SIEMENS

GSM-R

Railway Communication
The Modern Way

Combining the Requirements

Railways use many different systems for various applications. The systems described below represent only those most commonly used in UIC countries.

Application	Communication System in Use
Train radio	Trunked radio system working at 460 MHz
Shunting team communication	80 and 450 MHz radio with walkie-talkie functionality
Local service teams	Analog 160 MHz radio system
Tunnel communication	Analog 450 MHz radio system
Passenger communication	Public mobile communication system (analog systems, GSM now in introduction phase)
Automatic train control	Railroad-based cable (signal-transmission at 36/56 KHz)
Train diagnostics	
Train numbering	
Schedule changes	
Ticketing	

Train Radio

Train radios in use today provide typical analog trunked radio system functions. Future systems will have to support these as well as new functions. The trunked radio systems vary among the UIC countries.

The main function of train radio is communication between train controller stations and train drivers. With analog radio, there is no call setup comparable to circuit switched communication systems. Analog radio provides an open channel which can be accessed by all users by pressing the talk button. All other users are able to listen to the call.

Shunting Team Communication

Shunting teams use an analog radio system in the 80 MHz and 450 MHz frequency band with push-to-talk function. Group members are able to communicate to each other by pressing a button at the mobile station. The mobile station itself is ruggedized to withstand environmental conditions.

Local Service Teams

Today, railroad maintenance personnel either use walkie-talkies or trackside-installed telephones connected via railroad-based cables.

Tunnel Communication

To communicate in tunnels in the event of an emergency, the railway personnel and emergency services communicate via analog radio systems in the 450 MHz band and by phones mounted within the tunnels.

Passenger Communication

Passenger communication via PLMN and PSTN is possible via private handsets for GSM subscribers in areas with very good coverage. Alternatively, in some trains, passengers may use public coin or card telephones based on analog public land mobile networks.

Automatic Train Control ATC

Train control systems are either operated only at a signaling level (optical, electro-magnetic and mechanical signals) or they use signaling and train control via railroad-based cable or analog radio. These systems are not flexible and are cost-intensive in both procurement and operation. Furthermore they do not allow traffic to cross borders unless the traction engine is replaced.

Train Diagnostics

Train diagnostics are performed on the train while it is running (e.g. supervision of brakes, axles, etc.). When the train returns to its home railway station or depot, the diagnostic data is evaluated.
Some modern trains such as ICE are able to send the diagnostic data to the depot at a predefined location on the journey.

Train Numbering

Train numbers are individually configured from country to country. International trains have commonly agreed running numbers. The trains are addressed by calling the actual running number on the open channel of the analog trunked radio system.

Schedule Changes

Today's schedules are available on paper or are accessible via the internet. At the railway stations, delays to trains are displayed, but not the impact for follow-on connections. In trains, delays and follow-on connections are announced via loudspeaker by the train driver to the passengers.

Ticketing

Ticket machines located remotely or carried by train personnel cannot be updated online and do not offer an online banking interface. This means that tariff changes and electronic cash-payments involve work-intensive post-processing functions.

Meeting the Challenge

Currently, very many different networks and systems featuring different services are in use. In most cases, these are not compatible. Communication is typically restricted to the relevant system in use – this may be either trunked radio, typical walkie-talkie or ISDN closed user group via PABX network. Flexible configuration of different group members in groups dependent on a specific work order is not possible without changing equipment. This situation is not regarded as satisfactory.
With so much at stake, a modern reliable railway communication system is essential. Based on GSM – the world standard for mobile communications – a new digital system for railway communication has been developed: GSM-R.

A modern railway aims to optimize costs and improve services. Furthermore, international traffic requires new solutions. A future-proof integrated communication solution is necessary to fulfill these requirements.

GSM-R
The Future-proof Solution

The railways organized via UIC agreed to introduce a GSM-based communication system for railways. The railway specific requirements are part of GSM phase 2+.

GSM-R – The System Solution

The most widely spread standard in the world today, with its ISDN-like services, guarantees a future-proof and cost-optimized system solution.

Within several working groups (EIRENE, MORANE, ERIG) international railway and communication experts specify requirements for GSM-R and applications running on the GSM platform.

In Europe ETSI reserved the frequencies from 876–880 MHz for the uplink and 921–925 MHz for the downlink as GSM-R-band – the other GSM-frequencies can be used for railway purposes as well.

The GSM-R Network

A typical GSM-R network is built of several cells alongside the tracks or within train stations. Each cell is equipped with one or more trans-

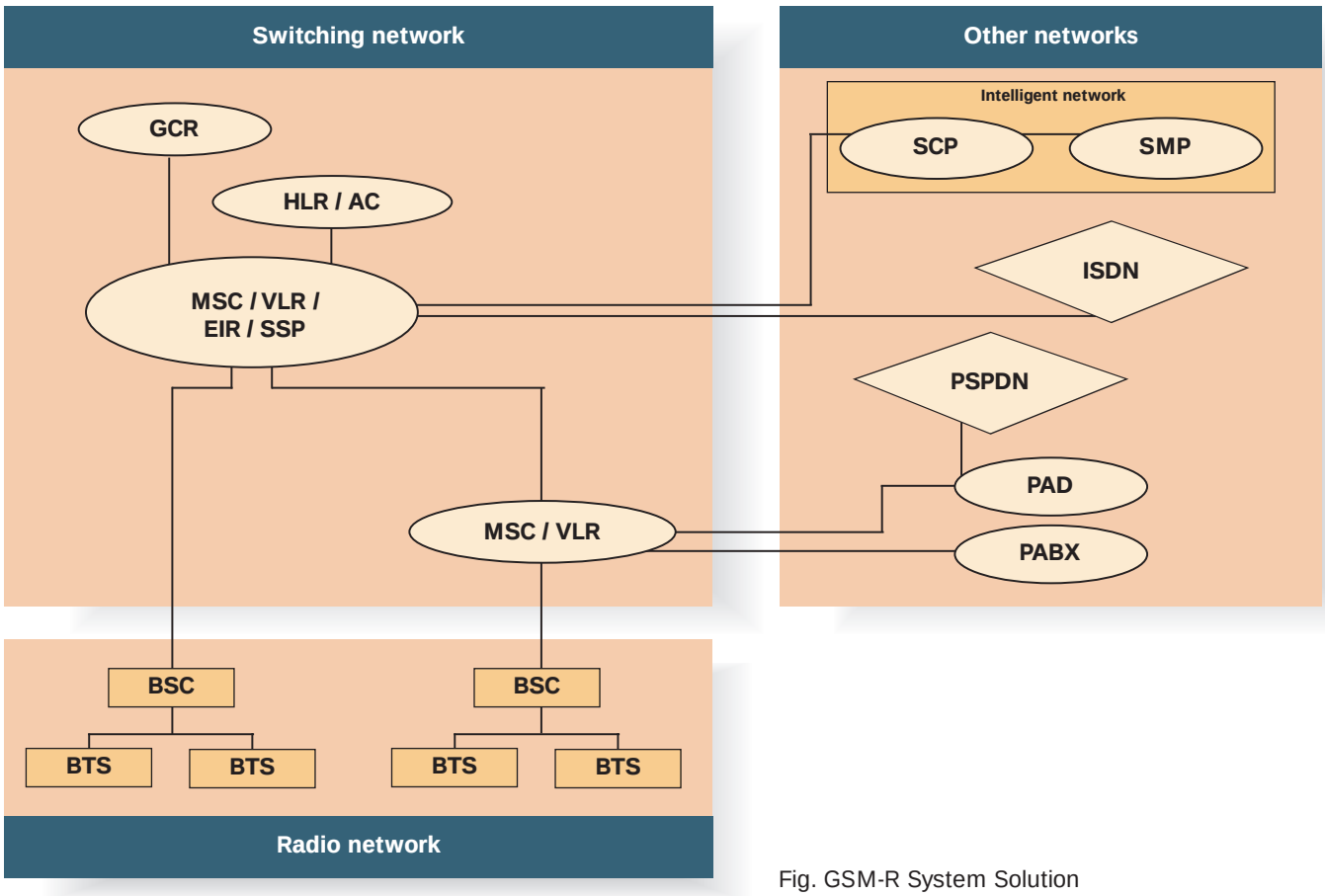


Fig. GSM-R System Solution

ceivers depending on communication density. One base station controller is responsible for a defined number of cells.

In turn, base station controllers are connected to the MSC/VLR. The MSC interconnects all communication links and provides interfaces to other networks.

HLRs linked to the network are addressable both nationally and internationally via the Signaling System No.7, thus enabling communication across international borders.
Existing railway PABX/ISDN telephones and networks can be directly connected to the MSC. Furthermore the access to IN functionality enables an easy and attractive design of additional applications.

Evolution of GSM-R

Mobile communication in general and GSM in particular have grown at a phenomenal rate in the last 15 years, and there is no apparent slowing down.
New technologies like GPRS will allow for better use of radio resources, new data services and will open up a new and attractive world for modern railway organizations – the world of Internet.

The Siemens strategy for UMTS will guarantee a seamless migration from today's to future mobile radio technologies.

Railways will enjoy the whole range of telecommunication activities from voice to fax to e-mail to multimedia services – all via a single platform.

GSM-R Benefits

- **Cost Reduction:**
  In operation and maintenance
- **Higher Performance:**
  New radio services, higher traffic capacity
- **Additional Revenue:**
  New customer related services like information services, cargo tracing, etc.
- **New Services:**
  Automatic ticketing, etc.
- **Interoperability:**
  International communication and signalling
- **Future Proof System:**
  Evolving the existing platform

GSM-R
The Convincing Advantages

Convincing benefits turned GSM-R into reality. Before December 1998 thirty-two railway authorities had already committed themselves to this technology. Here is an overview of the UIC-standardized applications. However, there are many more which we from Siemens have already developed and implemeted for our customers.

Train Radio

Standard GSM tele- and bearer services are used for most train radio functions. The specific railway requirements have been standardized in GSM Phase 2+, following the requirements of the EIRENE working group. These so-called ASCI (Advanced Speech Call Items) features are currently under development.

– Voice broadcast service:
The voice broadcast service (VBS) will be used to broadcast railway emergency calls within predefined areas. It may be accessed from both fixed and mobile subscribers and is built up as a simplex connection (one speaker – many listeners).

– Voice group call service:
The voice group call service (VGCS) can serve many types of group communication. Especially shunting team communication, train radio, and emergency communication will require this functionality. A mobile or fixed subscriber may require a group call. This will be built on a common channel for all listeners, thus saving system capacities. All members of a group will be able to listen. If a member requires the talk function by PTT (Press-To-Talk) a duplex connection will be built up for as long as required.

VBS and VGCS require a new register in GSM, the Group Call Register (GCR). Siemens has integrated the GCR into the MSC platform. Siemens BSS has been enhanced for the new paging functions, channel management and handovers required for group calls.

– Priority Services (eMLPP):
Several communication applications such as railway emergency calls or automatic train control require an immediate call setup regardless of the network load resulting from other active calls. eMLPP interrupts a lower priority call at once and gives precedence to high priority call setup, if no empty traffic channel is available in the respective cell. This priority management is maintained by HLR/AC and MSC/VLR/GCR. The preemption function is carried out by the BSC.

Shunting team communication

A shunting team is usually only temporary and group members may vary. The VGCS will allow dynamically changing group call compositions without the need for the individual group members to change either equipment or frequency.

Local Service Teams

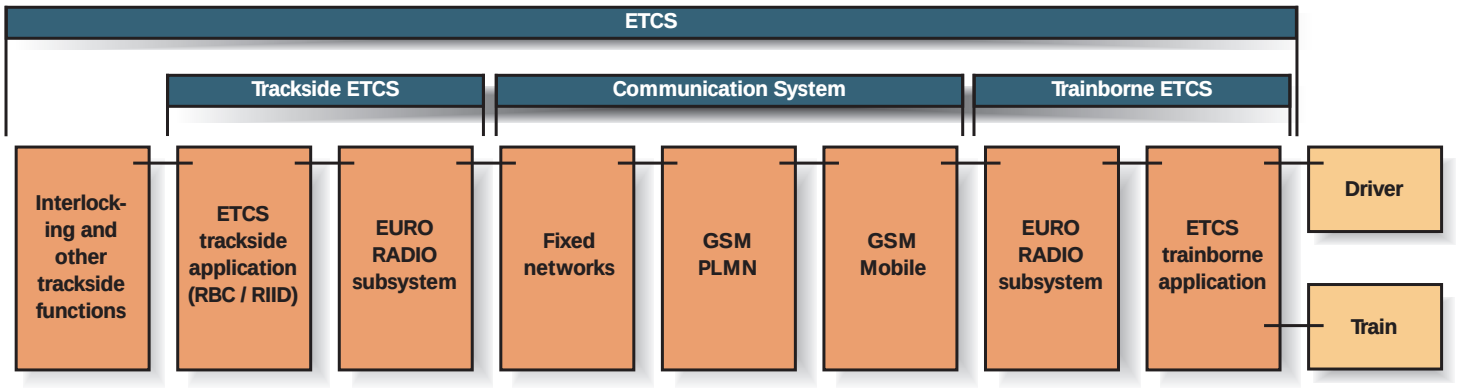
By using GSM-R mobiles it will become significantly easier to reach railroad maintenance personnel. As an alternative, new trackside and tunnel telephones will be based on GSM-R. Personnel can then be located according to their location and function.

Tunnel Communciation

Railway personnel will use GSM-R and even public GSM as a redundant system. The advantages of GSM-R are better coverage of the 900 MHz band inside the tunnel, and the use of all train functions via one system in the case of an emergency.
Siemens advanced radio network planning can provide optimized tunnel solution.

Passenger Communication

Due to license restrictions and frequency resources, the GSM-R band will not be used for public communication. To improve service quality in PLMN, railway operators will install GSM repeaters on some trains. This will enable passengers to use private handsets in areas with only average coverage. In addition, coin or card telephones based on GSM will be installed in trains.



Automatic Train Control

Automatic train control will be implemented according to ERTMS/ETCS. ETCS is a harmonized modular ATP/ATC system using GSM as a transmission system.
A standard GSM bearer service (BS 2x) will be used to transmit data from fixed to mobile ATC computers. The actual location of the train is achieved via GPS or other location services and transmitted via GSM-R. ATC is specified as ERTMS/ETCS in a European task force. In its final stage, it will replace existing signaling and train control systems. Generally, information such as speed profile, train condition, and trackside data are exchanged between trackside and train-borne applications.
The train's position, speed, number of cars and other train-borne information will be transmitted to the radio block center. The radio block center network compares traffic data of all trains in the respective area and transmits the relevant speed profile to each individual train. This application allows railways to operate their trains via moving block structures. This will reduce the necessary distance between trains on a single track and result in optimized usage of the track and in less train delay.

Automatic train control facilitates safe management of high-speed trains even in exceptionally heavy traffic. It is therefore an essential application for railway organizations.

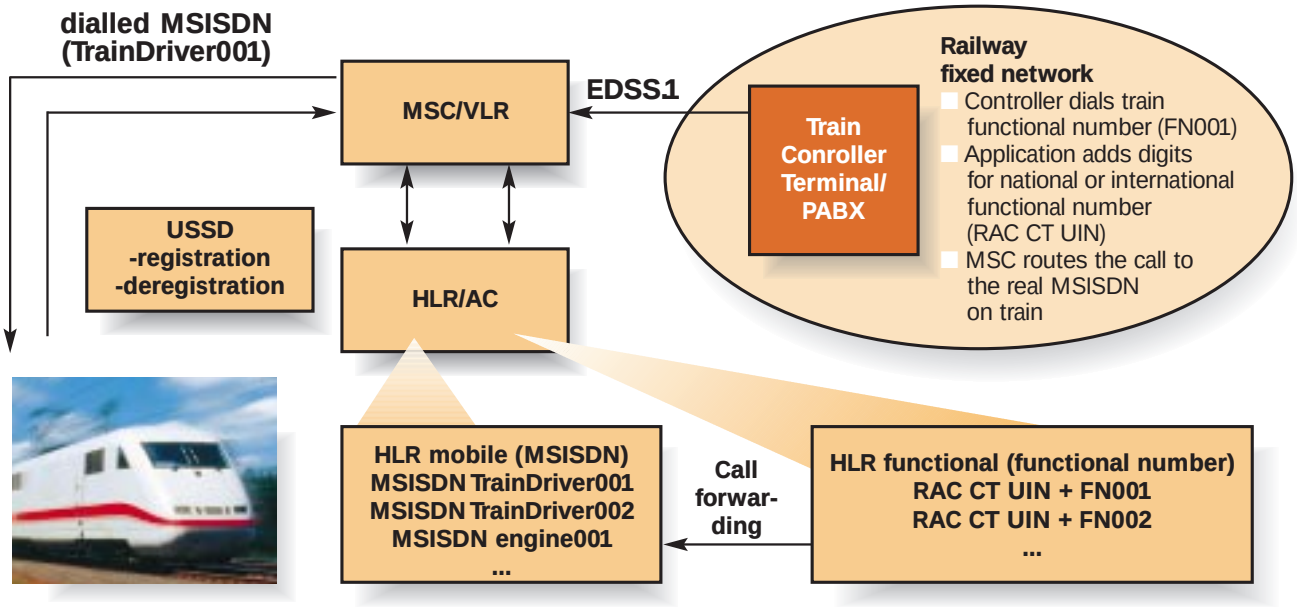


Fig. Functional Addressing: No MSISDN exists for the functional number FN001. The TrainDriver001 registers himself under this number with his MSISDN. Every call to FN001 will be forwarded now to this MSISDN.

Train Diagnostics

Diagnostic data will be transmitted under ATC where needed for train control. All other diagnostic data is collected on the running train and transferred via GSM-R as required.

Addressing Functions

To allow traffic to cross borders without changing equipment and to enable international use of functions on the train, a Europe-wide numbering scheme has been developed by EIRENE. Thus the following functions have been realized:

– Functional addressing:
A train is registered in its home country under a train number. This train number will now be combined with a functional number stored in a functional register in the HLR/AC. At the beginning of a journey the train driver registers his mobile number to this functional number. From now on, until deregistration, a call to the train's functional number will always reach the train driver, irrespective of the country through which the train is travelling.

Other functions on the train will register with an additional 2-digit subaddress of the functional number. Thus up to 99 functions – catering service, ticketing, etc. – are reached by dialing the train's functional number in combination with this subaddress.

– Location dependent addressing:
A train on a journey, e.g. from Paris to Vienna, may pass several train controller areas. The connection between a train driver and the controller in charge must be easy to establish. By dialing a defined short number the train conductor will be automatically connected to the train controller responsible for this area. By combining short number and radio cell location (Cell ID), the MSC selects the corresponding long number. If a train is passing between two controller areas the connection can be established to both controllers. Siemens offers both functional and location dependent addressing as a HLR and/or IN-based solution.

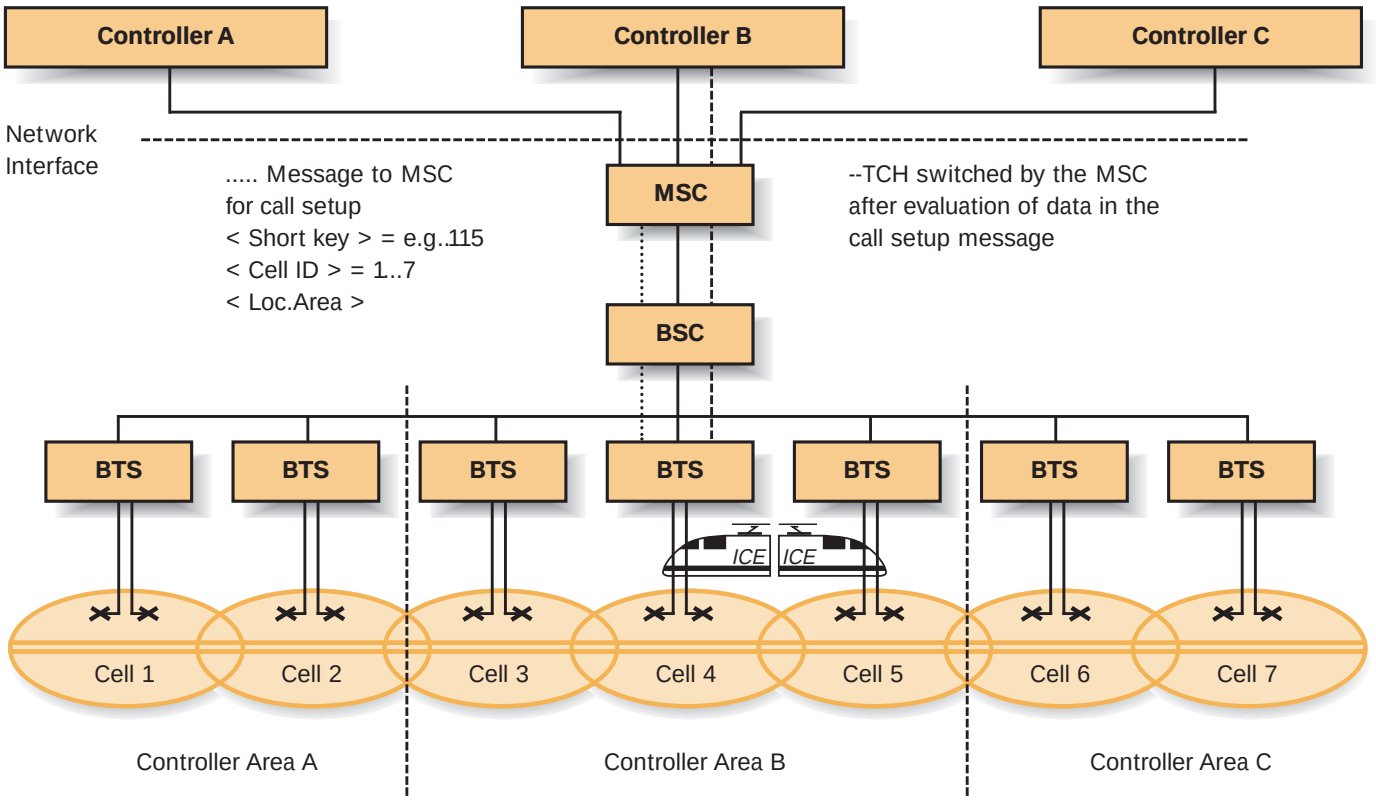


Fig. Location Dependent Addressing

Passenger Services

– Schedule information:
With ATC, train speed and arrival times can be calculated more flexibly. Resulting follow-on connections will be transferred via data services to the trains concerned, thus ensuring the best service as well as up-to-date information for the passenger.

– Ticketing:
Online update of ticket machines as well as electronic cash functions will be performed via GSM-R data services. New ticket machines with GSM-R interfaces may be placed whereever required. Post-processing and maintenance will be reduced to a minimum. Cash-flow will be increased and credits kept to a minimum.

Conclusion

GSM-R is a number of functions and parameters developed and adjusted in addition to GSM allowing railways best and efficient usage of the GSM standard.

GSM-R will provide maximum support to existing railway communication applications and major advantages over other existing analog and digital systems.

GSM is the world's most widely deployed digital wireless communication standard. It is secure and proven in operation.

GSM is future-proof thanks to ongoing standardization and the implementation of UMTS features.

Additional applications gained from an integrated network and internationally compatible features can also be introduced.

Abbreviations

AC	Authentication Center
ASCI	Advanced Speech Call Items
ATC	Automatic Train Control
ATP	Automatic Train Protocol
BSC	Base Station Controller
BSS	Base Station System
BTS	Base Transceiver Station
CT	Call Type
EDSS.1	European Digital Subscriber Signaling System No.1
EIRENE	European Integrated Railway radio Enhanced NEtwork
EIR	Equipment Identification Register
eMLPP	Enhanced Multilevel Precedence and Preemption
ERIG	EIRENE Radio Implementation Group
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
ETSI	European Telecommunications Standards Institute
FN	Functional Number (Type national or international)
GCR	Group Call Register
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communication
GSM-R	GSM for Railways
HLR	Home Location Register
IN	Intelligent Network
ISDN	Integrated Services Digital Network
MOC	Mobile Originated Call
MORANE	MObile RAilway radio Network for Europe
MSC	Mobile Switching Center
MSISDN	Mobile Station International ISDN Number
MTC	Mobile Terminated Call
PABX	Private Automatic Branch Exchange
PAD	Packet Assembler and Disassembler
PLMN	Public Land Mobile Network
PSPDN	Packet Switched Public Data Network
PSTN	Public Switching Telephone Network
RAC	Railway Access Code
RBC	Radio Block Center
RIID	Radio Infill Interface Device
SCP	Service Control Point
SMP	Service Management Point
SSP	Service Switching Point
TCH	Traffic Channel
UIC	Union International des Chemins de fer
UIN	User Identifier Number
UMTS	Universal Mobile Telecommunications Systems
USSD	Unstructured Supplementary Service Data
VBS	Voice Broadcast Service
VGCS	Voice Group Call Service
VLR	Visitor Location Register

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Order No. A50001-N3-P23-4-7600 • Printed in the Federal Republic of Germany • MR M540 SIE_432_99 PA 06995.