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FFFS for Voice and Data Services Functionality at borders between GSM-R networks

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List of Contents

1	Introduction.....	9
1.1	Scope.....	9
1.2	Dual Network Coverage Area.....	9
1.3	Factors affecting the DNCA.....	10
2	Voice Services Functionality at borders between GSM-R Networks.....	11
2.1	Prerequisites.....	11
2.2	Dimensioning of the DNCA for Voice Services.....	11
2.3	Operational rules for border crossing.....	13
2.4	Cab Radio (Voice, single MT).....	13
2.4.1	Prerequisites.....	13
2.4.2	Cab Radio in idle mode.....	13
2.4.3	Cab Radio in dedicated mode (busy in point to point call).....	16
2.4.4	Cab Radio busy as talker in VGCS or VBS (not a REC).....	16
2.4.5	Cab Radio in group receive mode (listener in VBS or VGCS, not a REC)....	17
2.4.6	Cab Radio in group receive mode (listener in REC).....	17
2.4.7	Cab Radio is busy as talker in a REC.....	18
2.5	Operational Radio Handheld OPH.....	18
2.6	General Purpose Radio Handheld GPH.....	18
2.7	Shunting Radio OPS.....	18
3	ETCS Data Services Functionality at borders between GSM-R Networks (CS-mode)	19
3.1	Prerequisites.....	19
3.2	DNCA for ETCS Data Services.....	19
3.3	Procedure.....	21
4	Miscellaneous non ETCS Data Services.....	21
5	International shared group calls numbering scheme.....	22
6	Inter PLMN Handover (IP-HO).....	23
6.1	General.....	23
6.2	Cab Radio in idle mode and IP-HO.....	23
6.3	Cab Radio in PtP voice call and IP-HO.....	23
6.4	Cab Radio as talker (not REC) and IP-HO.....	24
6.5	Cab Radio in group receive mode (not REC) and IP-HO.....	24
6.6	Cab Radio in group receive mode (REC) and IP-HO.....	24
6.7	Cab Radio as talker (REC) and IP-HO.....	24
7	Data service functionality at borders between GSM-R networks (PS-mode).....	26
7.1	Introduction.....	26
7.2	General definitions.....	26
7.3	Procedures for ETCS in PS mode.....	27
7.3.1	Scenario 1 PS-to-PS.....	27
7.3.2	Scenario 2a PS-to-CS limited RBC bearer capabilities.....	28
7.3.3	Scenario 2b PS-to-CS limited GSM-R bearer capabilities.....	28
7.3.4	Scenario 3 CS-to-PS.....	28
7.4	Online Key Management.....	28
7.4.1	General principles.....	28

References

- [1] EIRENE SRS version 16.0.0 / FRS version 8.0.0;
- [2] TSI OPE under "Implementing Regulation (EU) 2019/773 of 16 May 2019";
- [3] MORANE E12T6001 5.1 FIS for Functional Addressing;
- [4] SUBSET-037 EuroRadio FIS version 3.2.0;
- [5] SUBSET-137 Online Key Management FFFIS version 1.0.0;
- [6] SUBSET-093 GSM-R QoS requirements;
- [7] SUBSET-026 System Requirements Specification version 3.6.0;
- [8] SUBSET-039 FIS for RBC/RBC handover version 3.2.0;
- [9] SUBSET-023 Glossary of Terms and Abbreviations version 3.3.0;
- [10] 3GPP TS 44.018: " Mobile radio interface layer 3 specification; Radio Resource Control (RRC) protocol";
- [11] Radio Transmission FFFIS for EuroRadio;

Definitions

Balise:	The definition in accordance with SUBSET – 023 [9] applies.
Broadcast call:	The definition in accordance with EIRENE SRS [1] applies.
Cab Radio:	The definition in accordance with EIRENE SRS [1] applies.
Controller:	The definition in accordance with EIRENE SRS [1] applies.
Dedicated mode	The definition in accordance with 3GPP TS 44.018 [10] applies.
Dual Network Coverage Area:	A section of track where radio coverage is deliberately provided from two networks. EIRENE network: The definition in accordance with EIRENE SRS [1] applies.
ENRC:	The ETCS specific ENRC zone is the area in which the GSM-R connection to the RBC within the new network (East) is established.
EIRENE system:	The definition in accordance with EIRENE SRS [1] applies.
Voice ENRS:	The voice ENRS is the area in which the voice functional border crossing procedures are performed that are required to select and attach to the new network (East). For voice services the re-registration of the functional number(s) must also be performed within the voice ENRS.
ETCS ENRS:	The ETCS ENRS is the area in which the ETCS functional border crossing procedures are performed that are required to register and attach to the new network (East).
ETCS:	The European Train Control System (ETCS) is a signalling, control and train protection system designed to replace the many incompatible systems previously used by European railways.
ETCS Data Only Radio:	The definition in accordance with EIRENE SRS [1] applies.
ETCS Level 2/3:	The definition in accordance with Subset – 26 [7] applies.

EuroRadio:	Protocol suite to allow the transmission of ETCS related information between on board and corresponding ground entities (i.e. RBC) in accordance with SUBSET-037 [4].
Functional addressing/numbering:	The definition in accordance with EIRENE SRS [1] applies.
Functional identity:	The definition in accordance with EIRENE SRS [1] applies.
Functional number:	The definition in accordance with EIRENE SRS [1] applies.
General purpose radio:	The definition in accordance with EIRENE SRS [1] applies.
Group call:	The definition in accordance with EIRENE SRS [1] applies.
Group receive mode:	The definition in accordance with 3GPP TS 44.018 [10] applies.
Group transmit mode:	The definition in accordance with 3GPP TS 44.018 [10] applies.
Handover:	The definition in accordance with 3GPP TS 44.018 [10] applies.
Idle mode:	The definition in accordance with 3GPP TS 44.018 [10] applies.
Mobile station:	The definition in accordance with EIRENE SRS [1] applies.
Operational radio:	The definition in accordance with EIRENE SRS [1] applies.
Radio Block Centre:	The definition in accordance with Subset – 23 [9] applies.
Railway emergency call:	The definition in accordance with EIRENE SRS [1] applies.
Roaming:	The use of a mobile on any communications network other than the user's home network.
Shunting radio:	The definition in accordance with EIRENE SRS [1] applies.
Silent Period:	Encompasses the period of time for selection the new network and successful network registration.

Abbreviations

CC	Country Code
CS	Circuit Switched
CT	Call Type
DNCA	Dual Network Coverage Area
DNS	Domain Name Service
EDOR	ETCS Data Only Radio
ENRC	Eirene Network Re-Connection zone
ENRS	Eirene Network Re-Selection zone
ETCS	European Train Control System
FACCH	Fast Associated Control Channel
FC	Function Code
FN	Functional Number
GGSN	Gateway GPRS Support Node
GPRS	Generalized Packet Radio Service
HGGSN	Home GGSN
(E)GPRS	Enhanced GPRS
IP-HO	Inter PLMN Handover
KMAC	Key Message Authentication Code
KMC	Key Management Centre
MT	Mobile Termination
NDC	Network Destination Code
PDP	Packet Data Protocol
PLMN	Public Land Mobile Network
PS	Packet Switched
RBC	Radio Block Controller
REC	Railway Emergency Call
SGCA	Shared Group Call Area
TCS	Train Control System
USSD	Unstructured Supplementary Services Data
VBS	Voice Broadcast Services
VGCS	Voice Group Call Services
VGGSN	Visited GGSN
VSGSN	Visited SGSN

1 Introduction

1.1 Scope

Based on the latest EIRENE specifications [1] this FFFS describes the voice and data services functionality when a Mobile Station (MS) crosses the border between two EIRENE networks. The described border crossing procedure aims at minimizing the silent period for voice calls, including in particular REC.

ERTMS data applications can be either operated in circuit switched mode (CS-mode) or in packet switched mode (PS-mode). This document will elaborate on both modes of operation.

All relevant functional scenarios are described, e.g. border crossing in idle mode, with active point to point calls, with active group calls (REC and non REC group calls) and ETCS data communication in both modes of operation. In addition, the possible influence of inter PLMN handover on the above scenarios is addressed. All indicated timings assume normal operation.

Where harmonized international operational rules are referred in this document, further information may be obtained from "TSI Subsystem: Operation and traffic management" [2].

The document is a summary of existing requirements and available solutions and does not contain new technical requirements for network and mobiles. Consequently, these requirements are covered by the existing test specifications and do not require further testing or separate test activities.

NOTE: The use of MLPP supplementary service (pre-emption) applicable in CS-mode on inter GSM-R network trunks is not required because the average traffic load is low and no blocking of trunk lines is expected.

1.2 Dual Network Coverage Area

1. Due to the nature of GSM, it may happen that railway lines close to network borders also see coverage from a neighbouring EIRENE network. Since for lines running alongside such a network border but not crossing it, e.g. on the left and the right side of the river Rhine, a change of the network in the MT of the trains has to be avoided.
Therefore, automatic network selection is de-activated in GSM-R Cab Radios as well as in ETCS data only radios (EDOR).
2. Usage of GSM-R train radio in border crossing traffic therefore requires the change of the network (network reselection) to be effectuated deliberately (= in general in 'manual' or in 'directed' mode [1] and only in the dedicated sections of the border (crossing) line.
3. Where the rail track crosses the (operational) border between two EIRENE Networks (referred to as "West" and "East" in figure 1 below) there is a segment of rail track where intentionally overlapping radio coverage from both GSM-R networks is required for safeguarding of the border crossing processes as described in the following chapters. Hence, in this Dual Network Coverage Area (DNCA), both Networks West and East are available and shall be used according to operational rules.

NOTE: This (operational) border follows railways' operational needs and does not necessarily coincide with the political border of the two adjacent countries.

4. The functional procedures and related maximum procedure duration requirements for voice related services and ETCS data during border crossing are different. The basic considerations / models for deducing the DNCA are described in chapters 2.2 and 3.2 respectively.

1.3 Factors affecting the DNCA

1. The location of the (operational) border between two different railway infrastructure managers in many cases follows railways' operational needs and does not necessarily coincide with the political border of the two adjacent countries.
2. In addition to the location of the defined border between the control areas of the neighbouring traffic controllers, the location of the operational significant points on the track is important for the design of the DNCA.
3. The maximum line speed has to be considered in the design of the DNCA.
4. There may be several locations on the tracks at which communication between a driver and the operationally responsible traffic controller must be ensured which may influence the location of the EIRENE Network Re-Selection zone (ENRS), where the border crossing train changes from one EIRENE network to the next.

Examples of such locations are:

- Stop Signals
 - Point Switches / Turnouts
 - Protected level crossings
 - Switched (neutral) sections in the electric power supply (overhead catenary or electric rail)
 - Automatic level crossings (supervised)
 - Hot wheel / hot axle box detectors
 - Long tunnels
5. The following locations are generally not significant for the positioning of the ENRS:
 - Distant signals
 - Caution signals
 - Points operated on site / interlocked
 - Train-triggered and by train supervised level crossings
 - Level crossings without technical protection
 6. Variations from the above guidelines are possible and will depend on local conditions and operational requirements. The relevant operational points can be different on both sides of a border, resulting in an asymmetric DNCA.

Therefore chapters 2.2 and 3.2 consider only the basic factors for DNCA dimensioning. Detailed planning has to be made for each border taking into account the local influence factors listed above.

2 Voice Services Functionality at borders between GSM-R Networks

2.1 Prerequisites

1. The Mobile Station (MS) is equipped with one single Mobile Termination (MT) and is used for EIRENE voice services;
2. Parameters with the subscript H (e.g. CC_H , NDC_H) refer to the **Home** EIRENE network of the MS (the HPLMN). Parameters with the subscript 'W' (e.g. CC_W , NDC_W) refer to "Network **West**" and parameters with the subscript 'E' (e.g. CC_E , NDC_E) refer to "Network **East**". Network West or East could be the home EIRENE network or they could both be 'foreign' EIRENE networks.

NOTE: The home network in this context is defined by the SIM-card which is in use in the MS, hence it may differ from the rolling stock owner's home country, especially if there is no EIRENE network present yet.

3. The MS is assigned an MSISDN " CC_H+NDC_H+CT8 ", hence it can be reached:
 - a. from terminals within all foreign networks under this number (if there is no barring configured against this)
 - b. from the home network under CT8 (if there is no barring configured against this)
 - c. from terminals in foreign EIRENE networks under " $900+IC_H+CT8$ " (if there is no barring configured against this).
4. The user (driver, conductor etc) is registered to a Functional Number (FN) in Network West – " $CT2+UIN+FC$ ". It can therefore be reached:
 - a. from terminals within Network West under this number;
 - b. from terminals in other EIRENE networks under " $900+IC_W+CT2+UIN+FC$ ".

NOTE: CT3 are permanently registered to the MSISDN in the home network. Thus the "900+ICH" is needed if calling an engine number registered in a network other than that from where the call originates.

5. For Voice Group and Broadcast Calls the international Group call Identifiers (GID) included in EIRENE-SRS [1] (Table 9-8: Function Code field format for CT=5), including "299" for Railway Emergency Call need to be stored on the SIM of the MS.

2.2 Dimensioning of the DNCA for Voice Services

1. Within the DNCA the process of EIRENE Network Re-Selection (attach to new network and re-registration of functional numbers on the new network) shall take place for both traffic directions. The length of the DNCA and **EIRENE Network ReSelection** zone (ENRS) is derived from the time values of the border crossing procedures described in the following sections.
2. In general, for each traffic direction (NOTE 1), the ENRS has to be dimensioned to provide network coverage so that the procedures which must be performed during border crossing to select and reregister to the new network (East) can be finished before the relevant operational limit for border crossing is passed. The time required to perform the GSM-R network reselection is up to 20 seconds and the registration of functional numbers (EIRENE [1] FRS) is up to 30 seconds (NOTE 2).

NOTE 1: Dependent from the local infrastructure on the border-line, in most cases two different ENRS will exist, one for each traffic direction; The DNCA thus has to cover both from the very beginning to the very end.

NOTE 2: For availability reasons it may be desirable to include a safety margin of 10 seconds to handle failures in the reselection procedure within the ENRS zone.

3. Each ENRS within the DNCA (see figure 1) begins from the (radio-) switching point, i.e. the point, where the process of network (re-)selection in the MS has to be launched either manually by the driver at the MMI of the Cab Radio following an operational instruction or be triggered by a balise or similar (track-side) device.
4. The ENRS ends at the operational limit for the respective direction of the trains, i.e. the first operationally significant point, where network selection and functional registration of the MS in the new network have to be completed.
5. The following figure shows the DNCA for border crossing without ETCS. The picture shows the simplest (with identical operational limits from both border sides) situation for border crossing in both directions.
For voice services, border crossing in a single direction does not require a duplicate coverage. Once the procedure to select Network East is started no further coverage of Network West is required. The DNCA for voice is the result of the required ENRS for support of border crossing in the reverse direction.

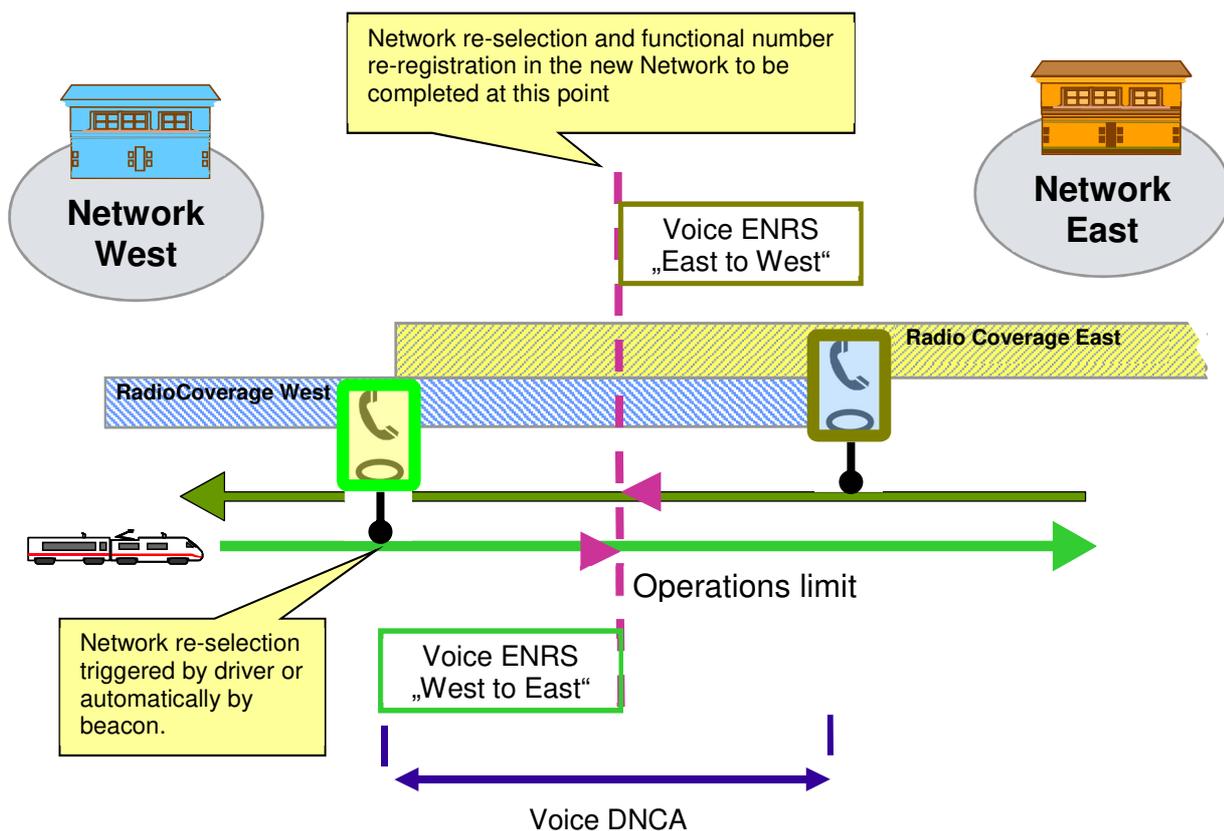


Figure 1: Dual Network Coverage Zone at EIRENE network borders without ETCS)

6. Furthermore, the beginning, end and thus the actual length of the DNCA depend on operational constraints and the factors mentioned in chapter 1.3 within the respective track section and therefore will differ from border line to border line.

2.3 Operational rules for border crossing

1. Ongoing PtP calls have to be terminated by the train driver to ensure the MS goes to idle mode when the sign indicating the start of the network selection procedure is passed during border crossing. This is already included in the TSI OPE operational rules. In idle mode, the network selection procedure can be invoked at the planned location. Automatic termination of active point to point calls by technical means during border crossing is not required. Calls which are not terminated by the driver will be dropped at the latest when the MS runs out of coverage of the old network.
2. In case it was not possible to perform EIRENE network reselection into Network East the operational rules as described in the TSI OPE shall apply.
3. For Group Calls which do not have priority 0, it is recommended that the driver releases the talker function (if necessary) and terminates/leaves
4. the ongoing group call at the corresponding sign-post. In this way the MS will go to idle mode and the network selection procedure can be invoked at the planned location (sign-post) during border crossing.
5. Ongoing priority 0 calls will be kept during border crossing. Deactivation or leaving of a priority 0 call / REC during border crossing is neither required nor technically supported. As described in chapters 2.4.6 and 2.4.7, coverage of the old network (West) will be lost during border crossing. After attaching to the new network (East) the Cab Radio will rejoin an ongoing REC / priority 0 call.

NOTE: As a consequence, the following point has to be considered in post incident analysis. As the confirmation for receipt of a priority 0 / REC is sent after the call is finished, no confirmation will be sent to the old Network West from the border crossing MS. Instead the confirmation will be sent to the new network to which the MS attaches after the coverage of the old network has been lost.

2.4 Cab Radio (Voice, single MT)

2.4.1 Prerequisites

The following paragraphs describe the behaviour of a mobile station (MS) in use as a Cab Radio during the border crossing process considering different modes of its operation.

1. The Cab Radio is configured to manual GSM network selection.
2. The Cab Radio is able to receive point-to-point calls (whereby the calling party uses the MSISDN or one of the FNs of the Cab Radio)
3. The Cab Radio is able to initiate point-to-point calls (dialling FN or MSISDN or ISDN of the called party) based on the internationally agreed access matrix.
4. The Cab Radio is able to join interoperable group calls (VBS and VGCS with GID as stored on the SIM of the Cab Radio).

NOTE: It should be noted that other GIDs may also be present.

5. The Cab Radio is able to initiate interoperable group calls (VBS and VGCS with GID as stored on the SIM of the Cab Radio^{Napaka! Zaznamek ni definiran.}).

2.4.2 Cab Radio in idle mode

1. The idle Cab Radio is situated in Network West and moving towards the adjacent Network East.

2. When passing the defined radio switching point of the respective traffic direction within the DNCA the idle Cab Radio is triggered to perform an EIRENE network reselection from Network West. This may immediately tell the Cab Radio to attach to Network East or it may begin a more general network selection process.
3. The trigger can be:
 - a) an MMI action by the train driver who is following an operational instruction
 - b) a balise or similar (track-side) device, which transmits a signal to the Cab Radio (via some external device(s)) when the train passes a specific point on the line.
4. Upon reception of the network selection trigger (see above) the Cab Radio starts the procedure to become attached to Network East:
 - a) The Cab Radio will detach from Network West and will then be unavailable for incoming/outgoing p2p calls, for incoming VGCS (including REC) and VBS (since it is no longer reading any NCH) and for outgoing VGCS (including REC) and VBS. This marks the start of the “silent period” for the Cab Radio.
 - b) There are then two possible behaviours:
 - 1) If the trigger explicitly specifies the reselection towards Network EAST, the Cab Radio will scan the GSM-R spectrum and find EAST being present in one of the possible cells (assuming the DNCA is configured correctly) and the Cab will now enter dedicated mode and perform a “Location Update” Attach in EAST.
 - 2) If the trigger does not explicitly specify the reselection towards Network EAST:
 - i. The Cab Radio will scan the GSM-R spectrum.
 - ii. The Cab Radio re-attaches to WEST and the driver is able to retrieve a list of the networks which it is possible to join. EAST will be in this list (assuming the DNCA is correctly configured). While the list is displayed, the Cab is again available for GSM-R calls on WEST.
 - iii. The driver selects which network he wishes to join (EAST).
 - iv. The Cab Radio will detach from WEST and, assuming that there is still a signal available from EAST, the Cab will now enter dedicated mode and perform a “Location Update type” Attach in EAST.

NOTE 1: During step 4 the Cab is partly unavailable for REC and any other calls.

NOTE 2: Since relevant information about Network East is available in the Cab Radio (this was provided together with the trigger signal or was pre-configured in the Cab Radio) this above procedure needs to be optimised or an alternative solution defined so that the maximum GSM-R network reselection delay of 20 seconds specified in chapter 2.2 can be achieved for 99% of attempts under normal conditions. This relates to the network selection procedure in section 10.5 of EIRENE [1]-FRS 8.0.0 whereby EIRENE networks are given preference.

NOTE 3: During the “silent period” the Cab Radio is unable to initiate or receive any point-to-point calls or group calls (including REC). It is therefore important that the operational aspects for the respective border-line are taken into account when determining the exact location and extent of the DNCA in order to minimise any operational hazards caused by this “silent” period.

- c) If, in either of the above two cases, attachment to Network East could not be completed the Cab Radio will lose connection to the networks entirely. Operational rules must cover this situation.

The subsequent steps are the same for both behaviours.

5. After receiving confirmation of successful Location Update the Cab Radio will enter Idle Mode and can initiate and receive any allowed calls including REC. This marks the end of the “silent period” for the Cab Radio. The following functional number (re-)registration processes can be delayed by such calls.
6. The Cab Radio will then re-register the first FC. During the USSD exchange the Cab Radio is unavailable for p2p calls as well as VGCS (including REC) and VBS. For a Cab Radio registered as FC01 using bulk registration permits all function codes to be registered in one step.
7. If all Functional Numbers cannot be registered using bulk registration:
 - a) The Cab Radio will enter Idle Mode and check if NCH was changed in order to detect any REC. If a REC is detected the Cab Radio will join it and the further steps below will be delayed until the REC terminates. The Driver can also originate a REC.
 - b) The Cab Radio will re-register the next used FC. During the USSD exchange the Cab Radio is unavailable for p2p calls as well as VGCS (including REC) and VBS.

NOTE: The registration duration is configured in the Cab Radio to give the lower radio layers sufficient time to finalise a complete scan of NCH.

8. Step 5 is repeated until all used (5 or max 10 –Optional-) FCs are re-registered. If the Cab Radio is able to use Bulk Registration step 6 is run only once.
9. The Cab Radio is now attached to Network EAST, functionally registered in EAST, in idle mode and available for all types of incoming and outgoing calls.
10. The idle Cab Radio, now visiting Network East, has the same communication possibilities as described in prerequisites part 2, 3, 4 and 5 above.
11. The functional deregistration from Network West is done by issuing the appropriate USSD string as defined in EIRENE [1] SRS after the registration in Network East is successfully completed.
12. During the USSD dialogue with the network as described under 7 above, the Cab Radio is intermittently unable to receive any incoming point-to-point calls and to recognise and join any group calls (including REC). This period, not included in the silent period for border crossing, will typically consist of a 2 to 5 second break for each USSD dialogue.
13. The Cab Radio is now registered with its still valid Train Number in Network East “CT2+UIN+FC” and hence can be reached from terminals within Network East under this number and from terminals in other EIRENE networks under “900+IC_E+CT2+UIC+FC”.

2.4.3 Cab Radio in dedicated mode (busy in point to point call)

1. The Cab Radio is busy in a point-to-point call. It is situated in Network West and moving towards the adjacent Network East.
2. The Cab Radio is able to receive further point-to-point calls utilising the Call Waiting Supplementary Service.
3. The Cab Radio is able to join group calls (VBS and VGCS with GID as stored on the SIM of the Cab Radio).
4. When passing the defined radio switching point of the respective traffic direction within the DNCA, the busy Cab Radio is triggered to perform an EIRENE network reselection from Network West to Network East.
5. The trigger can be:
 - a) an MMI action by the train driver who is following an operational instruction.
 - b) a balise or similar (track-side) device, which transmits a signal to the Cab Radio (via some external device(s)) when the train passes a specific point on the line. In this case the Cab Radio will inform the Train Driver about the occurrence of the trigger. (EIRENE [1] SRS clause 5.6.4i).
 - c) In either case the train driver will terminate the ongoing point-to-point call. He will then manually trigger the now idle Cab Radio to perform the EIRENE network reselection. The procedure specified under 2.4.2 will then apply.
 - d) Automatic termination of the call is not required. EIRENE [1] states that if termination does not occur, the driver will lose network coverage and the call will be dropped.

2.4.4 Cab Radio busy as talker in VGCS or VBS (not a REC)

1. The Cab Radio is busy as talker (first or subsequent talker) in VGCS or VBS. It is situated in Network West and moving towards the adjacent Network East.
2. The Cab Radio is able to receive a point-to-point call.
3. The Cab Radio is able to join further group calls (VBS and VGCS with GID as stored on the SIM of the Cab Radio).
4. When passing the defined radio switching point of the respective traffic direction within the DNCA, the busy Cab Radio is triggered to perform an EIRENE network reselection from Network West to Network East.
5. The trigger can be:
 - a) An MMI action by the train driver who is following an operational instruction.
 - b) A balise or similar (track-side) device, which transmits a signal to the Cab Radio (via some external device(s)) when the train passes a specific point on the line. In this case the Cab Radio will inform the Train Driver about the occurrence of the trigger. (SRS clause 5.6.4i)
 - c) In either case the Train Driver has to release the talker function so that the Cab Radio enters group receive mode. If the Train Driver had originated the VGCS or VBS then the Train Driver shall terminate the call otherwise the Train Driver shall manually leave the call. In the latter case the call will

continue for the other participants until otherwise terminated. The procedure specified under 2.4.2 will then apply.

NOTE: If the talker function is not released, the Cab Radio will eventually lose coverage of Network West and the talker will be dropped, thereby releasing the talker function.

2.4.5 Cab Radio in group receive mode (listener in VBS or VGCS, not a REC)

1. The Cab Radio is connected to a VGCS or VBS in group receive mode. It is situated in Network West and moving towards the adjacent Network East.
2. The Cab Radio is able to receive a point-to point call utilising FACCH in-band signalling.
3. The Cab Radio is able to join further group calls (VBS and VGCS with GID as stored on the SIM of the Cab Radio).
4. When passing the defined radio switching point of the respective traffic direction within the DNCA, the busy Cab Radio is triggered to perform an EIRENE network reselection from Network West to Network East.
5. The trigger can be:
 - a) an MMI action by the train driver who is following an operational instruction.
 - b) a balise or similar (track-side) device, which transmits a signal to the Cab Radio (via some external device(s)) when the train passes a specific point on the line. In this case the Cab Radio will inform the Train Driver about the occurrence of the trigger. (SRS clause 5.6.4i).
 - c) If the Train Driver had originated the VGCS or VBS then the Train Driver shall terminate the call otherwise the Train Driver shall manually leave the call. In the latter case the call will continue for the other participants until otherwise terminated. The EIRENE network reselection procedure as described in chapter 2.4.2 will apply afterwards.

2.4.6 Cab Radio in group receive mode (listener in REC)

1. The Cab Radio is connected to a REC in group receive mode. It is situated in Network West and moving towards the adjacent Network East.
2. The Cab Radio will remain connected to this group call after entering the DNCA for as long as the REC continues since the emergency call area at the border may consist of adjacent cells in Networks West and East (Shared Group Call Area = SGCA). Leaving of an ongoing REC group call is impossible therefore the driver remains in the REC until the coverage of Network West is lost.
3. Having lost the coverage of Network West during border crossing, the Cab Radio will go to idle mode and perform the EIRENE network selection procedure as described in chapter 2.4.2. After finishing this procedure, the MS will use the late entry functionality to re-join any ongoing REC within a SGCA configuration as listener. If no SGCA configuration is used, the MS will stay in idle mode after the registration within Network East has been finished.

2.4.7 Cab Radio is busy as talker in a REC

1. The Cab Radio is busy as talker in a REC in Network West and moving towards the adjacent Network East.
2. The Train Driver may release the talker function when entering the DNCA but will stay in this group call at least as listener for as long as the REC continues (see chapter 2.4.6).
3. After losing the coverage of Network West, the MS will go to idle mode and perform the network reselection procedure as described in chapter 2.4.2. As described in 2.4.6, the Cab Radio will re-join the ongoing REC as a listener in Network East if a SGCA configuration is used. After re-joining the REC, the talker function can be requested again by the Train Driver.

2.5 Operational Radio Handheld OPH

The OPH is configured for automatic GSM-R network selection with a preferred (home) network in most cases, but this may be overridden manually.

2.6 General Purpose Radio Handheld GPH

The GPH is configured for automatic GSM-R network selection with a preferred (home) network in most cases, but this may be overridden manually.

2.7 Shunting Radio OPS

Border Crossing Yards are not considered as being used. Therefore, the behaviour is out of scope of this document.

3 ETCS Data Services Functionality at borders between GSM-R Networks (CS-mode)

3.1 Prerequisites

This section applies to a Dual MT EDOR consisting of at least two MT applicable for the operation of ETCS level 2/3.

The Dual MT EDOR is configured to manual network selection mode. The Network selection is invoked by a message in an ETCS balise and not by an MMI input.

In the dual configuration of EDOR, one of the MTs is the active MT that is busy in a dedicated mode circuit switched data connection with the ETCS RBC. The other MT is the standby MT, which is idle.

3.2 DNCA for ETCS Data Services

The DNCA for ETCS border crossing may be different from the DNCA required for voice services as described in chapter 2.2 because the necessary functional procedures and related maximum procedure duration requirements are different.

On border lines equipped with ETCS Level 2/3 (figure 2), the ETCS ENRS for each direction is followed by a second area called EIRENE Network Re-Connection Zone (ENRC). Within the ETCS specific ENRC the connection to the RBC within Network East is set up and the communication session is established.

The ETCS ENRS may be different from the non-ETCS ENRS. For ETCS the ENRS includes only the network Re-Selection process. The new communication session establishment originated by the On-Board Unit (OBU) resulting in a GSM-R connection set up towards the RBC in the new Network East has to be performed within the ENRC.

The ETCS border crossing procedure uses the standby MT to accomplish the necessary functions. The availability of the standby MT permits functional border crossing procedures that require simultaneous connections to the old (West) and the new (East) network. During border crossing, the standby MT within the EDOR is triggered by the reception of a message in an ETCS balise or via radio in-fill unit to start the Network selection procedure to the new Network East. No manual (MMI) activation of the network selection procedure is required.

After registering to the Network East, the standby MT of the EDOR is triggered by another ETCS balise message or via radio in-fill unit to set up the data connection to the new RBC within Network East. The communication session establishment must be successfully completed before the RBC area of the new (the accepting) RBC is reached. If the border crossing balise group has been passed by the safe front-end of the train and the OBU gets the message "Taking over responsibility" from the accepting RBC, the MT within the EDOR that has a session still ongoing with the originating RBC will be ordered by the OBU to drop its active call on Network West and to perform network selection in Network East. Therefore, for ETCS border crossing in a single direction, a DNCA zone is required because the new communication session to RBC East must be established using Network East radio coverage before the RBC area of the RBC East is reached and before the connection to Network West is lost.

The maximum duration requirements for network registration time and connection setup time of the ETCS border crossing procedures within the ENRS and the ENRC are defined

in by SUBSET-093 [6], but ETCS engineering may allow longer network registration and connection setup time. According to SUBSET-093 [6], one retry attempt for call setup must be allowed and included in the procedure duration calculation.

NOTE 1: Based on SUBSET-093 [6] requirements, the resulting minimum ENRC duration yields into 40 seconds, time span that consists of the maximum network registration delay and 2*10 seconds for connection setup and one retry attempt.

NOTE 2: Additional time for establishment of the ETCS "safe" end to end connection may be added to ENRC area.

The following figure shows the ETCS DNCA in a scenario where ETCS operational requirements are symmetrical around the border and demand that GSM-R connection to the RBC East is established at the point when the border is crossed.

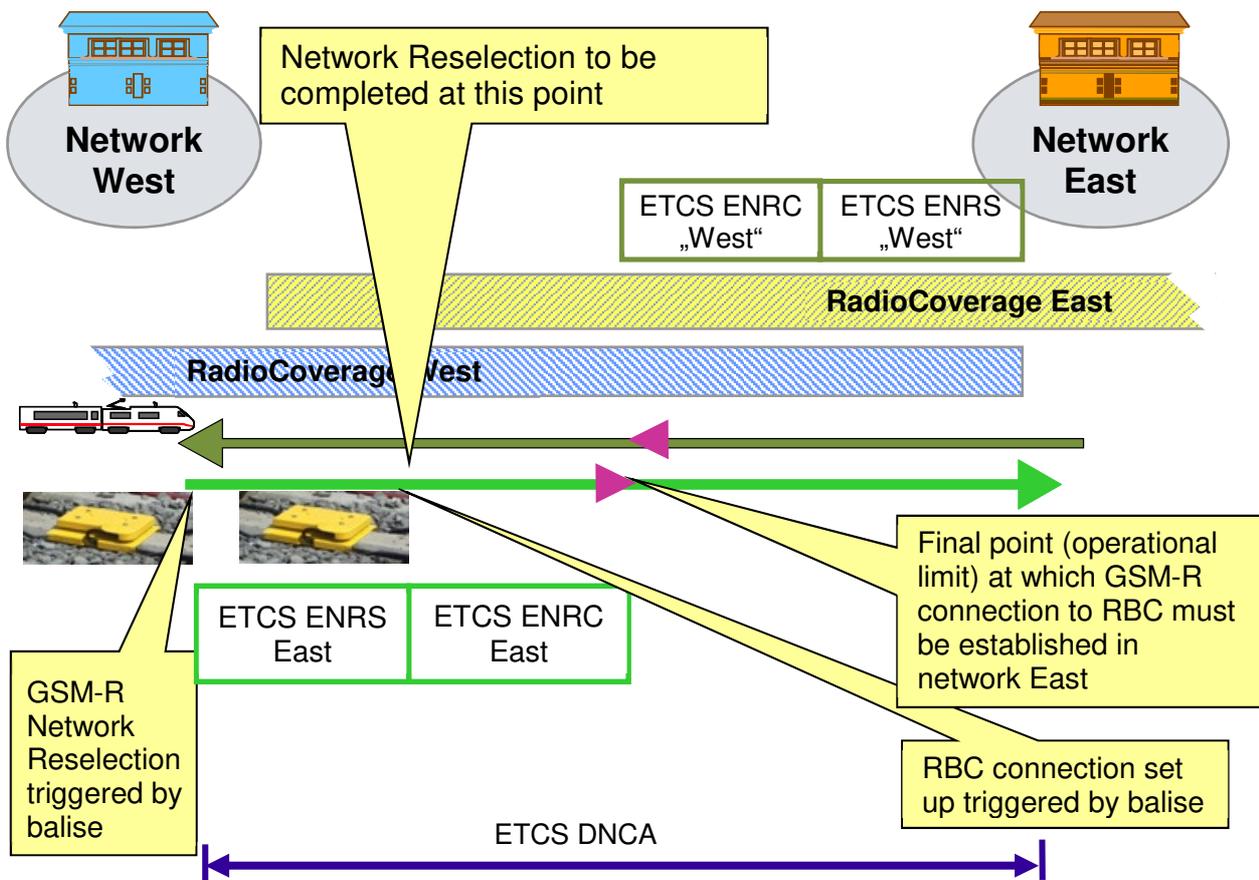


Figure 2: Dual Network Coverage Zone at EIRENE network borders including ETCS

3.3 Procedure

The procedure described corresponds to the nominal case, where there are two MTs available in the EDOR. The RBC Handover process is defined in SUBSET-26 [7] and SUBSET-039 [8], and it also covers the situation where only one MT is available.

1. The Dual MT EDOR is situated in Network West and moving towards the adjacent Network East.
2. The standby MT is idle and the active MT is connected with an RBC in Network West (RBC West).
3. When entering the DNCA and passing over the ETCS switch-over balise, the standby MT is triggered to perform a GSM-R network re-location from Network West to Network East.
4. The trigger is sent to the MT by the OBU by an AT command as defined in FFFIS for EuroRadio [11].
5. Upon receipt of the network selection trigger, the standby MT starts the procedure to become registered to Network East.
6. When registered, the standby MT responds to the OBU as defined in FFFIS for EuroRadio [11]. When passing over the ETCS balise related to ENRC, the OBU will now trigger the standby MT to establish a dedicated mode data connection with an RBC in Network East (RBC East).
7. The standby MT shall respond to the OBU as defined in the FFFIS for EuroRadio [11].
8. The ETCS on board application is now connected with both RBC West and RBC East. After the RBC handover procedure, the OBU will be under the control of RBC East and will terminate the connection to RBC West. There is no requirement for a specific time when the OBU is connected to both RBCs.
9. The previous standby MT is now the active MT and is in dedicated mode data connection with RBC East.
10. The previously active MT is now the standby MT.
11. The OBU will instruct the new standby MT to perform a GSM-R Network relocation from Network West to Network East.
12. Upon receipt of the network selection instruction, the standby MT starts the procedure to become registered to Network East. Note that registering the standby MT to the Network East need not be performed within DNCA; only coverage from the new (East) network is required.
13. When registered, the standby MT informs the ETCS application about its successful registration.
14. The active MT and the standby MT are now both attached to Network East. This completes the ETCS border crossing procedure.

4 Miscellaneous non ETCS Data Services

See Chapter 2.4.3. The handling is the same as for point to point speech calls.

5 International shared group calls numbering scheme

This chapter relates to International group calls whose radio cells belong to two GSM-R networks.

Requirement 13.2.4 of EIRENE-SRS [1] specifies that:

“Where Railway emergency group call areas are controlled by more than one MSC within one or more network(s), a unique anchor MSC is defined for each group call area.”

The anchor MSC (A-MSC) is responsible for the group call. The other(s) MSC(s) are called relay MSCs (R-MSCs).

In the following example, the radio cells 1 and 2 are linked to the MSC of Network West, while the radio cells 3 and 4 are linked to the MSC of Network East.

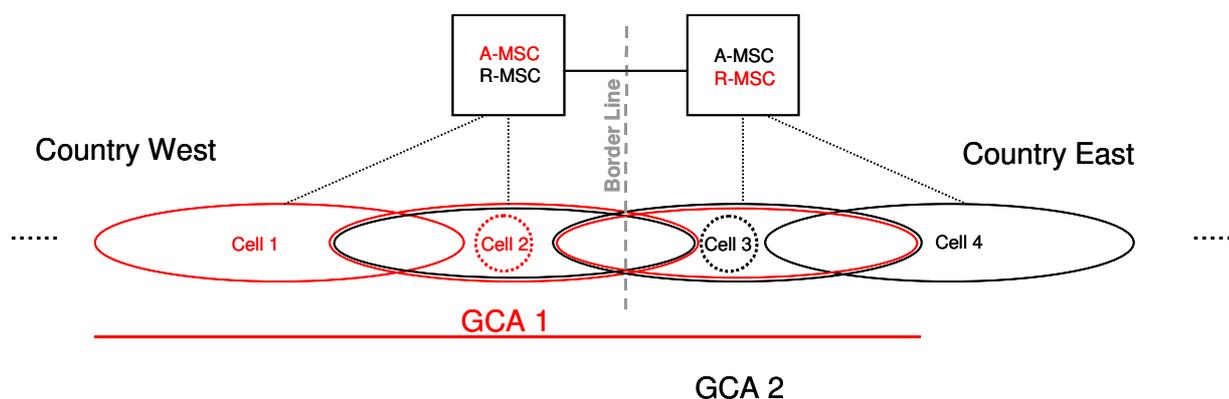


Figure 3: Example for an international group call

The group call reference numbers must be unique in both networks. Therefore, requirement 9.5.4 of E-SRS V15.4.0 specifies that “In network boundary areas, the Service Area shall be allocated on a bilateral basis.” The service area is identical to the group call area. The respective group call reference consists of 8 digits. The first five digits constitute the GCA number and the last three ones the group identity (GID).

Therefore, the following GCA numbering scheme shall apply: The first digit of the GCA is 9 and indicates an international GCA. The second digit indicates the A-MSC network (Anchor MSC network identifier AMNI). In this way up to 9 neighbours can be considered. Generally, such a number should be sufficient. In exceptional cases with more than 9 neighbours then multilateral agreements could become necessary.

The group call area format is therefore 9XYYYY, with X as A-MSC network identifier (AMNI = 0-9) and YYY as service area number.

6 Inter PLMN Handover (IP-HO)

6.1 General

The entire chapter 6 is for information only.

IP-HO uses the standardised handover procedures without functional modifications. Coherent database enhancements and modifications within the radio and the core network part must be performed in order to introduce IP-HO. The database changes required within the radio subsystem to support IP-HO will also enable the use of cell reselection functionality within all corresponding cells of both networks when a SGCA configuration is used.

In detail the introduction of IP-HO impacts the procedure described within chapters 2.4.2 to 2.4.7.

The following chapters detail IP-HO procedures for CS voice services only.

For IP-HO in speech call scenarios some technical restrictions e.g. by restricting HO target cell selection or specific operational rules may be applied.

6.2 Cab Radio in idle mode and IP-HO

For this scenario the procedure described in chapter 2.4.2 applies.

6.3 Cab Radio in PtP voice call and IP-HO

Introduction of IP-HO for point to point calls will allow handover of an ongoing call during border crossing. Since after the IP-HO procedure further coverage from the new Network East is given for the call, no call drop due to loss of coverage will happen.

The use of IP-HO for voice calls extends the silent period for network reselection to the end of the call which may be beyond the defined border crossing sign. While the call is maintained, the train is still registered to the functional number of the old Network West and cannot be reached using the CT2 number of Network East. Due to silent period a REC establishment delay seems reasonable.

The operational rules described in chapter 2.3 require that a call is terminated by the train driver when the ENRS (signs) is entered in order to have the silent period and the re-registration to the new network at the defined location. When these operational rules are followed, activation of IP-HO has no influence on this type of call. If a point to point call is maintained using IP-HO during border crossing and a REC is ongoing or started within the new Network East, the Cab Radio is informed about the ongoing REC with the function "notification in ongoing (PtP) calls". The Cab Radio will join the ongoing REC also in border crossing scenario with the use of IP-HO.

Taking above described circumstance of IP-HO into account, the use of IP-HO is not recommended for voice point to point calls. The operational rules that require termination of calls at the defined network border are sufficient. No technical measures to exclude IP-HO for voice calls are required.

6.4 Cab Radio as talker (not REC) and IP-HO

For non-REC VGCS or VBS no SGCA configuration is normally used. In a non-SGCA configuration the behaviour of a talker will not be modified by the introduction of IP-HO because for a talker only established downlink cells of the ongoing group call are allowed as handover target cell.

In addition, the operational rule described in chapter 2.4.4 requires that the talker releases the talker function and leaves the VGCS / VBS when entering the ENRS.

6.5 Cab Radio in group receive mode (not REC) and IP-HO

For non-REC VGCS or VBS usually no SGCA configuration is used. In a non-SGCA configuration the behaviour of a listener in group receive mode will not be modified by the introduction of IP-HO.

In addition, the operational rule described in chapter 2.3 requires that the listener deselects/deactivates the GID and leaves the VGCS/VBS when entering the ENRS.

6.6 Cab Radio in group receive mode (REC) and IP-HO

If no SGCA configuration is used, the procedure in chapter 2.4.6 applies and there is no change introduced by IP-HO.

If SGCA configuration is used and IP-HO is activated, the cell reselection process is activated for the REC listener during border crossing.

Cell Reselection between GSM-R networks enables the MS to access the notification channel (NCH) in a cell of the new Network EAST much faster. Access to the NCH can be achieved without performing the network selection and location update procedures. With IP-HO the interruption time of the listener during border crossing will be similar to a scenario with a cell change within one network during a REC receive mode. In this scenario the network selection and registration procedures are performed after the REC is finished and thereby shifting it from the location of the planned border crossing sign.

6.7 Cab Radio as talker (REC) and IP-HO

If no SGCA configuration is used the procedure of chapter 2.4.7 applies and there is no change introduced by IP-HO.

If a SGCA configuration is used and IP-HO is activated, the talker will be able to perform a handover between the two networks within all cells of the SGCA.

As described in chapter 2.4.7 operational rules for REC border crossing are not yet harmonized. When rules enforce an unconditional train stop, border crossing during an ongoing REC is impossible and introduction of IP-HO has no influence on the behaviour.

When no train stop is required, the introduction of IP-HO will allow the talker to maintain the talker function in a SGCA configuration during border crossing without the interruption for network selection and location update as described in chapter 2.4.7. As a consequence of IP-HO, maintaining the talker function also shifts the network selection and registration procedure from the planned border crossing sign.

The voice transmission interruption duration caused by IP-HO is the same as the interruption caused by any network internal MSC controlled handover. Therefore, use of IP-HO will not lead to increased voice transmissions interruptions for REC talkers.

7 Data service functionality at borders between GSM-R networks (PS-mode)

7.1 Introduction

(E)GPRS as a transport bearer allows the IP-based exchange of information between trainborne and trackside. In addition to the non ETCS applications used for informal exchange, online key management application or ETCS application can also use (E)GPRS bearer services for the execution of operational tasks. Since (E) GPRS is not necessarily required as an interoperability criterion, mixed variants from PS to CS and vice versa are used in addition to the pure PS mode GSM-R network relocation.

The following chapters describe these different cross border scenarios (PS-to-PS, PS-to-CS, CS-to-PS) using ETCS application and refer to the CS-mode scenario in sub-clause 3.2 and 3.3 if the process or parts of the entire process are not fundamentally different. Please note that chapter 7 will not provide any kind of engineering advices.

7.2 General definitions

This chapter provides the necessary settings necessary for operation under PS mode conditions:

1. (E)GPRS provides the packet-oriented bearer service within the GSM-R domain.
2. ETCS “Control Command Signalling” application is using the local applicable and the adjacent applicable Radio Block Controller (RBC) always taking into account the local breakout (VGGSN) of the GSM-R Land Mobile Network.
3. ETCS “Online Key Management” application on the train always obtains keys from the home KMC in accordance with SUBSET-137 [5]. Routing to the home KMC requires the use of the home network breakout (HGGSN).
4. The Access Point Names (APN) used for ETCS and ETCS Online key management are specified by EIRENE SRS [1].
5. The QoS profile associated to the APN as part of the subscriber profile contains the relevant information to obtain the appropriate transport resources of the (E)GPRS bearer service. In this context, the SGSN, including the Visited SGSN, has the capabilities to retrieve from the HLR the relevant subscription information of a (visiting) subscriber.
6. EIRENE numbering plan global addressing, i.e. short codes, are not applicable to PS-mode.
7. The ETCS application obtains the RBC transport mode capabilities, i.e. CS-mode and/or PS-mode, and the applicable RBC IP-address by using the selection scheme defined in SUBSET-037 [4] Annex I. Even when the GSM-R network supports PS mode, the ETCS-DNS provides information about the RBC transport system capabilities.
8. The ETCS DNCA becomes direction dependant according to the local applicable GSM-R and RBC transport capabilities, i.e. combination of CS-mode/PS-mode, and the resulting maximum time duration of the scenarios.

9. The capabilities of the target network and the corresponding RBC, i.e. availability of (E)GPRS Bearer Service and RBC PS transport mode, demand the selection of the appropriate procedure. There are three potential bearer services relocation scenarios applicable for the ETCS-DNCA:

Scenario 1 PS-to-PS: The target GSM-R network and the corresponding RBC support PS-mode bearer services.

Scenario 2a PS-to-CS limited RBC bearer capabilities: The target network supports PS-mode bearer services, but the corresponding RBC supports only CS-mode capabilities.

Scenario 2b PS-to-CS limited GSM-R bearer capabilities: The target network supports only CS-mode bearer services, then CS-mode procedure applies.

Scenario 3 CS-to-PS: The target GSM-R network and the corresponding RBC support PS-mode bearer services.

NOTE: The document will not consider the dimensioning of the PS-mode transport capabilities (i.e. the number of TDMA timeslots used simultaneously and the transport system up to the Radio Block Controller).

7.3 Procedures for ETCS in PS mode

7.3.1 Scenario 1 PS-to-PS

The following transactions are applicable:

1. If the target network supports PS mode, based on the network registration information received by the EVC, it shall select the standby Mobile Termination (MT) as part of the EDOR (no active PDP context (session) or CS call), to register (CS-domain see sub-clause 3.3 steps 1 - 5) to the target network and to attach (PS-domain) to the target network. The EVC shall obtain RBC transmission capabilities from the local applicable ETCS-DNS before establishing the logical connection to the target RBC in accordance with SUBSET-037 [4].

NOTE 1: For PS mode, the selection of the EDOR is different from the procedure for RBC handover within one GSM-R network. This difference is identified by the reception of the ETCS message to initiate network registration to a different GSM-R network. The FIS for EuroRadio SUBSET-037 [4] defines that for the network internal RBC handover in PS mode, the same MT (EDOR) as for the already established connection shall be used to establish a second PDP context to the new RBC.

NOTE 2: According to EIRENE SRS [1], the EDOR consists of at least two MT's, necessary for cross border operation when reselecting between the RBC's that belong to different administrative realms.

2. The selected MT shall start the CS-domain registration procedure and afterwards the GPRS attach to register the MS to the new GSM-R network. With the completion of the PS-Mode service setup process, a dynamic IP address of the corresponding local GGSN will be assigned to the MT.
3. The EVC shall initiate ETCS-DNS queries in order to obtain:
 - a) The RBC transmission capabilities;
 - b) The RBC IP address based on the RBC ID (ETCS information) described in SUBSET-37 [4].

4. After session establishment between the EVC and the RBC, in accordance to SUBSET-037 [4], other ETCS communication layers shall be set-up (Safety Layer etc.).

NOTE: The length of DNCA may be extended to allow retry attempts of network registration and PS Service setup procedures within the DNCA.

5. Steps 8 – 14 of sub-clause 3.3 apply, performing network registration and GPRS attach to the target network.

7.3.2 Scenario 2a PS-to-CS limited RBC bearer capabilities

1. Steps 1 – 5 of sub-clause 3.3 apply;
2. Steps 1 – 5 of sub-clause 7.3.1 apply;

7.3.3 Scenario 2b PS-to-CS limited GSM-R bearer capabilities

1. Steps 1 – 14 of sub-clause 3.3 apply;

7.3.4 Scenario 3 CS-to-PS

1. Steps 1 – 4 of sub-clause 3.3 apply;
2. Steps 1 – 5 of sub-clause 7.3.1 apply;

7.4 Online Key Management

7.4.1 General principles

1. Online Key Management information exchange between the train KMAC entity and the KMC (Key Management Centre) is only applicable in GSM-R PS-mode.
2. In accordance to SUBSET-137 [5], the KMAC entity on the train shall always obtain key information from the Home-KMC.
3. If a train is visiting another administrative domain, i.e. roaming in another GSM-R network, the KMAC entity on the train shall query the Home-KMC. Accordingly, the APN applicable for Online Key Management will be restricted to use the home breakout (HGGSN).
4. The KMCA entity on the train is responsible to establish the logical connection towards the Home-KMC. Chapter 4.2.6 of SUBSET-137 [5] defines a list of events which are not applicable during border crossing.
5. [SUBSET-137 [5] neither requires the support KMC Handover nor Online Key Management session continuity when relocating between GSM-R networks. Accordingly, lost online KMC sessions are required to be re-established after GSM-R network reselection.

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