%	36%	15%	5%	4%	3%
120	150	15,8	HEAD	HIC15	543	83%	44%	15%	3%	0%	0%
120	150	15,8	THORAX	CON3MS	58	-	89%	62%	33%	1%	-
120	150	15,8	THORAX	TTId	87	-	-	1%	0%	-	-
120	150	15,8	ABDOMEN	APF	11419	-	-	89%	24%	-	-
120	150	15,8	ABDOMEN	PIC	3806	-	3%	0%	-	-	-
120	145	15,8	HEAD	HIC36	667	87%	29%	10%	3%	2%	1%
120	145	15,8	HEAD	HIC15	959	99%	87%	49%	15%	2%	0%
120	145	15,8	THORAX	CON3MS	68	-	94%	76%	49%	1%	-
120	145	15,8	THORAX	TTId	95	-	-	2%	0%	-	-
120	145	15,8	ABDOMEN	APF	30127	-	-	100%	100%	-	-
120	145	15,8	ABDOMEN	PIC	10042	-	76%	7%	-	-	-
90	155	9,0	HEAD	HIC36	183	44%	2%	0%	0%	0%	0%
90	155	9,0	HEAD	HIC15	182	19%	6%	2%	0%	0%	0%
90	155	9,0	THORAX	CON3MS	60	-	90%	65%	36%	1%	-
90	155	9,0	THORAX	TTId	58	-	-	0%	0%	-	-
90	155	9,0	ABDOMEN	APF	22529	-	-	100%	100%	-	-
90	155	9,0	ABDOMEN	PIC	7510	-	32%	2%	-	-	-
90	150	9,0	HEAD	HIC36	235	54%	4%	0%	0%	0%	0%
90	150	9,0	HEAD	HIC15	490	77%	37%	12%	3%	0%	0%
90	150	9,0	THORAX	CON3MS	80	-	97%	87%	67%	3%	-
90	150	9,0	THORAX	TTId	67	-	-	1%	0%	-	-
90	150	9,0	ABDOMEN	APF	28323	-	-	100%	100%	-	-
90	150	9,0	ABDOMEN	PIC	9441	-	66%	6%	-	-	-
90	145	9,0	HEAD	HIC36	336	68%	9%	1%	0%	0%	0%
90	145	9,0	HEAD	HIC15	828	97%	78%	37%	10%	1%	0%
90	145	9,0	THORAX	CON3MS	109	-	99%	98%	92%	17%	-
90	145	9,0	THORAX	TTId	108	-	-	4%	1%	-	-
90	145	9,0	ABDOMEN	APF	39983	-	-	100%	100%	-	-
90	145	9,0	ABDOMEN	PIC	13328	-	97%	30%	-	-	-

Table 52: Simulation results of cases at 90 km/h and 120 km/h.

6.4.2.2 Lowsider at 60 km/h

Note: β is the theoretical impact angle, θ is the lean angle, VAL is the actual values of the Injury Criterion and AISx+ is the probability of receiving AIS grad.

VEL km/h	***β*** [deg]	***θ*** [deg]	BODY REGION	INJURY CRITERION	VAL	AIS1+ [%]	AIS2+ [%]	AIS3+ [%]	AIS4+ [%]	AIS5+ [%]	AIS6 [%]
60	155	4,0	HEAD	HIC36	79	16%	0%	0%	0%	0%	0%
60	155	4,0	HEAD	HIC15	119	8%	3%	1%	0%	0%	0%
60	155	4,0	THORAX	CON3MS	37	-	71%	30%	12%	0%	-
60	155	4,0	THORAX	TTId	49	-	-	0%	0%	-	-
60	155	4,0	ABDOM EN	APF	12413	-	-	94%	39%	-	-
60	155	4,0	ABDOM EN	PIC	4138	-	4%	0%	-	-	-

60	150	4,0	HEAD	HIC36	71	14%	0%	0%	0%	0%	0%
60	150	4,0	HEAD	HIC15	88	4%	1%	0%	0%	0%	0%
60	150	4,0	THORAX	CON3MS	54	-	87%	57%	28%	1%	-
60	150	4,0	THORAX	TTId	60	-	-	0%	0%	-	-
60	150	4,0	ABDOMEN	APF	16986	-	-	100%	94%	-	-
60	150	4,0	ABDOMEN	PIC	5662	-	10%	1%	-	-	-
60	145	4,0	HEAD	HIC36	48	7%	0%	0%	0%	0%	0%
60	145	4,0	HEAD	HIC15	41	0%	0%	0%	0%	0%	0%
60	145	4,0	THORAX	CON3MS	63	-	92%	70%	41%	1%	-
60	145	4,0	THORAX	TTId	71	-	-	1%	0%	-	-
60	145	4,0	ABDOMEN	APF	13654	-	-	98%	60%	-	-
60	145	4,0	ABDOMEN	PIC	4551	-	5%	0%	-	-	-
60	155	8,1	HEAD	HIC36	9	0%	0%	0%	0%	0%	0%
60	155	8,1	HEAD	HIC15	24	0%	0%	0%	0%	0%	0%
60	155	8,1	THORAX	CON3MS	7	-	31%	6%	2%	0%	-
60	155	8,1	THORAX	TTId	31	-	-	0%	0%	-	-
60	155	8,1	ABDOMEN	APF	7585	-	-	34%	2%	-	-
60	155	8,1	ABDOMEN	PIC	2528	-	1%	0%	-	-	-
60	150	8,1	HEAD	HIC36	15	0%	0%	0%	0%	0%	0%
60	150	8,1	HEAD	HIC15	37	0%	0%	0%	0%	0%	0%
60	150	8,1	THORAX	CON3MS	32	-	65%	24%	9%	0%	-
60	150	8,1	THORAX	TTId	30	-	-	0%	0%	-	-
60	150	8,1	ABDOMEN	APF	5331	-	-	10%	0%	-	-
60	150	8,1	ABDOMEN	PIC	1777	-	1%	0%	-	-	-
60	145	8,1	HEAD	HIC36	24	1%	0%	0%	0%	0%	0%
60	145	8,1	HEAD	HIC15	63	1%	0%	0%	0%	0%	0%
60	145	8,1	THORAX	CON3MS	32	-	65%	25%	9%	0%	-
60	145	8,1	THORAX	TTId	32	-	-	0%	0%	-	-
60	145	8,1	ABDOMEN	APF	4315	-	-	5%	0%	-	-
60	145	8,1	ABDOMEN	PIC	1438	-	0%	0%	-	-	-

Table 53: Simulation results of cases at 60 km/h, with theoretical lean angle and double lean angle.

6.4.2.3 Results

To distinguish simulation results at 60 km/h with double lean angle (required for realizing the desired lowsider in PC Crash), next figures plot these data with the velocity set to 65 km/h. Figure 59 and Figure 60 show the variability of the HIC with respect to the initial velocity and the impact angle β. As expected, the HIC values increase as velocity does. However, sharper impact angles do not always produce higher HIC values.

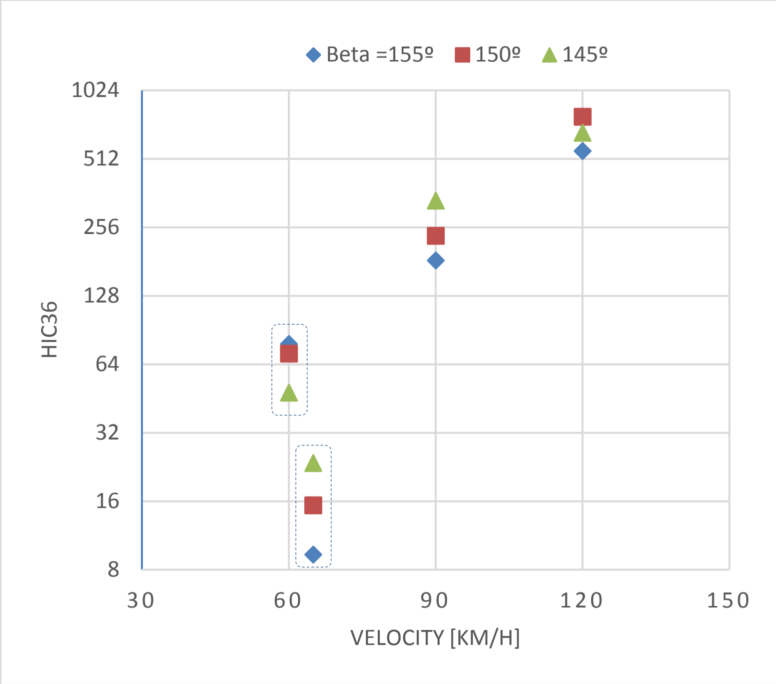

Figure 58: HIC36 values vs. initial velocity and different impact angles (β)

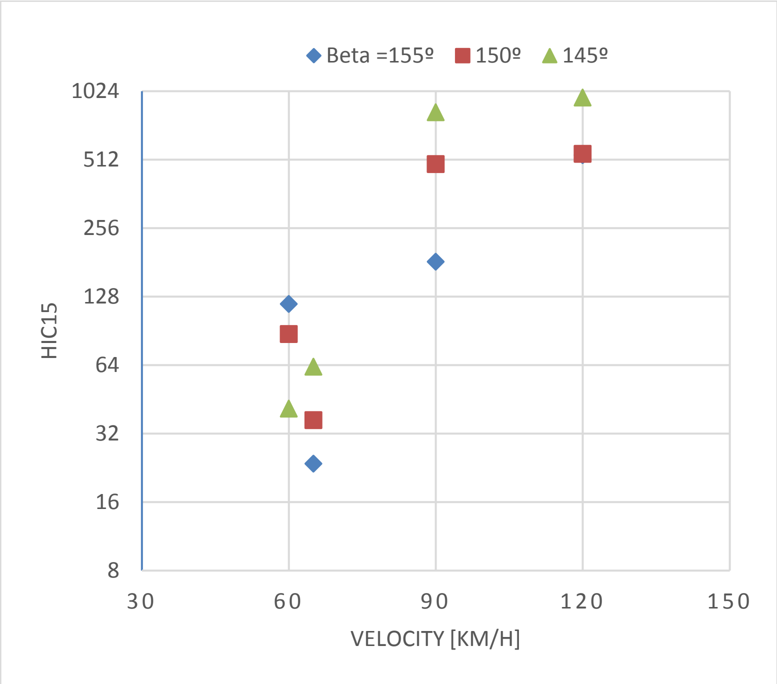

Figure 59: HIC15 values vs. initial velocity and different impact angles (β)

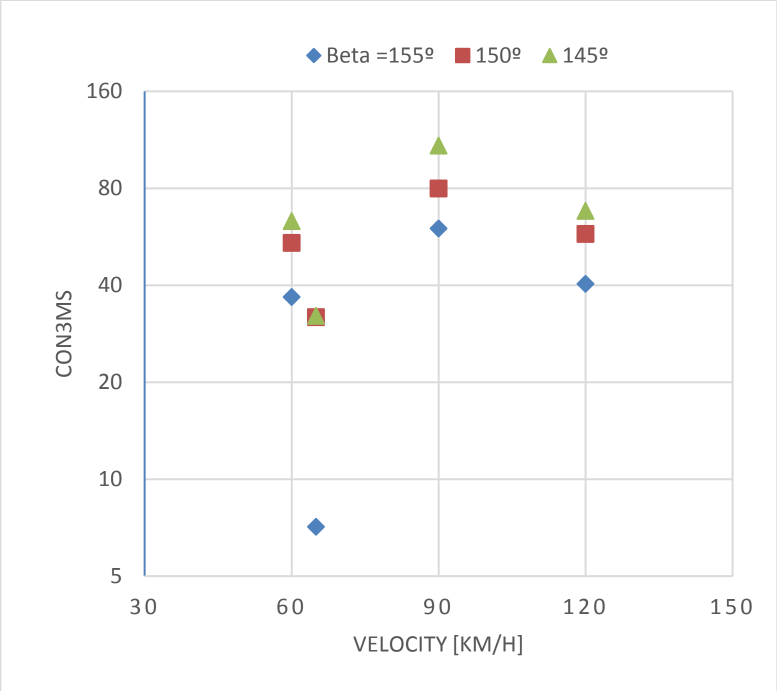

Figure 60: CON3MS values vs. initial velocity and different impact angles (β)

Figure 61 shows that the thorax acceleration based injury criterion CON3MS does not show a clear dependency with respect to the velocity. However, CON3MS values grow with sharper impact angles. Similar conclusions are observed in the TTI values shown in Figure 62.

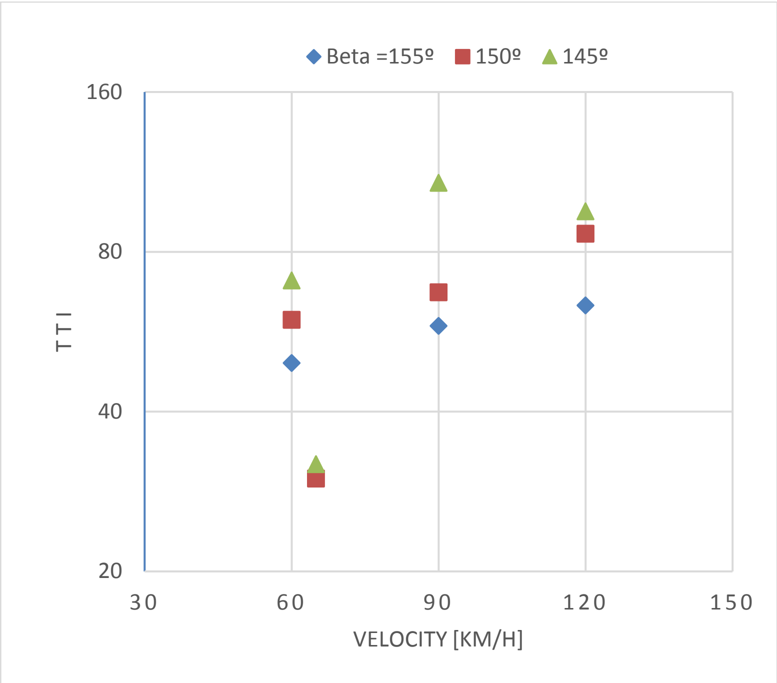

Figure 61: TTI values vs. initial velocity and different impact angles (β)

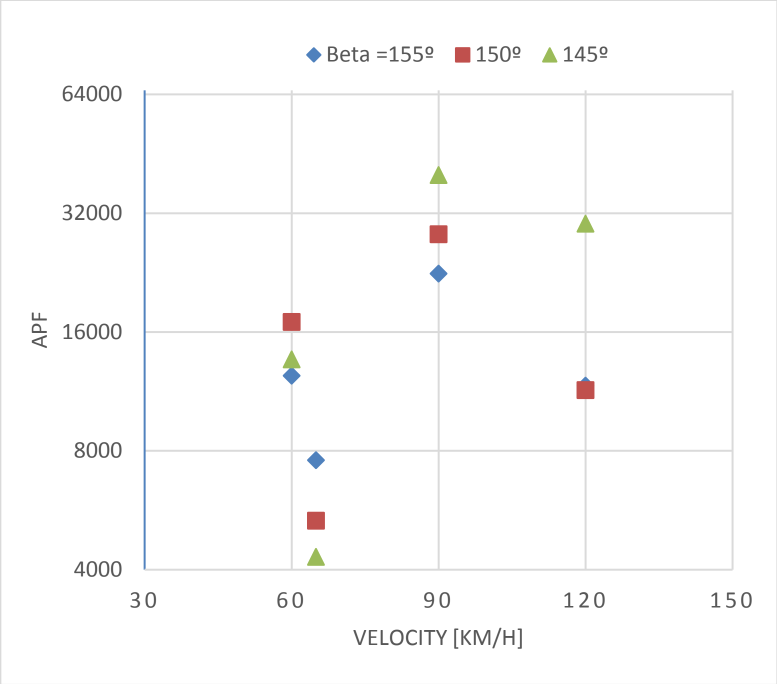

Figure 62: APF values vs. initial velocity and different impact angles (β)

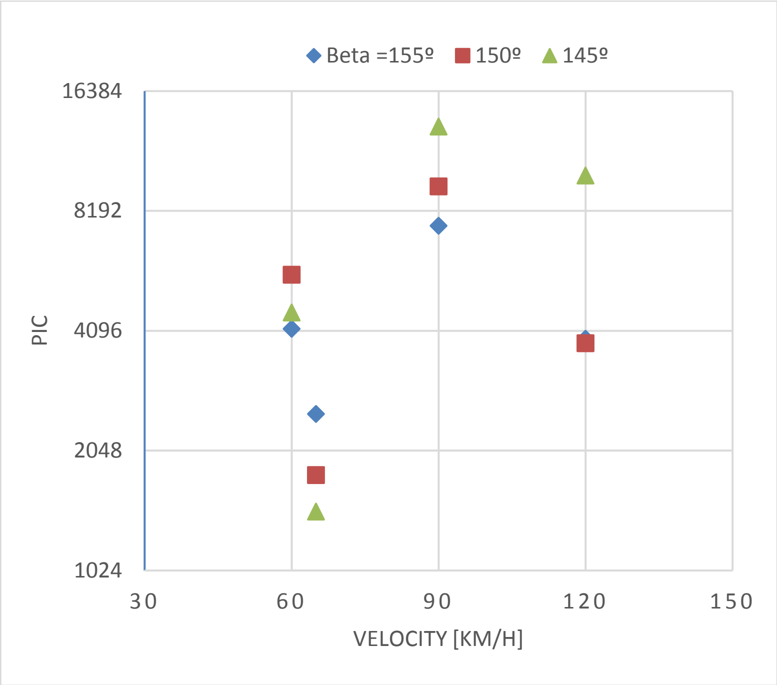

Figure 63: PIC values vs. initial velocity and different impact angles (β)

Similar behavior encountered in APF and PIC injury criteria, as shown in Figure 63 and Figure 64 there is no clear dependency with respect to the velocity and to the impact angle.

Therefore, from this study following conclusions can be drawn:

- Injury severity probabilities grow with the injury criteria values and, hence, the values of the injury criteria can be used to analyze the influence of the simulation parameters in the level of intensity.
- As expected, injury severity level in the head increases clearly with the velocity. In other words, motorcycle's velocity is a relevant parameter to estimate the level of severity of the head.
- For the thorax and abdomen severity levels, bike's velocity is not a determining parameter.
- Except for the thorax (CON3MS and TTI) results do not show a monotonous relation between the values of the injury criteria and the impact angle. This makes sense since the level of severity is related with the order in which the different parts of the rider's body impact against the wall, and their relative orientation. None of these is determined by the theoretical impact angle.
- Consequently, in addition to the motorcycle's velocity, a robust estimator for the level of severity requires the measurement of some rider's magnitudes (accelerations and contact forces) that can be actually measured with sensors worn included in the rider's suit.

6.5 Summary

This study investigates motorcycle to vehicle and single accidents of motorcycles with regards to the possibility to estimate the injury severity of the rider. The analysis is based on multi body simulations performed in PC Crash. Several simulation runs showed a correlation between a defined accident type and the physical loads on the rider. Derived from that the main target was to identify a specific set of features which classifies the estimated injury severity. One of the main features is the motorcycle's velocity which correlates with the injury severity in almost every type of accident. Furthermore the signal basis and the features differ on the type of accident.

For bike to vehicle accidents the shape of the collision opponent has a high influence on the rider injuries. Therefore the collision angle and impact point could be identified as relevant parameter for an adequate estimation of an injury severity of the rider. In its approach, the estimation is based on the 3D acceleration sensor signals of the motorcycle in front crash and side impact scenarios. That causes limitations for the range of the estimation because it just records the impact of the bike against an opponent. Furthermore, there is a lack of information about the impact point of the rider at the first impact and no information about the potential second impact of the rider against other objects.

The single accident analysis deals with the approach of rider based sensors integrated into the personal protective equipment (PPE), e.g. helmet and/or jacket. It enables the assessment of the loads cause by a collision between rider and an object (e.g. wall). The considered case is a lowsider accident in which the rider hits a wall as second impact. Beside the main factor collision speed, the impact angle has been identified as relevant parameter.

Finally the combination of both concepts shows the potential for an adequate injury severity estimation which could be linked to an eCall system. The assessment of the second impact of the rider is of vital importance and cannot be provided by the bike. Therefore, sensors equipped on the rider itself deliver the most reliable signals. However, the motorcycle based sensor signals deliver additional information like velocity, collision angle etc. which allows the draw of conclusions of the accident itself. The knowledge about what kind of accident occurred enhances the robustness of the injury severity estimation.

6.6 Conclusion

In a nutshell, the two injury severity estimation concepts presented are prototypical solutions for this study which showed their potentials for further investigations. Beside the precision of the features for the estimation algorithm, the requirements of the sensors and the communication between bike and PPE has to be defined in a future project. Due to the fact that in general the corresponding eCall system is located on the motorcycle, the information about the estimated injury severity has to be communicated from the PPE to the motorcycle and further to the emergency center. Therefore the minimum set of data (MSD) of the eCall system has to be enabled to fulfill these requirements, with the restriction that the PPE needs to be part of the solution. A pure motorcycle based solution might not be sufficient to estimate the injury severity. Linked to the MSD the output of the severity estimation has to be specified. A first proposal could be a four-stage concept and the related measures which are taken:

0. No injury severity estimation available
1. Light severity (AIS 0-1) → waiting on response on a call
2. Medium severity (AIS 2-3) → send ambulance and try to call
3. Heavy severity (AIS4+) → send ambulance and helicopter directly

Within this project it was out of scope to look more deeply into the consequences and impact of a severity estimation extension. Hence, it is proposed to work on this topic in a follow-up future project. Within this follow-up project, useful ratings and measures in collaboration with the emergency center should be defined. Moreover, requirements and test proceedings for such a system have to be defined.

7 Summary and outlook

Within this document three major topics were discussed: First the potential impact of eCall systems on motorcycle safety, second the determination of the necessity for a particular eCall trigger mechanism and the predictability of the expected injury severity of an incident.

In the first part the general accident situation of P2W was introduced, before looking closer at the situation in the Europe Union and subsequently in specific European countries in more detail. The P2W casualties in Europe were estimated to be 287 871 in 2014, of which 4,564 were fatalities and 44,515 with serious injuries. Statistics showed that fatal P2W accidents were more likely to occur in rural areas. Then the principles of rescue chains in Europe were presented and using three accident scenarios the impact of eCall systems on the rescue chain were discussed. As next step a crucial review of eCall benefit studies was presented. The review concluded that there are only a small number of real eCall benefit studies available and these mainly cover passenger cars. Hence, a different approach was adopted to estimate the eCall potential. As a result, a high benefit potential is expected from an eCall system for up to 14.514 [5%] casualties per year in Europe, assuming an eCall installation rate of 100% for motorcycles. This includes 30% of all fatally and seriously injured P2W users. These numbers provide an initial indication of the expected benefit of eCall for motorcycles. However, for a more precise benefit estimation and precise reduction potentials, further analysis has to be done.

The second part of this report deals at first with improvement potential for determining the necessity of an eCall launch using statistical methods. As a result a decision accuracy of 80% for a logistic model and 90% for random forest was achieved. Based on simulations, a severity estimation method for P2W was formulated for an advanced eCall system along with its requirements. The goal for this eCall extension is to improve the rescue chain by using accurate severity information and also to reduce the number of unnecessarily activated eCalls. One result was, that for most accidents scenarios the motorcycle collision velocity and collision angle to the opponent is crucial for the severity of the accident. For most cases such information could be determined by an in-vehicle system only. Further it was shown that for other cases, where the rider was separated from the bike and hence experience significant other loads than the bike, additional sensor data of the rider are needed for a precise severity estimation.

In the future, further analysis should be done on the presented topics, for example a fundamental estimation of the expected benefit by an eCall system for motorcycles. To improve European road safety continuously, the expected benefit of using accident severity information should be exploited, in particular its potential to avoid unnecessary eCall launches. In order to do this, the presented approaches should be further analysed before commercialisation.

The main takeaways are again summarized here:

P2W accident situation:

- 1.2 million traffic fatalities worldwide in 2013
- Of which 23% were P2W users.
- In 2016, casualties caused by traffic accident in Europe were estimated to 1.86 million casualties.
- Injured P2W users account for 15% in all casualties, 18% in all fatalities and 17% in all seriously injured road users in Europe.

Organization of rescue chains in Europe :

- Main benefit eCall expected for accidents at night, in single vehicle accidents, high severity, in rural areas or abroad.

eCall potential estimation

- Available studies point out that the total number of fatalities could be reduced up to 3% - 8% and up to 10% for seriously injured (depending on the country) assuming an eCall system installation rate of 100%.
- In Europe, up to 14.514 P2W users (5%) could have a high benefit potential by an eCall System. This includes 30% of all fatally and seriously injured P2W users.

Determine eCall relevance by statistical methods:

- Up to 90% distinction accuracy for the necessity for a particular eCall trigger by statistical methods can be achieved.
- The random forest method is with 90% accuracy better than the one of the multinomial logistic model (80%). The multinomial logistic model however provides an easier interpretation of its parameter.

Severity prediction model:

- Two prototypical injury severity estimation models were analyzed.

- For bike-to-vehicle accidents at least collision speed and collision angle are needed to get an accurate severity estimation for an in-vehicle system only.
- For single P2W accidents additional sensors on the rider are needed for a more accurate estimation.

8 References

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5.8. M28 – State of the art definition of a eCall equipped Powered 2 Wheel prototype

M28 - State of the art definition of a eCall equipped Powered 2 Wheel prototype

Harmonised eCall European Deployment

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1 INTRODUCTION

1.1 Purpose of Document

The purpose of this deliverable document "M28 – State of the art definition of an eCall equipped Powered 2 Wheel prototype" is to summarize the results achieved in the sub-activity A3.6 "Retrofit" concerning the state of the art of the OEM solution and to describe the corresponding modifications needed to fit an aftermarket P2W eCall retrofit system.

For the complete description of the retrofit solution hence refer to the document "A3.6 – Retrofit. Final Report" [1]

This document has a strong basis on the sub-activity 3.4 where it is been defined the Functional Description, Triggering algorithm and Global architecture of the P2W eCall system for a OEM solution.

Tanking this in to account I_HeERO sub-activity 3.6 group has defined a new architecture by considering specific issue of the retrofit device

In this analysis, the I_HeERO sub-activity 3.6 experts focused on the limitations of the eCall aftermarket system positioning, the access to internal communications and installation difficulties in order to define the functionalities through a system which is not installed by default in the vehicle.

These issues are explained in detail hereinafter.

- Section.2 Retrofit functional description, which explains the minimum set of functions necessary to guarantee an eCall retrofit device performance in a P2W vehicle
- Section 3 Analysis of specific issues for triggering which indicates how to deal with the defined algorithm not having access to the motorcycle sensors.
- Section 4 HMI for retrofit devices which defines the minimum requirements for the rider interface.
- Section 5 Global architecture where it is summarized the requirements for the proposal architecture of a retrofit P2W eCall system.

1.2 I_HeERO Contractual References

I_HeERO stands for Infrastructure Harmonised eCall European Pilot.

I_HeERO is an action under the Grant Agreement number INEA/CEF/TRAN/A2014/103743 and the project duration is 36 months, effective from 01 January 2015 until 31 December 2017. It is a contract with the Innovation and Networks Executive Agency (INEA), under the powers delegated by the European Commission.

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2 RETROFIT FUNCTIONAL DESCRIPTION

In general, the Functional Description of a system designed for OEM applications (described in detail in the report of the sub-activity 3.4, section 2 – “Functional description” [2]) **also applies to Retrofit devices**.

Here **only the differences between the OEM and Retrofit solution, in terms of functional description, are highlighted**.

For the complete description of the functional description hence refer to the document “M26_D3_4_BasicArchReco” [3].

The configuration in Figure 1, in the exception done by I_HeERO experts, identifies the so-called “Minimum Requirements”, which represent, by definition, the minimum set of functions necessary to guarantee an eCall performance in a P2W vehicle.

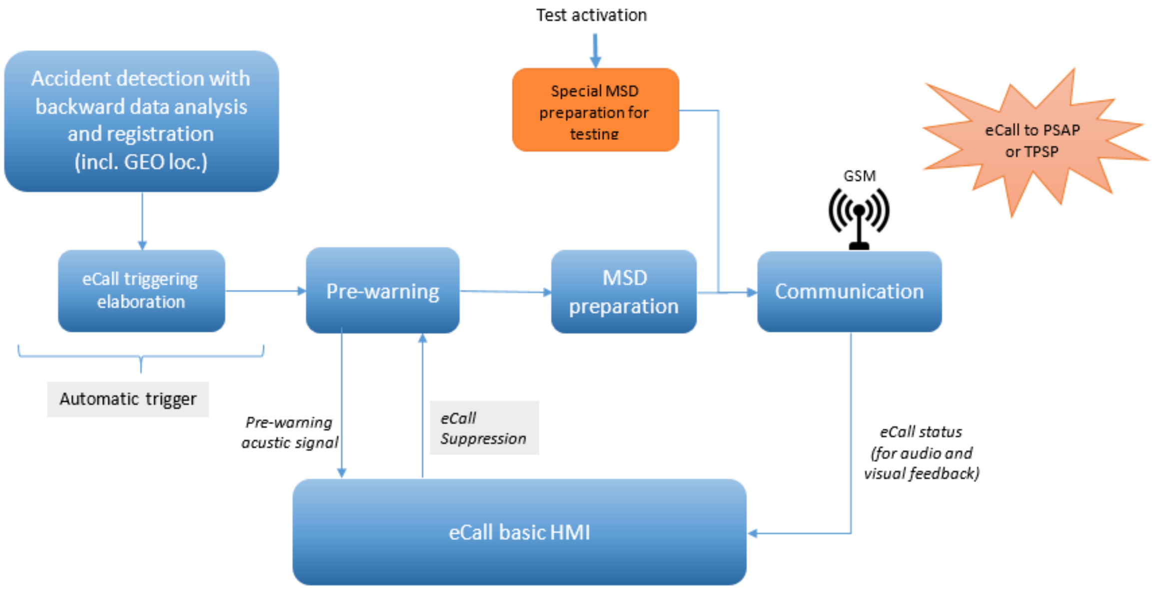

Figure 1. Macro-function

By looking at Figure 1 it is possible to identify 3 main steps in the eCall sequence:

1. Automatic trigger detection - the IVS, by using dedicated and vehicle's sensors detect the conditions for triggering an eCall, prepare geo-localisation information necessary for the accident positioning and assembly information for the MSD.

2. Pre-warning – before launching the eCall, the IVS wait for a time of 20÷30s allowing the rider to suppress the call sequence because the injury level is judged by himself not requiring rescue.

3. eCall launch, Communication – pre-warning time is expired and the eCall is then generated starting the data communication with the PSAP or a TPS. After the pre-warning time the call cannot be stopped by the rider, only the PSAP or the TPS can do this operation.

By considering the top-level finite-state machine describing the functional behaviour of the system (Figure 2), it has to be noticed the presence of a "**main-switch**" signal.

In an OEM solution this main-switch refers to the "key-status", which is a signal directly available in an OEM implementation of the system.

In a Retrofit solution, the "main switch" signal must be maintained, but it requires more attention in its implementation. The "main switch" signal can be managed alternatively:

- DIRECTLY, with a wired connection of the retrofit device with the vehicle, capable of measuring the key-on/key-off status of the vehicle (this solution could be complex since it is highly vehicle-dependent and since it requires a non-trivial installation procedure).
- INDIRECTLY with a "virtual-key" signal (already largely used in insurance telematics boxes), that performs an estimation of the key-status of the vehicle using only internal sensors of the retrofit device (typically GPS and accelerometers). This can be done (for instance) by checking the speed (with GPS) and the vibration/movement energy detected by the accelerometers (warning: in electric vehicles the "virtual-key" implementation could be particularly tricky since at key-one and vehicle still there are no vibrations generated by the internal-combustion-engine)

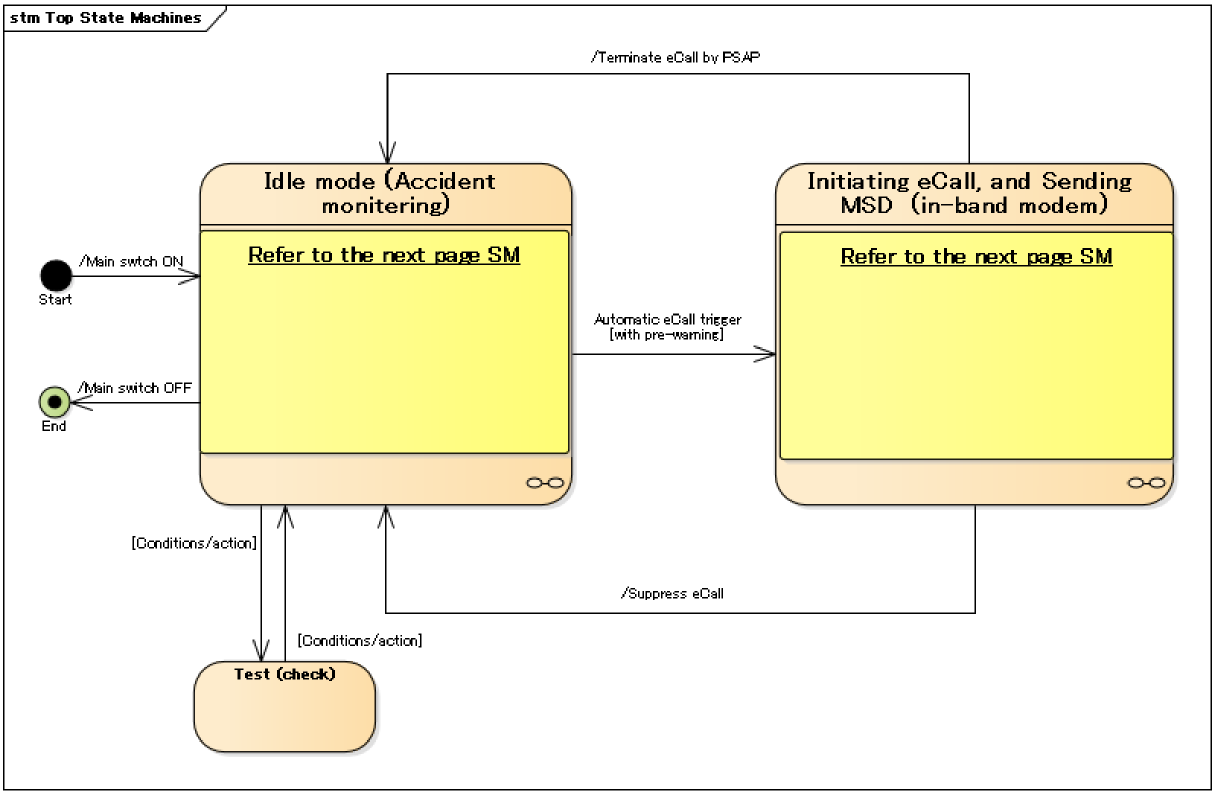

Figure 2. Top state machine

3 ANALYSIS OF SPECIFIC ISSUES FOR TRIGGERING

In general, the triggering criteria and strategies of a system designed for OEM applications (described in detail in the report of the sub-activity 3.4, section 3 – “Criteria for triggering” - and 4 -”Meta-algorithm for minimum requirement” [4]) **also applies to Retrofit devices**.

Here **only specific differences between the OEM and Retrofit solution, in terms of functional description, are highlighted**.

Issue # 1: speed measurement

In the meta-algorithm description, among other parameters, the following parameters play an important role:

- **Vmin** [m/s]: defines the minimum speed that the vehicle must have within the full monitoring window (see meta algorithm)
- **Vdeadzone** [m/s]: defines the near-zero speed range (near-zero-speed dead zone). This parameter is motivated by the fact that a speed sensors can be subject to some noise and can provide a small non-zero value of the speed even when the motorcycle is perfectly still

In an OEM-implementation, it is assumed that the vehicle speed can be measured directly from encoders installed on the wheels. The speed signal hence is highly reliable and affected by comparatively low measurement noise.

In a Retrofit solution, the vehicle speed is typically measured with a GPS system. A GPS-based speed measurement is highly dependent on the quality and availability of the signals from the satellites. Hence, specific tuning of the speed-based parameters and specific (additional) algorithmic solutions must be implemented.

Issue #2: accelerations.

In the meta-algorithm description, among others, the following internally-computed variables play an important role:

- VHPx(t) is an estimation of the longitudinal speed obtained by numerical integration AND High-Pass filtering of the longitudinal acceleration (High-Pass filtering is needed to avoid drifting; High-Pass filtering emphasizes only fast and strong events).
- VHPy(t) is an estimation of the longitudinal speed obtained by numerical integration AND High-Pass filtering of the lateral acceleration.

Such variables are typically computed starting from a 2-axis Inertial Measurement Unit (IMU), constituted by two accelerometers.

Whereas in a OEM implementation the correct orientation (X and Y vehicle body-reference axis alignment) and the correct vibration-filtering (vibrations typically coming from internal combustion engines) is guaranteed by the Motorcycle-Maker, in a Retrofit solution the (wrong) orientation and the vibration-sensitivity are potentially highly dependent by the installation procedure (and by the installing person).

To this end, the Retrofit solution must be designed in order to carefully take into account these issues (e.g. by software self-alignment using a 3 Degree of Freedom IMU and using vibration damping supports).

4 HMI FOR RETROFIT DEVICES

In general, the HMI of a system designed for OEM applications (described in detail in the report of the sub-activity 3.4, section 3 – "Basic Architecture Recommendations" [4]) **also applies to Retrofit devices but** with some slight modifications.

However, in this section a deep analysis of the eCall-similar retrofit devices is done in order to research **the differences between the OEM and Retrofit solution, in terms of HMI**.

It will be shown the results of a market research for similar to eCall devices which are suitable for an application on P2W.

This analysis and the previous work done in A3.1 T4 - Prototype and A3.4 T1 – Functional Description will lead to a HMI retrofit solution proposal for minimum requirements.

4.1 P2W eCall Challenges

The main difficulty for a P2W eCall system from the HMI point of view is the possible separation between the motorcycle and the rider in an accident situation. It is obvious, that the rider will be separated from the bike in case of a crash, because normally there are no mechanical occupant restraint systems available on a motorcycle.

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 of the accident. On a motorcycle, this is far more difficult because the P2W may not have inherent support for a voice communication available to the rider or if so, the probability of been the rider too far away from the motorcycle in order to answer any voice communication is very high.

Therefore, the meaningfulness of a mandatory voice connection has to be investigated and an alternative solution should be found.

Another important 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 and the crash resistance of all elements within its defined characteristics should be guaranteed.

4.2 Market product analysis

After a market research, some common features among the existing retrofit devices that fits this application were found, those are the following ones:

- **Sensor:** the acceleration carries the information of the impact caused by a crash or a fall down. In vehicle sensors of a motorcycle represent the most robust solution. Other sensors, such as tilting, contact or gyroscope sensors have been used for detecting the position of the subject.

- **Responders:** this feature implicitly shows the acceptance of crash detection algorithms. Direct call to emergency responders (911 for USA or 112 for Europe) requires a total absence of false alarm, while sending text messages to preselected numbers is a less constrained solution. Callback procedure does not require total absence of wrong notification but still needs high rejection of them.
- **Communication:** the type of communication could be text message (to specific operators or preselected numbers), callback procedure (to 911, 112 or company operators) or direct call.
- **Integrated communication:** an integrated GSM module (or other type of communication) is preferable in order to avoid the need of a connection of the smartphone to the device because an external phone can be damaged during an accident.
- **Portability:** the device can be used in different vehicles and the driver can share his safety system with familiar or friends.
- **eCall cancelation:** not having any false alarms is a key factor of the system, thus, many devices integrates a call cancelation mode. The cancelation could be done with voice connection once the call is launched or pushing a button before the triggering time.

In summary, after the study of the motorcycle devices, which is the main objective of this analysis, it could be concluded that:

- The accelerometer sensor is the most adopted choice for detecting an impact.
- A lean angle sensor is also integrated for the detection of fall downs or critic manoeuvres.
- A panic button for manual triggering is included in many devices.
- The preferred choice is to notify operators of the company of the product. Direct call to emergency authorities is rarely used so far due to the possibility of false alarm.
- Generally the call-back procedure is the most widespread option. This alternative is linked with the operators' service.
- It is preferable to integrate the GSM module and fix the component to the motorcycle owning to the fact that there is a high possibility of damaging drivers' smartphone.
- The analysed devices are mainly not portable.

4.3 eCall indispensable information

Concerning the HMI design, it was analysed what is the indispensable information the eCall system should gave to the motorcycle driver.

The HMI system may lead the driver some decision freedom. Presuming that the system will be automatically triggered in case of a crash, to give the driver the capability of cancelling the eCall if no help is needed. Or in contrast, having an emergency and if the eCall has not been triggered, the capability of making a manual call.

For this aim, it was considered that the driver should be informed of the status of the eCall system every moment in order to value the situation and act in consequence. The following ones are some of the questions this HMI should answer to:

- Is the system activated?
- Is the system currently making an eCall?
- How can I know if the eCall was launched and emergency services are on their way?
- How to cancel the eCall?

4.4 HMI Normative Review

In this chapter a complete review of the vehicle system normative was done regarding the HMI:

Norms Recommendations	Number	**Title**
ISO/IEC	14229	Road vehicles-**Unified diagnostic services** (UDS)-Part 1: Specification and requirements
UNE-EN ISO	15005	Road vehicles -- Ergonomic aspects of transport information and control systems -- **Dialogue management** principles and compliance procedures.
ISO	15006	Road vehicles-Ergonomic aspects of transport information and control systems-Specifications and compliance procedures for in-vehicle **auditory** presentation
UNE-EN ISO	15008	Road vehicles -- Ergonomic aspects of transport information and control systems -- Specifications and test procedures for in-vehicle **visual** presentation
ISO	16673	Road vehicles-Ergonomic aspects of transport information and control systems-Occlusion method to assess **visual demand** due to the use of in-vehicle systems
ISO/TS	16951	Road vehicles-Ergonomic aspects of transport information and control systems (TICS)-Procedures for determining **priority** of on-board messages presented to drivers
UNE-EN ISO	17287	Road vehicles -- Ergonomic aspects of transport **information and control systems** -- Procedure for assessing suitability for **use while driving**
ESoP-European Comission		European Statement of Principles on the **Design of Human Machine Interaction**

Table 1. Summary of the HMI Normative Review

It is important to point out the results gathered in the last document:

European Statement of Principles on human-machine interface (ESoP July 2008) [5] proposed some recommendations on safe and efficient in-vehicle information and communication systems.

Regarding the System behaviour principles it is worth stressing the following ones:

4.3.5.4. System behaviour principle IV

Information should be presented to the driver about current status and any malfunction within the system that is likely to have an impact on safety.

On the other hand, concerning the information about the system principles, those are the main ones:

4.3.6.2. Information about the system principle II

System instructions should be correct and simple

4.3.6.5. Information about the system principle V

Product information should be designed to accurately convey the system functionality.

Therefore, as a conclusion the HMI for a retrofit solution should be clear, simple and functional. The information should be factually correct and presented transparently and without ambiguity and it should also promote high acceptance of instructions by drivers. In addition, it is a necessary condition to ensure that the ability of the driver to be in full control of the vehicle is not affected (in a way, which compromises safety) by the behaviour of the information and communication system during normal operation or failure.

4.5 Decisions made about HMI for OEM' solution

Based on the A3.4 T1 Functional Description discussion done in October 2016 those are the minimum requirements defined for OEM devices:

	Pre-warning/ Cancellation on Manual triggering	Manual triggering	V=0	V>20 Km/h	Microphone	Speaker	Bluetooth	Additional MSD flag
BOSCH	X	X	X	-	-	-	-	X
BOSCH2	-	-	-	-	-	-	-	-
PIAGGIO	-	-	-	-	-	-	-	X
YAMAHA	-	-	-	-	-	-	-	-
BMW	-	-	-	-	-	-	-	-
KTM	-	-	-	-	-	-	-	-
HONDA	-	-	-	-	-	-	-	-
POLIMI	X	X	X	-	Cost?	-	-	X
CEIT	X	X	X	-	Cost?	-	-	X
DIGADES	X	X	X	-	-	-	-	X
CETEM	X	X	X	-	Cost?	Cost?	Cost?	X
UNIMORE	X	X	X	-	X	-	-	X
Result	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**

Figure 3. Functional description for manual triggering

As it is shown in Figure 3 the Activity 3 experts considered no necessary to include manual triggering and if optional, the additional MSD flag should be used.

	Pre warning	Automatic triggering	Microphone	Speaker	Bluetooth	Additional MSD flag
BOSCH	X	X	-	-	-	X
BOSCH2	X	X	Cost?	-	-	X
PIAGGIO	X	X	-	-	-	X
YAMAHA	X	X	-	-	-	X
BMW	X	X	-	-	-	X
KTM	X	X	-	-	-	X
HONDA	X	X	-	-	-	X
POLIMI	X	X	-	-	-	X
CEIT	X	X	-	-	-	X
DIGADES	X	X	-	-	-	X
CETEM	X	X	-	-	-	X
UNIMORE	X	X	Cost?	-	-	X
Result	**Yes**	**Yes**	**No**	**No**	**No**	**Yes**

Figure 4. Functional description for automatic triggering

For the automatic triggering system, it was considered to include a pre-warning which postpones the eCall to be launched just after the crash detection. The audio connection is not included in minimum requirements.

Based on the decision above and focusing specially on the HMI management solution this is the proposal done for the OEM devices.

#	STATUS	Audio and visual feedback	
		Audio (i.e., buzzer)	Visual (i.e., LED telltale) eCall
1	IDLE (Accident Monitoring) & eCall system diagnosis = OK	Nothing	OFF
2	IDLE (Accident Monitoring) & eCall system diagnosis = NG	Long noise (ex. 3s or more)	ON
3	Accident Detected → pre-warning	High rate sound [1] (synchro with blinking)	High rate blinking
4	Accident Detected → Automatic eCall launched	Double long sound [1]	Low rate blinking
5	Suppression by pushing button	Single long sound (feedback on button pushing, less than 3s)	OFF
6	Termination by PSAP	Nothing	OFF

Table 2. OEM solution proposal with single indicator for minimum requirements

This proposal uses a single indicator which would interpret six different status of the eCall system. This minimum information will arrive by two different channels, audio with a buzzer and visual with a LED tell-tale.

4.6 HMI retrofit solution proposal for the minimum requirements

The retrofit solution could adopt the same HMI proposal of the OEM solution by using a single indicator interface.

However, since the system is not installed by default, it is considered necessary to have a tell-tale which indicates the correct functioning of the system. On the other hand, due to the fact that the OEM solution is already defined and to facilitate its introduction to the market it was agreed not to change the meaning of the eCall led but to include an additional one which would show the status of the retrofit system.

Taking all this points into account, the retrofit HMI proposal for the minimum requirements is the following one:

#	STATUS	Audio and visual feedback		
		Audio (i.e., buzzer)	Visual (i.e., LED telltale) eCall	System ON Aftermarket
1	IDLE (Accident Monitoring) & eCall system diagnosis = OK	Nothing	**OFF**	**ON**
2	IDLE (Accident Monitoring) & eCall system diagnosis = NG	Long noise (ex. 3s or more)	**ON**	**ON**
3	Accident Detected → pre-warning	High rate sound [1] (synchro with blinking)	High rate blinking	**ON**
4	Accident Detected → Automatic eCall launched	Double long sound [1]	Low rate blinking	**ON**
5	Suppression by pushing button	Single long sound (feedback on button pushing, less than 3s)	**OFF**	**ON**
6	Termination by PSAP	Nothing	**OFF**	**ON**

Table 3. Retrofit solution proposal with single indicator for minimum requirements

5 GLOBAL ARCHITECTURE

In general, the Global Architecture of a system designed for OEM applications (described in detail in the report of the sub-activity 3.4, section 3 – "Basic Architecture recommendations" [4]) **also applies to Retrofit devices**.

Here **only the differences between the OEM and Retrofit solution, in terms of global architecture, are highlighted**.

For the complete description of the global architecture hence refer to the document "A3.4 T3 – Basic Architecture Recommendations" [4].

5.1 Basic Architecture Recommendations from OEM solution

For the design of an eCall in-vehicle system for Powered Two-Wheeler it was necessary to identify the issues that must be kept into consideration when dealing with L3 class vehicles.

After a deep analysis done by the I_HeERO Activity 3.4 group, the basic architectural proposal result on the following schema (see Figure 15).

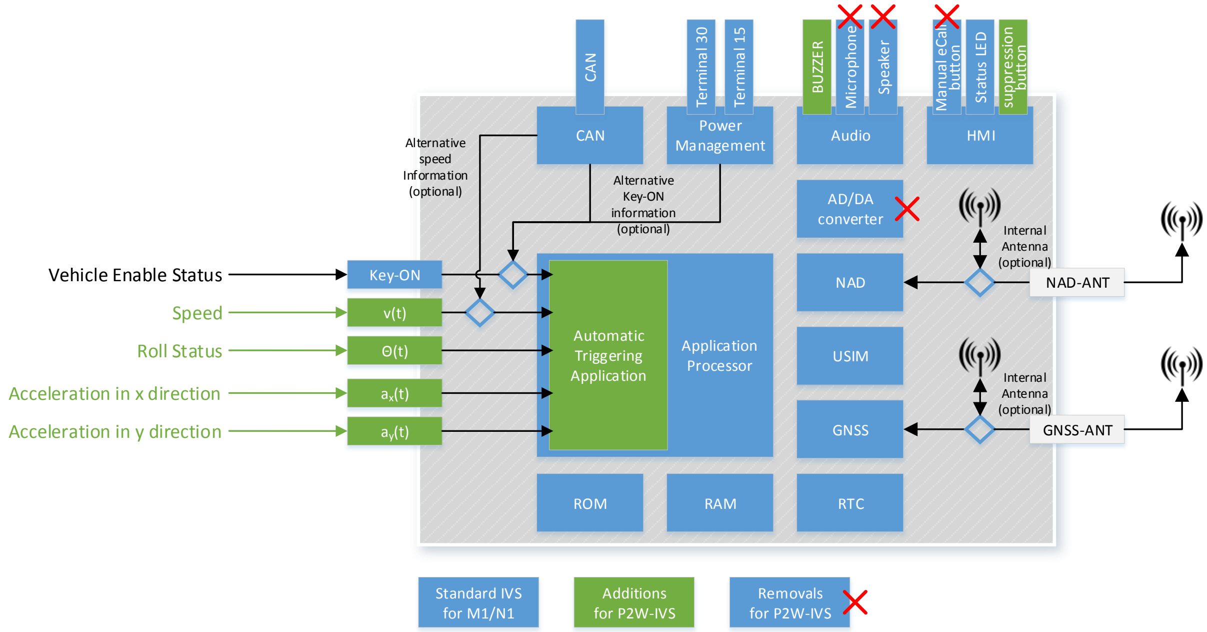

Figure 5. Functional blocks of an in-vehicle system for P2W

Starting from the functional blocks of an in-vehicle eCall system for M1/N1 class vehicles (highlighted in blue) there are additions and removals recommended for a P2W application. This blocks are described into detail in A3.4 T3 Report [4].

5.2 Main conclusions and Recommendations for Retrofit Solution

In general, the basic architecture recommendations for the global architecture of OEM fitted eCall devices provided by the final report of A3.4 T3, which are also valid for retrofit devices expect of a very few issues that are described next:

1. The retrofit HMI solution differs from the OEM solution is already described in chapter 4.7 of this report. This modification is due to the necessity of informing the driver about

the system readiness and available power supply in order to give the perception that the nomad system is working properly, I_HeERO experts see necessary to include and additional LED in the OEM HMI solution.

2. For the OEM solution in chapter 4.2.6 of the A3.4 T3 report the use of internal antennas both for GSM and GNSS is recommended as the connection of external antennas are costly and also a main risk for failures especially in severe crash situations.

   Nevertheless, even though for OEM solution with a special designed place for the eCall unit this might be an appropriate recommendation, in case of a retrofit device this needs to be studied. For retrofit solution there is the additional challenge of differing installation location with a sufficient mechanical protection to ensure a crash safe position of the device. The aim of a crash safe location contradicts the requirement of a good radio reception for the GNSS signal. In the other hand, about the GSM signal a sufficient signal quality can also be achieved when the eCall unit is mounted in a crash safe location.

   Therefore, for the retrofit solution the use of an external GNSS antenna is recommended, whereas for the GSM signal an internal antenna can be used.

Thus, the Basic Architecture Recommendation for a P2W in-vehicle retrofit system is shown in the next Figure:

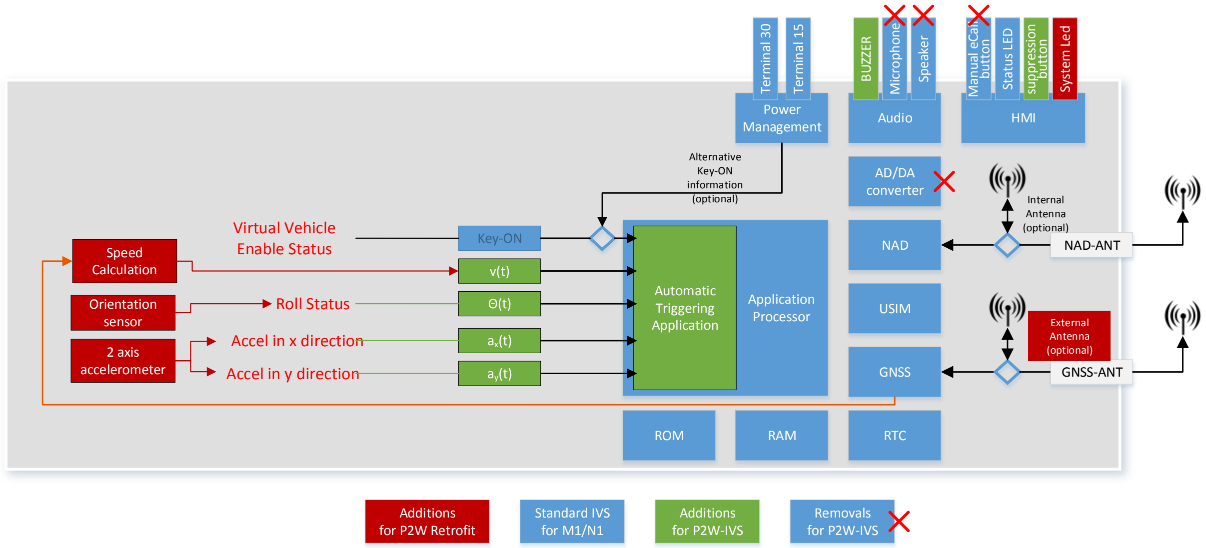

Figure 6. Functional blocks of an in-vehicle retrofit P2W system

Note that apart from the System Led and the External GNSS Antenna the Global Architecture for a P2W retrofit device should include additional sensors and calculations for the implementation of the triggering system which is based on the signals Key-ON, Roll Status, Speed and Accelerations as it was defined at Section 3 of this document.

REFERENCES

[1] *I_HeERO Activity 3 "A3.6 – Retrofit. Final Report",* 2017.

[2] *I_HeERO Activity3, "A3.4 T1 - M1, Functional Description - 20161115",* 2016.

[3] *I_HeERO Activity 3 "M26 – Basic Architecture Recommendations",* 2017.

[4] *I_HeERO Activity3, "A3.4 T3 – Basic Architecture Recommendations",* 2017.

[5] C. o. t. E. Communities, "2008/653/EC – European statement of principles on human machine interface for in-vehicle information and communication systems. Official Journal of the European Union.," [Online]. Available: http://eur-lex.europa.eu/le. [Accessed 2008].

5.9. M29 – Homologation process proposal for retrofit solutions

M29 - Homologation process proposal for retrofit solutions

Harmonised eCall European Deployment

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Lead contractor:	CEIT
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Prepared	Olatz Iparraguirre (CEIT)		30/10/2017
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1 INTRODUCTION

1.1 Purpose of Document

The purpose of this deliverable document “M29 – Homologation process proposal for retrofit solutions” is to provide some recommendations regarding the installation of the eCall system as a retrofit device to support the on-going preparation of draft Technical Standard document for the extension of eCall from M1/N1 vehicle categories to other categories including P2W

For this aim, the I_HeERO Activity 3 experts have studied the limitations of the eCall aftermarket system positioning, the access to internal communications and installation difficulties in order to define the functionalities for a nomadic device.

For the complete description of this study hence refer to the documents “M28_State_of_the_art_definition_of_eCall_equipped_P2W_prototype” [1] and “A3.6 – Retrofit. Final Report” [2]

In addition, for the definition of the test requirements for P2W retrofit devices, this sub-activity was based on the previous work of the sub-activity A3.2-Verification Requirements.

For the complete description of this study hence refer to the document “M24_D3_2_Verification_Requirements” [3]

1.2 I_HeERO Contractual References

I_HeERO stands for Infrastructure Harmonised eCall European Pilot.

I_HeERO is an action under the Grant Agreement number INEA/CEF/TRAN/A2014/103743 and the project duration is 36 months, effective from 01 January 2015 until 31 December 2017. It is a contract with the Innovation and Networks Executive Agency (INEA), under the powers delegated by the European Commission.

Communication details of the Agency:

Any communication addressed to the Agency by post or e-mail shall be sent to the following address:

> Innovation and Networks Executive Agency (INEA)
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> Avenue du Bourget, 1
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For Niedersächsisches Ministerium für Wirtschaft, Arbeit and Verkehr: Michael Schäfer Friederickswall 1, 30159 Hannover, Germany

e-mail address: iheero@mw.niedersachsen.de

2 FUNCTIONAL TEST CASES FOR IVS

In an overall view, the functional test cases for IVS described in detail in the report of the sub-activity 3.2, section 5 – "Verification Requirements" [3] **also applies to Retrofit devices.**

For the complete description of this requirements hence refer to the document "M24_Verification requirements" [3].

The objective of I_HeERO Activity 3 group to provide some recommendations for the verification of the IVS for P2W retrofit device. This tests are not described into detail, those are just some clues that should be evaluated further in order to make a complete definition of verification requirements.

In order to fulfil the functional test cases the European Standard EN 16454 [4] provides to demonstrate compliance of in-vehicle eCall systems to eCall Standards it is needed to test **IVS activation**, **GNSS module** and **Communication module**. However, it is not required those test related to **voice connection** and **manual triggering** eCall.

On the other hand, in order to check the correct functioning of the eCall triggering algorithm developed by I_HeERO Activity 3 group it is necessary to make an **eCall automatic triggering test**. For this aim, sub-activity 3.2 defined some test which covers no-trigger cases as well as must-trigger cases. (Please refer to document "M24_Verification requirements" Section 5.3 Automatic eCall: No-Trigger tests and Section 5.4 Automatic eCall: Must-Trigger tests)

2.1 Validation test with a laboratory prototype

This validation test does not represent how the validation of a real P2W retrofit device should be done. The aim of this section is just to show how the validation of a laboratory prototype developed by IHeERO Activity 3 group has been addressed.

2.1.1 Prototype

Sub-activity 3.6 group has designed a laboratory prototype, which implements the HMI requirements defined in the document "M28_State_of_the_art_definition_of_eCall_equipped_P2W_prototype" [1]. Additionally to the HMI functionality tests, it has been designed for the validation of data transmission and voice connection via in-band modem.

This prototype integrates a software developed by CEIT for the definition of the accident scenario and the reception of the accident data. It consist of:

-**MSD Generator.** IVS emulator PC that encodes the corresponding MSD and sends the message to the motorcycle.

-**IVS interface.** The motorcycle HMI itself, which enables to trigger the eCall and makes the corresponding audio/visual signal. It also includes a cancelation button.

-**MSD Decoder**. PSAP emulator PC that receives the eCall. It checks the data reception, displays the accident information on the screen and makes the voice connection with the IVS interface.

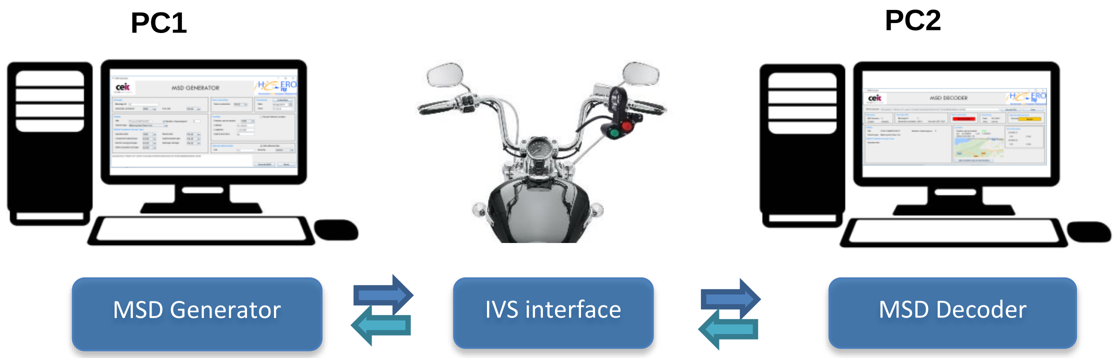

Figure 1. Sub-activity 3.6 prototype

2.1.2 Validation laboratory test

With this laboratory prototype, the data transmission and voice connection via in-band modem has been checked in order to fulfil the EN 16454 [4] requirements. The whole eCall communication chain since the MSD has been generated until the data arrives to the PSAP emulator PC is explained in the following figure:

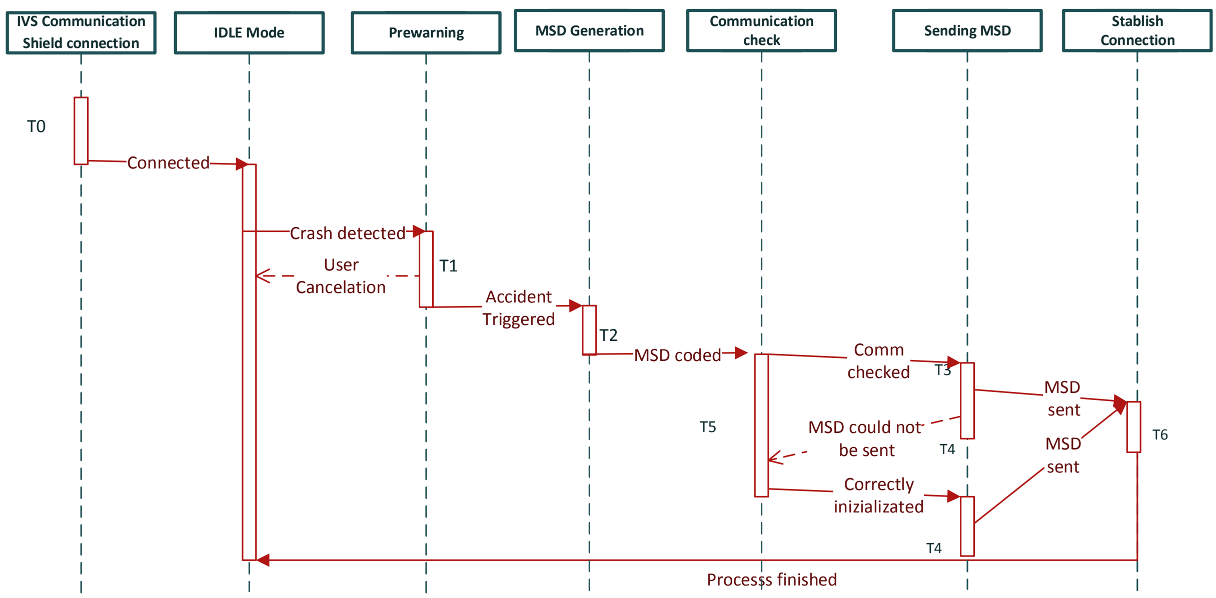

Figure 2. Message submission sequence

The timing parameters (T0 – T6) evaluated for the verification of EN16454 [4] requirements are described below together with the results:

Time	Description	Mean Value (s)
T0	Time to initialize communication module	33.0
T1	Prewarning time	20.0
T2	MSD codification	0
T3	Time to send the MSD to PSAP	1.7
T4	Time to detect an error occurred sending the MSD to PSAP	5.0
T5	Time to re-initialize the communication in case of error sending MSD	34.0
T6	Time to initialize the connection with PSAP	13.5

Table 1. Results of evaluated timing parameters for EN 16454 verification

This table summarizes the results of several test done in the validation process.

Note that the time needed for the initialization of the communication module (T0) is done just after the system is enabled and there is no need to repeat this process unless the communication system fails. On the other hand, MSD codification time (T2) is zero for the laboratory prototype because this task is done offline.

Additionally, the mean time for sending MSD to the PSAP depends on the threshold defined for the error detection (Threshold = 5 s, Mean Time = 1.7).

The time value defined by the EN16454 [4] standard regarding the maximum transmission time is 20 seconds. Therefore, considering that the eCall time is covered by T3+T6 of the table described above:

$$T3 + T6 = 1.7 + 13.5 = 15.2 \text{ s} \; \mathbf{< 20s}$$

It can be asserted that the eCall P2W laboratory prototype fulfils the requirements of the eCall end to end conformance testing regarding the data transmission.

3 INSTALLATION AND CERTIFICATION

Regarding the installation and certification issues it is noteworthy to differentiate between two different types of retrofit devices:

- **Full retrofit solution:** an eCall device which is prepared to fit any kind of motorcycle
- **OEM solution:** a prepared eCall solution to fit a specific motorcycle brand and model

The nature of this two solutions could lead to some different issues especially at the installation process.

3.1 Installation

Nowadays, some OEMs have already opened up their markets to the retrofit eCall systems for P2W. This, leaves open a new approach which is where the sensors should be positioned and how the connections should be addressed in different motorcycles in order to warranty its correct functioning. As it was described in “M28_State_of_the_art_definition_of_eCall_equipped_P2W_prototype” there are some main signals to take into consideration for P2W retrofit devices such as Key-ON, Roll Status, Speed and Accelerations. This issue could lead to serious limitations at the installation especially if the retrofit system should be prepared to fit any kind of motorcycle in a full retrofit solution.

Another issue of the installation of an eCall retrofit device is the first configuration of the system due to the fact that this could lead to data corruption such as introducing a false VIN number.

Based on the experience of the OEMs, the 75% of the customers do not consult to the manual for the installation process. For this reason and due to the fact that the eCall system is a device which compromises driving security, it is **strongly recommended to refer to the dealers or certified workshops** for the correct installation of the system and its certification.

3.2 Certification

3.2.1 First test

This first certification of the system could be done with an easy soft test for the validation that everything was trimmed in the installation (calibration of the sensors, connections etc.). At this step the VIN number should be provided in order to make a test Call. This call is ignored by the PSAP because the MSD sent has the test flag on but it ensures that all the communications are ready to be used.

3.2.2 Regular tests

The periodical technical inspection of category M vehicles is under discussion concerning tests of eCall IVS. The recommendation for P2W PTI concerning eCall IVS is to make no extra provisions in PTW until requirements for M category vehicles are available. These future requirements for M category vehicles shall be evaluated concerning feasibility for P2W.

Currently, I HeERO Activity 3 group see no necessary to have an additional regular test of the eCall system since the status is evaluated in the auto-diagnosis mode of the device itself.

4 OPEN ISSUES FOR P2W RETROFIT IMPLEMENTATION

Due to the extension of the P2W retrofit implementation issue, the scope of I_HeERO cannot cover all the detailed studies this problem requires by the end of the project. Therefore, the aim of this Section is to gather in summary the different approaches detected by I_HeERO Activity 3 consortium for future work on the implementation of P2W eCall retrofit devices:

- The **quality level of the components** need be ensured. The quality of the hardware used for the development of a P2W eCall retrofit device should be based in automotive standards
- The retrofit devices must be differentiated into:
  - Official dealer solution
  - Pure aftermarket solution
- The **installation process** need to be trustworthy. Safety devices which requires complex installation should not be installed by the customers
- **Homologation** process need to be assess
  - Quality assurance of triggering algorithm
  - Definition of a procedure for retrofit device certification
  - System verification. The validation in the laboratory conditions is easy, however, when the system is installed in the motorcycle the vibrations could compromised the reliability of the system.
- **Liability assessment** of the system need to be defined. In case of malfunction, who takes care about the responsibility?
- The **security level of the system** over the product life cycle need to be guaranteed (continuous upgrading)

5 REFERENCES

[1] *I_HeERO Activity 3 "M28_State_of_the_art_definition_of_eCall_equipped_P2W_prototype",* 2017.

[2] *I_HeERO Activity 3 "A3.6 – Retrofit. Final Report",* 2017.

[3] *I_HeERO Activity 3 "M24_D3_2_proposal_for_conformity".*

[4] *EN 16454:2015-12 "Intelligent transport systems - ESafety - ECall end to end conformance testing".*