VITE: Virtualisation of the Test Environment

Guideline for the development of the communication between RBC and Onboard unit through the GSM-R channel in the laboratory environment

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0.4	29/05/2018	All	Inserted GPRS section. Updated the rest of the doc based on the comments
1.0	31/05/2018	All	Review for final delivery

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1 INTRODUCTION

1.1 Purpose

The present guideline has the purpose to identify the issues related to the real GSM-R networks and to provide possible simulation in the laboratory environment in order to limit the field tests.

The main focus is on the SUBSET-093 KPIs simulation in order to recreate in the laboratory a real GSM-R network performance.

1.2 Intended audience / Classification

This document is public.

1.3 Associated documentation:

[1] UNISIG. (2016). Interoperability Test Environment Definition (FFFIS for TCL-OBU Adaptor).

[2] UNISIG. (2016). Interoperability Test Environment Definition (FFFIS for TCL-RBC Adaptor).

[3] UNISIG. (2016). Interoperability Test Environment Definition (General) – SUBSET-111-1

[4] UNISIG. (2016). UNISIG Interoperability Test – Guidelines – SUBSET-110.

[5] VITE Consortium. (2017). VITE-WP2-INE-DEL-2.2-v0.2-Test process framework.

[6] VITE Consortium. (2017). VITE-WP3-CED-DEL-3.1-v1.0-Lab architecture State of the art analysis.

[7] EIRENE FRS, GSM – R Functional requirements specification, Version 8.0.0, 21/12/2015

[8] EIRENE SRS GSM – R System requirements specification, Version 16.0.0, 21/12/2015

[9] UNISIG SUBSET-093, GSM-R Interface – Class 1 Requirements, rev 2.3.0, 10/10/2005;

[10] ERTMS/GSM-R Quality of Service Test Specification, Rif. O-2475, v. 3.0, 02/2007

[11] UIC ERTMS/GSM-R, ETCS in PS-mode – GPRS/EGPRS Guideline, Rif. O-8664, rev. 1.0.0

1.4 Abbreviations and Acronyms

CA	Consortium Agreement
EC	European Commission
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
GA	Grant Agreement
GGSN	GPRS Gateway Support Node
HTTP	HyperText Transfer Protocol
KPI	Key Performance Indicator
IOP	InterOPerability SUBSETs

MT	Mobile Terminal
OBU	On Board Unit
PC	Project Coordinator
RBC	Radio Block Center
RPC	Remote procedure call
S2RJU	Shift2Rail Joint Undertaking
SGSN	Serving GPRS Support Node
SS	SUBSET
TCL	Test Control and Logging
TCP/IP	Transfer Control Protocol/Internet Protocol
VITE	Virtualisation of the Test Environment
WP	Work Package
WPL	Work Package Leader
XML	eXtensible Markup Language
XML-RPC	Remote procedure call based on XML format

2 GSM-R CHANNEL DESCRIPTION

2.1 General

The GSM-R system is used in the Railway domain for the wireless communication both for Data and Voice services.

The Communication Channel of GSM-R System is based on the commercial GSM (Global System for Mobile communication) extended in terms of frequencies with the so called UIC band (876-880 MHz for up-link and 921-925 MHz for down-link) or, optionally, by the Extended-UIC Band (873-880 MHz for up-link and 918-925 MHz for down-link) as indicated in the following

	Sub-Bands	Frequencies (MHz)
	Extended UIC (E-UIC) frequency band	873-880/918-925
ER-GSM band 873-915/918-960 MHz	UIC frequency band	876-880/921-925
	Railways GSM (R-GSM) band	876-915/921-960
	Extended GSM (E-GSM) band	880-915/925-960
	Primary GSM (P-GSM) band	890-915/935-960

Figure 1 – Frequency as defined in EIRENE SRS [8]

The effects that can affect the GSM-R channel during the normal operation are the following:

- Blocking: the receiver is not able to receive the wanted signal due to a strong signal source usually generated from public operator;
- Receiver intermodulation: The unwanted intermodulation phenomenon comes from the non-linearity of the amplifier in the receiving chain and is generated when two (or more) signals are present in a non-linear circuit. These multiple signals are generated due to multipath.
- Doppler effect: it is the frequency shift observed from the receiver, both uplink and downlink, due to the relative speed between the source of the signal and the receiver.

All these effects lead to a degradation of the received information.

Usually, the evaluation of the system is performed in accordance with EIRENE FRS [7], EIRENE SRS [8] and SUBSET-093 [9] requirements.

2.2 Effects on ETCS radio communication

The effects depicted in 2.1 lead, in the ETCS communication, to a bits error in the most of the cases and a re-transmission of the message is needed (delay in the information transmitted). Consequently, the ETCS System manages the retransmission process where needed.

In other cases, where the issues are stronger, the interference decreases the quality level of the communication channel continuously monitored by the MT. If the interferences are strong enough, in term of amplitude and duration, the result could be the call interrupted. The ETCS system is in charge to establish again the communication.

3 GSM-R CHANNEL IN THE LABORATORY ENVIRONMENT

The following two possibilities can be explored for implementing GSM-R channel effects in the laboratory environment:

- Connect On-Board equipment to the Trackside using an ad-hoc GSM-R network completely under control;
- Connect On-Board equipment to Trackside using a wired connection (e.g. Ethernet).

In the first case the connection is like the real one and the different effects shall be created using ad-hoc instruments able to simulate Noise, Multipath and Doppler effects.

In the second case the issue shall be created introducing directly errors in the delivered packets. Using this method it is possible to have a better control on the introduced errors and to generate a pattern of errors close to the real world. The parameter of these patterns should be based on field results in order to define a realistic statistical distribution of the errors.

For example, based on the data collected in a test campaign, it is possible to simulate a “Transmission Interference” to be added to the transmission of a real ETCS communication and evaluate the effects on the transmission of the errors.

In the next chapter for each KPIs, a possible implementation of the channel error simulation is depicted.

4 IMPLEMENTATION OF GSM-R TRANSMISSION ISSUES IN THE LABORATORY ENVIRONMENT

4.1 General

The implementation of the GSM-R transmission issues may refer to a laboratory test environment compliant with SUBSET-110 and SUBSET-111 requirements ([4] and [3])

A representative test architecture structure is shown in the Figure 2. This picture shows a configuration with constituents RBC, RIU and OBU and their related Constituent Adaptors involved.

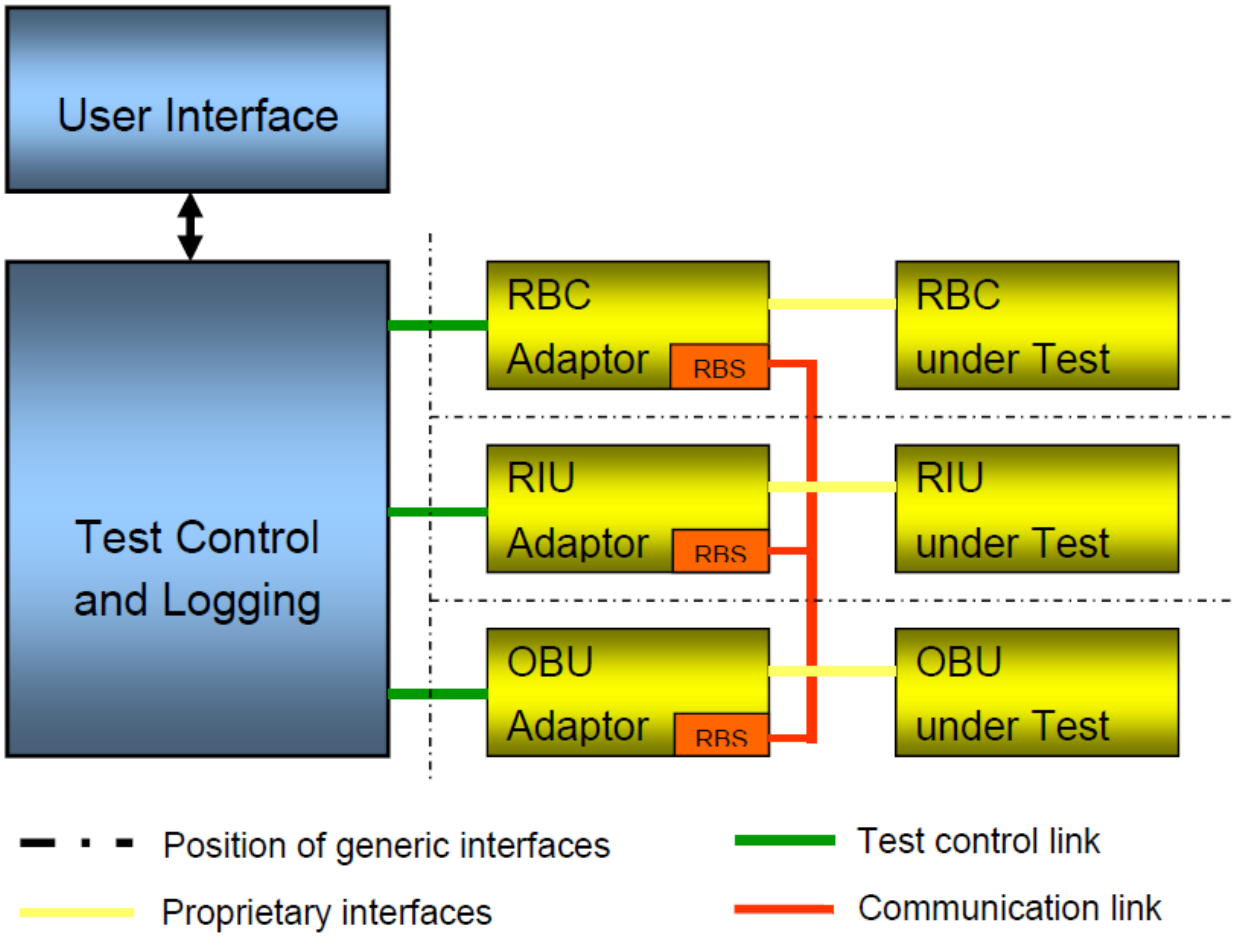

Figure 2 – Architecture Overview of the Test Environment

All the degradations on GSM-R Air-Gap described in the following chapters can be implemented both off-line in the scenarios generated before the tests execution and on-line during tests execution. In the second case GSM-R Air-Gap issues can be introduced and managed by the Test Control Unit inside the Test Control and Logging Unit (TLC) which is in charge to manage the communication among all the components inside the simulation loop.

In the following chapters all the requirements defined in the SUBSET-093 are reported and described.

It is also described a possible implementation of the channel errors based on the assumption that the channel is simulated via Ethernet and a real GSM-R network is not used.

Up to now, the SUBSET-093 is available only for the Circuit Switched mode (CS-mode) but in the next months a new version of the SS-093 will be issued including the QoS for the Packet Switched mode (PS-mode).

Referring to the Picture 4.2 of [4], reported for completeness as Figure 3, the conditions applicable to the test cases to be used in the test Scenarios can be also the degraded ones.

How to introduce the degradation is left to the lab implementation, in the next chapters it is described a guideline concerning what should be corrupt in order to introduce the disturbance.

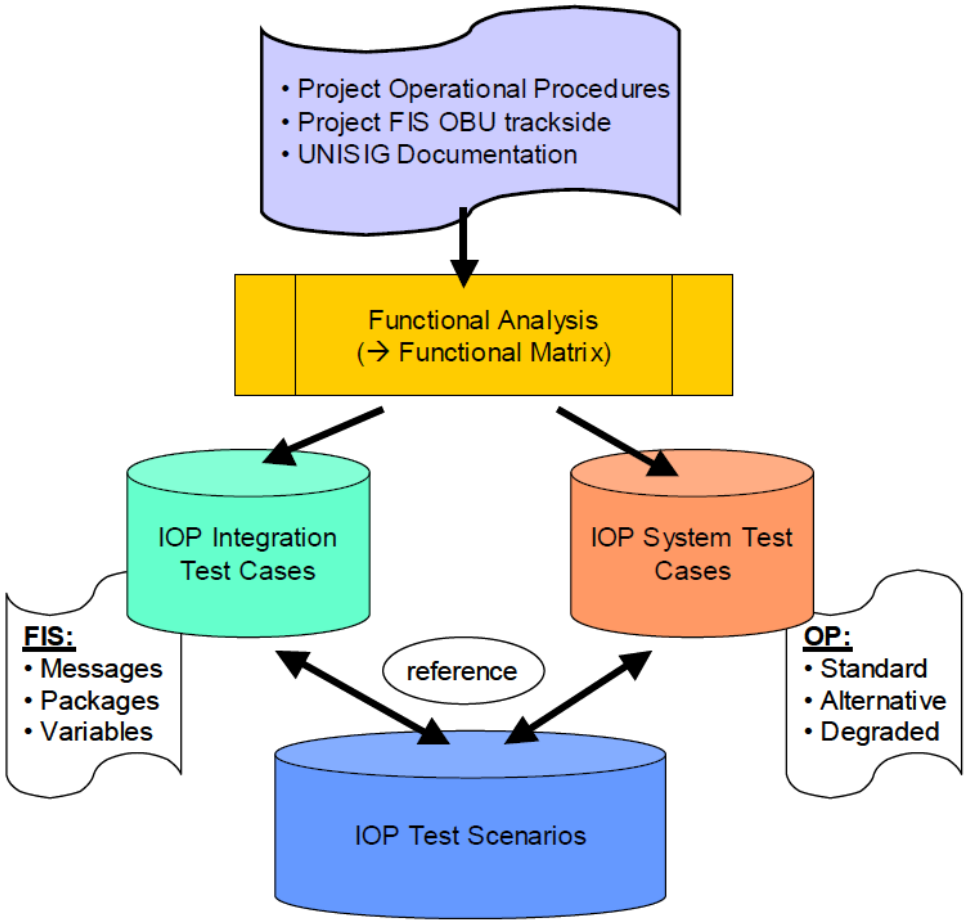

Figure 3 – Relation between test cases and test scenarios

4.2 Circuit Switched Mode

4.2.1 Connection establishment delay

4.2.1.1 Description

The connection Establishment Delay is defined as the value of elapsed time between the connection establishment request and the indication of successful connection establishment.

4.2.1.2 Implementation in the laboratory environment

In the laboratory environment this error can be simulated introducing a delay in the response of the trackside to confirm the establishment of communication session initiated by the On-Board sub-system.

The duration of the delay can be based on the on field results or based on the SUBSET-093 [9] limits (test within the limits and over the limits shall be foreseen).

This delay, according to the observations of the GSM-R Networks in place, should take place at:

- Start of mission: first connection;
- RBC-RBC handover: where, in normal operation mode, the second MT tries to establish a communication session with the accepting RBC;
- Reconnection after that the call it is interrupted due to relevant interferences.

As described in Figure 3 one or more dedicated “Degraded Test Case” it shall be created.

4.2.2 Connection establishment error ratio

4.2.2.1 Description

The Connection Establishment Error Ratio is defined as the ratio of the number of unsuccessful connection establishment attempts to the total number of connection establishment attempts.

4.2.2.2 Implementation in the laboratory environment

It is possible to simulate this error like for Connection Establishment Delay but in this case the connect message it is not received or it is received with errors.

As described in Figure 3 one or more dedicated “Degraded Test Case” it shall be created.

4.2.3 Transfer delay

4.2.3.1 Description

The Transfer Delay is defined as Value of elapsed time between the request for transfer of a user data block and the indication of successfully transferred end-to-end user data block.

4.2.3.2 Implementation in the laboratory environment

In the laboratory environment this parameter can be introduced as a delay in the data transmitted in both directions Trackside-to-Onboard and OnBoard-to-Trackside.

The transfer delay, usually, is evaluated by means of test method defined in the O-2475 [10] and it is a typical characteristic of each real network.

The duration of the delay can be based on the on field results or based on the SUBSET-093 limits (test within the limits and over the limits shall be foreseen).

As described in Figure 3 one or more dedicated “Degraded Test Case” it shall be created.

4.2.4 Connection loss rate

4.2.4.1 Description

The Connection Loss Rate is defined as Number of connections released unintentionally per accumulated connection time.

4.2.4.2 Implementation in the laboratory environment

This KPI represents the probability to have a connection lost in the real network. The simulation of these losses can done introducing a connection loss (e.g. using the disconnection primitive) randomly during the test campaign and evaluating the behaviour of the System.

As described in Figure 3 one or more dedicated “Degraded Test Case” it shall be created

4.2.5 Transmission interference

4.2.5.1 Description

In the transmission Interference KPI, two values are defined:

- T_{TI}: Transmission Interference Period;
- T_{REC}: Error Free Period.

A T_{TI} is the period during the data transmission phase of an existing connection in which, caused by the bearer service, no error-free transmission of user data units of 30 bytes is possible.

A T_{REC} shall follow every transmission interference period to retransmit user data units in error (e.g. wrong or lost) and user data units waiting to be served.

4.2.5.2 Implementation in the laboratory environment

It is possible to simulate a “Transmission Interference” to be added to the transmission of a real ETCS communication and evaluate the effects on the transmission of the errors.

The following two ways are possible:

- Create a pattern of pseudo random errors based on the handovers number and on the error due to external influences to be added to the data transmission and the error can affect the communication or not (each time the error it is applied in a different “position”). This solution is suitable for Interoperability test where real equipment is used;

- Insert the errors in the bit stream in a pre-defined position within the message sequence. This allows to explore the effect of the errors in a deterministic way guaranteeing a high repeatability in testing process. This solution is suitable for interoperability test where all the tools are simulated (e.g. Track-side equipment simulated, On-board subsystem real).

As described in Figure 3 one or more dedicated “Degraded Test Case” it shall be created.

The parameters to take into consideration in order to create the degraded Test Case(s) are the following:

1. Railway Line Length;
2. Number of BTS (usually one every 4/6 km);
3. Train Speed;

The relevance of these parameters is mainly based on the assumption that one of most critical issue is a BTS handover. Consequently, the Railway line length and the number of BTS lead to the number of handover in the line(e.g Railway line length 100 km, Number of BTS 20 (one every 5 km) → means that 19 BTS handover take place).

The train speed plays a role in terms of time between two handovers: an higher train speed it means that the recovery time is lower.

The handover maximum time defined in the EIRENE is 300 ms.

Furthermore, in order to simulate a real line environment, the simulation of external interferences shall be applied. The number and duration of these interferences shall be defined based on the SUBSET-093 limit.

4.2.6 GSM-R network registration delay

4.2.6.1 Description

The Network Registration Delay is the value of elapsed time from the request for registration to indication of successful registration by +CREG response.

4.2.6.2 Implementation in the laboratory environment

In the real networks the time used to complete a successful registration shall comply with SUBSET-093 requirement. In order to simulate this finite time, a delay between the registration

request and the indication of successful registration can be introduced each time a network registration is required, for example during a start of mission or after a connection lost.

4.3 Packet Switched Mode

As for the CS-Mode, also in the PS-Mode the main issue is related to the delay in delivering the information.

When a terminal is working in PS-mode can be in the following three states:

- Idle: the sub scriber it is not attached to the GPRS Mobility Management;
- Stand-by: the sub scriber is attached to the GPRS Mobility Management;
- Ready: the subscriber may send and receive data.

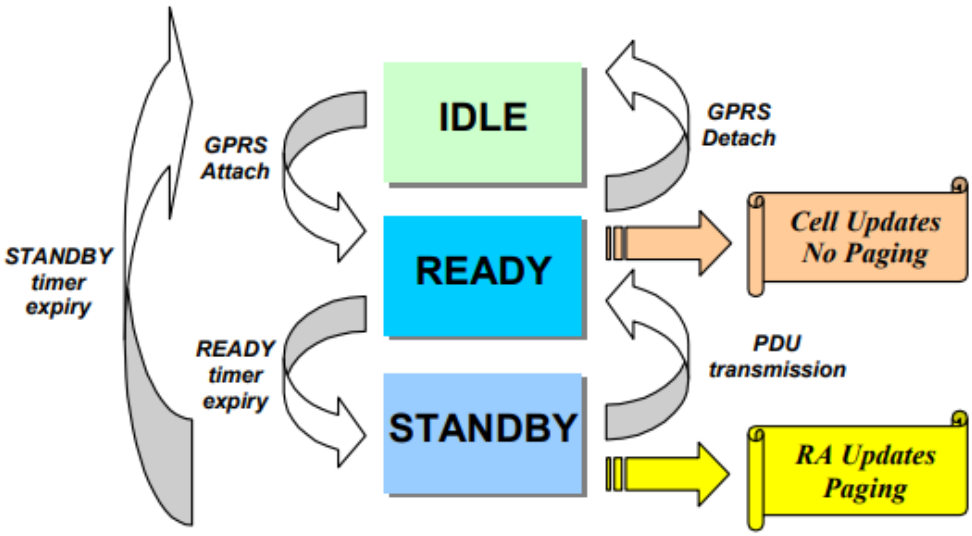

Figure 4 - GPRS Mobility Management state model

In Figure 4 the state model of the GPRS Mobility Management is reported (for detail see [11]).

The Session Management is in charge of Packet Data Protocol (PDP) Activation and Deactivation. The PDP context is used for routing purposes (for more detail see [11]).

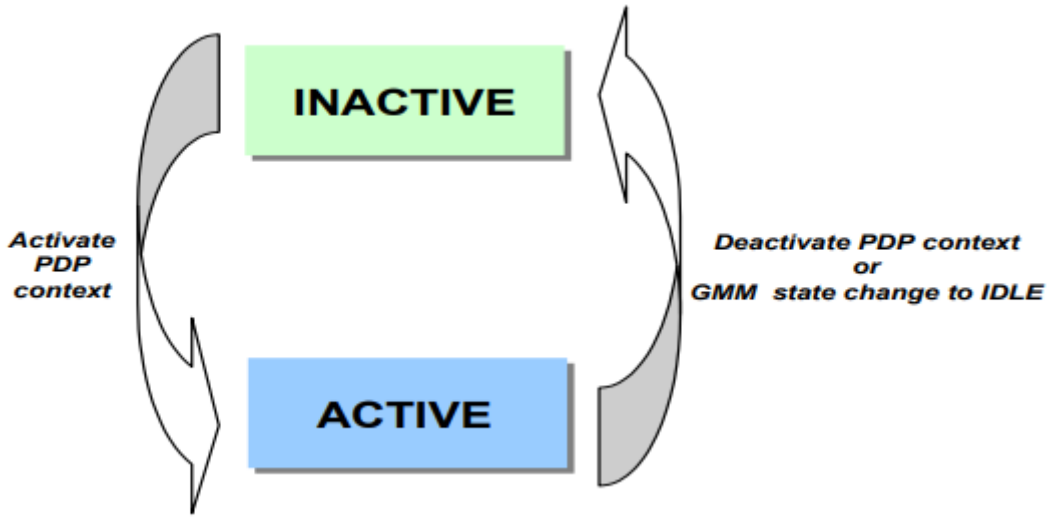

Figure 5 – PS-Mode – Functional PDP state model [11]

Here below are reported the possible KPIs to be tested to check the GPRS QoS.

4.3.1 GPRS Attach Procedure

4.3.1.1 Description

It is the procedure to be carried out in order to register the mobile to the right network.

4.3.1.2 Implementation in the laboratory environment

To be defined after the publishing of the new SUBSET-093 and the new O-2475 that will take care of PS KPIs.

4.3.2 PDP Context Activation

4.3.2.1 Description

It is the procedure that the system carry out in order to create a connection between mobile, SGSN and GGSN (same IP).

4.3.2.2 Implementation in the laboratory environment

To be defined after the publishing of the new SUBSET-093 and the new O-2475 that will take care of PS KPIs.

4.3.3 Domain Name Services

4.3.3.1 Description

Domain Name Services are used to resolve logical network node names into IP addresses or

vice-versa.

In PS-mode the use of GPRS/EGPRS requires the resolution of the applicable APN and the RBC identification.

4.3.3.2 Implementation in the laboratory environment

To be defined after the publishing of the new SUBSET-093 and the new O-2475 that will take care of PS KPIs.

4.3.4 Transaction Transfer Delay

4.3.4.1 Description

It is defined as the time elapsed between the sending of the Information message and the receipt of the Acknowledge Message.

4.3.4.2 Implementation in the laboratory environment

To be defined after the publishing of the new SUBSET-093 and the new O-2475 that will take care of PS KPIs

5 SUMMARY

This deliverable represents a Guideline for the development of a GSM-R channel simulator between On-Board and Trackside in a Laboratory Environment.

Based on SUBSET-093 [9] a list of possible issues related to real GSM-R system implementation are reported and possible development in laboratory environment are highlighted.

The normative reference framework (SUBSET-093 [9]) is foreseen to be updated, in the next month, in order to take into account the Packet Switched communication which it is now foreseen as requirements in the EIRENE standard [7] [8]. This could lead to a review of the existing KPIs and the introduction of new ones.

END OF DOCUMENT