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

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EVOLUTION SHEET

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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.

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 calls. In addition the possible influence of inter PLMN handover on the above scenarios is evaluated. All indicated timings assume normal operation.

Where harmonized international operational rules are referred to in this document, further information may be obtained from the “TSI Subsystem: Operation and traffic management” (TSI OPE 2012/757/EU)[1].

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: Use of preemption on inter GSM-R network trunks is currently not needed because the average 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[2]) 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)[3] there is a segment of rail track

[1] Note: TSI OPE does not currently include detailed requirements on border crossing behaviour. This document closes this gap.
[2] See EIRENE FRS v7.4 section 5.2.3.25ii to 5.2.3.25v
[3] This (operational) border follows railways’ operational needs and does not necessarily coincide with the political border of the two adjacent countries.

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.

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 ReSelection 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 <u>not significant</u> 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

- The Mobile Station (MS) is equipped with one single Mobile Termination (MT) and is used for EIRENE voice services

- Parameters with the subscript H (e.g. CC_H , NDC_H) refer to the **H**ome EIRENE network of the MS (the HPLMN) [4]. Parameters with the subscript 'W' (e.g. CC_W , NDC_W) refer to "Network **W**est" and parameters with the subscript 'E' (e.g. CC_E , NDC_E) refer to "Network **E**ast". Network West or East could be the home EIRENE network or they could both be 'foreign' EIRENE networks.

- 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).

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

- For Voice Group and Broadcast Calls the international Group call Identifiers (GID) included in EIRENE-SRS [2] (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 **E**irene **N**etwork **R**e**S**election zone (ENRS) is derived from the time values of the border crossing procedures described in the following sections.

[4] 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.

2. In general, for each traffic direction[5], 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 EIRENE requirement for registration of functional numbers (FRS 7.3 clause 11.3.2.3) is up to 30 seconds for registration of 10 functional numbers.
   Note: Bulk registration could significantly improve this time. This allows calculation of the minimum ENRS.[6]
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.

[5] Note: 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.
[6] 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.

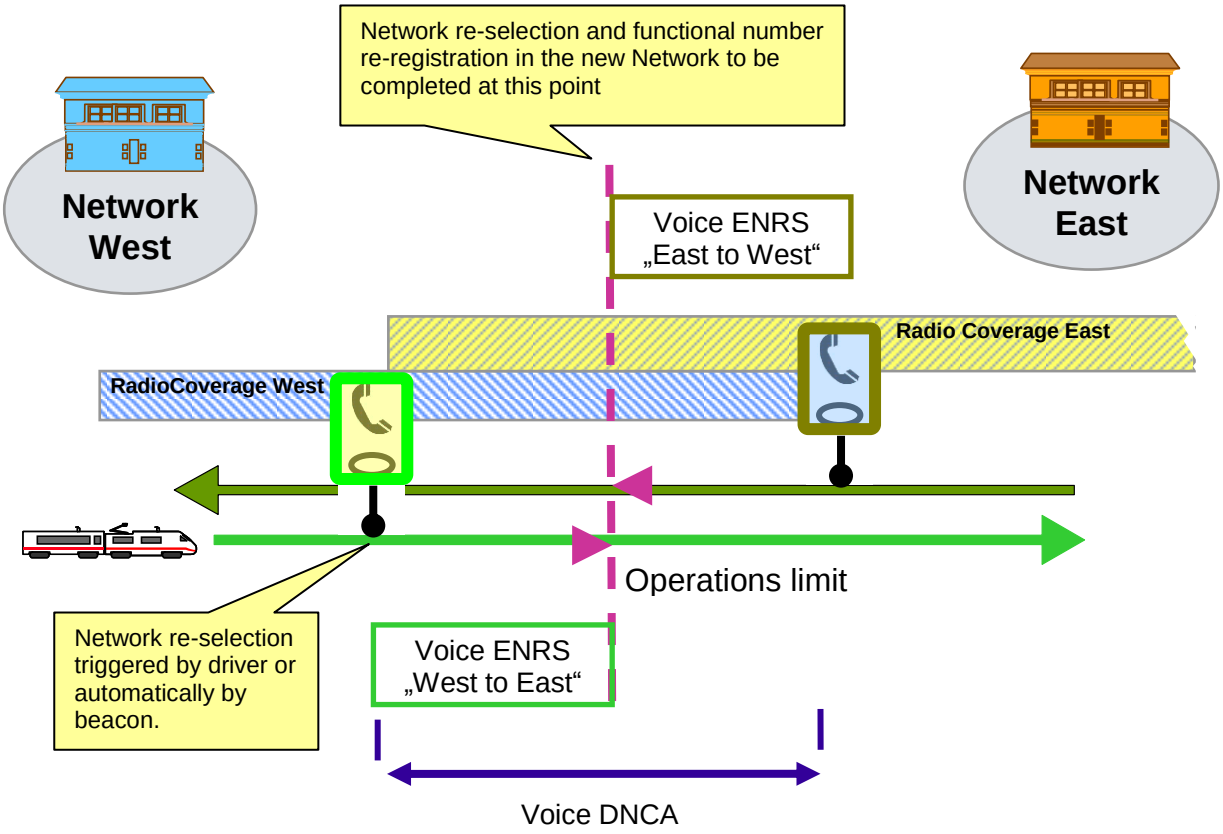

Figure 1: Dual Network Coverage Zone at EIRENE network borders without ETCS)

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[7]

[7] As long as Annex A-2 in the TSI OPE is still to be developed and the TSI are not yet set in force by the EU and the governments, bilateral agreements for the respective border line, in worst case (national) operational rules of the respective infrastructure manager, have to be applied.

3. For Group Calls which do not have priority 0 it is recommended that the driver release the talker function (if necessary) and terminate / leave 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.

4. 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[8]).

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[8]).

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.

[8] It should be noted that other GIDs may also be present.

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 or
   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:

      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 type” Attach in EAST.

      If the trigger does not explicitly specify the reselection towards Network EAST:
      - The Cab Radio will scan the GSM-R spectrum.
      - The Cab Radio re-attaches to WEST and presents to the driver 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.
      - The driver selects which network he wishes to join (EAST).
      - 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: During step 4 the Cab is partly unavailable for REC.
      Note: 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[9]. 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~~7~~ is repeated until all used (max 10) FCs are re-registered[10]. 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.

[9] This relates to the network selection procedure in section 10.5 of E-FRS 7.4.0 whereby EIRENE networks are given preference.

[10] The EIRENE FRS requires that the registration of up to 10 functional numbers shall last at maximum 30 seconds.

11. The functional deregistration from Network West is done by issuing the appropriate USSD string as defined in EIRENE 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 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 or
    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 SRS clause 5.6.4i)

6. 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.

7. Automatic termination of the call is not required. FRS V7.4.0 / SRS V15.4.0 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 or
    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)

6. 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.

7. 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 or
    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)

6. 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 rejoin 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

3.1 Prerequisites

1. This section applies to a dual MT EDOR for ETCS level 2/3.

2. The Dual MT EDOR is configured to manual network selection mode. Note that the Network selection is normally invoked by a balise and not by an MMI input.

3. 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 is 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, the ETCS ENRS for each direction is followed by a second area called EIRENE Network ReConnection Zone (ENRC). Within the ETCS specific ENRC the connection to the RBC within Network East is set up.

The ETCS ENRS is different from the non-ETCS ENRS. For ETCS the ENRS includes only the network Re-Selection process; the functional re-registration procedure is not required. 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.

For lines equipped with ETCS Level 2/3, an EDOR equipped with a second MT is operative on the train (see chapter 3.1). The ETCS border crossing procedure uses this second standby MT to accomplish the necessary functions. The availability of the second MT permits functional border crossing procedures that require simultaneous connections to the old (West) and the new (East) network.

During border crossing the second (standby) MT within the EDOR is indirectly triggered by a balise to start the Network selection procedure to the new Network East. No manual (MMI) activation of the network selection procedure is required.

After attaching to the Network East, the EDOR is indirectly triggered by an additional ETCS balise 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 first MT within the EDOR will be ordered by the OBU to drop its active call on Network West.

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 of the ETCS border crossing procedures within the ENRS and the ENRC are defined within subset 093. The corresponding values for network registration duration are 30 seconds (95%), 35 seconds (99%) and 40 seconds (100%).The maximum call set up time for the connection to the RBC is defined as 8.5 seconds (95%) and 10 seconds (100%). According to subset 093 a retry attempt for call setup must be allowed and included in the procedure duration calculation.

Based on these values, the ENRS + ENRC area spans a minimum of 60 seconds train driving time (40 seconds for the maximum network registration duration and 2*10 seconds for call setup and retry call setup attempts) for the GSM-R part.

Additional time (to be defined by the ETCS application) for establishment of the ETCS “safe” end to end connection may be included in the ENRC area and a second network registration process within the ETCS ENRS may be included based on national considerations.

E.g. an ETCS DNCA which allows a second registration process for safety reasons and a time span of 30 seconds for set up of a safe ETCS end to end connection will have a duration of 2*40 + 2*10 + 30 = 130 seconds.

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.

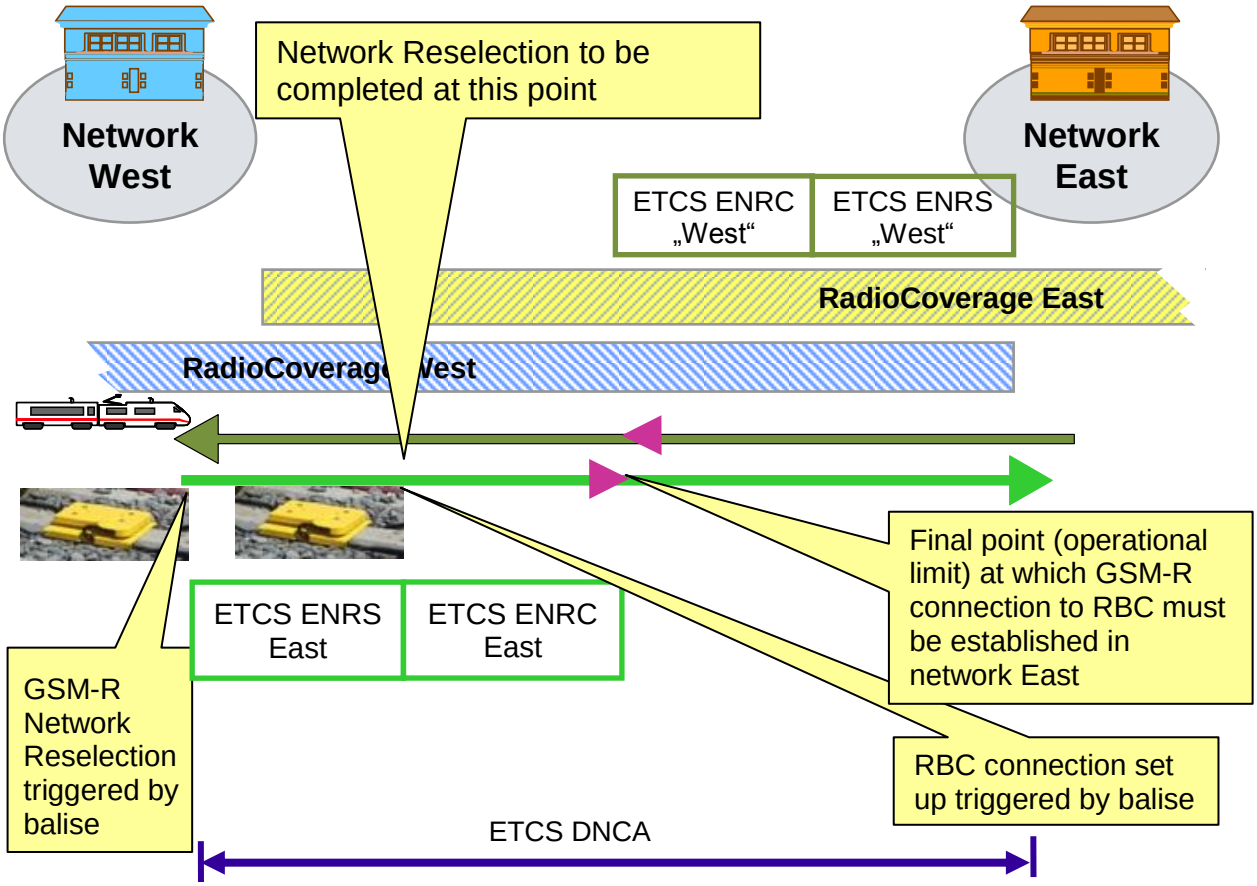

Figure 2: Dual Network Coverage Zone at EIRENE network borders including ETCS

3.3 Procedure

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 selection 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.

5. Upon receipt of the network selection trigger, the Standby MT starts the procedure to become attached to Network East.

6. The Standby MT attaches to Network East within 40 seconds according the SUBSET 093 requirements and responds to the OBU as defined in FFFIS for EuroRadio. 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.

8. The ETCS on board application is now connected with both RBC West and RBC East. The OBU is now under 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 Standby MT to perform a Network reselection from Network West to Network East.

12. Upon receipt of the network selection instruction, the Standby MT starts the procedure to become attached to Network East. Note that attaching the Standby MT to the Network East need not be performed within the DNCA; only coverage from the new (East) network is required.

13. The Standby MT attaches to Network East within 40 seconds, as given by the Subset 093 requirements, and informs the ETCS application about this.

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 E-SRS V15.4.0 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.

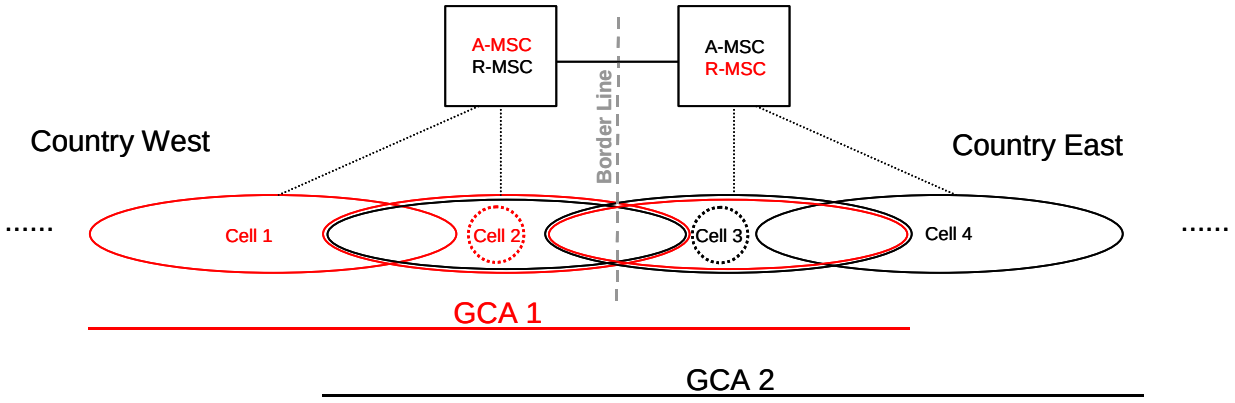

Figure 3: Example for an international group call

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 9XYYY, with X as A-MSC network identifier (AMNI = 0-9) and YYY as service area number.

6 Inter PLMN Handover (IP-HO)

This chapter 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 has the following influence on the procedure described within chapters 2.4.2 to 2.4.7.

The Implementation Report I-080 requested the support for IP-HO only for ETCS data connections. Within the following section the influence of IP-HO on all type of border crossing scenarios is analysed in order to decide if IP-HO must be restricted to (ETCS) data calls or can be used without restrictions. Note that a restriction to data calls will require a modification of the handover cell selection procedure.

It shall be noted:

- The following chapters describe how IP-HO procedures could work as per current state of the art of the standards.
- There is currently no standardized test specification of the IP-HO procedure to validate the system behaviour in the operational conditions described below.

6.1 Open Item for technical restrictions on use of IP-HO

It could not be decided in the BX working group if the use of IP-HO for speech call must be technically restricted, e.g. by a modification of the HO target cell selection procedure, in order to discriminate between speech and data, or if operational rules were sufficient.

The topic will be addressed to the responsible operational expert group (TSI OPE) for a final decision.

6.2 Cab Radio in idle mode and IP-HO

No modification of the procedure described within chapter 2.4.2 when use of IP-HO is introduced.

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. With introduction of IP-HO for voice calls, the silent period for network reselection is shifted to the end of the call and not at 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. In addition it is impossible to initiate a REC without delay (silent period).

The operational rules described within 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 a 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 of the ongoing REC with the function “notification in ongoing (ptp) calls”. Using this function after IP-HO is similar to the scenario with an inter-MSC handover of a ptp call within one GSM-R network. The Cab Radio will join the ongoing REC also in border crossing scenario with use of IP-HO.

Taking above described effects of IP-HO into account, the use of IP-HO is not re-commended for voice ptp 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 mentioned in 2.4.6 is applicable and there is no change introduced by IP-HO.

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

With Cell Reselection between GSM-R networks the MS will be able 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 mentioned in 2.4.7 is applicable 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.

6.8 EDOR and IP-HO

Introduction of IP-HO will allow the modification of the procedure for ETCS border crossing as described in chapter 3.2 in order to have a shorter DNCA (depending on the ETCS operational requirements) and a more secure border crossing procedure. The established functional procedure for ETCS border crossing shall be retained as much as possible in order to allow an easy introduction of IP-HO.

The ETCS border crossing procedure when using IP-HO shall be as following:

When entering the ENRS the standby MT within the EDOR will start the network selection and afterwards in the ENRC the RBC connection set up procedure as described in chapter 3.2. The RBC connection set up procedure must be finished at the point where it is operationally required to control the train from Network East.

In parallel, the active MT within the EDOR will also get coverage from Network East and based on the handover parameter setting an IP-HO handover from Network West to Network East will be performed for the active MT. Once within Network East, the active MT can maintain the data connection to the RBC West without requiring any further radio coverage from Network West. Therefore the introduction of IP-HO for EDOR border crossing will allow the DNCA to be shortened, depending on the ETCS operational requirements. With use of IP-HO the minimum ETCS DNCA area is independent from the ENRS and ENRC and spans for each moving direction two times the duration of the IP-HO procedure duration (of about 2*6 seconds, value to be confirmed by IG). For such a

scenario the ETCS operational requirements must allow that the GSM-R connection to the new RBC East can be set up behind the point where the border is crossed.

The duration of an IP-HO is similar to the duration of a network internal inter MSC handover. The above minimum IP-HO ETCS DNCA area includes a safety margin for a second IP-HO attempt before the connection to the old RBC is lost due to lack of coverage. With use of IP-HO the ETCS DNCA zone may be shortened because the coverage of Network East can be used to maintain the ongoing data connection to RBC West. Details depend on the ETCS operational requirements. In a scenario as depicted in figure 2 where ETCS operational limits require that the GSM-R connection to the new RBC East is set up at the point where the border is crossed, use of IP-HO will not shorten the ETCS DNCA.

This will also improve the security of the procedure because the active MT connection can be maintained without losing coverage when there are problems causing delays in finishing the border crossing procedures of the second, previously standby MT. The following figure shows the minimum ETCS DNCA which can be achieved with use of IP-HO during border crossing.

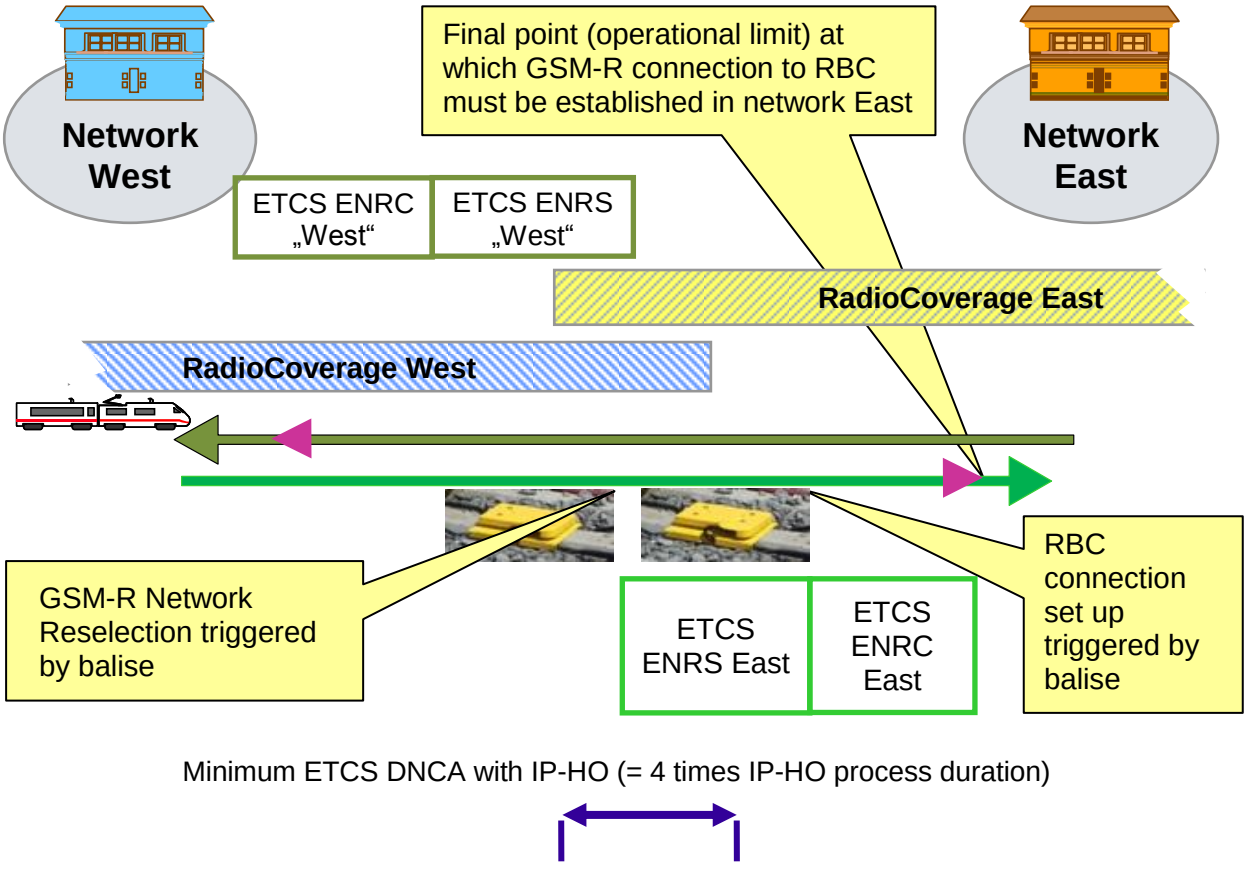

Figure 4: Minimum DNCA including ETCS and use of IP-HO

7 GPRS functionality at borders between GSM-R networks

This chapter is for information only.

Note that the following section describes the basic behaviour of a GPRS system at border crossing. Any further details on dimensioning of DNCA etc. cannot be given since they depend on the details of the used applications (e.g. ETCS over GPRS) and of the basic supported GPRS roaming model (Use of HGGSN or VGGSN) used in GSM-R interconnections: All these basics inputs are not defined up to now.

7.1 Prerequisites

- The Mobile Station (MS) is equipped with one single Mobile Termination (MT) and is used for packet services (GPRS).
- 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.
- The MS is attached to GPRS (GPRS attached).
- PDP context is activated (PDP context activation).
- Static or dynamic IP address is assigned to the MT.
- The MT can transmit/receive IP packets to/from its peers.

7.2 Packet (GPRS) MT (single device); GPRS attached

1. The Packet (GPRS) Mobile Station is situated in Network West and moving towards the adjacent Network East.

~~1.~~2. The MT is attached to GPRS (GPRS attached).

~~1.~~3. PDP context is activated (PDP context activation).

~~1.~~4. Static or dynamic IP address is assigned to the MT.

~~1.~~5. The MT can transmit/receive IP packets to/from its peers.

~~2.~~6. When passing by the defined radio switching point of the respective traffic direction within the DNCA the GPRS MT is triggered to perform an EIRENE Network reselection ENRS from Network West to Network East.

1.7. The trigger can be a MMI action by the train driver who is following an operational instruction.

1.8. The trigger can alternatively be a balise or similar (track-side) device, which transmits a signal to the GPRS MS (via some external device(s)) when the train passes a specific point on the line (This is termed directed network selection in the EIRENE FRS v7.3.0 section 5.2.3.25ii to 5.2.3.25v).

3.9. Upon receipt of the network selection trigger (see above) the GPRS MT starts the procedure to deregister from Network West and register to Network East. The procedures to be followed to close and reopen the GPRS connection has to be performed by the controlling application:

4.10. During execution of the network selection procedure, i.e. after leaving Network West and until joining Network East within the ENRS (GPRS attached and PDP context activated), the GPRS MS is unable to transmit or receive packet data. This silent period is longer than the maximum network selection delay specified in 2.4.2. 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.

5.11. After the silent period, the GPRS MS is network attached to Network East.

1.12. If this could not be completed before leaving the DNCA, the GPRS MS will lose connection to the network entirely. Operational rules will then apply.

1.13. After having attached to Network East the application will perform:

a. The MT will be attached to GPRS (GPRS attached).

a.b. PDP context will be activated (PDP context activation).

a.c. Static or dynamic IP address will be assigned to the MT.

1.14. The GPRS MS is now registered and can transmit/receive IP packets to/from its peers.

7.3 ETCS over GPRS

ETCS over GPRS procedures and detailed protocol adaptations are not yet defined and therefore ETCS over GPRS is not considered in this version of the document.

8 Abbreviations

CT	Call Type
DNCA	Dual Network Coverage Area
EDOR	ETCS Data Only Radio
ENRC	Eirene Network ReConnection zone
ENRS	Eirene Network ReSelection zone
ETCS	European Train Control System
FACCH	Fast Associated Control Channel
FC	Function Code
FN	Functional Number
IP-HO	Inter PLMN Handover
MT	Mobile Termination
PLMN	Public Land Mobile Network
REC	Railway Emergency Call
SGCA	Shared Group Call Area
USSD	Unstructured Supplementary Services Data
VBS	Voice Broadcast Services
VGCS	Voice Group Call Services

9 Definitions

Balise

A passive or active device normally mounted in proximity to the track for communications with passing trains. A standard for passive balises has been devised within the EUROBALISE project. It may be used for initiating directed network selection.

Broadcast call

A call made to all members of a pre-defined group within a local geographical area. Only the initiator of the call may talk with all other group members listening only.

Cab Radio

The radio and associated user and other interfaces installed in the cab of a locomotive and for use principally by the locomotive driver.

Controller

An individual responsible for the conduct of some aspect of train operations (also known as dispatcher). For the purposes of this specification the following functional roles of controllers are defined:

- primary controller;
- secondary controller;
- train controller;
- power supply controller.

Dependent upon local circumstances, a number of functional roles can be carried out by a single controller or a single functional role can be carried out by a number of controllers.

Dedicated mode

A mobile station is in dedicated mode when it has a traffic channel (TCH) at its disposal.

Dual Network Coverage Area

A section of track where radio coverage is deliberately provided from two networks.

EIRENE network

An EIRENE network is a railway telecommunications network, based on the ETSI GSM standard, which complies with all related mandatory requirements specified in the EIRENE FRS and SRS. An EIRENE network may also include optional features and these shall then be implemented as specified in the EIRENE FRS and SRS. The EIRENE network excludes terminals.

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

An EIRENE system is a railway telecommunications system based on the ETSI GSM standard, which complies with all related mandatory requirements as specified in the EIRENE FRS and SRS. An EIRENE system may also include optional features and these shall then be implemented as specified in the EIRENE FRS and SRS. The EIRENE System includes terminals.

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 select and attach to the new network (East). For ETCS services no re-registration of the functional number(s) has to be performed within the ETCS ENRS.

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

One type of Mobile Station. It is the radio equipment dedicated to support the ETCS train control application data transmission requirements. This equipment includes one or several radio transceivers and their enclosure.

ETCS Level 2/3

Levels of ETCS which use GSM-R data communication for the transmission of movement authority and other information to trains, and for the reception of train information from each vehicle.

Functional addressing/numbering

A term used to describe the process of addressing a call using a number representing the function a user is performing, rather than a number identifying the user's terminal equipment.

Functional identity

The full alphanumeric description of the function performed by a called or calling party within the functional numbering scheme, identifying them by function or role rather than by a specific item of radio equipment or user subscription. The functional identity can include characters and/or numbers.

Functional number

The full number used within the functional addressing scheme to contact an end user/system by function or role rather than by a specific item of radio equipment or user subscription.

General purpose radio

A standard GSM radio based closely on commercially available units for general use.

Group call

A call made to all members of a pre-defined group within a local geographical area. Only one member of the group may talk at any instant with all other group members listening only.

Group receive mode

The state of a mobile station when it is engaged in a group or broadcast call as a listener.

Group transmit mode

The state of a mobile station when it is engaged in a group call as a speaker. This may be as ‘first talker’ or ‘subsequent talker’.

Handover

The process by which connection between the GSM mobile and the GSM network is maintained as the mobile moves from area to area, by passing communication channel control from one base station to another or between different channels in one cell.

Idle mode

A mobile station is in idle mode when it is not involved in a call.

Mobile station

One of five mobile radio types based on the type of role they will perform and the environment in which they will operate:

a) Cab Radios for the transmission of voice and non-safety data – for use by the driver of a train and/or by other on-train systems;

b) General purpose radios – for general use by railway personnel;

c) Operational radios – for use by railway personnel involved in operations such as trackside maintenance.

d) Shunting radio - for use by railway personnel involved in train operations such as shunting.

e) ETCS data only radios - for the transmission of train control data.

Operational radio

A handheld radio suitable for use by people involved in railway operations.

Radio Block Centre

An ERTMS/ETCS term referring to a centralised safety unit to establish and control train separation using radio as the train to ground communication medium.

Railway emergency call

A call of highest priority for informing drivers, controllers and other concerned personnel of a level of danger requiring all Railway movements in a pre-defined area to stop. Two types of Railway emergency calls are defined:

- Train emergency calls (for Railway emergencies whilst not involved in Shunting operations).
- Shunting emergency calls (for Railway emergencies whilst involved in Shunting operations).

Roaming

The use of a mobile on any communications network other than the user's home network.

Shunting radio

A handheld radio suitable for use by people involved in railway operations including shunting operations.

Silent Period:

Time where it is impossible to receive or originate a REC during border crossing because the MS is not attached to any network. It excludes the time needed for the functional registration of a Cab Radio because functional registration is no prerequisite for reception of a REC. The silent period includes the time for selection the new network West and performing a successful location update as described in chapter 2.4.2

Train control system (TCS)

The process by which the movement of a train is influenced without any action by the driver. For the purposes of this specification, reference to the train control system also encompasses automatic train protection, automatic train operation and in-cab signalling.

Train mode

Train mode is the operational mode of mobile terminals, where at least the train emergency call 299 and the group call "all drivers in same area" 200 are activated on the SIM and the shunting emergency call 599 is de-activated.

10 References

[1]: EIRENE SRS / FRS 15.4.0 / 7.4.0

[2]: TSI OPE link:
http://ec.europa.eu/transport/rail/interoperability/interoperability/interoperability_en.htm

[3]: MORANE E12T6001 5.1 FIS for Functional Addressing