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Company / organisation	**UIC ERTMS/GSM-R Operators Group**	
	UIC ERTMS/GSM-R ENIR/NMG	

FFFS for Voice and Data Services Interconnection & Roaming between GSM-R networks

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EVOLUTION SHEET

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0.0.1	21/07/15	OG	First Issue by Erik van Bommel
0.0.2	28/07/15	OG WG I&R	Update after telco with Robert Sarfati, Dirk Brucks, Klaus-Dieter Masur and Erik van Bommel
0.0.3	09/09/15	OG WG I&R	Review and comments of whole document from Dirk Brucks, Klaus Dieter Masur, Robert Sarfati and Erik van Bommel
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0.0.5	22/10/15	OG WG I&R	Remarks and comments from ENIR/NMG (Dirk Brucks, André Jambe and Frédéric Coursant), TIG and OG processed.
0.0.6	22/10/15	OG WG I&R	Review after presentation of the document in Plenary#7
0.0.7	05/11/15	OG WG I&R	Comments reviewed from TIG. Clause 6.18 changed to O, Annex A deleted.
1.0.1	09/11/15	UIC	Approved version based on 0.0.7 on Voice Services
1.0	22/12/15	UIC	Final version for CS

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1. REFERENCES

1.1 Documentation

[EIRENE FRS]	EIRENE, System Requirement Specification, version 16.0.0
[EIRENE SRS]	EIRENE, Functional Requirements Specification, version 8.0.0
[CDD]	ENIR-08020-v1.6_CDD, Common Design Document ENIR v1.6

1.2 Abbreviation / Acronyms

BC	Break out Code
CC	Country Code
CDD	Common Design Document
CCS7	Common Channel Signaling #7
CPN	Called Party Number
CT	Call Type
DPC	Destination Point Code
ENIR	UIC - European Network Integration for Railways group
GID	Group call Identifier
GMSC	Gateway MSC
GIRA	GSM-R Interconnection and Roaming Agreement
GSM-R	Global System for Mobile communications – Railway
GT	Global Title
GTT	Global Title Translation
IC	International Code
IM	Infrastructure Manager
IPR	International Public routing
ISPC	International Signalling Point Code
ISUP	ISDN User Part
I&R	Interconnection & Roaming
MAP	Mobile Application Part
MSC	Mobile Switching Center
MSISDN	Mobile Station International ISDN Number
MTP	Message Transfer Part
NDC	National Destination Code
NI	Network Indicator
NMG	UIC – Network Management Group
NUC	Nailed Up Connection
O&M	Operation & Maintenance
PLMN	Public Lands Mobile Network
POI	Point Of Interconnection
RDS	Routing Data Set
SCCP	Signalling Connection Control Part
SDC	Short Dialling Code
STP	Signalling Transfer Point
TRA	Transit Routing Agreement
UN	User Number

2. GENERAL

2.1 This document specifies technical conditions and functionalities to be fulfilled for Interconnection and Roaming of GSM-R networks in order to enable interoperable international train traffic. (I)

2.2 The statements made in the specification are assigned to one of four categories: (I)

- **Mandatory for Interoperability** (indicated by '(MI)' at the end of the paragraph). These are the requirements, **with respect to the authorisation in the EU according to the TSI,** that are considered in the European Directives to be relevant for interoperability as **fulfilling the essential requirements for the Control-Command and Signalling subsystem** related to safety and technical compatibility which must be met by the rail system, the subsystems, and the interoperability constituents, including interfaces according to the corresponding conditions set out in Annex III of the Directive 2008/57/EC. It is mandatory that each railway subsystem in the EU meets these requirements on lines under the scope of the Directive to ensure technical compatibility between Member States and safe integration between train and track.
- **Mandatory for the System** (indicated by '(M)' at the end of the paragraph). These requirements must be complied with together with the "Mandatory for Interoperability (MI)" requirements in order to deliver an EIRENE compliant system. The M requirements ensure additional level of system technical integration and compliance to existing standards; they allow that the technical characteristics of the network and fixed terminal system are compatible with each other and with those on board the trains to be used on the rail system.
- **Optional** (indicated by '(O)' at the end of the paragraph). These requirements allow the selection (or non-selection) of a set of requirements on a national basis and shall not be used as a precondition for the acceptance of roaming mobile equipment on GSM-R networks. When an option is selected, the method defined in the SRS and FRS by which such features are implemented becomes mandatory (M), both to provide a consistent service and to present a recognised and agreed standard to manufacturers in order to obtain economies of scale in development and manufacture.

  In addition:

- **Information** (indicated by '(I)' at the end of the paragraph). These are statements intended to provide explanatory notes.

2.3 The EIRENE requirements are described in documents [EIRENE FRS] and [EIRENE SRS]. (I)

3. ORGANIZATION

3.1 The UIC - Network Management Group (NMG) coordinates and facilitates the GSM-R services for interconnection and roaming for IMs that have a need to ensure cross border operations. The NMG reports to the European Rail Implementers Group (ERIG) and interacts with Operators Group (OG) as well as Functional Group (FG). (I)

3.2 The NMG provides a platform for IMs to: (I)

- Exchange relevant information among IMs;
- Provide templates (e.g. roaming agreements, O&M agreements);
- Provide testing guidelines;
- Agree on roadmaps and planning issues among IMs (e.g. new I&Rs);
- Coordinate usage of national allocated numbers (e.g. GIDs, SDCs).

3.3 The UIC - European Network Integration for Railways group (ENIR) ensures the technical definition, implementation and monitoring of the GSM-R European wide overlay network offering a high Quality of Service. The ENIR group reports to the NMG group. (I).

3.4 The tasks of ENIR are: (I)

- Overall design of the GSM-R overlay network;
- Elaborate, provide and maintain the configuration of the GSM-R overlay network with so called Routing Data Sets (RDS);
- Coordination of changes in the overlay network;
- Traffic measurement and prediction in order to provide a future proof architecture;
- Process description and detailed implementation procedures for new IMs to get connected to the GSM-R overlay network but also for changes in the current network (see [CDD]);
- Provide test plan guide for IMs.

3.5 The GSM-R Interconnection and Roaming Agreement (GIRA) is a bilateral agreement between two GSM-R IMs who have a need for interconnection and roaming. The GIRA and its appendixes describe the tele-, bearer and supplementary services used during roaming, the details of the communication relations and specify if public roaming is supported. (I)

3.6 The GSM-R International Transit Routing Agreement (TRA) is a multi-party agreement between all GSM-R IMs who have a need to connect to the GSM-R overlay network. It is needed to enable communication relations between different non-adjacent GSM-R networks by using hub functionality via so called nailled-up connections for transit services. The network configuration is specified and agreed on multilateral bases. (I)

4. REQUIREMENTS FOR INTERCONNECTION & ROAMING

4.1 The requirements that are classified as MI in [EIRENE FRS] and [EIRENE SRS] shall be supported. (M)

4.2 The requirements that are classified as M in [EIRENE FRS] and [EIRENE SRS] shall be supported. (M)

4.3 Based on the bilateral decision of the IMs if the requirements that are classified as O in [EIRENE FRS] and [EIRENE SRS] should be supported. (I)

4.4 A high availability of the Interconnection & Roaming are needed for train operation. The availability requirement can be agreed upon on between IMs. (I)

5. OVERLAY NETWORK

5.1 The international GSM-R overlay network consists of national GSM-R networks within different countries. (I)

5.2 Basically only one GSM-R network per country exists. (I)

5.3 Physical interconnections and gateway nodes / Point of Interconnections (PoIs) of these GSM-R networks are forming the international GSM-R overlay network, providing cross border interconnection and roaming services. (M)

5.4 A geo-redundant configuration of a GSM-R network is based on two gateway nodes in an active-active configuration within the same GSM-R network connected to the GSM-R overlay network instead of a single configuration / connection. (I)

6. NETWORK ARCHITECTURE

6.1 In order to perform interconnection and roaming an overlay network architecture is required. The architecture of the GSM-R overlay network shall be designed with a layered hierarchical structure approach. (M)

6.2 The upper layer of the GSM-R overlay network shall be built of centralised hub nodes. These centralised hub nodes shall provide the transit functionality to exchange both control plane and user plane information between all GSM-R networks. The centralised hubs shall also act as origin and destination nodes. (M)

6.3 The locations of the centralised hubs are selected in such a way that a cost optimized network architecture is achieved, mainly related to the costs of transmission links. (I)

6.4 The access layer of the GSM-R overlay network shall be formed by the peripheral (non-hub) nodes. Peripheral nodes shall act as origin and destination entities for control and user plane. (M)

6.5 In the access layer of the GSM-R overlay network a transit function for other GSM-R networks shall not be provided except in a geo-redundant node configuration (active – active) for the 'partner node' within the same network / country. (M))

6.6 The GSM-R networks consist of either: (I)

- a combined node (embedded STP and user traffic exchange); or
- a separate node configuration (stand-alone STP and stand-alone user traffic exchange).

6.7 Three relations of network interconnections exist: (I)

- Hub to hub;
- Hub to non-hub;
- Non-hub to non-hub.

6.8 In order to design the GSM-R overlay network, a set of rules are needed. The rules must be clear on how a node will be connected (physical layer) and what routing rules will be used (logical layer). The rules in section 6.9 until 6.18 shall be applied for both the physical layer and the logical layer. (M)

Physical layer

6.9 To guarantee a high availability of the hub function in the GSM-R overlay network at least two independent hub nodes in different countries shall be installed. (M)

6.10 Every country shall have at least two physical independent links to the GSM-R overlay network. This can be realized with direct link(s) to a hub node and/or with direct link(s) to a non-hub node, depending on the general overall design developed. (M)

6.11 Nailed-up connections (NUCs) are used to provide physical connectivity (trunk groups and signalling link sets) to hub nodes. The number of hops should not be a limiting factor. (I)

6.12 The dimensioning of the physical links should be done on a case by case basis. As a minimum step one 2 Mbit/s (E1) link is used with 31 time slots available. As a guideline a minimum of one timeslot is needed for each signalling link set. For traffic trunk group dimensioning it is advised to base the dimensioning on the estimate usage and traffic analyses. (I)

6.13 Hub sites shall be fully meshed connected. (M)

Logical layer

6.14 Every country shall have a logical connection to at least two hub nodes in different countries. (M)

6.15 Preferably each country should be connected to all hubs (in the case that more then two hubs are used in the overlay network). (O)

6.16 If non-hub nodes in different countries have a direct physical link (e. g. to neigbouring country), these countries shall also have a direct logical link. (M)

6.17 This direct logical link connection is the preferred route (1st path) and the alternative paths will run over the hub nodes. (I)

6.18 The routing should provide bi-directionality for signalling only on the first path. This means that the return path is using the same route as the initial path (forward and backward path are equal). (O)

7. TYPE OF INTERCONNECTIONS

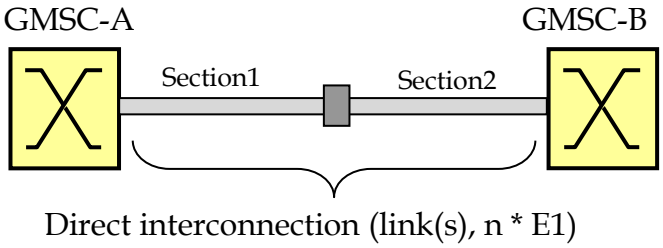
7.1 To enable interconnection and roaming services, a logical interconnection shall be established between the GSM-R networks. The logical interconnection is based on a physical connection, carried out via direct interconnection (tranmission link) or via nailed-up circuits (routed in existing physical interconnection links). (M)

7.2 The physical interconnection link between GSM-R networks shall be used to exchange both control plane and user plane information. (M)

Direct physical interconnection

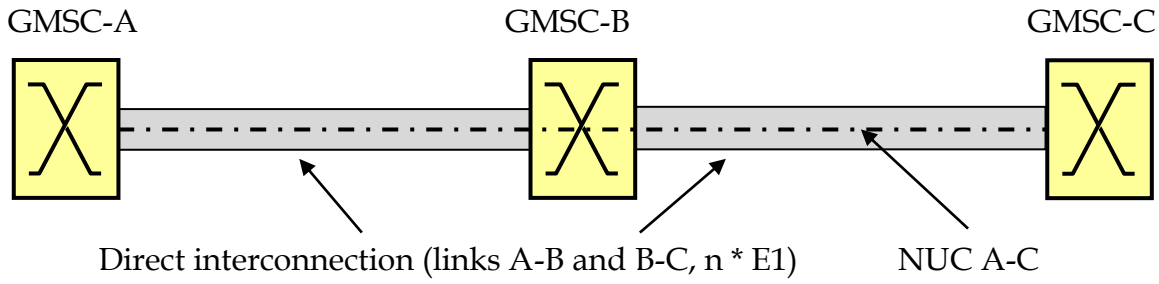
7.3 A direct interconnection link is a physical connection, defined by (at least) one 2 Mbit/s (E1) connection link between two Gateway MSCs directly connected to each other. This link consists of one or more sections provided by one or more carriers. (I)

7.4 One 2 Mbit/s (E1) carries up to 31 time slots of GSM-R user and/or signalling data. (I)



Physical nailed-up interconnection

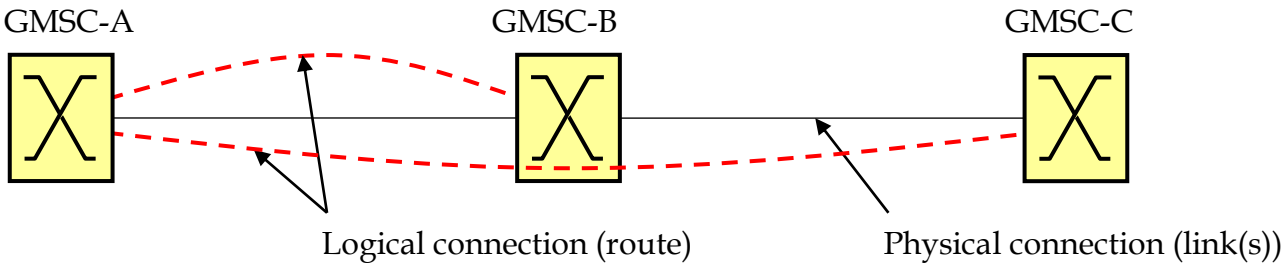
7.5 A nailed-up connection (NUC) is established via at least one other GSM-R network in-between. These GSM-R networks are connected via direct interconnection links. This kind of interconnection requires physical through connection of timeslots, so called nailed-up connections. Typically NUCs are used to connect non-Hubs to Hubs where no direct interconnection exists. (I)



Logical connection (route)

7.6 An End-to-End communication relationship (over a predefined way / path) is called "route". (I)

7.7 A logical connection can be established on a direct interconnection and/or via a NUC interconnection. (I)

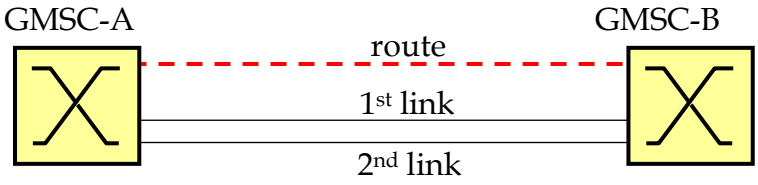


Availability

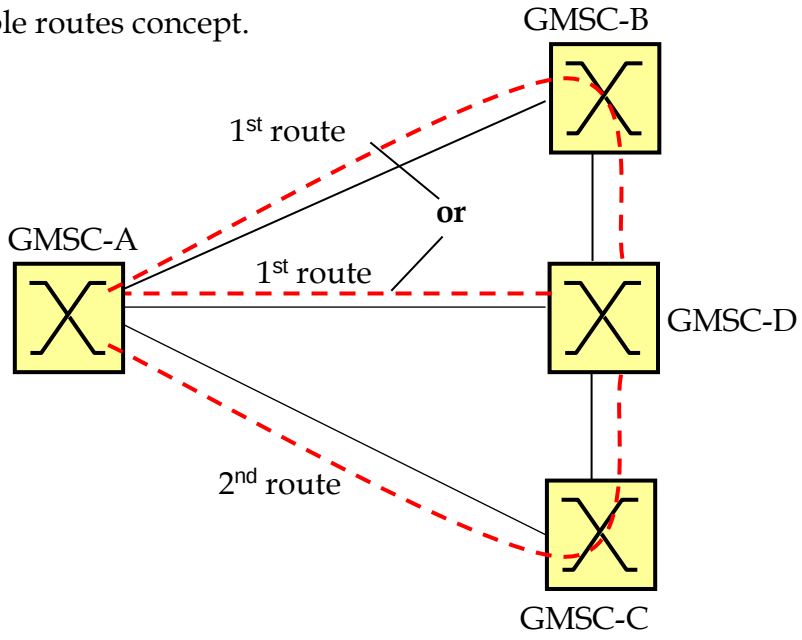
7.8 The availability of a single transmission link is a matter of the bilateral Service Level Agreement. The commonly used availablility is 98,5%. (I)

7.9 To increase the availability of the transmission connection there are two options: (I)

- Use redundant physical links for one route.



- Use a multiple routes concept.



8. DIMENSIONING

8.1 The physical transmission network dimensioning should be properly designed. The design and dimensioning of the physical transmission network is based on a set of rules defined by ENIR/NMG.(I)

8.2 The task of every IM is to monitor the traffic on the physical transmission network to ensure that the occupation rate does not exceed the predefined limit as set by ENIR/NMG. (I)

9. ROUTING PRINCIPLES

9.1 In order to reach the required End-to-End availability and to avoid circular routing of control plane and user plane information, a logical routing details are defined and documented in [CDD]. In this chapter the routing principles are given allowing IMs to enable interoperable train traffic. (I)

9.2 Based on the routing rules, the complex algorithms and the unpredictable migration/rollout of GSM-R networks, the calculation is done by a network planning tool, managed by UIC. (I)

9.3 All possible communication relations between the connected GSM-R networks are considered in the calculated routing paths (Full communication matrix). This includes the minimum number of hops and length of physical links for all alternative routes to a certain destination (I)

9.4 The calculated international routing paths for user plane and control plane information (CCS7) need to be considered when establishing an overlay network in a Routing Data Set (RDS). (M)

9.5 A RDS consists of the following items: (I)

- Physical and logical network maps;
- Detailed routing reports for physical NUC paths;
- Detailed routing reports / specifications for user plane and control plane information (CCS7);
- End-to-End routing plans for user plane and control plane information (CCS7), MTP and SCCP routing;
- Detailed numbering and ID table containing the different numbering schemas, IDs and labels for each country / GSM-R network.

9.6 This RDS shall to be applied by the relevant GSM-R network operators in the specified time. (M)

Signalling (control plane) routing strategy and rules

9.7 CCS7 routing targets for ISUP, SCCP and MAP messages is based on International Signalling Point Codes (ISPCs) used in the Message Transfer Part (MTP), Network Indicator (NI) = 00. (I)

9.8 The Destination Point Code (DPC) is the ISPC of a destination node. (I)

9.9 Global Title Translation (GTT) based routing strategy is used in non-hub nodes. Destination Point Code (DPC) of next hub / adjacent node is addressed except if geo-redundant configuration exists where the geo-redundant node is used as STP using the Message Transfer Part (MTP). (I)

9.10 DPC routing strategy based on the Message Transfer Part (MTP) is used in hub nodes. DPC of final destination node is addressed. (I)

9.11 Hub node priority level shall be defined (e. g.: CH(Zurich)=highest, D(Frankfurt)=second highest, CH(Basel)=lowest priority). (M)

9.12 In order to meet the requirements of the availability alternative routing via several routing paths shall be performed. (M)

9.13 The alternative routing paths are weighted excluding load sharing. The sequence is based on the existing physical connections to the destination network. (I)

- 1st priority: direct connection (if applicable);
- 2nd priority: direct connection via geo-redundant node in source or destination network (if applicable);
- 3rd priority: via hubs in the given hub priority.

User traffic (user plane) routing strategy

9.14 Bearer routing (speech and data) is controlled by ISUP CCS7 protocol. (I)

9.15 The destination GSM-R network is derived from the called party number (CPN). Supported are the numbering plans E.164 and EIRENE, in the international format.

- E.164: Country Code (CC) + National Destination Code (NDC) + first digits of the subscriber number, in case not a whole NDC-number block is assigned to the GSM-R network with NPI=E.164, NOA=International. (I)

- EIRENE: Break out Code (BC) + International Code (IC) + Call Type (CT) + User Number (UN) with NPI=E.164, NOA=Unknown. (I)

9.16 Hub node priority level shall be defined (e. g. CH(Zurich)=highest, D(Frankfurt)=second highest, CH(Basel)=lowest priority. (M)

9.17 In order to meet the requirements of the availability alternative routing via several routing paths shall be performed. (M)

9.18 The alternative routing paths are weighted. The sequence is based on the existing physical connections to the destination network. Load sharing will be performed to geo-redundant destinations only. (I)

- 1st priority: direct connection (if applicable);

- 2nd priority: direct connection via geo-redundant node in source or destination network (if applicable);

- 3rd priority: via hubs in the given hub priority.

9.19 Nodes with transit routing functionality shall support the feature origin depending traffic routing. (M)