EUROPEAN RAILWAY AGENCY			
EX-POST EVALUATION **OPERATIONAL REQUIREMENTS** **OF RAILWAY RADIO COMMUNICATION SYSTEMS**			
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1. EXECUTIVE SUMMARY

This report is an ex-post evaluation of today's railway communication system (GSM-R) which is referenced in the European legal framework within the CCS TSI. GSM-R, that was initially installed (in the years 1995- 1999) as a system to fulfil the needs for voice communication and, later on, for ETCS data transmission, is used not only for ETCS but also for other railway applications . Today's information indicates that GSM-R will be supported by suppliers until at least 2030. This ex-post evaluation is a step within the roadmap of defining the next generation communication system(s) for train operations. According to this roadmap, the definition of the evolution of the system needs to be ready by 2018 in order to be able to start operational deployment in 2022. The objective is to identify lessons learned on the current set of operational requirements before starting the process of defining operational and technical requirements for the next generation communication system(s). This ex-post analysis of the operational requirements may also lead to some potential actions within the GSM-R framework in case some elements are highlighted which need particular attention.

The applied methodology mainly consisted of drafting a questionnaire and summarising the answers to the questionnaire, focusing on negative and positive impacts of the railway communication system on punctuality, safety and interoperability. In addition, the opinion of the different stakeholders is asked for to identify which requirements should be changed or added for the next generation communication systems. In total, around 20 answers were received from different organisations (infrastructure managers, railway undertakings, suppliers, NSAs).

For **punctual train operation**, the unavailability of radio communication services may directly impact train operation. In particular on ETCS L2 lines – ETCS requires uninterrupted communication -, during train departure procedures and during shunting processes. The reported negative contribution of GSM-R to punctuality is very limited, due to the fact that the achieved availability levels for GSM-R networks are reaching values up to 99,995%, exceeding the requirements of 99,95% for ETCS data applications (excluding the planned unavailability for maintenance reasons). The availability for voice and non ETCS data applications is only slightly lower, but also exceeding the requirements.

Besides technical reasons (such as network outages or failures of the on board equipment), specific attention has to be drawn to the fact that a substantial part of train delays are caused by the unintended use of railway emergency calls by train drivers in some Member States. In

such cases, the redesign of an appropriate man-machine interface should be considered, taking into account the human behaviour.

For **safe train operation**, the respondents expressed that GSM-R has a positive contribution to safety, in particular for alerting multiple train staff (train drivers, dispatchers) in emergency situations. No safety accidents with fatalities are reported with a causal linkage to the railway communication system. Nevertheless, a number of hazards are reported in emergency situations, mainly linked to the unavailability of communication services (caused by e.g. interferences) or due to misrouted calls in case of emergency situations.

Limited issues are reported related to **interoperability** of the CAB-radio (technical interoperability/availability). The national rules indicated that relate to this respect are dealing with the required availability level of the CAB-radio (in UK) or indicate the usage of a public handheld as fall-back solution (in e.g. Belgium). Some reported answers refer to a need to change the current key characteristics listed in Subset 093 (Quality of Service). The hand-over time of 20 seconds at borders (to allow transitions between different GSM-R networks) is also reported as one of the elements that could be improved. Besides the limited number of technical issues reported, some answers emphasize that in the roadmap of the next generation communication system, the aspect of operational interoperability and operational procedures for train drivers should be reconsidered aiming to achieve a fully minimal harmonised set of operational rules for train drivers (further facilitating cross-border operation). An example to support this statement is the different operational use of group communication calls within Member States. Another example (although not related to requirements legally mandated in the TSI) is the shunting communication services offered by GSM-R which are not widely implemented, partially due in some cases to a 'too long call setup time', partially due to the prior existence of other communication systems. These examples demonstrate the need for matching the operational requirements with the technical requirements and technical configurations.

The 2 main reported key items for the **ETCS data application** with respects to the radio communication system are 'interferences' and 'ETCS over GPRS'. These topics are already listed as Agency priority activities in the GSM-R field.

Therefore, the answers demonstrate that the system performance of GSM-R is positively contributing to a punctual, safe and interoperable train operation. In particular, the high availability required for the voice and ETCS data communication services and the fast and simple voice communication for alerting multiple train staff (train drivers, dispatchers) in emergency situations are key characteristics that are required in today's train operation and will be required in future train operation.

The answers confirm the high priority of some ongoing activities ('interferences', 'ETCS over GPRS') and demonstrate that some specific topics could require additional investigation within the current framework ('unintended use of railway emergency calls', 'wrong cell reselection/misrouted calls', 'matching of the shunting operational requirements with the technical solutions').

The report includes also a potential (not exhaustive) list of future railway applications in which radio communication services will be used. Although these applications are mostly not part of the scope of the CCS TSI, these applications may serve as an input to the feasibility and economical assessment of the different network architecture models due to the synergies created. These applications will have to be monitored, including the identification of their key characteristics (e.g. ATO, remote monitoring, radio object controllers).

The answers confirm that in the roadmap of the next generation communication system the aspect of operational interoperability and operational procedures for train drivers should be reconsidered (e.g. different usage of voice group calls).

The shift of specific railway features from the communication layer towards the application layer in the next generation communication system is defined as a principle mainly for economic reasons. A question was included to evaluate the potential impact of this principle and which critical requirements could hinder shifting the specific 'Railway' features towards the application layer. The main answers on critical requirements that should be kept are security aspects, safety aspects (incl. railway emergency call and short call setup times), prioritisation of calls, QoS-requirements (incl. availability). The common views on how would the shifting of railway features to the application layer have a potential positive safety impact are an increase in the flexibility for the development of safety supporting services (e.g. more accurate train positioning not based on radio parameters) and higher consistency of the system (due to an easier management of obsolescence, thanks to an easier migration/update of the communication layer).

The main conclusions of this study are:

- The system performance of GSM-R is positively contributing to a punctual, safe and interoperable train operation.
- The high availability required for the voice and ETCS data communication services is a key characteristic that will be required in any future system.

- The main functionalities available in GSM-R for voice communication are also key for the operation of the rail services, and they will continue to be required in future systems.
- A fast and simple mechanism for alerting multiple train staff (train drivers, dispatchers) evolution of the system
- The functionalities available today should be available when the system evolves; there is no major indication of functionalities not used or functionalities missing, therefore, the current set of functional requirements is a valid starting point, although it will have to be periodically reviewed in case any further needs arise.
- Harmonization of the operation is needed in order to be able to promote the use of a common functionality.

2. REFERENCES, TERMS AND ABBREVIATIONS

2.1 Reference Documents

Ref. N°	Author	Title	Last Issue
[1]	UIC	Book: Compendium on ERTMS – chapter 6 'Railway Communication: the GSM-R developments'	1st edition – 2009
[2]	UIC	EIRENE FRS – GSM-R Functional requirements specification	Version 7.4.0
[3]	UIC	EIRENE SRS – GSM-R System requirements specification	Version 15.4.0

2.2 Definitions and Terms

Term	Definition
ATO	Automatic Train Operation
DSD	Driver Safety Device
EIRENE	European Integrated Radio Enhanced Network
ETCS	European Train Control System
FWI	Fatalities and weighted injuries
GSM	Global System for Mobile Communication
IM	Infrastructure Manager
MDBSAF	Mean Distance Between Safety Failures
OTA	Over-The-Air (programming)
RU	Railway Undertaking (as defined in Directive 2004/49/EC)
VBC	Voice broadcast call
VGC	Voice group call

3. INTRODUCTION

3.1 Background

3.1.1.1 The history and project background can be found in [1] (Chapter 6 'Railway Communication: the GSM-R developments'). Following main milestones of GSM-R are:

- Technology GSM: a decision was taken to adopt GSM as technology, which was at that time (1995 – 1999), considered to be the best digital system in commercial operation with products available.
- Operational Railway Requirements GSM-R: It was clear since the beginning that GSM could not fit all the requirements needed for an efficient railway service and that therefore it was necessary to identify and, and add some specific functional features to the GSM specifications, resulting in EIRENE and MORANE specifications as well as amendments to ETSI/3GPP specifications.
- Spectrum: The request for frequencies resulted to provide a spectrum of 4 MHz adjacent to the public GSM-band (GSM-R band) and to allocate this for railway use only.

3.2 Objectives of the ex-post evaluation

3.2.1.1 This ex-post analysis is a step within the roadmap of defining the next generation communication system(s). The objective is to identify lessons learned on the current set of operational requirements before starting the process of defining requirements for the next generation communication system(s). This ex-post analysis of the operational requirements may also lead to some potential additional actions within the GSM-R framework in case some aspects are highlighted which need particular attention.

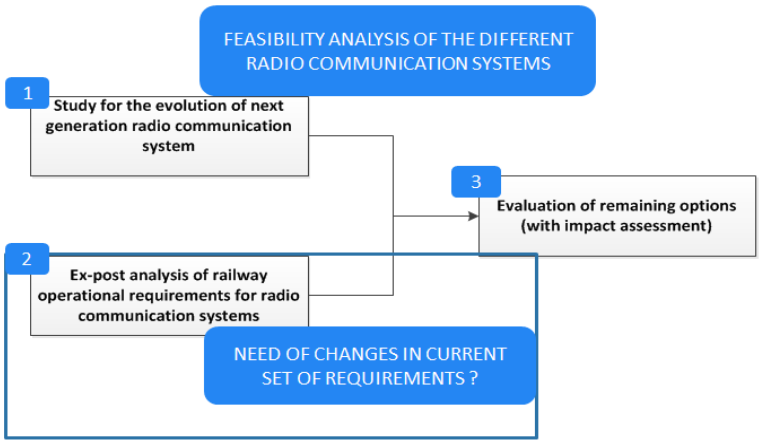
3.2.1.2 The ex-post analysis has as main objective of creating transparency on the experiences of the different stakeholders (infrastructure managers, railway undertakings, suppliers and NSAs) related to the current operational performance of the radio communication systems. The ex-post analysis has not the objective of performing an economic analysis on the GSM-R network or GSM-R terminals. In the next step, an impact assessment will be made on the different network models

in order to select potential future network models for the next generation communication systems.

3.2.1.3 Context: Today's GSM-R, that was initially developed as a system for voice communication and ETCS data transmission, is used not only for ETCS but also for other applications, included voice-based ones. At the same time, today's prognosis is that GSM-R will be supported by suppliers until at least 2030. We therefore need the definition of the evolution of the system ready by 2018 in order to be able to start operational deployment in 2022.

3.2.1.4 Scope of the study: The objective of the questionnaire is to analyse the existing operational requirements of the GSM-R radio communication systems. The purpose is to identify the need for any possible changes for the operational requirements in next generation radio communication system, including possible simplifications in order to achieve an optimal set of requirements. Therefore, it is important to involve mainly the operational departments (and not only the telecommunication stakeholders) before defining any next generation communication system.

3.2.1.5 The objective of the ex-post analysis (step 2 – see figure below) is to analyse the added value (mainly on punctuality, safety) of the radio communication system towards the operational requirements (independently from any technical constraints). Another study (step 1 – see figure below) on radio communication is on-going, more reflecting on future trends in communication systems (technical study). The input of these studies will form the base to identify which topics/requirements have to be analysed in-depth as part of the definition of the future communication systems (step 3 – see figure below).



3.3 Methodology

3.3.1.1 The applied methodology consisted to send out a questionnaire towards the different stakeholders. The questionnaire has been tested with 4 different stakeholders in order to check the completeness of the questionnaire and the clarity of the questions. The questionnaire is addressed to operational and communication experts within infrastructure managers, railway undertakings, national safety authorities and suppliers of communication systems within railways.

3.3.1.2 This report will summarise the received answers without any further analysis. The received individual answers will be put in '*italic*' style without any change made by ERA (except for editorial aspects). In the main report, a summary of the answers will be made according to the interpretation of the answers by ERA. The goal is to identify common points on particular subjects or raising conflicting points on particular subjects.

3.3.1.3 ERA received answers from following organisations

Type of organisation	Organisation
IM	Switzerland, Belgium, Germany (joint answer), Finland (joint answer), Sweden, Austria, France (joint answer), Czech Republic, UK (1 IM), UK (joint answer), Slovakia, Italy, Netherlands (Bulgaria > no information)
NSA/Ministry	Finland (joint answer), Poland, Czech Republic (same answer as IM), Germany (same answer as DB), Spain, UK (joint answer), Lithounia, Italy, NSA Netherlands (example of safety incident) (Estonia/Bulgaria/Slovenia > no information)
RU	Finland (joint answer), Sweden (JV), Norway, Austria (freight), France (joint answer), Germany (joint answer), UK (joint answer), Italy
Suppliers	NSN, Kapsch, Siemens
Others	UK (joint answer with RSSB)

3.3.1.4 The questionnaire has been structured in 3 main blocks, being voice, ETCS data and future operational concept.

3.3.1.5 For the first 2 blocks (voice, ETCS data), the questions are divided in 3 main areas (punctuality impact, safety impact and specific questions).

3.3.1.6 The last block is more an open block related to ideas for the future operational concept including the identification of potential new railway applications (subdivided in 'mission critical' applications, 'passenger information' applications and 'passenger entertainment or other data' applications).

4. VOICE APPLICATION

4.1 INTRODUCTION

4.1.1.1 The section 'summary of answers' is an interpretation of ERA in function of the reported answers with the aim of summarising the answers as factual as possible without commenting on the statements itself. The reported answers are put in *'italic'* style. Some data figures are removed from the answers in order to respect the confidentiality requested by certain respondents. In such case, data ranges will be included within the summary of answers.

4.2 VOICE – PUNCTUALITY IMPACT

4.2.1 Punctuality impact – technical causes & operational consequences

4.2.1.1 The answers contain following main elements related to the positive contributions of the GSM-R communication:

- *The radio voice communication allows a fast exchange of information between traffic controllers and train drivers, avoiding the latter's to leave the train cab to reach fixed phones at signals or along the track (e.g. one answer cited that in case of heavy snow and hard weather, the communication between dispatcher and drivers is 3 times higher than normal).*
- *A proprietary telecommunication network like GSM-R, allows IMs to introduce easily, at reduced cost, centralized voice recording systems to store communications between controllers and drivers, to be used for verbal instead of written dispatches and to be used for post-incident analyses: the use of verbal dispatches is time saving and in this sense has an impact on train punctuality.*
- *Another example of positive impact of GSM-R on train punctuality is 'train ready' information, allowing chief conductors, to smoothly inform controllers, that the necessary checks on train have been completed and train is ready to depart.*
- *In shunting mode, it is not only related to punctuality, but a basic functional requirement.*

4.2.1.2 The data received on train delays caused by radio incidents ranges from 0 minutes of train delay per million train km up to a maximum of approximately 150 minutes of train delay per million train km. The questions did not reflect on the percentage of train delays due to railway communication incidents in respect to the overall

percentage of delays in the railway system, however most of the answers indicate that this percentage is estimated low due to the high availability of the railway communication services and due to the limited operational consequences of unavailability of the communication services.

4.2.1.3 The answers contain following main elements related to the negative contributions on punctuality due to GSM-R communication:

- the unavailability of the railway communication system due to different technical reasons (CAB radio faults, network faults, transmission failures/ interferences). The percentages of punctuality impact linked to the technical causes may differ between Member States, mainly due to the different numbers of technical incidents per cause, but also due to different operational consequences linked to the technical incidents. The unavailability of the railway communication service has in general the highest impact if it occurs during the train departure process (as in this case the train may not depart without having registered > registration faults). After the train departure, the unavailability of the railway voice communication service has in most cases no or limited punctuality impact as on most networks the train may continue its mission.

  "Failing download of schedule-data via CAB radio causing delays up to 30 min/train."

  "Failure of voice services are very rare and have most likely no impact on train delays. However there are value added services such as "Ready for Departure by SMS" whose failure may lead to delays."

  "Registration issues have been experienced throughout the rollout of GSM-R, which have been attributed to interference from public operators, network design issues, system configuration issues relating to the bespoke alphanumeric registration process, data entry issues relating to the signaller needing to interpose the alphanumeric train reporting number in the train describer system prior to registration being attempted and human factors issues relating to drivers inputting incorrect data via the cab mobile DMI."

- the unintended activation of railway emergency calls

4.2.1.4 Unavailability of the railway communication and different operational consequences:

Example 1: some differences in operational rules may impact the percentages of punctuality impact for similar technical causes (see e.g. comparison of Member States answers in case of CAB-radio faults):

Cause	**Operational consequence**	**Percentage of punctuality impact**
On-board equipment failure	*During the mission: the train finishes its mission and returns to the maintenance centre* *In case of a failure detected before the train departure, there is a punctuality impact*	*0%*
Cab radio faults	*If the radio cannot be used in a train, then the train must be removed from service.* *The cab radio reliability has been affected by both hardware, software issues and retro fitment to existing trains. However, the faults have been split into two categories from an operational perspective i.e. service effecting failures and non-service effecting failures. In simple terms those faults that render the cab mobile inoperable (e.g. failure to connect to network), thus removing access to core GSM-R functions (e.g. Railway Emergency Group Call) will normally result in the effected train being taken out of service. However, non-service effecting faults (e.g. failure to register CT2) will not result in the effected train being taken out of service, as the driver still has access to core GSM-R functionality.*	*38%*
Cab radio faults	*In case of a not working CAB radio, the train is still allowed to operate on the tracks up to the next station.* *In case of a not working CAB radio, only one train is allowed to operate on the tracks the responsibility-area of one dispatcher.*	*/*

Example 2:

Cause	*Operational consequence*	*Percentage of punctuality impact*
Transmission	*Speed limitation on the incident perimeter for*	*~ 60%*

Failure Network failure	*a duration superior to 4 hours.* *Speed limitation on the incident perimeter for a duration superior to 4 hour.*	*~ 19%*
Infrastructure faults	*If the network is unavailable, then trains may continue to run.*	*6.5%*
	In case of a GSM-R-drop-down for longer than 72 hours the max. speed of the trains is limited to 120 km/h.	

4.2.1.5 Unintended activation of railway emergency calls is reported as one of the main causes of punctuality impact in relation to railway communication services.

Some statements within the report are:

"Trackside-emergency-calls of unknown initiators are a big problem, because there has to be initiated a REC due to operational rules."

"Approximately 9000 passenger delay minutes due to radio voice reasons. The main cause is emergency calls, which were caused partly unintentional."

"Even if not related to radio voice communication interruption, we have experienced a negative contribution to train punctuality due to a large amount of false emergency calls sent accidentally mainly by train drivers throughout the Cab Radio dedicated button. We believe Eirene FRS req.5.4.7 should clearly specify an agreed HW and/or SW mechanism to be implemented on Cab Radio to protect against accidental use. In fact, being this requirement not adequately specified, every Cab Radio Vendor has implemented a different solution, in some cases revealed extremely weak and inadequate! Also NOBOs, involved in Cab Radio certification process, have showed not to put adequate attention on this point."

4.2.2 Punctuality - Availability levels for radio voice communication services

4.2.2.1 Availability requirements of the railway communication system at infrastructure level:

Some examples on availability targets from Infrastructure Managers are summarised in the table below:

	KPI	***Safety/***	***Target***	***Achieved***	***Comment***

	Description	***Punctuality ; related***		***(measured)***	
IM.1	*Outage of network*	*Punctuality*	*NSS: 99,999%* *BSS: 99,995%* *BTS: 99,99%*	*99,93% (2013)*	*An outage of the network may not affect the train operations.* *If a train communication is not working at start of mission, the train may not operate because of the missing departure ready information.*
IM.2	*Availability of the GSM-R network incl. dispatcher systems*	*Yes*	*99,8%*	*99,95%*	
IM.3	*Functionality lost BSS*	*Safety and punctuality*	*99,90%*	*99,91%*	*This is not an end user KPI, it's used to see that operation and maintenance is on right level over time.*

4.2.2.2 In the table below, you find an extract from Railway Group Standard GK/RT0094 (KPI definition) which is applicable in the UK.

"National Railway Group Standard GK/RT0094 is an Notified National Technical Rule (NNTR) and (available from RGS Online) defines the KPI's associated with call success rate performance, call set-up times, successful completion of journey registration stage 1 and 2, speech quality, and handover."

KPI definition	Minimum performance level	Notes
Railway emergency group calls successfully connected and completed (for fixed-to-mobile and mobile-to-fixed calls).	98%	Call 'successfully connected' is defined as a call which is successfully established between the user terminals in question (in other words, the call reaches the called terminal). Call 'completed' is defined as the established call being held continuously for a period of two minutes and then terminated as a normal release.
Network originated high priority point-to-point calls and train voice radio originated high priority point-to-point calls connected and completed.	98%	
All other calls, not covered by the above, successfully connected and completed.	97%	

Table 19 Call success rates

In general, one answer clearly indicated different target values for train voice application and ETCS data application (99,80% for voice application while 99,95% for ETCS data application).

4.2.2.3 Availability requirements of the railway communication system at vehicle side:

One example indicated the reliability level required for CAB-mobiles (in case of train voice application):

"There is also a contractual KPI set between the IM and a cab radio supplier for a cab radio reliability target of 50,000 hours MTBF. Other non-contractual KPI's noted by cross-industry groups are; frequency of REC calls (by route), and number of REC's spurious v genuine."

Reliability & availability requirements are mentioned within the CCS TSI as part of Index 28, which is reserved for addressing such requirements. These requirements are currently under discussion as the objectives and usage of the requirements within the CCS TSI may be interpreted differently. The sector may fear that these availability requirements are seen as a design target, while the intention of the CCS TSI is to have a reliability & availability requirement in order to reach a sufficient safety level for authorisation for placing into service of the vehicle. Objective 2 leads to lower minimal values, while objective 1 is to adapt the reliability and availability requirement according to the performance and business needs.

28	Reserved	Reliability — availability requirements		

Extract TSI CCS – Annex A – Table A2 – Mandatory Specifications

Besides these requirements on the GSM-R system itself, the overall availability of the train voice services could even be higher in reality due to the fall-back solutions of using the public network (use of public handhelds or use of public roaming).

Belgium: *"According to a Belgian National Safety Rule every train driver must have a public gsm, which is used as a fall-back procedure for RECs. A train driver has to subscribe himself with his service gsm into a server system. This way, a controller may call a train driver if necessary. This procedure has 2 inconveniences:*

- *it takes a lot more time than a simple REC Group Call*
- *it requires a special attention from the controller: as the gsm does not receive a REC Group Call, he has to make a special gsm point to point call (he must not forget it)"*

Austria: *"On low priority lines public mobile communication networks are already used for track to train communication but not as a roaming solution with cab radios and GSM-R SIM cards."*

4.2.2.4 Use of public roaming:

- Member States using public roaming: Germany, Italy, Switzerland, Sweden (mainly during roll-out phase of GSM-R);

Operational restrictions when using public roaming are:

Germany: *"Future operational rules (within 3 to 4 years): trains that are not possible to use public roaming have to stop in case of incident of GSM-R. For next generation communication system, rules should be set up how to deal with this aspect."*

- Member States not using public roaming, however under evaluation/testing: Austria, France (based on study on TSI CCS Scope Extension);

- Member States not using public roaming: Belgium, Finland, Netherlands, Bulgaria, UK;

Following reasons are mentioned for not using public roaming:

"In Belgium we used to have roaming but we have decided to stop it.

Reasons:

- *Roaming to a public network after a loss of GSM-R connection takes +/- 30 seconds, switching back to GSM-R afterwards does not happen automatically, a manual intervention of the driver is necessary.*
- *Group calls cannot be handled during roaming."*

4.2.2.5 Availability – next generation communication system – network model

The unavailability of radio communication services may directly impact train operation. In particular on ETCS L2 lines – ETCS requires uninterrupted communication -, during train departure procedures and during shunting processes. The reported negative contribution of GSM-R to punctuality is very limited, due to the fact that the achieved availability levels for GSM-R networks are reaching values up to 99,995% (see 5.4.1.1), exceeding the requirements of 99,95% for ETCS data applications (excluding the planned unavailability for maintenance reasons). The availability for voice and non ETCS data applications is only slightly lower, but also exceeding the requirements.

4.2.2.6 Availability – next generation communication system – terminals

Feasability: limited information has been provided on reliability targets for terminals (except for the indicative reliability target of 50 000 hours). It is not expected that the reliability target for terminals itself will be influenced by the selected network model (and chosen technology) for the next generation communication system.

4.3 VOICE APPLICATION – SAFETY IMPACT

4.3.1 Positive contribution of GSM-R to safety

4.3.1.1 GSM-R as bearer is not defined in the specifications as a safety system, however it is considered as mission critical (subset 037, EIRENE) contributing to safety.

4.3.1.2 Following main common qualitative elements are reported to the operational safety benefits of the GSM-R system.

- GSM-R contributes to safety in emergency situations where a prompt communication on between drivers, controllers and potentially other actors (e.g. fire brigades in case of tunnels) in any point of the line is possible (and adds one more barrier at incidents to avoid disasters);

  Example:

  "Even though this area is still operated with the analogue legacy radio, it is to be noted that during the derailment in Bretigny, Railway Emergency Call played a key role as it stopped a passenger train (RER) moving towards the accident area. It proves again – if needed - that the reliability (availability) and performance (call setup success ratio and call setup time) are very important for future implementations of REC."

  This emergency communication includes the need for registered users' location and displays the users that are located in his/her control area in each dispatcher terminal screen.

  Example:

Incident	***Mitigation***	***Positive contribution***
During 2012, in the area of the mountainous Gotthard line several large rockfalls caused interruptions of the railway line of several days.Also casualties occurred.	*A new application based on GSM-R (SMS) has been implemented.* *This alerts in case of rockfall (sensors) the responsible authorities (incl. dispatcher). All trains in the*	*A new rockfall occurred in summer 2012 in the same critical area could be prevented. Thanks to the new application, within 4 seconds, the dispatcher was alerted - the trains could be stopped within 30 seconds.*

	dedicated area can be stopped.	

- GSM-R reduces the need for train drivers to leave their train and access lineside fixed telephones.

4.3.1.3 Following safety benefits have been reported once by one of the respondents

- *GSM-R sends out a radio alarm in case of lack of driver vigilance;*
- *Improved audio quality for incident resolution;*
- *Point to point typology of GSM-R is considered as an operational improvement* (as compared to analogue 'group' communication)

4.3.1.4 One answer reported on the quantification of the operational safety benefit

Quantification: *"The most recent (2011) estimates of the safety benefit of GSM-R indicate that the benefit is approximately 0.13 FWI per year. This was an update of a previous study undertaken in 2003 where the benefit was estimated at 0.37 FWI per year. The reduction in benefit is a result of a reduction of train accident risk over the period, primarily as a result of the introduction of TPWS. These estimates are the national benefit of GSM-R over the CSR/NRN mix that GSM-R replaces.*

Underlying reasons: *"Previous cab radio systems in GB did not transmit a message to other driving cabs if a driver made an emergency call to the signaller, indeed the earliest system (NRN) did not send emergency calls to the controlling signaller but to the secondary controller. Hence, GSM-R has introduced a safety benefit in more rapidly advising drivers of an emergency. We have seen examples where this has avoided damage to trains and equipment and possible fatalities to people on the trackside (trespassers).*
In addition, the provision of GSM-R in driving cabs using the older NRN system has reduced the risk to train drivers having to vacate the cab and use a trackside telephones to contact the signaller."

4.3.1.5 The main reported number of railway emergency calls by IMs ranges between 1 REC per 50.000 trainkm up to 1 REC per 300.000 trainkm. One RU reported very few REC (1 per 650.000 trainkm)

Some reported underlying reasons from IMs related to the number of RECs are:

"About 1200 emergency calls per months; 95% are test calls with dispatchers. Opinion to decrease the Number of REC's: shift test-calls to another GID"

"Most (appr. 98 %) of the emergency calls are unintentional, started by mistake of the mobile phone users. There is no practical evidence how time critical those very few REC incidents have been."

"Note that in NL the automatic block system is widely applied, where controllers cannot switch signals on red in case of danger. GSM-R voice communication between controller and driver is always used in these potential dangerous situations, either by point to point calls or by railway emergency calls, in order to prevent further escalation.

- REC: 1 per 150.000 trainkm (in total approx. 1000 REC/year)

- On average 16 cabradios are involved in a REC.

- The alerting function is the most important functionality, leading to immediate driving on sight. The 2 seconds call setup time is arbitrary, and has in general no direct relation to the effect of the REC.

- The subsequent voice group communication fails many times due to not using the push-to-talk button by the driver."

4.3.2 Safety incidents (negative contribution of GSM-R to safety)

4.3.2.1 There are some incidents reported, however in general very few accidents reports have been provided. The incidents are reported for following communication services:

- Emergency calls

  "Investigation report of an incident in 2011. One of the conclusions in the report states that after the first accident the GSM-R emergency call did not get through, and because of this a second accident could not be avoided."

- Shunting calls

  "Due to the disturbances e.g. voice cuts between the shunting leader and driver there have been several shunting collisions. Luckily no lives have been lost yet".

4.3.2.2 Following main technical hazards have been communicated in relation to the above incidents (similar technical causes as mentioned in the unavailability of communication calls due to unavailability of the network):

- Technical hazard – interferences:
  "Signal of public GSM is stronger than GSM-R signal (interferences issues mainly safety impact in shunting areas). When the impact is too big, operational rules let the shunting members move to shunting in public-GSM (point-to-point-calls). 1300 shunting yards (end 2014: 1400 locations). Some interference issues are shifting in time (e.g. close to football stadium). Interferences issues (since 2007: 300 interference issues of which 60 are solved)."

  "Interferences (Strasbourg in 2011, T4 Tram Train Aulnay Bondy in 2013).
  Interferences might lead to the loss of an emergency call (worst case) or of a radio call."

- Technical hazard: wrong cell selection/misrouted calls (part of network faults)

  "One or two cells in group call are not available, mainly when system is down during one or two days. During this period, process to reconfigure network is not possible due to the ways how groups are built up (train location should not be cell based)."

  "Wrong cell selection (quote example in Reims in 2012 and in Strasbourg in 2011). An inappropriate cell selection may lead to incorrect addressing and mis-diffusion of a REC and thus create dangerous situations (not sending REC to trains on the expected line). eREC could have solved such an issue."[1]

- Technical hazard: CAB-radio faults

  "Track blocked by stones. Train crashed. Cab-radio was not able to send emergency call (defective CAB-radio due to crash). 112 via public network. CAB-radio single point of failure. 15 up to 20 minutes before controller closed the signals."

[1] Remark received on statement after publication of draft report: *"The effect of eREC on the described scenario is not comprehensible since eREC is not capable of changing the cell reselection procedure and does not modify the algorithm how to select and attach to a radio cell."*

"There is no competition on the GSM-R handheld terminal markets and the available handheld terminals and their accessories are not always reliable enough for the railway safety related communication."

- Technical hazard: border crossing

  "An inter GSM-R network transition generates a technical radio loss of at least 20sec.

4.3.2.3 The main reported mitigation measures in place for the above technical hazards are categorised in function of the technical hazard.

Reported mitigation measures for technical hazard 'interferences':

Hazard	Mitigation Measures
Interference leading to : *Absence of communication on a limited area* *No emission/diffusion of the Radio Emergency call in that area*	*For the moment, there is no simple and fast mitigation measure for interference cases declared after the construction of the network.* *Periodic measurements of the radio coverage are necessary to detect such case.*
Interference	*Filters* *Coordinations*
Interferences	*Coordination with public operators, introduction of filters/improved radios?*
Interference from public networks	*Other communication networks used, TETRA and/or public GSM*

- Reported mitigation measures for technical hazard 'wrong cell selection/misrouted calls (part of network faults)':

Hazard	Mitigation Measures
Wrong cell selection leading to : *(1) When calling, the driver communicates with the wrong operator* *(2) wrong Radio Emergency Call diffusion*	*Technical measures :* *(1) eLDA XY or eLDA GPS* *(2) eREC* *Operational measures:* *(1) Driver : use of trackside phones (that do not depend on GSM-R)*

	(2) No measure exists.
Cell re-selection on Group Calls	*National Shunting model developed*
LDA based on cell of origin of the call is not used because of its inaccuracy	*We use, only for users registered to train functional numbers, eLDA where the 1200/1400 call routing is based on train positioning systems information.*
The UK operational design considered the probability of call being routed to other than the controlling signaller, and in doing so implemented the notion of routing calls where eLDA routing was not available to a predefined signaller (nominated signaller concept). In incidents whereby the nominated signaller receives a call, then the signaller will take the lead in the associated communication and establish a clear understanding using the voice protocols defined within the national operational rules. In incidents where the nominated signaller is not responsible for controlling the train concerned, then the call will be transferred to the controlling signaller providing the connected signallers functional identity can be displayed to the driver. Calls of this nature are not considered to be misrouted, as they have been routed as defined within the operational design. However, there have been instances of misrouting whereby a call has been routed to the unintended recipient.	*In these circumstances the risk of miscommunication is mitigated through signaller/driver competence and the correct application of operational rules (including voice protocols). Network Rail have undertaken technical investigations in order to establish the cause(s) of misrouted calls and where necessary implemented recommendations, details of these technical investigation can be obtained from Network Rail upon request.*

- Technical hazard: CAB-radio faults/network faults:

Hazard	**Mitigation Measures**
Track blocked by stones. Train crashed. Cab-radio was not able to send emergency call (defective CAB-radio due to crash). 112 via public network. *CAB-radio single point of failure.* *15 up to 20 minutes before controller closed the signals.*	*Train conductors should have GSM-R handhelds 569 call;* *but what about freight trains...* *Automatic emergency call if train crashes (crash detector launches*

	emergency call).
Voice cuts	*GSM-R terminals and accessories improved. Communication rules improved.*
Outage of GSM-R for longer times and/or big areas	*Fall-back systems based on roaming and set-up of operational rules;*

4.3.3 Shifting the 'R'-features towards the application layer – Next generation communication system

4.3.3.1 For the next generation communication system, there is a principle defined to shift the specific railway features from the communication layer towards the application layer, mainly for economic and technical reasons. In order to evaluate the feasibility of this principle in relation to the potential impact on safety, 2 questions have been added into the questionnaire:

- In your opinion, are there some critical requirements that could hinder shifting the specific GSM-R 'Railway' features from the communication layer towards the application layer (for a next generation communication system)?
- In your opinion, are there advantages in safety that support the shifting of the specific GSM-R 'Railway' features from the communication layer towards the application layer (for a next generation communication system)?

4.3.3.2 The main common answers on critical requirements that could hinder shifting the 'R' features towards the application layer are:

- Security/safety aspects (besides voice - also valid for ETCS L2/L3 communication)
- Prioritisation of calls
- QoS-requirements (incl. availability – also valid for ETCS L2/L3 communication)

"I see advantage to use the application layer to everything; it opens up for use of standard platforms in the future. But we are very keen to the QoS for the critical functionality as emergency calls, driver-dispatcher calls and ETCS L2 and L3 communication."

- Shorter call setup times (esp. in case of shunting calls – see also 4.5.2)

"Special attention needs to be paid on timing aspects in group communication (e.g. group establishment, gathering the uplink, Push to Talk reaction time, etc.)"

4.3.3.3 The main common reported answers on a potential positive impact on safety by shifting the 'R'-features towards the application are:

- This may lead to more flexibility in the development of safety supporting services, including easier enhancement and error correction. As an example, a more accurate train positioning (not based on radio parameters);

- This may lead to higher availability due to better management of obsolescence, easier migration/updates of the communication layer;

"Moving towards bearer/technology independence will make the change management (SW updates, changes in technologies and systems) much easier while not affecting the services. Therefore the safety related function and features become more reliable and less technology dependent."

"When 'R'- features are independent of the kind of communication bearer, the overall availability of the functionality can be improved."

4.3.3.4 The above elements will be part of the feasibility study of the next generation communication system for each of the proposed network architecture models.

4.4 VOICE APPLICATION – INTEROPERABILITY

4.4.1.1 Most answers (10/15) do not report any interoperability issues due to different radio voice operational functionalities between networks that hinders to operate on multiple networks (infrastructure managers/NSAs/RUs) or that have an important impact on the requirements for the CAB-mobiles (suppliers).

4.4.1.2 Following answers reflect the reported interoperability issues

Answers:
National Railway Group Standard GK/RT0094 is a Notified National Technical Rule (NNTR) and (available from RGS Online).
Delay during the authorisation phase:

- National operational functionalities that have to be developed. *- Different authorisation processes* *Such national specificities have to be better described in order to be taken into account by each RU willing to circulate on that network.*
The items listed as 'optional' in the specifications have the potential to cause problems where implementation results in modified system behaviour on part of a journey. It must not be possible for an IM to mandate anything which is not cited as mandatory in the various international documents.
The GSM-R network in Norway has a specific feature which demands an updated software version for the Cab-Radios. The Swedish trains operating in Norway must have this SW version.
On occasions, differing interpretations can result in seemingly slightly different network behavior. This can, in turn, cause significantly different cab radio behaviour. *An example relates to VGCS calls where a cab radio which was perfectly OK on a 'supplier1' network starts to drop out of VGCS calls on a 'supplier2' network. All parties believe that they comply with the relevant specifications but there is clearly a difference.*
Interoperability issues reported in other questions
"Interruption of train-movements related to differences in operational rules in member states causing delays of 15 to 30 minutes per train (e.g. Dutch trains are not able to use "forced deregistration"; French trains receiving the "Trackside-emergency-call" on the CAB radio with priority 0[2])."
Different behaviours in CABs, for example handling of USSD, SIM card configuration, SMS,…

4.4.1.3 It has to be noted that these issues are not related to the EIRENE specifications or the implementation of EIRENE. They are mainly caused by different operational rules or additional applications.

4.4.1.4 The conclusion that no specific technical interoperability issues have been reported on EIRENE specifications is also due to the interoperability testing. Following remark is raised in relation to this testing:

[2] Remark received after published draft report: "*Concerning French trains receiving the Trackside emergency call on the CAB radio with priority 0, that is not due to differences in operational rules between Member states but because of bugs in SIM cards. These SIM cards are now updated to solve this problem.*"

"…Because normally the terminals/ cab radios are tested in an End-to-end system between the different terminal suppliers and the infrastructure supplier before they will be used in the field. In the TEN-TA 3rd call project such an End-to-End interoperability test is included and will be executed in 2014 based on next baseline/ EIRENE release."

The approved GSM-R test specification is voted in RISC (June 2014).

4.5 EIRENE SPECIFICATIONS

4.5.1 Group calls

4.5.1.1 In following table, the reported answers on the use of group calls are summarised:

- Number of group calls (per trainkm/year);
- Can you explain your experiences related to the use (e.g. contribution to safety/punctuality) of this functionality?

	Answers Group Calls
CH	*<1% of total callsGroup. Calls are primarily used for passenger information purposes.*
BE	*In Belgium, the 200 group-call has been implemented. There are approximatically 3 Group-Calls a day; this means 0,3048 GC (Group Call) for each linekm a year.* *Nearly 80% of these are initiated by the train driver; and the other 20 % by the Traffic Control;*
DE	*The only group call beside REC in train radio is the Group call 200 (All drivers in one area) with priority 2. This call is forbidden to be used by drivers by national operational rules. Only dispatchers are allowed to use this call in very few situations, when there is no other way to reach a driver.* *The Group call has no contribution to safety. For punctuality it may have a positive or negative contribution to punctuality. The positive contribution is, when a driver, that couldn't be reached, will answer to the group call and the train can move on. The negative contribution – and that is the majority – is, that a necessary call of a secondary dispatcher to a driver will be interrupted by the group call 200 because of priority 2. That's the reason why it is prohibited for the drivers, because the driver cannot imagine what's going on in the group-call-area. A group call with priority 3 is needed.*
AT	*For reporting period of 1.9.–31.10.2013:* *Call type: Amount of calls: Call minutes:* *PtP calls 366 651 pcs (68%) 4 787 017 min (33%)* *Group calls 12 995 pcs (2%) 3 661 062 min (25%)*

	Shunting group calls 13 991 pcs (3%) 2 575 139 min (18%) *Shunting PtP calls 146 380 pcs (27%) 3 652 132 min (25%)* *Most of the Group Call minutes are caused by the used national shunting communication method which has been developed to overcome the cell re-selection and PTT- delay issues of the basic Group Call functionality of the GSM-R. The national shunting communication method is used in: shunting communication, brake inspection and switchman communication.* *Due to the technically unsolved issues of cell re-selection and PTT- delay the basic GSM-R* ***Group Call usage is actually a hazard*** *rather than a safety related functionality.*
SE	**Groupcalls** **Calls** / **Minutes** **Period** / **299** / **200** / **Övriga** / **Totalt** / **299** / **200** / **Övriga** / **Totalt** 2012-01 31 208 106 345 27 75 102 204 2012-02 33 214 174 421 35 98 186 319 2012-03 24 216 172 412 11 64 154 229 2012-04 31 179 121 331 24 63 131 218 2012-05 24 165 233 422 14 70 277 361 2012-06 18 146 129 293 9 42 150 201 2012-07 45 150 122 317 26 68 129 223 2012-08 29 226 150 405 26 89 149 264 2012-09 28 173 161 362 21 47 163 231 2012-10 27 169 186 382 22 79 190 291 2012-11 35 206 172 413 32 191 151 374 2012-12 25 157 130 312 20 51 149 220 2013-01 35 206 140 381 19 74 130 223 2013-02 35 163 153 351 46 181 173 400 2013-03 30 173 230 433 51 202 490 743 2013-04 34 173 655 862 26 46 727 799 2013-05 28 223 680 931 38 330 777 1145 2013-06 34 199 600 833 74 120 753 947 2013-07 14 189 538 741 16 80 743 839 2013-08 24 155 544 723 20 41 710 771 2013-09 24 177 890 1091 30 44 950 1024 2013-10 23 167 884 1074 24 39 1007 1070 2013-11 19 191 617 827 12 56 837 905 *In the table above all group calls for the whole network is included, also calls for test. GC functionality is seldom used.*
FR	*The Group calls between drivers in the same area are of main interest for the safety of the traffic.*
ES	*Group calls are not in use in ADIF's network.*

	ERA comment: This answer has to be interpreted as group calls other than RECs.
UK	*The concept of group calls in its self is not an issue for the GB application, although we have no operational use for other than GID299. The VGCS GID200 mobile originated function is not used in GB, as there is no operational requirement to justify its implementation and there were a number of safety related concerns raised by operators during the development of the GB operational design e.g. risk of distraction to drivers. However, the GB application does incorporate the use of dispatcher originated broadcast calls that are based on GCA and targeted at trains entering defined train detection sections. Future enhancements to the system will include an acknowledgement message that can be initiated by the driver with the minimal of interaction (i.e. a single button press). This enhancement enables the feature to be used for a variety of operational situations that would otherwise require the train to be stopped and cautioned, thus causing a negative impact on performance.*
NL	*Group calls are used for voice communication between drivers.*
IT	*No. From a strictly railway point of view, the GSM-R is an "open system" and consequently does not affect the "Safety" of the railway system.*

4.5.1.2 The main observations are the different operational usage of group calls is demonstrated by the answers above.

4.5.1.3 Some reported operational reasons for not using group calls by train drivers are:

- risk of distraction by train drivers (safety related);
- voice group calls (with priority 2) may disturb the calls between a (secondary) dispatcher and the train driver for which the communication may be more important (punctuality related);

4.5.1.4 Some reported operational reasons for the usage of group calls are:

- usage in case of passenger information purposes;
- usage of communication between drivers (without specifying which operational scenario is envisaged);

4.5.2 Shunting calls

4.5.2.1 In following table, the reported answers on the use of shunting are summarised:

- On how many locations are shunting radio voice calls used with GSM-R?
- Do you expect changes in the future number of locations?

	Answers Shunting
CH	*Currently shunting with GSM-R is under heavy testing. Rollout is expected to start in April 2014. Nationwide approx. 150 shunting team locations will be equipped with a GSM-R capable shunting device, which has been developed for IM.*
BE	*None. For shunting analogue radio systems are used for the moment.*
DE	*In 350 locations shunting radio voice calls are used.* *In 10 big locations shunting radio voice calls are needed and cannot be implemented because of missing frequencies.* *The usage of shunting radio voice calls is decreasing because the number of shunting teams with less than 3 members is increasing. And for those teams and the shunting-movements of train-engines point-to-point-calls are the better opportunity because they don't have to change between train- and shunting radio.*
FI	*Instead of Eirene defined Shunting Mode we are using a national shunting communications method. There are 78 shunting areas defined in the GSM-R network. GSM-R is not used on all of the locations. In the future the number of locations will decrease due to e.g. radio controlled locomotive usage, decreasing amount and centralization of railway cargo traffic etc. Also due to the increasing amount of interferences from the public networks the end users are looking for alternative communication methods for shunting e.g. national TETRA network.*
SE	*No shunting at all, some RUs have test it but have not been satisfied with the performance.*
AT	*- On how many locations are shunting radio voice calls used with GSM-R?* *At the moment: 1 pilot in Linz* *Next start of operation: 1 pilot in Ludesch* *Planned: around 70 (in areas where GSM-R is already provided)* *- Do you expect changes in the future number of locations?* *Depending on the implementation of public roaming, we could consider if all other locations will be covered with GSM-R handhelds. Then there will be around 106*

	locations in summary.
FR	*GSM-R is not used for shunting in France.*
ES	*Shunting calls are not in use in ADIF's network*
UK (Crossrail)	*We will use GSM-R within the maintenance depot to co-ordinate shunting moves. This will be quicker and safer and will avoid the cost of installing many fixed telephones.*
UK	*The use of shunting mode was not considered within the GB operational design.*
LT	*LG don't use GSM-R for shunting because of delay during VGC. There is about 2 seconds delay at the moment you push PTT button till you can speak.*
IT	*Not in use*
NL	*GSM-R for shunting is not used in NL yet.*

4.5.2.2 The use of GSM-R for shunting purposes is not widespread in general. 4 out of 13 answers indicate to use (or have plans to use) GSM-R for shunting purposes. The reported reasons of not using GSM-R for shunting reasons are:

- too long call setup time (about 2 seconds delay between the moment of pushing PTT-button until you can speak)
- interferences with public network
- decreasing amount of centralised railway cargo or big shunting teams

4.5.3 Mandatory for interoperability versus optional requirements

4.5.3.1 Safety targets: besides the availability targets, following additional (safety) targets are reported:

KPI description	Punctuality /Safety related	Target	Achieved (measured)
On-board : outage of the principal source of energy of the cabradio	*Yes*	*3 hours of autonomy in case of shortage of the main power supply including 30mn of autonomy for call emission only.*	*Yes*

Non emission of the Radio emergency Call by the Cab radio	*Safety*	*10^{-5} per hour*	*Yes*
When a REC is received at the antenna level, lack of its transmission by the Cabradio	*Safety*	*10^{-5} per hour*	*Yes*
DSD alarm	*Safety*	*transmission of the DSD alarm to the secondary controller*	*Yes*

4.5.3.2 Comparable safety requirements are incorporated in the Railway Group Standard GK/RT0094 (national rule for UK) for following requirements:

- Call success rates (see part 7.1);
- DSD (see part 3.3 'Driver only operation of passenger trains);

4.5.3.3 Most answers on which existing performance requirements of the radio communication network could be changed in respect to the punctual and safe operation of trains report on the call setup times:

Current requirement (if any)	**Proposed requirement**	**Comment (explanation)**
Call-set up time for REC. *Delay in terminal in order that connection in network is made.*	*Clearly defined and measurable. Definition in EIRENE creates problems (contribution of mobile/ network). Analysis of use cases is needed. Requirement: speech indication;*	
Call set-up times are too long.	*Call set-up times shorter than 2 seconds for all types of calls with respecting the priority of REC.*	
Call setup time : 5 sec	*500ms*	*Too long in dense area network. Hinder punctuality*

REC : 2 sec	*1 sec*	*The future radio system must improve the REC setup time*
Delay during VGC	*Not more than 0,5 second*	*For shunting*
REC call setup time	*Requirement to be relaxed, f.i. equal to normal PTP calls setup time.*	*Call setup is not the issue on the implementation of REC service in GSM-R networks: the main point is the cell-based REC area granularity, which causes profit loss due to delays on trains not affected by emergency situations.*

4.5.3.4 Other reported performance requirements which could be changed are:

Current requirement (if any)	**Proposed requirement**	**Comment (explanation)**
Capacity issues – some areas still use analogue systems (e.g. shunting). Even though GSM-R band is extended, no products are available (Germany is one of the few MSs having the allowance to use extended GSM-R band).		
		No identified changes needed due to enough performance today.
	Availability requirement	*Today we have signal levels but no clear requirement on availability and QoS*
Handover at the border crossings with	*Seamless handover without*	

20 seconds black-out.	*black-outs for all types of mobile terminals.*[3]	
The rechargeable battery operation times for GPH and OPH defined in SRS are too short.	*Define at least 12 hours, better 24 hours, battery operation time.*	*The usual working time of railway staff (maintenance, operational) is 12 hours. Besides that, the quality of batteries has improved from the time when the first release of EIRENE specifications was printed.*
Availability RBC (signalling)	*Only system redundancy*	
Sending text messages or calling the train driver	*Reintroduction of sending speed target signs (like in Austria before introduction of GSM-R)*	
Dispatcher simulates less speed for saving energy and has to phone the train driver to inform him about changed speed limit e.g. faster freight trains behind slower	*Automatically transmission of the simulated speed limits*	

[3] Remark received after publishing draft report: "*A Seamless Handover would be possible if the (existing) function "Inter PLMN Handover is used during border crossing. However the correct procedure at border crossing is to be mentioned her which has a blackout period is network selection and network registration / network attach. A requirement for network selection without any blackout period is unreasonable and cannot be fulfilled by any technology. Furthermore it contradicts the existing requirement for manual network selection for cab radios. Some types of radios are not used in border crossing operation, to apply enhanced requirements to this category of mobiles is unreasonable. In general border crossing and roaming requirements must be analysed in more detail.*"

passenger trains		
At least in Germany fire brigades / police use a communication system which is independent from and incompatible with GSM-R.	*For the FRMCS a common system base may be in the scope of the analysis*	

4.5.3.5 Following question has been asked in relation to EIRENE-specifications:

"In your opinion, please indicate if some radio voice functionalities of the type M/MI (mandatory/mandatory for interoperability) within EIRENE (FRS 7.3.0 / SRS 15.3.0) are not needed as M/MI-requirement on your network or your vehicles?

Please reflect on specific GSM-R functionalities (e.g. functional addressing, location dependent addressing, voice group call service, voice broadcast service, railway emergency calls, priority and pre-emption in case of voice group calls) and specific operational modes (e.g. shunting mode).

☐ *Yes (some M- or MI-functionalities are not needed)*

☐ *No (all M and MI-functionalities are needed)"*

The answers indicating that some M or MI-functionalities are not needed are summarized in the table below:

Answers	**Explanation**
Voice Broadcast Service	*There is no need for VBS*
Eirene shunting mode	*Eirene shunting mode is too complex to be used by the end users and also there are technical difficulties with the Group Calls. The OPS terminals are also too expensive. Due to these reasons a national shunting communication*

	method was developed.
Closed User Group	*There is no need for CUG*
Roaming	*No need for national or international roaming*
Shunting mode	*Shunting*
Text messaging	*Not used (Text messaging might be used in the future.)*
Broadcast calls	*Not used (group calls are sufficient)*
Shunting	*As long as shunting is not a must established by the IM, it could be optional if ADIF's network*
The ability to register and deregister ten functional numbers 11.3.23 and 11.3.3.3 of FRS. (This is excessive and not always possible in 30s.) This requirement should flow from a valid operational requirement. It may only be necessary for the first FN to be registered within a time, with the remaining registering in the background.	
The ability to select which functional identify to use prior to making a call (See 11.2.3.3 of FRS). (In GB this is seen as degrading safety by not displacing the role of the person initiating the call.)	
The need to enter FN once where ETCS is present needs to be reviewed and a requirement based on an operational need developed that includes the possibility for EIRENE entry and failure management.	
Voice Group Call between drivers	*Not used*
Voice Broadcast	*Not used*
There are some generic MI requirements which can be reconsidered: - *Support of 500 km/h for networks* - *Environmental requirements for mobile equipment* - *Call setup times*	*These requirements have to be related to local (region, line-*

	characteristics) circumstances and not as a (cost driving) generic condition. *Seen from interoperability perspective, M would be sufficient.*

4.5.3.6 It has to be emphasized that some of the above technical requirements are in the current set of specifications not mandatory for interoperability (e.g. shunting). The analysis of the need of the technical requirement within a network depends on the definition of the operational scenario. This has also been reported within some of the answers:

"For the future communication system, operational features have to be specified more clearly prior to the definition of any technical solution. M and MI requirements corresponding to a technical solution have to be replaced by the functional need corresponding to it. A unique "Mandatory" versus "Optional/Informative" approach for the requirement definition (no more M and MI separation) is very welcome."

"The existing EIRENE specifications were written as system requirements in order to start the development and delivery of equipment. Any relation with operational processes is missing. As a consequence not all requirements are traceable and "why" cannot be answered."

In that respect, ERA has a defined roadmap in which the objective is to define first the operational interoperability requirements before setting the detailed functional and technical requirements of the next generation communication system(s). This will include a clear separation between Mandatory'' and 'Optional' requirements.

The strategy of the next generation architecture network model(s) will be defined in parallel, as the strategy will be defined by some high-level strategic objectives (incl. feasibility and economic aspects).

4.5.3.7 Following question has been asked in relation to EIRENE-specifications:

Please indicate if any and which optional functionalities within EIRENE (FRS 7.3.0 / SRS 15.3.0) are needed within your network/fleet?

☐ *Yes (some optional functionalities are needed)*

☐ *No (no optional functionalities are needed)*

The answers indicating that some optional functionalities are needed are summarized in the table below:

Answers	**Explanation**
Direct Mode	*Lack of frequencies & option has never been developed*
Forced deregistration on the cab radio	*Due operational rules, the forced deregistration has to be done by the driver after negotiation with the controller.*
The use of the group ID's 250 – 259 in areas without controller or switchman is needed for communication between drivers.	
SMS text messages	*Some SMS based applications have been taken in use (e.g. OTA, train departure permission etc.)*
Call diversion on no reply, Call diversion on not reachable	*End users are given rights to use the supplementary services*
SMS	*E.g. used for SIM-card changes via OTA.*
GPRS	*Used for several applications*
Text messages	*Text messages are implemented for railway specific applications.*
Network interconnection	*Is at the moment only informative mentioned in the EIRENE specification but is a vital functionality for interoperability.*
Provision of additional location information	*LDA is not accurate enough for railway specific call routing to dispatchers (short dialling codes).*
GPRS	*From capacity point of view packet oriented mobile data services are needed for future applications.*

Train departure system	*Automatically announcement of departure to the dispatching centre (before change of system: phone-call was necessary)*
eLDA XY	
eLDA GPS	
DSD Alarm	
Efficient REC diffusion (to be defined : eREC is the technical answer to this need)	
Access to public network	
Further specifications or improvement of specifications are still under work and are necessary for the future radio system: *Cabradio DMI specifications* *Quality of Service for ERTMS* *Cabradio tolerant to Interferences (not functional though)*	
National Railway Group Standard GK/RT0094 is an Notified National Technical Rule (NNTR) and (available from RGS Online) identifies the options from within the ERIENE specifications that have been selected for the GB application of GSM-R.	
Support of automatic network selection on Cab Radios equipped with RFI SIM-Card and running on lines not equipped with GSM-R radio coverage.	*With this feature Cab Radio selects autonomously, without driver intervention, the available GSM-P network in case of unavailability of GSM-R signal. When registered in GSM-P, Cab radio searches every 6 minutes if GSM-R signal is available again and if this the case, it comes back to GSM-R.*

4.5.3.8 Following question has been asked in relation to national radio voice functionalities

"National specific radio voice usage: please indicate if and which specific national radio voice functionalities are not used by (or used differently from) the EIRENE specifications (FRS 7.3.0 & SRS 15.3.0)?

☐ *Specific national radio voice functionalities are used*

☐ *No specific national radio voice functionalities are used*

If specific national radio voice functionalities are used or needed, please explain which and why"

The answers indicating that 'specific national radio voice functionalities' are used are summarized in the table below:

Answers	**Explanation**
"Logical" voice announcements in dedicated area	*Due influencing neighboring cells (lakeside) it is not possible using the conventional VBS. Therefore a solution was developed, providing a voice announcement (conference call to FN) to all trains/passengers within a dedicated "logical" (trackside) area.*
National shunting method is being used	*Eirene shunting mode is too complex to be used by the end users and also there are technical difficulties with the Group Calls. The OPS terminals are also too expensive. Due to these reasons a national shunting communication method was developed.*
Shunting	*Some RU use their own shunting radio system (not based on GSM-R).*
Train emergency stop	*Train emergency stop can be activated by a dispatcher or a signaller and causes vehicle emergency braking*

1. High Priority Point to Point Call (Yellow Button) - This provides a way of contacting the Signaller Urgently without stopping trains which did not prevent Interoperability). *2. The ability to register using alphanumeric codes (As these are used for train descriptions in NR). Such a facility is mentioned in the FRS but any such application would contravene the requirements of the SRS (critical error).* *3. Ability to register non-unique train running numbers (As they are not unique within NR).* *4. Ability see short messages carried as optional tags in call control messages to and from drivers such as "Stopped at Signal", "Wait" and "Contract Signaller when safe" (These were seen a beneficial for train operations but do not prevent interoperability). The UUIE spec should specifically identify such messages and require EIRENE devices that don't support such messages to ignore the request i.e. do not alert.* *5. Mobile originated group 200 calls are not used.*	
The ability of GPH/OPH to send, in the OTDI field of the emergency call, the Subscriber number (call Type 8) of the call originator if no registration to Functional Number is present.	*This features explicitly requested by RFI to GPH/OPH suppliers, allows traffic controllers to identify the originator of a REC call, also in case the originator is not registered to FN (f.i. maintainer along the track)*
RFI DTC CSI SR OR 10 003 A, RFI DTC CSI SR OR 10 004 A and ANSF 6665/10. 4	*National radio voice requirements.*

4.5.3.9 Following question has been raised in function of the optimisation of the current set of requirements

"In your opinion, can the current set of requirements be optimised (e.g. further simplification/higher level of detailed specifications)?"

[4] National rule to be investigated.

Following answers have been received:

Y/N	Answers
Y	*- simplify of the registration process using external interfaces (e.g. RFID, Card reader, timetable,..)* *- MMI supporting USSD-commands, e.g. for simple services or Queries*
Y	*After having sent a REC, our controllers would like to have:* *- either a confirmation that all trains within the pre-defined area have received it;* *- or an indication which train did not receive it (if any).*
Y	*It should be possible to load schedules or operation charts to enable an (semi)automatic registration and deregistration.*
Y	*The set of regulated requirements should focus on the very essential functions and features that are relevant and mandatory for interoperability* ***only****. The need for technical and technology specific requirements should be carefully considered and avoided where possible. Information and communications technologies are evolving very rapidly, so that technical requirements would have to be frequently updated and harmonized with the latest developments.* *In order to make the systems and applications useful, versatile and user friendly, they need to be customized, not regulated, to fulfil the users' specific needs. E.g. the Driver Machine Interface (DMI) has a very detailed and rigid specification.*
N	
Y	*The M and MI-functions in the EIRENE-specification are – from an operational point of view – needed also in the future, but, in some cases the requirement is too detailed (and based on the ASCI-facilities) which may be achievable in another way with new technology (e.g. push to talk may not be necessary for group calls if implemented with another technology).*
Y	*e.g. activation of group IDs not clear;* *Harmonization of GID & SDC;* *Handling of CAB Radios should be harmonized;*
N	
Y	*A clear separation of functional requirements and technical requirements is necessary: the split between SRS and FRS has to be clearer.* *A formal approach has to be taken.*
N	
Y	*The work being done on number harmonisation needs to be incorporated into the specifications. National values have no place in an interoperability specification.*
N	

N	
Y	*In particular agreed and overall valid and mandatory Test Specifications included in TSI for Certification of both mobile equipment and networks* *PLUS* *Revised mobile equipment specs for interference handling with aligned revised network specs*
Y	*There are arguments for moving in both directions which may mean that the current level is about right.* *Areas where equipment from different suppliers must interface to each other are generally well defined at the moment but with some exceptions (see 3.1.15). However interfaces which are purely internal to equipment from one supplier need not be defined at all. This implies that a clear decision is required about which interfaces fall into which of these categories.*
N	/
N	/
Y	*The existing EIRENE specifications were written as system requirements in order to start the development and delivery of equipment. Any relation with operational processes is missing. As a consequence not all requirements are traceable and "why" cannot be answered.* *Some other requirements do need further investigation. Example: language selection in cabradio's, without indicating what languages have to be supported.* *There are also requirements, which are essential for interoperability, but are missing. Example: roaming between GSM-R networks.* *Cost reduction of equipment (radios and network) seems possible when a reduction of requirements can be achieved.*

4.5.3.1 Following comments have been received on the following question:

Do you want to add specific topics/comments related to this questionnaire on voice communication?

Answers
1/ Need for geolocalization of trains on lines along with their direction: *The geolocalization of rolling stocks and trains along with their direction of traffic is a general need of all GI and RUs for continuous train supervision, voice radio communications and efficient diffusion of emergency call.* *The future radio communication system should therefore be the common medium enabling this localization of trains and their directions.*

2/ Need or not for a generic standard as communication layer:

A return of experience of the GSM-R as a voice radio communication system has to be conducted in order to define a strategy on that topic.

In our opinion, this study should allow us to evaluate the benefit (or loss) related to the fact that GSM-R was built from a standard widely used by service provider:

Prices: GSM-R equipment (ground network) is derived from GSM equipment. Development costs of the GSM part are supposed to have been supported by the telecom industry, railway industry should have supported only the specific part of GSM-R. Was it really the case?

Obsolescence: GSM-R decision was taken during the 90's, when GSM equipment were deployed on a large scale by telecom service providers. 15 years later, GSM-R deployment is still on-going but telecom service provider are deploying the 4th generation of GSM technology. GSM equipment is obsolete for years. GSM-R equipment will hardly be supported 10 years after the last deployment. Taking into account railway industry delays and life cycle (development of railway specific features, decision to deploy, deployment of ground network), is it really interesting to rely on a standard develop for telecom service provider which has a much shorter life cycle?

To better control prices and obsolescence would it be interesting (from economical and obsolescence point of view) to try to develop a railway specific solution?

3/ Need for higher performance, availability, robustness and QoS

The radio voice calls between drivers and controllers and the REC are critical functions which may hinder regularity and the overall safety of the railway system in case of failure/disruption. Therefore, the future radio communication system has to provide greater overall performance (transmission delay, QoS, reliability, robustness).

4/ A system efficient and responding to well-defined functional requirements

A trial has to be established based a complex and dense traffic configuration for the voice application considering degraded traffic conditions. This trial must be resistant to the traffic conditions and railway network topology of Paris area for instance

5/ Need for tolerance to interferences and a future-proof approach

The future radio communication system has to be tolerant to interferences from existing and future technologies in adjacent bands or from the same band.

6/ Need for seamless border crossings

A particular attention has to be brought to the transition between networks. The absence of service should be drastically reduced with the new system.

One of the main problems to use GSM-R for shunting operation is that trunking systems are easier to use and faster. New technologies should provide better features than those which they have to substitute.

Stop one train function is a concept that has been raised by some user of the system, as they like to be able to target a specific train in an urgent or emergency situation and send it a predefined stop command.

High priority point-to-point call (eMLPP2) that can be initiated by either a mobile user or signaller, this enables a targeted point-to-point call to be initiated that will where necessary pre-empt lower priority calls (i.e. those with a lower eMLPP). 5

The interface between GSM-R and ETCS needs to be improved so as to ensure users are only required to input common data once and where necessary to ensure failure messages are displayed on the source of the failure to facilitate fault diagnosis and rectification.
The concept of national values needs to be further enhanced through the ongoing work relating to harmonisation.

Consideration should be given to the specification of a harmonised DMI taking into consideration application constraints, e.g. design constraints associated with retro fitment and the variety of cab designs.

Intelligent software that is capable of determining the routing of a call based upon its eMLPP, the functional identity of the initiator, the location of the originator, geographic location of originator and the potential points of conflict within the vicinity of the originator (e.g. a cab mobile originated REC would be automatically routed to the controlling signaller and only other cab mobiles that are likely to be effected by the emergency, i.e. train movement that based upon their location could come into conflict with the originator).

Train Ready to Start (TRTS) function is potentially beneficial, as it has the potential to deliver performance improvements and reduce Capital Expenditure through reducing lineside equipment.

Increased use of berth triggered pre-recorded messages that can be acknowledged upon receipt, those potentially reducing the need to stop and caution trains using conventional methods, thus delivering performance benefits whilst maintaining existing levels of safety.

Greater use of the public address interface to enable passenger information to disseminate more effectively during times of disruption, thus improving the timely delivery of accurate up to date information.

[5] Remark received on published draft final report: "*eMLPP is a technology (circuit switched) based solution for a general requirement. E.g. in a future packet switched based FRMCS where shared resources are used, pre-emption is not required or reasonable, precedence functions (e.g. automatic answering) may be sufficient*".

4.6 VOICE APPLICATION - FINDINGS

4.6.1.1 GSM-R has a positive contribution to punctuality and safety as it offers a platform for fast and simple communication.

4.6.1.2 The negative impact on punctuality by GSM-R is mainly defined by the availability of the radio communication service. Besides the availability of the system, the unintended use of railway emergency calls has also been reported as one of the factors causing train delays.

4.6.1.3 Limited incidents have been reported in relation to radio communication hazards. The hazards are mostly related to the unavailability of the emergency call (especially in case of interferences) or to the misrouting of the emergency calls (wrong cell reselection). Most respondents expect that the principle to shift railway features from the communication bearer towards the application layer will create no negative impact on safety under the condition that some key requirements can be fulfilled (such as Quality of Service, security and prioritization of calls). Some respondents expect a positive impact on safety due to flexibility in developing safety supporting services and a potential increase in availability by the potential use of multiple communication bearers.

4.6.1.4 Technical interoperability: few technical interoperability issues have been reported in relation to the usage of CAB-mobiles in the different Member States. The additional GSM-R test specifications (voted in June 2014) will further contribute to the avoidance of potential different interpretations of EIRENE-specifications.

4.6.1.5 Mandatory for interoperability versus optional requirements: the optimization of the requirements should lead to a better split between mandatory for interoperability and optional requirements.

4.6.1.6 Operational interoperability: the way how the different technical functions within GSM-R are used in train operations is not fully harmonized across Europe (e.g. usage of voice group/broadcast calls). In that respect, further alignment of the operational requirements will be needed with the aim of creating operational interoperability for communication procedures for train drivers. In that respect, the operational requirements for shunting should also be clarified.

5. ETCS DATA APPLICATION

5.1 ETCS DATA APPLICATON – PUNCTUALITY

5.1.1.1 A limited number of answers have been received in relation to punctuality impact of radio data incidents.

5.1.1.2 Following main causes and consequences have been reported:

		Cause (e.g. interferences, technical failures, handover problems, capacity constraints, …)	**Operational consequence (e.g. service/emergency brake, contact with dispatcher/controller, …)**	**Percentage of punctuality impact**	**Comment (explanation/additional study report)**
IM	*1*	*Technical failure in core network*	*ETCS L2 Service outage / Diverting trains*	*100%*	
RU	*1*	*Lost radio contact*	*Service brake*	*(0.3 percent of all incidents)*	*IM working to improve*
IM	*1*	*Modems onboard*	*Drop call*	*50%*	*Software problems?*
	2	*BSS failure*	*Drop call*	*50%*	*Power, transmission or BTS HW*
IM	*1*	*GSM Outage*	*No train operation with ETCS L2 or fallback to national signalling system*		*No relevant outages have been occurred.*
	2	*Capacity constraints*	*Additional use of other radio systems (e.g. analogue radio or public mobile communication systems for railway*		*A study about capacity constraints is ongoing.*

			specific voice communication in areas with high traffic) *Alternative operational concepts*		
NSA	*1*	*Interferences*	*Occasional service/emergency brake*		
IM	*1*	*GSM-R data radio holes*			
	2	*FTN card faults*			
	3	*Signal strength*			
	4	*Interference issues form public mobile network*			

5.1.1.3 Following main findings on incidents of radio data communication network affecting the punctual operation have been shared:

	Answers
IM	*Incidents in the GSM-R Core network affect train operation (with ETCS L2) nationwide. This is new in comparison with traditional regional interlocking systems.* *Over the past we had virtually no incidents on the radio network side affecting ETCS L2 train operations (thanks to redundant coverage). But in 2013 we two MSC incidents leading to significant train delays on ETCS L2 tracks (70'000 passenger delay minutes), even with full MSC redundancy. The problems were caused by either modifications to the MSCs or SW bugs.* *Lessons: Also redundant architecture does not guarantee 100% availability.*
NSA	*There is only pilot installation of ETCS L2 on 22 km line in the time being. No difficulties in GSM-R communication were identified during the test operation – there are public packet radio networks*

	not yet, which may cause the harmful interferences.
IM	*No problems of GSM-R outages in areas where ETCS L2 is in live operation.* *No issues in tunnels with leaky feeders.*
IM	*Approximately 660 delay minutes due to telecoms (over last 2 years). Only operational consequences information is related to delay minutes.* *Main causes in last 2 years are GSM-R network issues, GSM-R data radio holes and FTN card faults. Earlier issues during commissioning include signal strength and interference issues from public mobile network.*

5.2 ETCS DATA APPLICATION – SAFETY

5.2.1.1 There are no reported significant accidents due to radio data incidents:

	Y/N	**Answers**
IM	*N*	*No safety impact (GSM-R in connection with ETCS L2 does not have any safety related impact).*
IM	*N*	*Upgrades to the network and ETCS upgrades e.g. removal of radio holes were identified and carried out earlier in the project. Not aware of any incidents (hazards) post commissioning that have required mitigation measures.*
IM	*N*	
NSA	*N*	*No incidents in which the performance of the radio data communication network could have played a role in the safe operations of trains running with ETCS Level 2.*

5.2.1.2 A limited number of answers have been reported related to hazards of data communication systems for trains running with ETCS Level 2/3:

	Hazard	Mitigation measures	Comment (explanation/additional study report)
IM	/		*There are no known safety related incidents where radio data communications played a key role.*
IM	/		*There are no incidents which require additional measures.*
NSA	*Interferences*	*Occasional service/emergency brake*	*Implementation of UMTS 900 may cause transmission problems in some areas.*

5.3 ETCS DATA APPLICATION – INTEROPERABILITY

5.3.1.1 There are no reported interoperability issues reported for EDORs that hinders operation on multiple networks (RUs)[6] or that lead to an important impact on the requirements for the EDORs;

	Y/N	Answers
Supplier	*N*	*If there would be rather due to differences of operational rules between networks than technical differences – since technical network interoperability is guaranteed via IOT performed with EC funding by the two GSM-R network suppliers in Europe*
Supplier	*N*	*As already explained for the cab radio (voice), EDOR will be tested in conjunction with the network in the future as well based on a specific interoperability test case as basis for certification, which will be developed in cooperation between suppliers and ERA as part of the TEN-TA 3rd call project and will become part of CCS TSI.* *The future EDOR will include radio modems for CS and Packet data to guaranty interoperability for current CS based ETCS and future based GPRS ETCS*

[6] Similar remark has been reported in relation to GSM-R voice for Swedish trains running on Norwegian network which is covered in the section on voice application ("*Norway has a slightly different GSM-R voice-radio system. This makes it necessary for Swedish vehicles to have updated GSM-R software to allow cross-border operation in Norway.")*

		systems.

5.4 ETCS DATA APPLICATION – PERFORMANCE

5.4.1.1 Following question has been addressed in relation to operational targets:

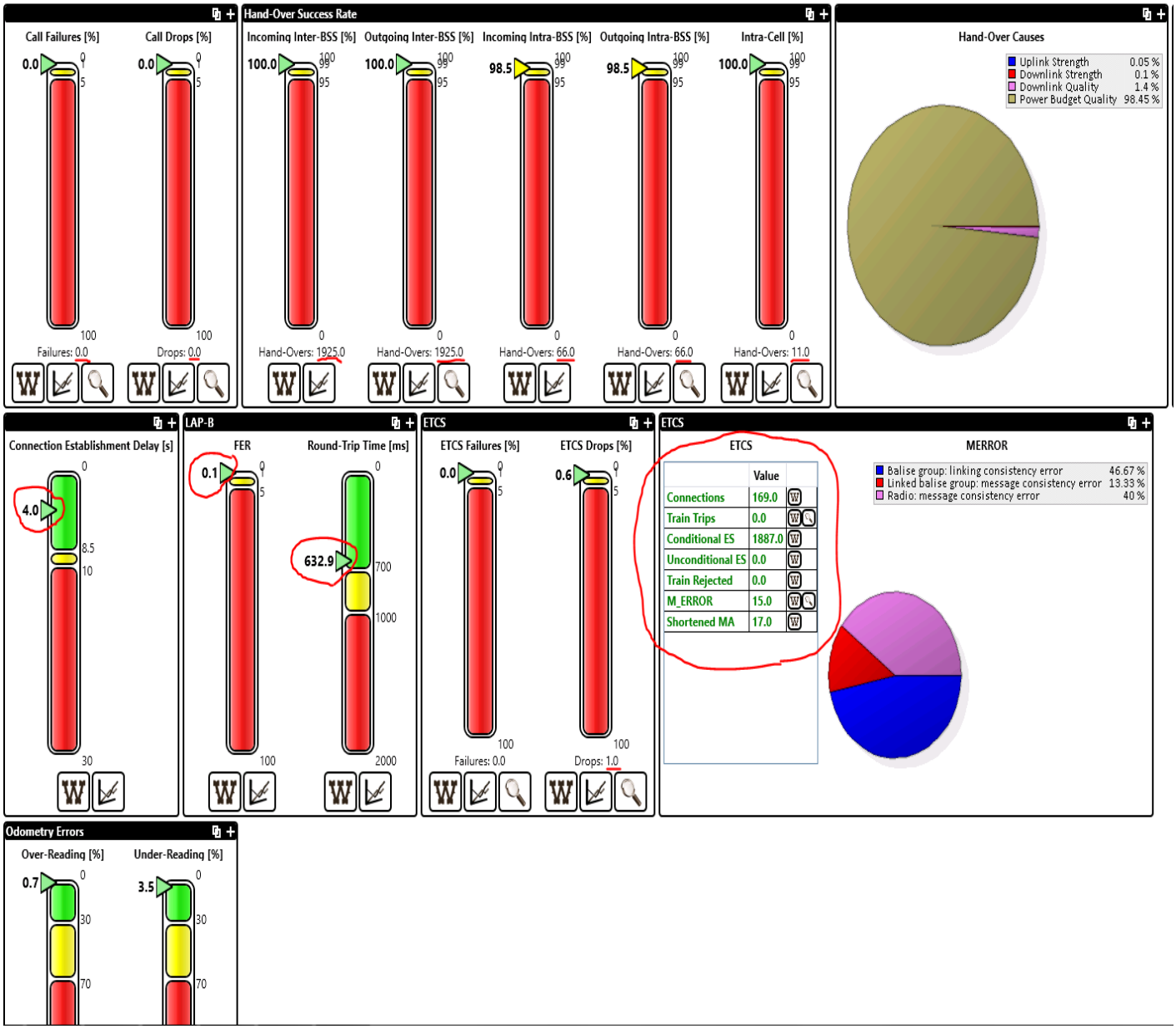
"Are there any operational targets (contractual/KPI) set related to radio data communication networks/mobiles in order to achieve the required punctual and safe operations of trains running with ETCS Level 2/3 on the railway system?

Please distinguish in function of the type of lines if necessary."

	Number	**KPI Description**	**Target**	**Achieved (measured)**	**Comment**
IM	*1*	*Session drops / 100 hours of operations*	*1*	*10*	
	2	*Passenger Delay Minutes p. year.*	*140'000*	*150'000*	*Figures of 2013*
IM	*1*	*Subset 093*			
	2	*Transmission interference requirements are very stringent*			
IM	*1*	*Use subset-093*	*Comply with the specification*	*All train runs are evaluated*	*Setup times* *Time between handovers* *Frame error rate* *Round trip delays*
	1	*Outage of the communication network*	*Availability* *NSS: 99,999%* *BSS: 99,995%* *BTS: 99,99%*		
RU	*1*	*outage of the*	*No outages*	*No*	*ETCS Level 2*

		communication network			*failure/problem*
IM/RU	*1*	*Subset 093*		*yes*	*Document under maintenance*
	2	*Availability requirement deduced from the RAM requirement 02s1266 §2*		*Yes*	*Document for information*
	3	*GSM-R delay for ETCS*	*Line-dependent*	*Yes*	*French approach proposed to the UIC as an input for the maintenance of Subset 093*
IM	*1*	*Availability of the radio network*	*99,95*	*99,995*	
	2	*Communication losses per 100 running hours*	*1*	*1.6*	*Ref. subset 093. Note that subset 093 is GSM-R only. The requirements and reports cover also the ETCS communication layers*
	3	*Unintended train stops per 100 running hours*	*-*	*0.7*	*The requirements and reports cover also the ETCS communication layers*

5.4.1.2 Following example have been shared with a dashboard for monitoring of different operational targets:



5.4.1.3 Following comment have been shared in relation to operational targets:

"QoS and reliability requirements with a clear separation between the on-board objective and the network objective are necessary to guarantee safe and uninterrupted operations of trains."

5.4.1.4 Following question addresses the potential improvements to performance requirements:

"In your opinion, which existing performance requirements of the radio data communication network could be changed in respect to the punctual and safe operation of trains running with ETCS Level 2/3 on the railway system?"

The reported answers are:

	Number	**Current requirement (if any)**	**Proposed requirement**	**Comment (explanation)**
IM	*1*	*/*	*Availability requirement*	*Why coverage/ QoS requirement / and not availability*
	2	*Transmission interference requirements: current definition can be improved/ much too stringent*		
IM	*1*	*Dual layer BSS (national requirement on ETCS L2 lines)*	*Availability requirement*	
IM	*1*	*KPIs in subset 093 – error free period not correct*		*Implementation report was provided by ÖBB*
	2	*Some KPIs in subset 093 not achievable or too strict*	*Requirements much to high – leading to high testing costs (statistically validation)*	
	3	*Availability– Coverage level – 92dB*	*Harmonised availability definition (discrepancy between RBC and GSM-R data); Double coverage is not needed (radio planning increased interference risk;…)*	
RU			*Stable build-up of the*	

		Outage of the communication system	*system*	
IM/RU	*1*	*Connection loss rate (10-2 per hour)*		*Insufficient in case of dense traffic. To be as low as technically possible*
	2	*TTI/TREC*	*To be replaced by a different KPI (GSM-R delay)*	
	3	*Transmission delay*		
	4	*Re-emission mechanism*		
	5	*Communication capacity*		

5.4.1.5 Please add (if any) your general comments on the performance requirements:

	Answers
IM/RU	*Performance is to be improved with the future system. It is today insufficient for safe and uninterrupted operations.* *Migration towards IP packet radio transmission seems to be a necessity both from a standard perspective and from a performance point of view.* *QoS KPI of the radio transmission criteria must be redefined accordingly. Typical performances:* - *Session establishment delay and reestablishment delay (TBD, typically < 1s / < 500ms)* - *Round trip delay (< 100ms)* *Obviously when using packet mode it is necessary to the technology shall provide functions for:* *Mobility management at speeds compatible with railway operations up to 350km per hour and shall not degrade the above KPIs.* *Guarantee a minimum bandwidth for certain class of users* *It is also important to consider the capacity offered by the network: it shall be able to support ERTMS traffic in dense areas. More throughput and communication capacity are required for dense traffic areas and disrupted conditions of traffic.*

	The TTI/TREC KPI is not relevant for ETCS L2.
IM	*Note: For the cl 158, a minimum MDBSAF of 25000 miles (40000 Km) has been set as a target below which active investigations shall be prompted. The Cl 158 averaged 35000 miles MDBSAF over the first 6 months of 2013. Active investigations have not been prompted to investigate this.*

5.4.1.1 Following question has been addressed in relation to the mandatory for interoperability specifications:

"In your opinion, please indicate if some ETCS radio data functionalities of the type M/MI (mandatory/mandatory for interoperability) within EIRENE (FRS 7.3.0 / SRS 15.3.0) are not needed as M/MI-requirement on your network or your vehicles running with ETCS Level 2/3?

☐ *Yes (some M- or MI-functionalities are not needed)*

☐ *No (all M and MI-functionalities are needed)"*

Following answers have been reported:

	Y/N	**Answers**
IM	*N*	
RU	*Y*	*The activation of the driver safety device shall automatically trigger the Cab radio to send a data message.Train will stop when DSD is activated.*
IM	*N*	*For packet based ETCS system most of the MI requirement have to be specified in a new way*
IM	*N*	*Priority is a must (e.g. in stations), especially in case of capacity issues.* *Is the defined short dialling code for ETCS really needed?*
RU	*N*	
IM/RU	*N*	*The EIRENE requirements are fully specific for a GSMR data circuit type of communication; it is not relevant to build a specification for a future technology based on existing EIRENE requirements.*
IM	*N*	
IM	*Y*	*FRS sections 16.2.2.1 'The ETCS data only radio shall select the mobile radio network*

		as directed by the ETCS application. (MI)' and section 16.2.3.1 'The ETCS data only radio shall handle calls as directed by the ETCS application (MI)'. These requirements may need to be changed in order to allow the radio layer to select an alternative network following failure of the primary comms bearer.

5.4.1.2 Following question has been addressed in relation to specific/additional ETCS radio data functionalities:

"Specific/additional ETCS radio data functionalities: please indicate if other specific/additional ETCS radio data functionalities are not covered by (or different from) the EIRENE specifications (FRS 7.3.0 & SRS 15.3.0) for running with ETCS Level 2/3?

☐ *Specific/additional ETCS radio data functionalities are needed*

☐ *No specific/additional ETCS radio data functionalities are needed*

If specific/additional ETCS radio data functionalities are needed, please explain which and why:"

Following answers have been reported for which specific/additional ETCS radio data functionalities are needed:

Answers	Explanation
ETCS over Packet Data connection	*Required for capacity reason -> Increased spectrum efficiency*
Availability requirement	*Subset-093 is informative and you can run train with good performance every day without fulfilling the specification*
IP Packet switching	*Improved capacity, robustness, performance, resistance to interference, availability.*
Possible future need for ETCS data radio to be interfaced to an on-board train mobile gateway or router.	*To provide additional availability from other comms public bearers and also to provide future migration path to GSM-R successor. Ability to select 'preferred' or 'best comms bearer available' at EURORADIO layer.*

5.4.1.1 Following question has been addressed in relation to the optimisation of the current set of ETCS radio data functionalities:

"In your opinion, can the current set of functionalities be optimised (e.g. further simplification/higher level of detailed specifications)?

☐ *Yes*

☐ *No*

If yes, please explain:"

Following answers have been reported:

	Y/ N	**Answers**
IM	*N*	
IM	*Y*	*Open the standard as soon as for ETCS over the packet domain*
IM	*Y*	*Subset 093 - error free period not correct* *Measurement O-2475 is too strict (although informative) especially in relation with ETCS GPRS spec.*
RU	*N*	*Not enough experience with ETCS Level 2*
IM/RU	*Y*	*Packet switching over IP is required for the reasons exposed above.* *When migrating towards packet transmission, we will remove a capacity limitation. This will allow implementing a redundant radio connection from the EVC to the RBC and improving the system availability.*
IM	*N*	
IM	*Y*	*Yes, given that authorisation is split between the IM and the RU, the requirements should be written so that the IM and RU can independently tests and provide evidence to support authorisation of their system elements and not rely on an interpretation or functionality from the other party. Also the link between acceptable packet transfer ratio and signal strength is not clear the pass mark should be stated clearly. Finally it is theoretically possible to get to a position where all trains are stopped and a driver cannot communicate to the signaller without initiating a REC. This would occur if all available timeslots were used for ETCS (Priority 1) preventing a Driver calls (Priority 2). This needs to be addressed possibly by allowing high priority voice calls at P0 and reducing the priority of some ETCS transactions e.g. mode change, to P4.* *The ETCS KPI work should also allow for differential requirements along a line of route as*

		proposed in the Implementation Report developed by SNCF.
Supplier	*Y*	*In particular agreed and overall valid and mandatory Test Specifications included in TSI for Certification of both mobile equipment and networks* *PLUS* *Revised mobile equipment specs for interference handling with aligned revised network specs*

5.5 ETCS DATA APPLICATION – FINDINGS

5.5.1.1 A limited number of answers have been reported on punctuality. Most answers reflect on the unavailability of the radio data service which includes several technical causes such as on-board mobiles, network faults and interferences (similar technical causes as those for the radio voice application). Besides technical failures, also capacity constraints are reported as cause for train delays (see performance aspects).

5.5.1.2 A limited number of answers have been reported on safety issues. The only reported hazard relates to the occurrence of interferences.

5.5.1.3 The answers on the current set of requirements report a common view on the need for additional capacity (change request 'ETCS over GPRS' part of maintenance release 2 of Baseline 3).

5.5.1.4 The answers on the current set of requirements include multiple comments on the QoS and availability requirements (as part of the informative specifications within subset 093) and the possible redefinition of these KPIs.

6. FUTURE OPERATIONAL CONCEPT

6.1 Introduction

6.1.1.1 In the last block of the questionnaire, questions have been raised to identify potential ideas and needs for a future operational concept in relation to the next generation communication systems. In that respect, the potential railway applications to be covered by a communication system are identified and categorised in 3 application areas, being Mission critical applications, passenger information applications and passenger entertainment applications.

6.1.1.2 Besides the list of applications, there is also a request to indicate the key technical characteristics for the communication system of each of the applications. This will allow defining the high-level requirements necessary for the next generation communication system(s) if these systems are expected to cover the particular application.

6.1.1.3 One answer (SNCF) reflected beyond application level and technical requirements on the future idea of operational concept:

A top-down approach starting with the operational needs and users requirements should be undertaken. In order to achieve it, a return of experience on GSM-R as a data and voice medium should be conducted.

1/ Functional scope of the future radio communication system

In our opinion, the applicative scope of the future radio communication system has to be limited to the strict interoperable applications in order to have the most cost/efficiency ratio.

2/ Core Railway applications related to interoperability to be covered by the future radio communication system are:

- *ETCS L2/3*
- *Radio voice communication between Drivers and Dispatchers/Controllers*
- *Transmission of geo localization of trains and trains direction information*

3/ Main operational characteristics:

- *Seamless transitions between two different national networks*

- *Operationally-efficient radio emergency call diffusion (limited to the necessary trains)*
- *Interoperable and improved location addressing abilities in order to address uplink discrimination in case of complex meshed railway networks (e.g. Paris Area).*
- *Access to the public network (by using a different radio module in the EDOR instead of roaming for instance, in order to avoid interference issues)*

4/ Main foreseen technical characteristics:

- *IP packet switching*
- *Modularity: in principle, a clear physical separation between railway application layer and the communication layer.*
- *Tolerance to interference*
- *Faster transmission of data messages for ETCS*
- *Improved performance for voice and data (communication delay, QoS, Reliability)*
- *Broadcast and multicast concepts for ETCS*

5/ A special attention has to be paid to the following topics when choosing the relevant technology (either public or specific):

- *Life expectancy of the railway radio system*
- *Economical assessment*
- *Obsolescence management*
- *Migration strategy*
- *Continuous supervision of the future radio communication system: radio coverage, radio equipments*

6.2 Mission Critical Applications

6.2.1.1 Following main new applications are reported in the general section:

- *Automatic train operation (driverless operation, including online video from drivers cabin)*
- *Remote monitoring*
  - *in case of on-board default, Helpdesk can log in for remote failure analysis,*
  - *access to maintenance manuals/checklist*

- *Remote fall-back (use of unoccupied drivers' cabin)*
- *Adaptive driving influencing (saving energy and train advisory speed)*
- *Emergency situations*
  - *Automatic emergency message towards operational centre;*
  - *Accurate position indication to the driver/dispatcher in case of an accident*
  - *Predefined voice-prompt*
- *Train departure*
  - *USSD-messages over GSM-R (safety related and fast delivery time)*
  - *Automatic registration of train (e.g. triggered by RFID tag, GSM-R smartphone, third party system, …)*
- *Train schedule*
  - *Connection to time schedules*
- *Automatic translation services (e.g. the driver can communicate in his language all the time)*

6.2.1.2 Following question has been addressed in relation to mission critical applications:

Could you list the current and future mission critical railway data applications which could influence the requirements of the next generation railway radio communication system(s)?

Following answers have been reported:

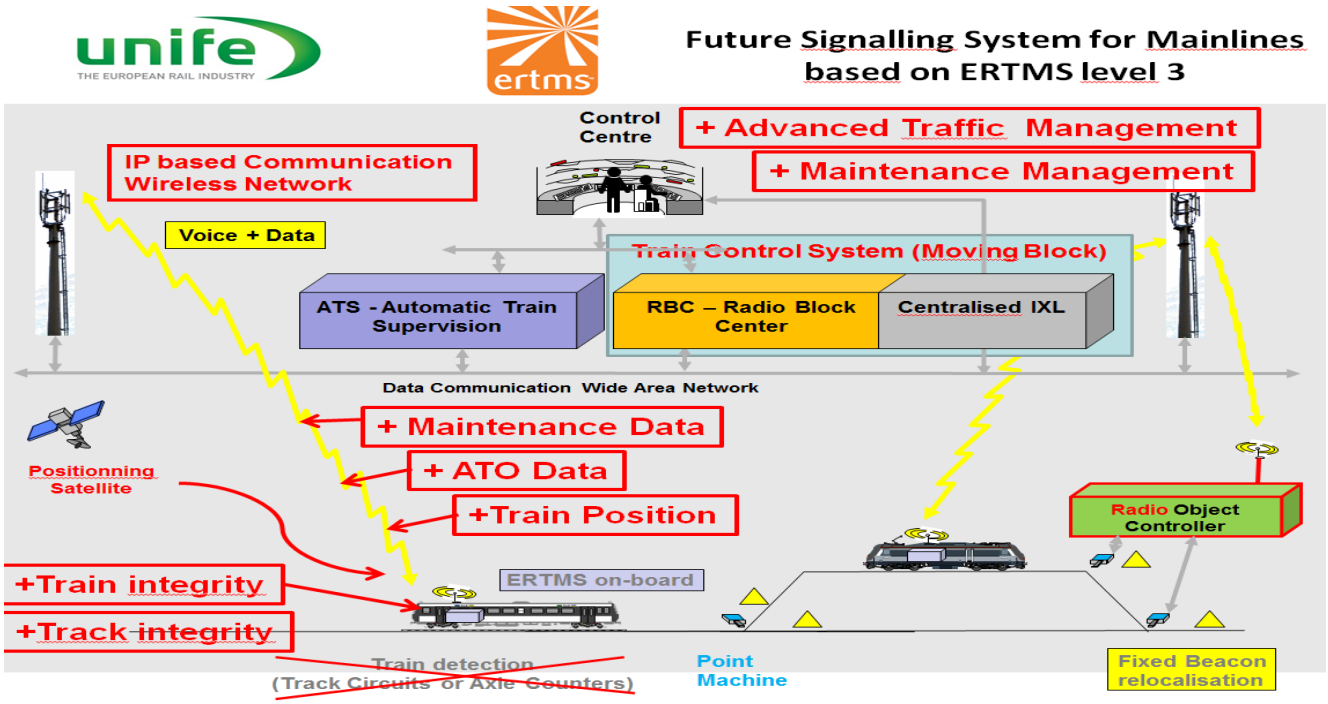
Organization	Nr	Name of data application	Description of data application	Functionality already implemented (yes, no)	Main characteristics/key requirements of data application (e.g. bandwidth, data rate, QoS, security, required communication technology, …)
IM	*1*	*DICE*	*USSD-messages*	*No (this year)*	*Transmission speed, limited data*
	2	*ETCS L2*	*Use of circuits switch data for the moment and GPRS in future*	*Implemented for L3 and L4. 1/3 of network will use this technology in future (+/- 1000linekm)*	
	3	*ATWT4*	*Supervision of working areas*	*Tests are just starting*	*The goal is to increase the safety for those working areas*
IM/RU	*1*	*"Train Ready"*	*ref. TAP/TAF TSI*	*yes*	*Call attempt to SDC 1777 converted to data message.*
	2	*Infrastructure Restriction Notices*		*Under development*	*Secured on-line data connection, network or technology independent.*
	3	*Incidents, situational awareness*			
RU	*1*	*ETCS*		*Yes, partly*	*High availability, low bandwidth*
	2	*GSMR Voice*		*Yes*	*High availability, low bandwidth*
	3	*Electricity consuming measurement*	*Measure how much electricity the train is*	*Test phase ongoing*	*High availability, low bandwidth*

		system	*consuming in traffic. Result sent to land based server.*		
IM	*1*	*ETCS L2 and L3*		*Yes*	*High availability, low bandwidth*
	2	*Traffic information system*	*PA, information signs and clocks in stations*	*Yes*	*High availability, low bandwidth*
IM	*1*	*Signaling Controlled Warning System*		*Yes*	*Reselection times (time of round trip) within GPRS; influenced application to cover technical limits*
	2	*Braking test system*		*Yes*	*SMS*
	3	*Track monitoring; measurement of check points (hot wheel detection)*		*Yes*	
	4	*Tracking services (train positioning)*		*Pilot phase*	
	5	*Shunting application (set right route for shunting vehicle>); often problems related to coverage*		*Pilot phase*	
	6	*Power plants; control of applications by public communication network*		*No*	*Coverage problem or interconnection problem (GSM-R network as gateway to connect to these systems)*
	7	*Laptops of train*		*Yes*	*Some applications not*

		drivers to download information			*possible to integrate into GSM-R due to bandwidth problems*
RU	*1*	*End-of-train detector*	*Safety-critical data application*	*No*	*-*
	2	*Emergency calls*	*Safety-critical data application*	*Yes*	*Priority calls*
	3	*Shunting communication*	*Safety-critical data application*	*Yes*	*Closed channels*
	4	*Automatic speed limit*	*Energy saving data application*	*No*	*Automatic conjunction between dispatching center and train*
	5	*Announcement of train stops*	*Faster traffic flow*	*No*	*Automatic train stop announcement for faster workflow in the signalbox*
NSA	*1*	*ETCS*	*ETCS*	*Yes*	*More capacity and faster establishment procedures*
IM	*1*	*On-board CCTV relayed to control centers*	*Improved passenger safety and security and incident response*	*Yes, to limited extent but constrained by bandwidth and network coverage*	*Bandwidth*
IM	*1*	*ETCS Critical Operational Permission data, requiring high reliability*			
IM	*1*	*ETCS Train Monitoring (Onboard Systems)*			

6.2.1.3 Shift2Rail: besides the reported answers, the Shift2Rail program also includes the future signalling concept based on ERTMS Level 3. This future concept includes the steering and controlling of decentralised infrastructure objects (points) by radio communication means (instead of today's fixed cable communication). Data

communication between radio object controller (linked to points) and control centre/train control system;



6.3 Passenger Information Applications

6.3.1.1 Following question has been addressed in relation to passenger information applications:

"Could you list the current and future passenger information railway data applications which could influence the requirements of the next generation railway radio communication system(s)?"

Following answers have been reported:

	Name of data application	**Description of data application**	**Functionality already implemented (yes, no)**	**Main characteristics/key requirements of data application (e.g. bandwidth, data rate, QoS, security, required communication technology, …)**
RU. 1	*PIS*	*Passenger Information System*	*Yes*	*Medium need of bandwidth today (GPRS). Bandwidth will increase with more passenger information sent to the train.*
2	*Repeater System*	*Increase the train inside coverage of the public mobile networks.*	*Yes for 2G and 3G.* *Ongoing testing 4G.*	
IM.1	*Orientation (control) system for passengers*	*To provide individual information for every passenger regarding reservation, connection times, facilities at the railway station,*	*No (partly)*	*Bandwidth*

		menu for the dining car, car rentals and many more (complete travel chain)		
IM.1	*Improved visibility to passengers of connecting services*		*Yes, but better required*	*Interconnection of systems - smart filtering for data relevance to passengers*
IM.1	*Connections*	*Being able to show copy of departure screens at next station on board*	*No*	
IM.2	*Reservation updates*	*Access to reservation and ticketing systems for on-board staff*	*No*	
IM.3	*Seat reservation indication, no*	*Real time updates onboard.*	*Yes, but limited and via other systems.*	
IM.4	*PA operated remotely.*	*Improving the dissemination of accurate up to date information .*	*Yes, but limited.*	
IM.1	*Passenger information*			
IM.2	*Video surveillance*			

6.4 Passenger Entertainment Applications

6.4.1.1 Following question has been addressed in relation to passenger entertainment applications:

"Could you list the current and future passenger entertainment or other data applications which could influence the requirements of the next generation railway radio communication system(s)?"

Following answers have been reported:

	Name of data application	**Description of data application**	**Functionality already implemented (yes, no)**	**Main characteristics/key requirements of data application (e.g. bandwidth, data rate, QoS, security, required communication technology, …)**
RU.1	*Internet On board*	*WiFi connection for train passengers via laptops, tablets and smartphones*	*Yes*	*Large bandwidth* *High QoS* *Using public mobile networks*
2	*Merge of PIS and Internet On board*	*Both systems combined into one system*	*Partly. Still two systems.* *We have an Infotainment system which is retrieving data from PIS.*	*This combined system will provide passengers with all the information and services needed when travelling by train.* *Large bandwidth needed and high QoS.*
IM.1	*Rail entertainment systems*	*To provide movies, newspapers, music and many more on the individual device of the passenger*	*No*	*Bandwidth*

	Augmented reality	*Provision of interesting information about building, landscape, history and many more which is passed during the trip.*	*No*	*Bandwidth*
IM	*WiFi or internet access via cellphone (4G etc.)*		*Yes, but constrained by bandwidth - in urban metro services with high number of users on one train*	*Bandwidth, Infrastructure coverage*
IM.1	*Wifi, Public wifi connectivity*			*Need to make sure does not make system too big when could be done over public systems*
IM.2	*Films*	*Streaming of films along train*		*Require way to update films and content*
IM.1	*Onboard entertainment services*			

6.5 Future Operational Concept - Findings

6.5.1.1 A first potential (not exhaustive) list of new applications is identified in the previous sections in function of the 3 application areas. These applications could lead to a change to the current technical requirements of the next generation communication system(s).

6.5.1.2 In the next phase of the roadmap of the next generation communication system, this list of applications have to lead to some key characteristics of the next generation communication system in order to analyze the feasibility and economic assessment of the different network architecture models. This will mainly require additional input on the required data volumes for the reported applications.

7. CONCLUSIONS OF EX-POST EVALUATION

7.1.1.1 The answers demonstrate that the system performance of GSM-R is positively contributing to a punctual, safe and interoperable train operation. In particular, the high availability required for the voice and ETCS data communication services and the fast and simple voice communication for alerting multiple train staff (train drivers, dispatchers) in emergency situations are key characteristics that are required in today's train operation and will be required in future train operation.

7.1.1.2 The answers confirm that some ongoing activities/priorities of the Agency are reported as aspects by the stakeholders for which further improvements in performance can be made:

- Interferences
- Capacity: change request on 'ETCS over GPRS'

7.1.1.3 The answers confirm that in the roadmap of the next generation communication system the aspect of operational interoperability and operational procedures for train drivers should be reconsidered as there is a strong link between these operational requirements and the technical requirements for the next generation communication system. This reconsideration aims at fully harmonised operational rules for train drivers (further facilitating cross-border operation).

7.1.1.4 The answers include a potential (not exhaustive) list of railway applications in which radio communication services are used. These applications have to be monitored further including the identification of their key characteristics (e.g. ATO, remote monitoring, radio object controllers). The answer refer also to the refinement of the current key characteristics listed in subset 093 (Quality of Service) and the possible addition of availability requirements. This will serve as an input to the feasibility and economical assessment of the different network architecture models.

7.1.1.5 The answers demonstrate that some specific topics could require additional investigation within GSM-R for following aspects:

- Voice communication: unintended use of railway emergency calls
- Wrong cell reselection/misrouted calls
- Shunting: matching of the operational requirements with the technical solutions

8. ANNEX 1 – QUESTIONNAIRE

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