

Part I

GSM/EDGE Standardization

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1

GSM Standardization History

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1.1 Introduction

GSM, the Global System for Mobile communications, owes its worldwide success to the continued progressive and backward-compatible evolution of its open industry standard and to visionary yet simple ideas such as global roaming – enabling, thanks to a harmonized spectrum, the use of a device with the same number outside its home network, multivendor environment – enabling different vendors to implement with sufficient freedom compatible products based on the same standard, SMS¹ –enabling people to text each other, etc.

First aimed at providing mobile voice communications, GSM developed early on into a rich system offering supplementary services and other data communications, well ahead of the analogue systems then sporadically deployed in several regions of the world and which were incompatible. GSM has been and is by far the most widely used and most successful communications system of all time, enabling, at the time of writing, over four billion subscribers [1] to communicate in just about every single country of the world, just about everywhere (including airplanes) and with virtually everyone. The success of GSM is, simply put, staggering. Of all the active digital mobile subscriptions worldwide, more than 80% are GSM [2].

This chapter relates the history of GSM standardization from the early 1980s to the late 2000s and lists the main features and functionalities that have gradually been introduced in GSM specifications.

¹ SMS: Short Message Service.

1.2 History

Initially launched as a European initiative in 1982 by CEPT,² the Groupe Spécial Mobile (Special Mobile Group) was tasked to develop a standard for mobile telephony across Europe in the 900 MHz band. Five years later in 1987, the signature by thirteen countries³ of a Memorandum of Understanding to develop a pan-European common cellular telephony system in the 900 MHz band marked the official birth of GSM, set for service launch in 1991. ETSI, the European Telecommunications Standards Institute, created in 1988 by CEPT to handle all telecommunication standardization activities, became in 1989 the sole entity responsible for the GSM standard.

By 1990, the first set of specifications, GSM Phase 1, was frozen and published. By 1995, GSM Phase 2 was available, followed a couple of years later by GSM Phase 2+ which also introduced the concept of “yearly” release. The publication of the specifications into backward-compatible phases/releases has been a cornerstone of the evolution of the GSM standard and a model for future standards. It has ensured the availability in the specifications of a same phase/release of a consistent set of services, functionalities and features on both network and terminal sides and the inherent compatibility between equipment of different phases/releases. Since the first “release” in Phase 2+, known as Release 96 (or R96), nine others have been published (or are being developed): R97, R98, R99, Release 2000 later renamed Rel-4, Rel-5, Rel-6, Rel-7, Rel-8 and Rel-9. Release 9 is still in the making at the time of writing while stage 1 requirements for Release 10 are being laid out. Release 4 marked the transfer of GSM specifications within the Third Generation Partnership Project or 3GPP in the year 2000.

3GPP was established in December 1998 as a collaboration project between ETSI (Europe), ARIB⁴ (Japan), TTC⁵ (Japan), ATIS⁶ (North America), TTA⁷ (South Korea) and CCSA⁸ (China) to develop a global third generation mobile phone system specification, that is UMTS commonly referred to as “3G”. Though originating from GSM concepts and seen as part of the GSM family, UMTS is not as such an evolution of GSM. It was developed as a new system using GSM as a model. UMTS requires a new radio interface and the deployment of brand new radio networks, and thus is not backward-compatible with GSM – a UMTS phone cannot work in a GSM system nor can a GSM phone work in a UMTS system. The UMTS core network and architecture, however, though requiring new IP-based interfaces, were largely based on the GSM core network and architecture.

In the following sub-sections, non-exhaustive lists of services, features and functionalities characterizing each GSM phase/release are provided.

² CEPT: Conférence Européenne des Postes et Télécommunications (the European Conference of Postal and Telecommunications Administrations).

³ Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom.

⁴ ARIB: Association of Radio Industries and Businesses.

⁵ TTC: Telecommunication Technology Committee.

⁶ ATIS: Alliance for Telecommunications Industry Solutions.

⁷ TTA: Telecommunications Technology Association.

⁸ CCSA: China Communications Standards Association.

1.3 Phase 1

GSM Phase 1 contains the following items:

- Basic telephony using full-rate speech codec (FR) at 13 kbit/s [3] with a speech quality comparable to that of POTS⁹ wireline.
- Emergency calls using a single number (“112”) even if the SIM¹⁰ is not present or the PIN¹¹ is not entered. The growing deployment of GSM outside Europe led to the introduction in Phase 2+ (R96) of additional numbers (in the SIM) to be regarded as emergency numbers.
- Support for multiple data services (up to 9.6 kbit/s) allowing, for example interconnection with ISDN,¹² modem connection through PSTN.¹³
- Security through authentication and confidentiality in order to protect operators and subscribers against malicious actions by third parties. Authentication to verify and confirm a subscriber’s identity. Confidentiality to preserve the privacy of a given piece of information [4]. See Chapter 4 for more details on the evolution of GSM security.
- Short message service (SMS) either point-to-point or using cell broadcast [5, 6].
- Supplementary services pertaining to call barring and call forwarding such as barring of all incoming calls, barring of incoming calls when roaming outside the home network, call forwarding on no reply, call forwarding on mobile subscriber busy, etc.
- Support for facsimile (fax) communications (Group 3: the most widely used) [7, 8].

1.4 Phase 2

GSM Phase 2 contains the following items:

- Half-rate speech codec (HR) at 5.6 kbit/s allowing a higher maximum number of voice users compared to FR speech, at the expense of speech quality [9].
- Enhanced Full-Rate speech codec (EFR) at 12.2 kbit/s. EFR provides a considerable speech quality improvement over FR [10].
- Half-rate data services allowing a higher maximum number of data users.
- SMS enhancements such as SMS concatenation, replacement.
- Supplementary services such as enhancements to call barring and forwarding, calling line identification presentation and restriction, multiparty calls, etc.
- Fax enhancements.
- Support of GSM in the 1800 MHz band that is DCS¹⁴ 1800 as well as interworking between GSM 900 and DCS 1800, and multi-band operation by a single operator.

⁹ POTS: Plain Old Telephone Service.

¹⁰ SIM: Subscriber Identity Module.

¹¹ PIN: Personal Identification Number.

¹² ISDN: Integrated Services Data Network.

¹³ PSTN: Public-Switched Telephone Network.

¹⁴ DCS: Digital Cellular System.

1.5 Phase 2+

1.5.1 Phase 2+, R96

Release 96 contains the following items:

- Data services at 14.4 kbit/s.
- High-Speed Circuit-Switched Data (HSCSD) allowing the use of multiple 9.6 kbit/s or 14.4 kbit/s channels in one direction for considerably faster data transfers. HSCSD offers data rates up to 38.4 kbit/s (four times 9.6 kbit/s) or 57.6 kbit/s (four times 14.4 kbit/s) for Type 1 mobile stations that is mobile stations not required to transmit and receive at the same time [11].
- ASCI (Advanced Speech Call Items) Phase 1 for GSM railway systems (GSM-R) containing for example Voice Broadcast Service (VBS) calls supporting one talker and several listeners and Voice Group Call Service (VGCS) allowing calls supporting several talkers and listeners [12, 13].
- CAMEL (Customized Applications for Mobile networks Enhanced Logic) Phase 1. CAMEL enables the definition of services on top of existing GSM services such as allowing using the same phone number when roaming outside one's home network. CAMEL Phase 1 offers call control related functionalities.
- SIM Application Toolkit (SIM ATK) which provides standardized means for applications (e.g. banking, weather) residing on the SIM to interact proactively with the mobile station.
- Support of additional call set-up MMI procedures allowing emergency calls to be placed with emergency numbers stored in the SIM thus catering for the expansion of GSM in countries using other numbers than "112" for emergencies.

1.5.2 Phase 2+, R97

Release 97 contains the following items:

- GPRS (General Packet Radio Service) allowing packet-switched data connections down to the GSM radio interface thus providing a more efficient use of network and radio resources compared to circuit-switched data. Resources are assigned when data are transmitted, and released otherwise thus creating packet transmissions. Four coding schemes, CS-1 to CS-4 using GMSK¹⁵ modulation, and link adaptation allow adaption of the channel coding to the channel conditions thus enabling an efficient use of radio resources. Data rates up to 20 kbit/s per time slot per direction are possible [13].
- GPRS encryption using the GPRS-A5 algorithm (GEA¹⁶). See Chapter 4 for more details on the evolution of GSM security.
- Security mechanisms for SIM ATK.
- ASCI Phase 2.
- CAMEL Phase 2.

¹⁵ GMSK: Gaussian Minimum Shift Keying.

¹⁶ GEA: GPRS Encryption Algorithm.

1.5.3 Phase 2+, R98

Release 98 contains the following items:

- AMR (Adaptive Multi-Rate speech codec): Definition of mechanisms to support AMR speech (narrow-band or AMR-NB) in GSM enabling the adaptation of the speech codec to the link quality and/or capacity requirements by means of an optimized link and codec adaptation. To this end, eight codec modes are defined: 4.75, 5.15, 5.9, 6.7, 7.4, 7.95, 10.2 and 12.2 kbit/s.¹⁷ The higher the bitrate, the higher the source coding and the weaker the channel coding. In GSM, AMR channel coding is defined for GMSK full-rate channels (TCH/AFS) for all codec modes and for GMSK half-rate channels (TCH/AHS) for 4.75 kbit/s to 7.95 kbit/s codec modes [15]. AMR has also been defined as the default speech codec for UMTS.
- Location Services (LCS) in CS Domain: Definition of mechanisms to support location technologies in GSM based on cell identity (or Cell ID), E-OTD,¹⁸ TOA¹⁹ and A-GPS.²⁰ LCS supports both mobile station-assisted positioning (the terminal takes the measurements while the network calculates the position) and mobile station-based positioning (the mobile station both takes the measurements and calculates the position).
- Support of GSM/GPRS in the 1900 MHz band (PCS 1900).

1.5.4 Phase 2+, R99

Release 99 contains the following items:

- EDGE (Enhanced Data rates for Global Evolution): EDGE was specified as a global evolution path for GSM operators, and, in the US, TDMA operators. Through the introduction of the 8-PSK²¹ modulation on the GSM air interface for both packet-switched data (EGPRS – Enhanced GPRS) and circuit-switched data (ECSD – Enhanced CSD), EDGE boosts peak and average data rates as well as network capacity. EGPRS provides data rates up to 59.2 kbit/s per time slot per direction (i.e. up to 473.6 kbit/s per 200kHz carrier), supports incremental redundancy (Hybrid Type II ARQ²²), introduces a wide range of modulation and coding schemes using GMSK and 8-PSK modulations, as well as new link quality measurement quantities, the combination of which allows accurate link adaptation in varying channel conditions [16]. ECSD provides data rates up to 43.2 kbit/s per time slot, hence significantly reducing the need to allocate multiple time slots to increase data rates for CS data and thus addressing a main issue inherent to HSCSD: capacity. ECSD also allows fast power control.
- DTM (Dual Transfer Mode): Definition of mechanisms to support parallel CS and PS connections on the same carrier for a given mobile station, hence significantly reducing the

¹⁷ AMR 12.2 speech codec is compatible with EFR.

¹⁸ E-OTD: Enhanced-Observed Time Difference.

¹⁹ TOA: Time Of Arrival.

²⁰ A-GPS: Assisted GPS.

²¹ 8-PSK: Octal Phase Shift Keying.

²² ARQ: Automated Repeat reQuest.

complexity otherwise implied for class A mobile stations (where the CS and PS connections are independent) [17]. A DTM mobile station is hence referred to as a simple Class A mobile station. DTM multislot classes 1, 5 and 9 are supported [18].

- Enhanced Measurement Reporting: Definition of mechanisms allowing the reporting of more than six neighbor cells for mobility purpose thus providing benefits for multiband and/or multisystem scenarios (e.g. GSM and UMTS).
- GSM/UTRAN²³ Interworking: Definition of mechanisms to support interworking (mobility) between GSM and UMTS. Handover from GSM to UMTS is specified in the CS domain, and cell re-selection otherwise.
- Support of A5/3 and GEA3: Definition of the support in GSM of the KASUMI f8 algorithm introduced in UMTS, using a ciphering key of 64 bits. See Chapter 4 for more details on the evolution of GSM security.
- GSM 450 band: Uplink 450.4–457.6 MHz and Downlink 460.4–467.6 MHz (GSM400).
- GSM 480 band: Uplink 478.8–486 MHz and Downlink 488.8–496 MHz (GSM400).
- GSM 850 band: Uplink 824–849 MHz and Downlink 869–894 MHz (GSM850).

1.5.5 Phase 2+, Rel-4

Release 4 contains the following items:

- NACC (Network Assisted Cell Change): definition of mechanisms allowing the mobile station to notify the cell to which it will reselect (Cell Change Notification), and the network to provide in turn system information pertaining to this cell thereby reducing the access time in this cell.
- Delayed Downlink TBF Release/Extended Uplink TBF mode: Definition of mechanisms maintaining a layer 2 link (TBF²⁴) in a given direction between a mobile station and the network when no data is exchanged between the mobile station and the network on this TBF, hence avoiding TBF re-establishment when new data is incoming, thus improving latency and reducing signaling.
- DTM Multislot Class 11 [19].
- Extended DTM Multislot Class: allowing the support of half-rate PDCH (Packet Data Channel) together with full-rate PDCH(s) in DTM.
- Gb over IP: Definition of IP transport over the Gb interface between the BSC²⁵ and the SGSN,²⁶ as an alternative to frame relay.
- GERAN/UTRAN Interworking additions: Definition of interworking between GERAN and UTRAN low chip-rate TDD.²⁷

²³ UTRAN: UMTS Terrestrial Radio Access Network.

²⁴ TBF: Temporary Block Flow.

²⁵ BSC: Base Station Controller.

²⁶ SGSN: Serving GPRS Support Node.

²⁷ TDD: Time Division Duplex.

- Dynamic ARFCN Mapping: Definition of mechanisms to allow dynamic mapping of ARFCN (Absolute Radio Frequency Channel Number) to different bands hence overriding the fixed ARFCN numbering. An ARFCN identifies a GSM carrier (200 kHz).
- GSM 750 band: Downlink 747–762 MHz and Uplink 777–792 MHz (GSM700).

1.5.6 Phase 2+, Rel-5

Release 5 contains the following items:

- Support of High Multislot Classes for (E)GPRS.
- GERAN Iu mode: Definition of architecture and mechanisms to connect the GSM/EDGE Radio Access Network to the same Core Network as UTRAN via the Iu interface (Iu-ps and Iu-cs). The Iur-g interface was also defined allowing the connection and exchange of control-plane information between two BSCs or between a BSC and an RNC, similar to the Iu-r interface in UTRAN [20].
- Wideband AMR (AMR-WB): Definition of mechanisms to support AMR-WB speech codec [21] in GSM. AMR-WB yields a major improvement of speech quality over other speech codecs and exceeds POTS wireline voice quality. Five codec modes (6.60, 8.85, 12.65, 15.85 and 23.85 kbit/s)²⁸ are supported through the use of 8-PSK full-rate channels (O-TCH/WFS). Codec modes up to and including 12.65 kbit/s are supported through the use of GMSK full-rate channels (TCH/WFS) and 8-PSK half-rate channels (O-TCH/WHS). There is no support for GMSK half-rate channels.
- AMR 8-PSK HR: Definition of layer 1 and layer 3 (RR²⁹) support for AMR (4.75–12.2 kbit/s) through the use of 8-PSK half-rate channels (O-TCH/AHS).
- EPC (Enhanced Power Control): Definition of Enhanced Power Control allowing faster Power Control for GMSK and 8-PSK channels, through the use of power control (and reporting) on every SACCH³⁰ block (occurring every 120 ms) instead of every SACCH frame. A SACCH frame consists of four SACCH blocks thus occurs every 480 ms.
- eNACC (External NACC): Definition of mechanisms to support external NACC, that is NACC between two BSCs, through the introduction of RIM (RAN Information Management) procedures allowing the exchange of information (e.g. system information) between two BSCs [22].
- Flow Control over the Gb interface: Definition of mechanisms to allow the SGSN to adapt its scheduling of data over the Gb interface, according to the scheduling (leak rate) of the PFCs³¹ on the radio interface [23, 24].
- Connection of a BSC to multiple Core Network nodes: Definition of mechanisms allowing a BSC to connect to multiple SGSNs, MSCs³².

²⁸ It should be noted that a total of nine codec modes are defined for AMR-WB: 6.60, 8.85, 12.65, 14.25, 15.85, 18.25, 19.85, 23.05 and 23.85 kbit/s.

²⁹ RR(C): Radio Resource (Control) protocol.

³⁰ SACCH: Slow Associated Control Channel.

³¹ PFC: Packet Flow Context.

³² MSC: Mobile Switching Centre.

- Improvements to GSM/UTRAN interworking, for example compressed inter RAT handover information.
- Location Services in the PS Domain.

1.5.7 Phase 2+, Rel-6

Release 6 contains the following items:

- PS Handover: Definition of mechanisms allowing the assignment of PS resources to a mobile station in a target cell prior to the mobile station being handed over to that cell [25].
- Multiple TBFs: Definition of MAC mechanisms allowing parallel TBFs in downlink and/or uplink between a mobile station and the network to enable better multiplexing between data flows of different quality of service [26].
- MBMS (Multimedia Broadcast and Multicast Service): Definition of mechanisms to support Multimedia Broadcast and Multicast Service in GERAN, allowing the network to send (MBMS) data to a plurality of mobile stations on the same radio resources [27].
- GAN (Generic Access Network): Definition of mechanisms and architecture allowing access to GSM services (via the A and Gb interfaces) through an internet access (using e.g. Wireless LAN, BlueTooth) by tunneling non-access stratum protocols between the network and the mobile station. This allows for example access to GSM outside GSM radio coverage [28].
- DARP Phase 1 (Downlink Advance Receiver Performance Phase 1): Improvements of the reception performance of the mobile station through the use of single antenna interference cancellation (SAIC).
- ACCH Enhancements: Definition of mechanisms to increase the robustness of FACCH³³ and SACCH by means of repetition and, when supported, chase combining as the robustness of the traffic channel increases. ACCH enhancements are supported with legacy terminals.
- FLO (Flexible Layer One): Definition of mechanisms allowing the configuration of the layer 1 at call set-up, for PS domain, thus allowing optimized support of IMS³⁴ services in GERAN Iu mode only [29].
- DTM Enhancements: Definition of mechanisms to allow direct transition between packet transfer mode and dual transfer mode, without releasing the PS resources (i.e. without transit through packet idle mode) [30].
- Support of High Multislot Classes for DTM (E)GPRS.
- Definition of A5/4 and GEA4: Definition of the support in GSM of the KASUMI f8 algorithm using a 128-bit encryption key, thus aligning the security level of all 3GPP radio access technologies. However, the signaling support allowing the use of A5/4 and GEA4 was completed in Release 9. See Chapter 4 for more details on the evolution of GSM security.
- TETRA³⁵ (TAPS) – T-GSM 380 band: Uplink 380.2–389.8 MHz and Downlink 390.2–399.8 MHz (GSM400).

³³ FACCH: Fast Associated Control Channel.

³⁴ IMS: IP Multimedia Sub-system.

³⁵ TETRA: Terrestrial Trunked Radio. TETRA specified by ETSI is meant for professional usage (PMR: Professional Mobile Radio) by for example transportation, public safety or other military organizations. TAPS, TETRA Advanced Packet Service, is an adaptation of GPRS/EGPRS for data communications only.

- TETRA (TAPS) – T-GSM 410 band: Uplink 410.2–419.8 MHz and Downlink 420.2–29.8 MHz (GSM400).
- TETRA (TAPS) – T-GSM 900 band: Uplink 870.4–915.4 MHz and Downlink 915.4–921 MHz (GSM900).
- U-TDOA (Uplink time difference of arrival): Definition of mechanisms to support location service for both GSM and GPRS using the time difference between the received signals from a mobile station to determine its position. The support for U-TDOA was driven by FCC E911 requirements in the US [31].

1.5.8 Phase 2+, Rel-7

Release 7 contains the following items:

- GSM Onboard Aircrafts: Not part of 3GPP specifications the work to define GSMOBA,³⁶ initiated by a mandate of the European Commission, spanned 3GPP Releases 6 and 7 time-frames. To ensure compliance with 3GPP requirements and essentially compatibility with legacy GSM terminals, 3GPP involvement was necessary. It consisted of 3GPP reviewing and guiding the design of the GSMOBA system which was under the responsibility of the ETSI GSMOBA and CEPT ECC PT SE7 groups. The airborne GSM system provides GSM/GPRS connectivity in an aircraft cabin during cruise flight (above 3000 meters) enabling phone calls, SMS, and other data exchange, for example e-mail. It operates in the 1800 MHz band and ensures, by means of a Network Control Unit (NCU) installed in the cabin, that any harmful interference to a terrestrial mobile network is prevented. To this end, the NCU transmits on at least the GSM400, GSM900, DCS1800 and UMTS bands, a wideband noise signal of which the power can be adjusted as a function of the altitude of the aircraft. GSM coverage in the cabin is provided by an onboard GSM BTS (OBTS) which is further connected by means of a satellite link to the terrestrial mobile network. The OBTS makes use of uplink power control to limit the transmit power of terminals to its lowest specified level that is 0dBm [34, 35].
- EGPRS2: Definition of mechanisms to support (combinations of) higher order modulations (16QAM, 32QAM), turbo coding and higher modulation symbol rate to boost data rates up to twice those of EGPRS. Two levels, EGPRS2-A and EGPRS2-B, were specified in both uplink and downlink directions.
- LATRED (Latency Reduction): Latency Reduction features, that is RTTI and FANR.
- RTTI (Reduced TTI³⁷): 10 ms over two time slots, instead of 20 ms over one time slot.
- FANR (Fast Ack/Nack reporting): Definition of a mechanism which consists of piggy-backing RLC³⁸ acknowledgement information within RLC/MAC blocks for data transfer. It is also known as PAN (Piggy-backed Ack/Nack).
- RLC non-persistent mode: Definition of RLC protocol behavior where RLC retransmissions are allowed for a limited amount of time. This can be seen as a hybrid RLC mode between RLC acknowledged mode and RLC unacknowledged mode where the RLC performance

³⁶ GSMOBA: GSM OnBoard Aircrafts. Also known as MCA (Mobile Communications onboard Aircrafts).

³⁷ TTI: Transfer Time Interval.

³⁸ RLC: Radio Link Control.

is significantly increased compared to unacknowledged mode while maintaining a delay budget unlike the RLC acknowledged mode. It was first introduced in Release 6 for MBMS, and expanded in Release 7 to other applications.

- DCDL or DLDC (Downlink Dual Carrier): Definition of mechanisms for the transmission of data to a mobile station over two simultaneous independent downlink carriers (200 kHz), hence enabling higher data rates compared to EGPRS.
- DARP Phase 2 (Downlink Advanced Receiver Performance Phase 2): Also known as mobile station receiver diversity (MSRD), DARP Phase 2 improves the reception of a transmitted signal by using two antennas to enable diversity techniques between the two received signals.
- PS Handover between GAN and GERAN and GAN and UTRAN.
- DTM Handover: Definition of mechanisms to support concurrent handovers of CS and PS resources in DTM [36, 37].
- SIGTRAN³⁹ support over A, Lb, Lp interfaces: Definition of IP transport for control-plane traffic on the A interface (between the BSC and the MSC), the Lb interface (between the BSC and the SMLC⁴⁰) and the Lp interface (between the MSC and the SMLC).
- A-GNSS: Definition of a generic signaling method to support navigational satellite systems other than GPS, for example support of Galileo [31] (see Release 7 version).
- GSM 710 band: Downlink 698–716 MHz and Uplink 728–746 MHz (GSM700).
- T-GSM 810 band: Uplink 806–821 MHz and Downlink 851–866 MHz.
- A-GPS minimum performance requirements, aligned with UTRAN.
- Mobile Station Antenna Performance Evaluation Method and Requirements.
- VGCS⁴¹ Enhancements.

1.5.9 Phase 2+, Rel-8

Release 8 contains the following items:

- GERAN/E-UTRAN⁴² Interworking: Definition of mechanisms allowing interworking (mobility) between GERAN and E-UTRAN, in the direction from GERAN to E-UTRAN.
- A interface over IP: Definition of IP transport for user-plane traffic over the A interface (specifically, between the BSC and the MGW) [32].
- Gigabit Gb interface: Definition of a 1000-fold increase of the data rates supported over the Gb interface, up to 6 Gbit/s, hence allowing more mobile stations with faster data transfers and thereby preventing the radio access from being limited by the capacity of the Gb interface.
- GAN Iu: Generic Access to the Iu interface, reusing the same principles as introduced for GAN, in Release 6 [33].

³⁹ SIGTRAN: Signaling Transport protocol stack for PSTN signaling over IP.

⁴⁰ SMLC: Serving Mobile Location Center.

⁴¹ VGCS: Voice Group Call Service.

⁴² E-UTRAN: Evolved UTRAN. E-UTRAN refers to the radio access network part of the EPS (Evolved Packet System), the core network part being referred to as EPC (Evolved Packet Core). E-UTRAN and EPC are commonly known as LTE (Long-Term Evolution).

- MUROS (Multiple User Re-using One Slot): Feasibility study to select a technique allowing several voice users sharing the same radio resources, hence yielding voice capacity improvement.
- WIDER (Wideband pulse shape for RED HOT level B): Feasibility study to select an optimized pulse shape for EGPRS2-B in the downlink in order to exploit fully the benefits of the higher modulation symbol rate used in EGPRS2-B.

1.5.10 Phase 2+, Rel-9

- GERAN aspects of Home (e)Node B Enhancements: Definition of mechanisms allowing interworking (mobility) between GERAN and (E-)UTRAN Home (e)Node Bs, in connected mode.
- Local-Call Local Switch: Definition of mechanisms allowing the two parties of a call served by the same BSS to be locally switched by the BSS (with involvement of the MSC).
- Support of A5/4 and GEA4: Definition of the signaling means in GSM to allow the use of the KASUMI f8 algorithm using a 128-bit encryption introduced earlier in Release 6. See Chapter 4 for more details on the evolution of GSM security.
- CBC-BSC Interface: Definition of the interface and related protocol between the Cell Broadcast Center and the BSC.
- VAMOS (Voice services over Adaptive Multi-user channels on One Slot): Definition of mechanisms to support concurrent voice users sharing the same radio resources at the same time, thus allowing up to two full-rate speech users or up to four half-rate speech users on the same timeslot.

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