EENA Operations Document

eCall Key Performance Indicators

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1   Executive summary

> *"The entire method consists in the order and arrangement of the things
> to which the mind's eye must turn so that we can discover some truth."*
> René Descartes- Rules for the Direction of the Mind: X.379

The goal of this document is to build a roadmap for Key Performance Indicators use in eCall services. It is clear that KPIs are a great tool to test a service's strengths and weaknesses. Yet, finding out what the correct data is and how to read it is challenging. How do we interpret the information so it can serve as a map to improvement?

This document will tackle these questions by outlining the best practices and objectives of eCall KPIs. Firstly, we will briefly introduce the eCall architecture and its crucial components. Secondly, we will explain the importance of KPI in setting objectives. We will then introduce the eCall KPI definition from HeERO[1] and its recent evolution. Moreover, we will discuss the outside elements influencing KPIs, such as car manufacturers and MNO services. We will identify the correct way to temper their influence. Lastly, we will submit some practical recommendations and set the needed requirements.

The document tries to highlight two main aspects of this topics:
1) eCalls involve more than just communication networks such the ones used for regular 112 calls and thus their quality is subject to different factors.
2) eCall quality has been so far officially defined and recorded in laboratory scenarios, where most situation have been replicated, but a mass deployment test environment hasn't been deployed yet.

1.1   Abbreviations, glossary, and references

All definitions of terms and acronyms related to 112 are available in the 112 Terminology EENA Operations Document[2]. The abbreviations not included in this document will be specified in the following chapters.

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[1] Harmonised eCall European Deployment project
[2] http://www.eena.org/uploads/gallery/files/operations_documents/2012_10_16_112terminology.pdf

2   eCall architecture

The eCall infrastructure covers different elements to make sure that the service is and the localization data are available at PSAP premises. This chapter presents a general view of the architecture, which will be used as a reference to define KPIs and critical elements in the next chapters.

2.1   components of an eCall

The 112 number is used to send data and to establish the voice channel between the passengers of the vehicle and emergency services. It is based on a quasi-simultaneous data and voice link over the same channel. The voice and data link is made with an in-vehicle device (IVS[3]) which has been specifically designed and standardised for eCall.

This approach guarantees an EU-wide availability of prioritised and free eCall data transmission through established 112 voice call mechanisms. In the case where the data is not sent or received for any reason, the eCall continues as a normal 112 emergency call. The eCall is received directly by a public (or under public mandate) safety answering point (PSAP) and decoded by means of an in-band modem[4] designed specifically for eCalls. The service will be free of charge for the citizen. M1 and N1 vehicles, i.e. passenger cars and light duty vehicles (in the future, other types of vehicles may be equipped with eCall but on a voluntary basis), will be equipped with the necessary technology with the same technical standards and the same quality of services objectives.


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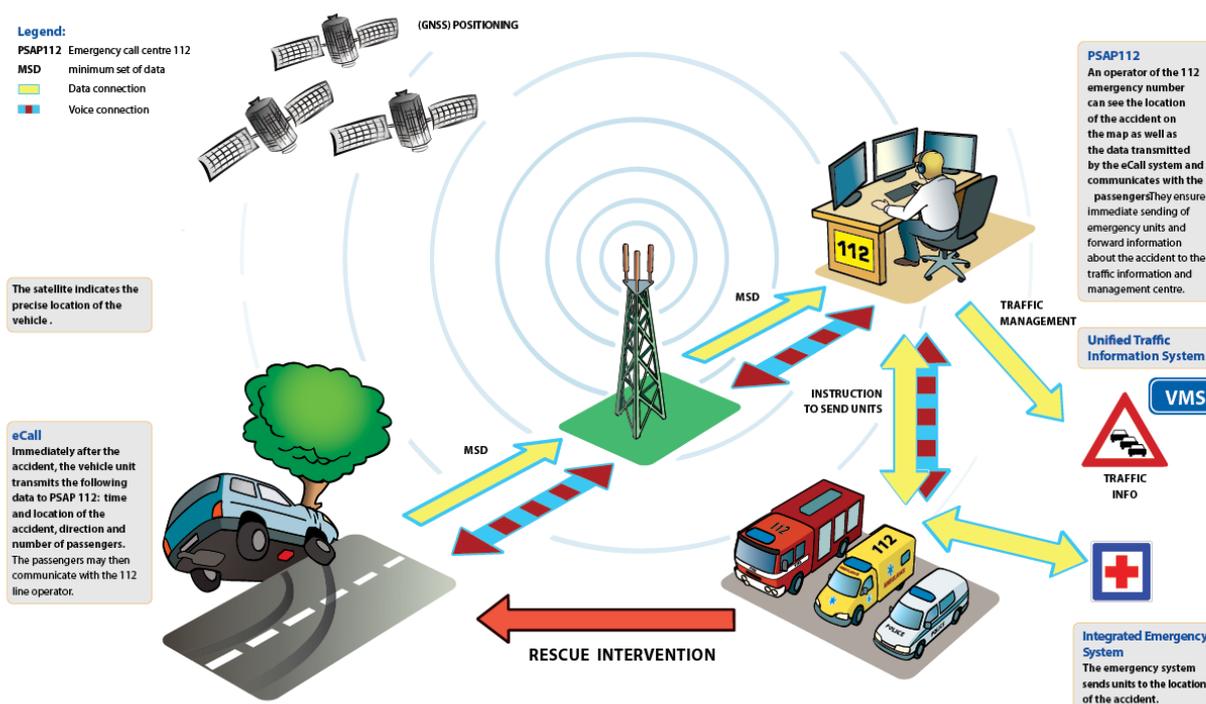
[3] IVS (In-Vehicle System) is an important element of the eCall infrastructure and is subject to KPI monitoring. See next chapters for more details.

[4] In-band modem is an important element of the eCall infrastructure and is subject to KPI monitoring. See next chapters for more details.

The eCall in-vehicle system is powered-up and initialised when the vehicle is started. After the triggering of the eCall (either manually or automatically), other communications that are in progress are suspended, if needed. Microphone and loudspeakers are fully dedicated to the emergency call. The in-vehicle system alerts the occupants that an eCall message is being sent. At the same time the in-vehicle equipment connects to the network[5] and the emergency call to 112 is established and routed to the most appropriate PSAP. Each vehicle manufacturer is responsible of the design of his vehicles, in terms of IVS device positioning and transmission capabilities (i.e. antennae[6] for GSM communication).

2.2 TPS eCall and differences with pan-European eCall

The TPS eCall management by the TPSP is divided into two steps and described in the following sections. The picture below shows a very high level generic picture of pan-European eCall process versus TPS eCall process.
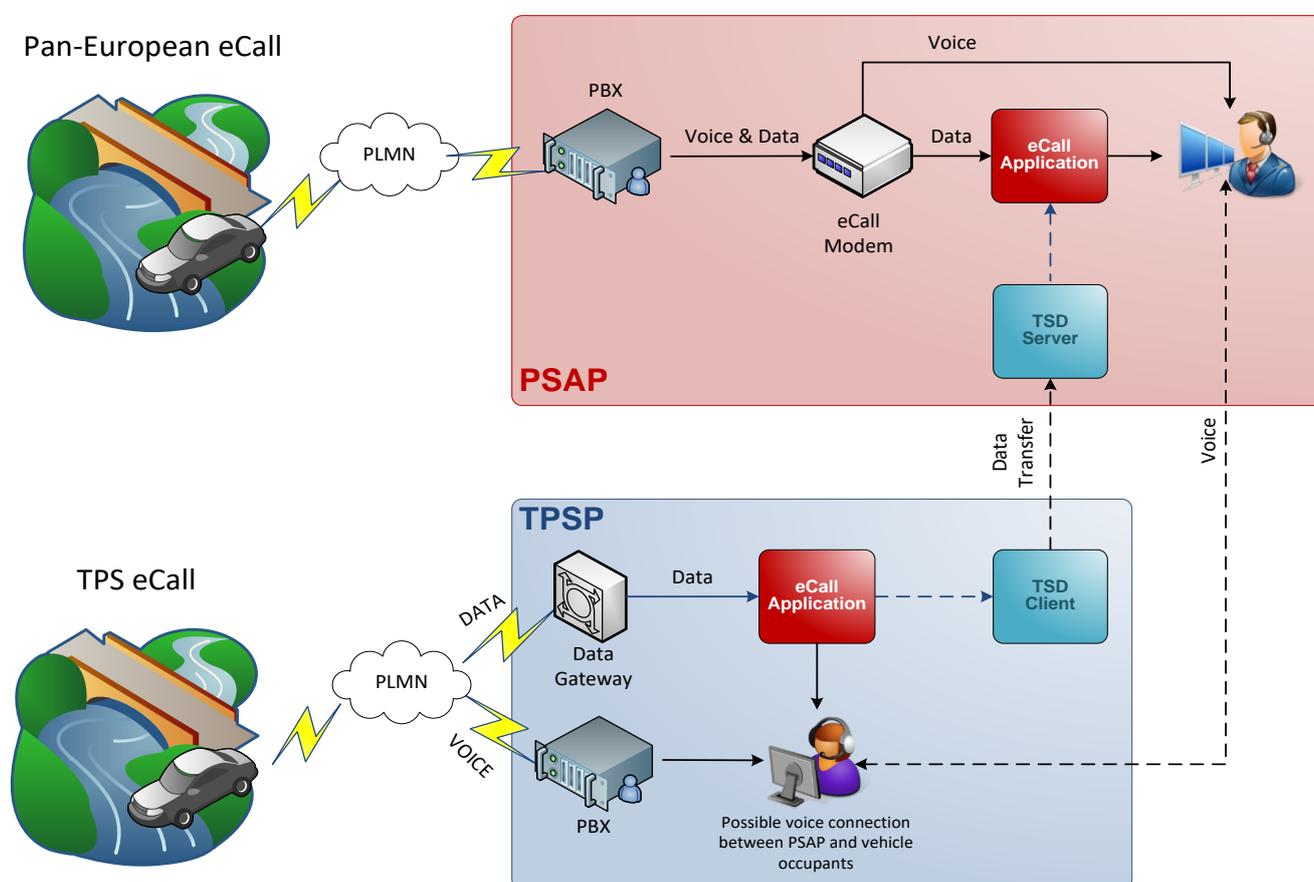
EN 16102[7] addresses technologies and methods of delivering data and voice, from the vehicle to the TPS Call Centre premises. EN 16102 bases its own data set on EN 15722[8] (MSD format), however

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[5] The IVS will connect to the GSM network and in order to reach the PSAP, the call will then be turned to the PSTN network.
[6] Final decision on the location of the IVS device in each vehicle is made by automotive manufacturers.
[7] Intelligent Transport systems – eCall – Operating requirements for third party support
[8] Intelligent transport systems — eSafety — eCall minimum set of data (MSD)

EN 16102 does not describe or suggest the technology to be adopted for data and voice transmission from the vehicle to the TPS. Technological choices of data and voice transmission are left to the car manufacturers and TPS providers, provided they can achieve the same level of detailed information as the regular pan-European eCall. This means that TPSP may use whatever technology it chooses to collect information included in a MSD-like package sent by a vehicle requesting intervention and make it available to PSAPs. To reach this goal, the TPSP must take all technological measures to be equipped with MSD and voice reception, deal with any retransmission request from a car to TPSP premises and the forwarding of same to the respective PSAPs.

In relation to the delivery of a TPS eCall to the PSAPs, the current version of the EN 16102 standard does not prescribe a single methodology; it rather states that "TPS providers must forward TPS eCalls (data and voice) to the most appropriate PSAP" and provides different technological examples on how to do it. Regardless of the method described in the EN 16102 standard, the current document also states clearly that this obligation includes the capability of the TPSP to correlate the TPS eCall voice part with its correspondent data part before forwarding it to the most appropriate PSAP. TPS providers are allowed to add any valuable information to the original MSD transmission from the vehicle. In this case, the final package will be called TSD (TPS-eCall Set of Data). Whenever a TSD is generated from a TPSP, the terms and conditions for managing this extra data need to be agreed beforehand between the TPSP and the emergency services. On the other hand, if the TPS device installed inside the vehicle is not capable of providing the entire MSD package, with all the mandatory fields, the TPSP must be able to complete the missing information by its own sources, in order to provide a complete mandatory MSD to the PSAP.

3 Performance measurements

3.1 Why measure performance

Throughout time men have always used observation and measurement to decode the world. In all fields of knowledge, be it science, technology or economics, innovators have used data to improve on discoveries and methods. Evaluating metrics is ever more important today. Any organization cannot evolve without mapping its behaviour to understand faults and strengths. Key Performance Indicators help uncover behaviour patterns by focusing on quantifiable factors clearly linked to the drivers of success. They reveal the effectiveness of any action or method used in a process. The data provided is extremely important because not only does it show how efficiently a goal is being achieved but it reveals can be done to correct the inefficiencies. On a second level, data analysis can also expose the triggers are and how they influence change in performance.

The process for setting KPI is based on different factors and requires different steps. Firstly, organizations need to reflect on their purpose and set clear goals. The next step is defining the targets and the relative actions. Once all these items are set, an organization can check if the methods are on target and if the target is in itself correct. Data assessment exposes the ineffective actions by comparing them to another, ideal target. This ultimately leads to optimization and growth. Through performance measurement one can deconstruct a process, draw a conclusion on what is being done and work to create a better, safer strategy to:

- Ensure requirements and targets are met.
- Set the right objectives and comply with them.
- Provide standards for consolidations and establishing comparisons
- Provide a "scoreboard" for people to track their own performance.
- Highlight problems and determine areas for priority attention.
- Provide feedback for improvement.

3.2 How to use measurements

In evaluation, nothing is more important than using the right measurement strategy to assess data. This can vary greatly based on the field and tasks, but generally speaking it requires four key steps:

1. Establish goals: define the objectives and link them to desired performance quantifiers.
2. Establish Metrics: develop metrics to compare the actual performance to the desired one.
3. Understand Performance: study the gaps.
4. Initiate improvement actions.

These key steps need to be implemented in a cycle; once the fourth step is completed and the improvement actions are set, the organization will go back to step one to review the strategy. These steps should be continuously implemented in a virtuous circle, otherwise the improvements will be incomplete.
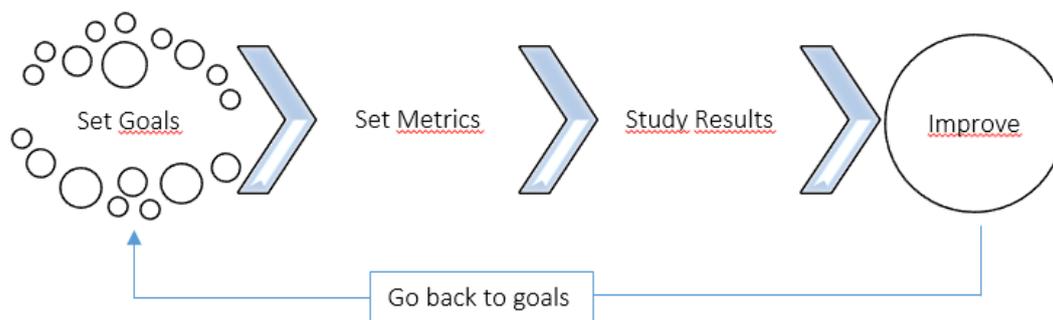
The above measurements should be included as part of a Continuous Improvement Plan. Similar plans are used by companies in different industries and are given various names, but the goal is the same - to measure the key factors and improve them. The above is a variant of the renowned Deming's "plan–do–study–act" cycle; a four–step model for carrying out change. This simple circle structure provides a prototype for analysing and studying performance. It's at the base of most organizational strategies and often it's the secret to their success. Before implementing the cycle however, one needs to clearly define what needs to be measured and how. This is the most crucial and difficult part of the process.

3.3 What exactly to measure and how to measure

To select the indicators, the organization needs to ask itself how it could know that a particular input or output has been successful. What data could give us a picture of how the activity is going? The selected indicators need to be SMART: Specific, Measurable, Achievable, Realistic, and Time-bound. If these qualities are in place, they can serve as compass for the success of the process. We should point out that success can mean progress towards a goal, but it can also be the repeated achievement of some operational objective.

How one collects data is also key for successful analysis. Once again, everything should start with identifying the process and activities. One should first understand what information one needs the data for. This assessment will lead to complete and definite parameters. It's important to keep in mind to always focus on quality over quantity. If the input for the data is incorrect or unfocused, the assessment will be incomplete and faulty. To achieve the right strategy, one needs to set parameters that are fitting and clear. Data should also relate to aspects that the organization can control. Lastly, the measuring software program needs to collect complete and unbiased information.

Choosing KPIs starts from understanding of what is important to the organisation. A common way to determine KPIs is to apply a management tool such as the balanced scorecard. This considers financial measures, but also customer, business process, and learning.

4   Key performance indicators

4.1   eCall KPIs definition from HeERO

The original HeERO project, set between 2011 and 2012, was meant to describe and demonstrate the end-to-end eCall architecture throughout different European countries who participated to the project. In particular, to test the service, HeERO project took care of defining KIPs for eCall and create methods to measure the results.

One of the most complex task was the collection of several standards that had to be considered, to build up a running and compatible system in every country without having difficulties caused by non-interoperability of different components. The following table shows the applicable standards, which were referred to in the HeERO project.

Description	Reference	Title
eCall requirements for data transmission	3GPP TS 22.101 10.0.0 ETSI TS 122 101	3rd Generation Partnership Project; Technical Specification Group Services and System Aspects Service aspects; Service principles (Release 10)
eCall Discriminator Table 10.5.135d	3GPP TS 24.008 10.0.0 ETSI TS 124 008	3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Mobile radio interface Layer 3 specification; Core network protocols; Stage 3 (Release 10)
eCall Data Transfer - General Description	3GPP TS 26.267 10.0.0 ETSI TS 126 267	3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; eCall Data Transfer; In-band modem solution; General description (Release 10)
eCall Data Transfer - ANSI-C Reference Code	3GPP TS 26.268 10.0.0 ETSI TS 126 268	3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; eCall Data Transfer; In-band modem solution; ANSI-C reference code (Release 10)
eCall Data Transfer – Conformance Testing	3GPP TS 26.269 10.0.0 ETSI TS 126 269	3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; eCall Data Transfer; In-band modem solution; Conformance testing (Release 10)
eCall Data Transfer – Characterisation Report	3GPP TS 26.969 10.0.0 ETSI TS 126 969	3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; eCall Data Transfer; In-band modem solution; Characterisation Report (Release 10)
eCall Data Transfer – Technical Report - Characterisation Report	3GPP TR 26.969 10.0.0 ETSI TR 126 969	3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; eCall Data Transfer; In-band modem solution; Characterisation Report (Release 10)
eCall minimum set of data	CEN EN 15722 Date: 2010-11	Road transport and traffic telematics – eSafety – eCall minimum set of data - Draft EN 081018

Pan European eCall Operating Requirements	CEN EN 16072 Date: 2010-9	Intelligent transport systems – eSafety – Pan European eCall - Operating requirements
High Level Application Protocols	CEN EN 16062 Date: 2010-9	Intelligent Transport Systems – eCall – High Level Application Protocols
Data registry procedures	ISO/EN 24978:2009	Intelligent transport systems - ITS Safety and emergency messages using any available wireless media - Data registry procedures

These standards form the basis of the KPIs' that have to be developed, to evaluate the capabilities of the eCall system components to fulfil the requirements of these standards. In particular, the following elements are of prime importance:

- the timings within the communication process between IVS and PSAP.
- the use of the eCall flag (Service Category) in the emergency call setup procedure.
- the correct generation coding, transmission of the MSD
- decoding and presentation of the MSD.

Due to the fact, that many of the defined KPIs are based on timing issues and a clear common understanding within the project is essential, the following was defined:

- The point of time, where the IVS starts the process to get in contact with the PSAP is called "call connection initiation",
- the corresponding phase is called "call establishment"
- where the transmission of the MSD happens is called "data transmission"
- where the voice communication happens is called "voice transmission"

In addition, the following significant instants are defined with respect to the module where the measurement takes place (IVS, PSAP, emergency service)

- $T_{0\text{-IVS}}$: IVS initiated the eCall (start of phase "call establishment")
- $T_{1\text{-IVS}}$: IVS starts the MSD transmission (start of phase "data transmission")
- $T_{2\text{-IVS}}$: End of phase "data transmission"
- $T_{0\text{-PSAP}}$: Initiated eCall is indicated at PSAP
- $T_{1\text{-PSAP}}$: Start of MSD reception at PSAP
- $T_{2\text{-PSAP}}$: Start of phase "voice transmission"
- $T_{3\text{-PSAP}}$: Start of dispatching information about incident to emergency services
- $T_{4\text{-PSAP}}$: Start of dispatching information about incident to TMC
- $T_{3\text{-ES}}$: Start of confirmation about incident handling to PSAP
- $T_{4\text{-ES}}$: Start of dispatching rescue forces

All these elements are used in the calculation of the results for different set KPIs. **Deliverable 4.2 of the original HeERO project defines a list of 31 different KPIs related to eCalls**. Details on those elements can be found in the original public available document[9]. Instead of repeating the

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[9] Please refer to this link for Deliverable 4.2 of HeERO
http://www.heero-pilot.eu/ressource/static/files/heero_wp4_del_d4-2-v1.3_final.pdf

whole list, we will refer to those elements which were designed to measure a multi-environment situation that might include out-of-control elements.

We will refer to the specific topic in one of the next chapters, but some examples of these KPIs include:

- KPIs that are calculated over different environments:

KPI_005: Duration until MSD is presented in PSAP
This KPI describes the duration from the initiation (automatically or manually) of an eCall to the presentation of the MSD content in the PSAP.

Unit:	*[s]*
Definition:	*MSD presentation time = point of time of presentation of MSD at operator's desk in PSAP (T_{2-PSAP}) - point of time for IVS initiated the eCall (T_{0-IVS})*

This is a good example that involves the calculation of timings from two different environments (IVS in the car and PSAP), where time synchronization cannot be automatically achieved, which can influence the final result of the test.

The environment in which these tests are run can influence the final result of the tests and those who handle eCalls and need to report back on quality of the service have to consider this situation. Similar to KPI_005, many other KPIs are influenced in the same way.

- KPIs that have a single working environment, but require external conditions in order to be calculated:

KPI_001a: Number of automatically initiated eCalls
This KPI measures the total number of automatically initiated eCalls

Unit:	*unit-less*
Definition:	*Every automatic initiation of an eCall is counted up to get an overview of the total number of automatically initiated eCalls.*

An eCall initiation can be achieved only if the GSM network meets the proper conditions, therefore, considering these conditions are met, the KPI can be calculated.

- KPIs that have no external influences:

KPI_010: Number of usable satellites
This KPI collects the number of actually visible satellites in operation in every particular case of position estimation.

Unit:	*unit-less*
Definition:	*Number of visible and operational satellites, as reported by the satellite navigation (GPS) receiver*

This KPI depends exclusively on technical parameters of the IVS, considering a satellite signal to be reachable.

- There is also a type of KPIs that are more general, but still influence the final results of an eCall:

KPI_023: GSM network latency
This KPI will measure the time it will take a call to pass through the GSM network before reaching the 112 national networks.
  Unit: [s]
  Definition: *GSM network latency = point in time when the call enters the 112 national network - point of time for IVS initiated the eCall ($T_{0\text{-}IVS}$)*

Elements such as network latency or reliability play an important role in the eCall delivery and will be discussed later as "out-of-control" elements.
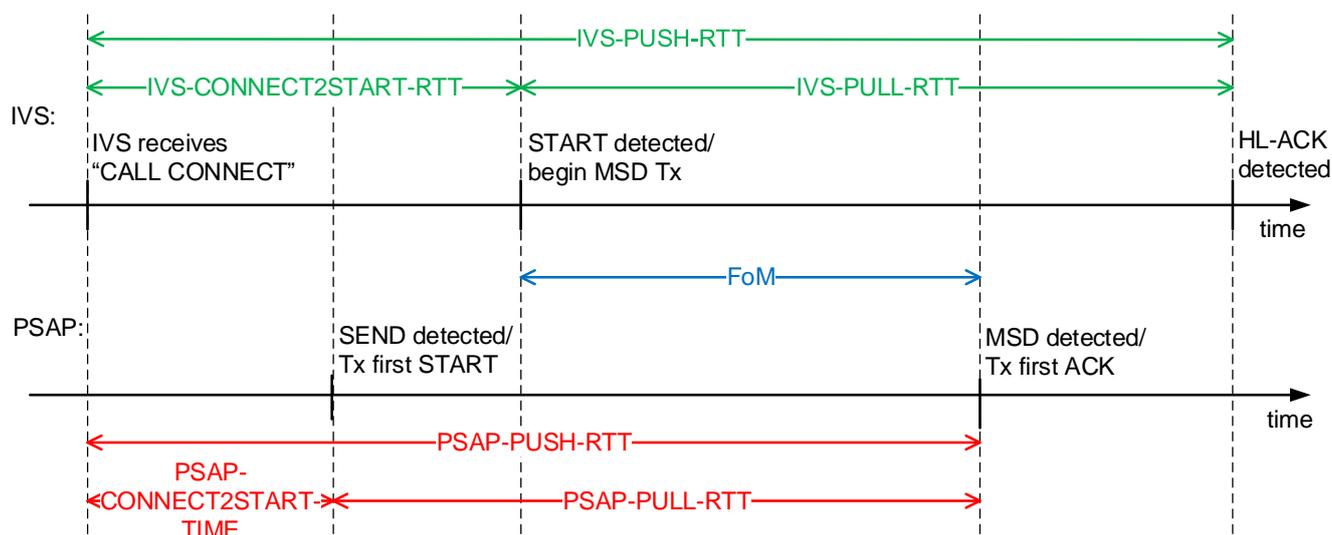
4.2 Evolution of eCall KPIs

Following the HeERO project, in 2015, 3GPP and ETSI created other reference documents[10] for the specification of eCall KPIs.

Note, however, that the performance numbers given in 3GPP are based on idealized simulations and do not reflect implementation margins.

Also note that the ETSI spec so far only contains IVS tests.

Keeping in consideration the heterogeneous environment in which eCalls are transmitted, the new documents try to define a more detailed structure for the calculation of KPIs.

For example, referring to **KPI_005** described in chapter 4.1, could be split in fragments such as the following figure:

14

EENA Operations document – eCall KPIs
European Emergency Number Association – EENA 112
Avenue de la Toison d'Or 79, Brussels, Belgium
+32/2.534.97.89 | info@eena.org

For every segment of the transmission, Annex D of TR 26.969 [13], provides all the indicators necessary to have a MSD transmission time overview.

Both TR 26.969 and TS 26.269 refer to tests run with different audio codecs for MSD transmissions. Codec play a very important role on eCalls, as their use in telco networks can impact on the final results and quality of the transmissions. More comments on this topic can be found in Chapter 5.1.

4.3 TPS eCall KPIs management

We would like to briefly address to the issues connected to TPS eCall transmission and the KPI measurements. Whereas EN16102 stays as the reference document for TPSPs, it defines only procedures referring to the pan-European eCall standards for end-to-end expected results.

There are no specific test procedures and indicators refer to overall TPS behaviour, such as the following example, taken from chapter 9.5 of EN16102, page 21:

> *The data link from the Mobile Network Operator interconnection point to the TPSP access point shall be automatically checked by the TPSP to ensure a permanent connection.*
> *Any failure shall be detected within 5 min.*

Or the example of chapter 9.6 of EN16102 page 21:

> *The call centre of the 'TPS-eCall receiver' shall answer in less than 15 s for 90 % of the voice TPS-eCalls, this being calculated over a period of one month.*
> *The TPSP shall use its ACD to provide the necessary statistics in order to prove that this requirement is fulfilled.*

Considering that the same document states in chapter 11, page 26 the following:

> *Where a TPS-eCall system supports all requirements contained in the main body of this European Standard, but in certain countries, the necessary PSAP infrastructure is not yet fully implemented to support automatic electronic data transfer from a TPSP, then such a system may still be described as TPS-eCall compliant.*

We suggest to PSAPs, when approaching TPSPs, to request proven KPIs matching the PSAP requirements. PSAPs have averagely higher service standards and, as already suggested in the EENA template agreement document[11], TPSPs should be able to fulfil these standards.

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[11] Please refer to http://www.eena.org/download.asp?item_id=120

5 Out of control elements

eCall technology, as explained in Chapter 0, relies very much on independent elements, such as IVS devices, in-band PSAP modems, but also on technologies shared with other technologies. Two in particular influence the overall quality of the results and, as a consequence, influence the service indicators. We discuss these elements in the following chapters and we indicate what actions has a PSAP to take, to obtain an appropriate Quality of Service estimation, that goes beyond laboratory testing, on which most of the eCall KPIs are based.

5.1 MNO service quality and availability

As regular 112 calls, also eCalls transit on the same networks (GSM + PSTN infrastructures).

The first important element to keep in consideration is that GSM signalling was addressed during the eCall standard definition, with the introduction of the eCall flag, while PSTN was not. The discussion of this chapter considers the deployment of a national or regional GSM network which has been upgraded with the eCall flag support and that a way to carry this information also on the PSTN network has been deployed, with a cooperation between MNOs and landline telco companies.

NETWORK COVERAGE

With these premises, we must underline once again the nature of an eCall: as of today, the eCall is made by and MSD in-band transmission and a voice call immediately following it, who are both subject to the heterogeneous behaviours of GSM and PSTN networks.

Effects, such as a degraded voice quality, with mixed effects (echoes, noise, etc.) are, most of the time manageable by the Call Taker, while in the MSD case this behaviour may actually impact on the delivery of the contents to the PSAP.

A poor GSM network quality my result in attenuation or other types of errors on the MSD transmission, that may result impossible to decode once arrived on the in-band modem, regardless of the times of retransmissions from the vehicle.

As of today, GSM networks are taken for granted, but a realistic situation of the coverage for all national MNO operators should be available to PSAPs.

The following pictures show an example of territory where eCalls could be heavily impacted, regardless of the PSAP in-band modem used or IVS device installed in cars: the portion shown represents a road connecting towns in a valley, between 1000 mt. high mountains. *This site is only 23 km away from the 112 PSAP in Brescia.*

This second picture shows the declared GSM network coverage by Vodafone Italia, in the same area (green areas are covered with GSM, white areas are not).
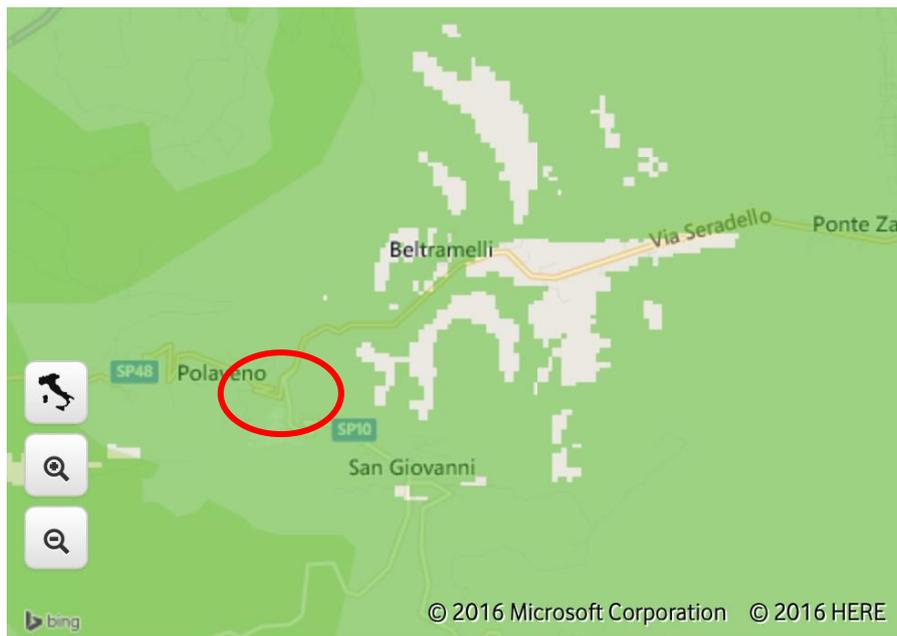
It is important to notice how the road in the valley looks poorly covered. Potentially the drop of MSD delivery in this area is high. Locating an eCall in this area may become quite difficult, considering only a few kilometres' radius cell base triangulation.

GSM CODECS

Another important network element to consider is the codec used by GSM networks on voice channels. Several tests run demonstrated how codecs impact on the MSD demodulation results.

TR 26.969 [13] document mentioned in this text, contains several test results conducted with different GSM codecs, such as the classic G.711 and G.729, but also the GSM HR codec, in different C/I conditions.

Codec themselves could be "monitored" or at least tested to understand which ones are suitable for MSD transmission, however many MNO networks are subject to codec change from BTS to BTS. Moving between two cell bases is a possible scenario when transmitting a MSD and codec change may impact that as well.

For more results connected to codec testing, please refer to TR 26.969 [13] document.

5.2 Car manufacturers

Although testing processes and KPIs are being set on IVS devices as well as on in-band modems, other elements come into play when we discuss about MSD delivery: car manufacturers have an important role in the placement of the IVS device and the elements used to transmit data, first and foremost antennae.

Car manufacturers have the final word on the configuration of antennae on their vehicles and this element may modify the behaviour of IVS devices test in laboratory.

In 2018, when eCall will be officially deployed, the aftermarket phase will be still small but it will grow with time and the effects of the different combinations of IVS devices and car configurations cannot be taken in consideration on current KPIs, especially those which calculate or determine the MSD receival ratio and message quality.

6   EENA recommendations

To summarise the current situation, eCall KPIs have been defined in testing environment which could not completely take care of the external environment influences. Most of the KPIs, as expected, refer to the quality of the end-to-end MSD delivery, as this is the distinctive element of eCalls compared to regular 112 calls.

IVS devices and in-band modems, main actors in the in the chain of MSD delivery, however are subject to external factors which a PSAP should take in account when measuring these elements with the proposed KPIs.

The main suggestion for PSAPs, to keep under control the situation with eCalls in the upcoming deployment, is to collect statistics based on these parameters:

1) IVS can use SIM cards from different MNOs so, whenever it's possible, it is important to be able to track the quality of eCalls, divided by carrier

2) Retrieve a geographic map of GSM network coverage, to understand the weak spots for MSD delivery, to activate retransmission procedures or other mitigation activities (see Chapter 5.1)

3) By using EUCARIS connections, try mapping the different car brands and models and correlate with the previous two parameters, to create a list of cases connected to poor quality eCalls (transmission time, no. of retransmissions required to receive an MSD)

It is also suggested to be careful when assessing a PSAP's own operational KPIs (e.g. time to be on scene for an ambulance, from the moment the call reaches the PSAP): this type of KPIs might be impacted by the external factors of eCall performance, as seen before. This means that, in some cases operational KPIs might experience a decrease of quality, for which mitigation actions should be taken in consideration by PSAPs.

Stakeholders	Actions
IVS and in-band modem manufacturers	Report for PSAPs the quality of service provided and the conditions of testing which set the laboratory eCall KPIs
MNOs	Provide the GSM coverage map as well as the network parameters (codecs used, etc.)
TPSPs	Consider the pan-European eCall KPIs and compare with their own results, to avoid misunderstandings when signing agreements with PSAPs
PSAPs	Keep track of statistics of eCall success/fail ratios and geographical incidence of such statistics, to address uncontrolled elements (from MNOs and car manufacturers)