ETSI TS 101 376-1-3 V3.3.1 (2012-12)

Technical Specification

**GEO-Mobile Radio Interface Specifications (Release 3);
Third Generation Satellite Packet Radio Service;
Part 1: General specifications;
Sub-part 3: General System Description;
GMR-1 3G 41.202**

Reference

RTS/SES-00328-1-3

Keywords

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Foreword

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   where:

- the third digit (n) is incremented when editorial only changes have been incorporated in the specification;

- the second digit (m) is incremented for all other types of changes, i.e. technical enhancements, corrections, updates, etc.

The present document is part 1, sub-part 3 of a multi-part deliverable covering the GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service, as identified below:

Part 1:   "General specifications":

   Sub-part 1:   "Abbreviations and acronyms; GMPRS-1 01.004";

   Sub-part 2:   "Introduction to the GMR-1 family; GMR-1 3G 41.201";

   Sub-part 3:   "General System Description; GMR-1 3G 41.202";

Part 2:   "Service specifications";

Part 3:   "Network specifications";

Part 4:   "Radio interface protocol specifications";

Part 5:   "Radio interface physical layer specifications";

Part 6:   "Speech coding specifications";

Part 7:   "Terminal adaptor specifications".

Introduction

GMR stands for GEO (Geostationary Earth Orbit) Mobile Radio interface, which is used for Mobile Satellite Services (MSS) utilizing geostationary satellite(s). GMR is derived from the terrestrial digital cellular standard GSM and supports access to GSM core networks.

The present document is part of the GMR Release 3 specifications. Release 3 specifications are identified in the title and can also be identified by the version number:

- Release 1 specifications have a GMR 1 prefix in the title and a version number starting with "1" (V1.x.x).

- Release 2 specifications have a GMPRS 1 prefix in the title and a version number starting with "2" (V2.x.x).

- Release 3 specifications have a GMR-1 3G prefix in the title and a version number starting with "3" (V3.x.x).

The GMR release 1 specifications introduce the GEO-Mobile Radio interface specifications for circuit mode Mobile Satellite Services (MSS) utilizing geostationary satellite(s). GMR release 1 is derived from the terrestrial digital cellular standard GSM (phase 2) and it supports access to GSM core networks.

The GMR release 2 specifications add packet mode services to GMR release 1. The GMR release 2 specifications introduce the GEO-Mobile Packet Radio Service (GMPRS). GMPRS is derived from the terrestrial digital cellular standard GPRS (included in GSM Phase 2+) and it supports access to GSM/GPRS core networks.

The GMR release 3 specifications evolve packet mode services of GMR release 2 to 3rd generation UMTS compatible services. The GMR release 3 specifications introduce the GEO-Mobile Radio Third Generation (GMR-1 3G) service. Where applicable, GMR-1 3G is derived from the terrestrial digital cellular standard 3GPP and it supports access to 3GPP core networks.

Due to the differences between terrestrial and satellite channels, some modifications to the GSM or 3GPP standard are necessary. Some GSM and 3GPP specifications are directly applicable, whereas others are applicable with modifications. Similarly, some GSM and 3GPP specifications do not apply, while some GMR specifications have no corresponding GSM or 3GPP specification.

Since GMR is derived from GSM and 3GPP, the organization of the GMR specifications closely follows that of GSM or 3GPP as appropriate. The GMR numbers have been designed to correspond to the GSM and 3GPP numbering system. All GMR specifications are allocated a unique GMR number. This GMR number has a different prefix for Release 2 and Release 3 specifications as follows:

- Release 1: GMR n xx.zyy

- Release 2: GMPRS n xx.zyy

- Release 3: GMR-1 3G xx.zyy

where:

- xx.0yy (z = 0) is used for GMR specifications that have a corresponding GSM or 3GPP specification. In this case, the numbers xx and yy correspond to the GSM or 3GPP numbering scheme.

- xx.2yy (z = 2) is used for GMR specifications that do not correspond to a GSM or 3GPP specification. In this case, only the number xx corresponds to the GSM or 3GPP numbering scheme and the number yy is allocated by GMR.

- n denotes the first (n = 1) or second (n = 2) family of GMR specifications.

A GMR system is defined by the combination of a family of GMR specifications and GSM and 3GPP specifications as follows:

- If a GMR specification exists it takes precedence over the corresponding GSM or 3GPP specification (if any). This precedence rule applies to any references in the corresponding GSM or 3GPP specifications.

  NOTE: Any references to GSM or 3GPP specifications within the GMR specifications are not subject to this precedence rule. For example, a GMR specification may contain specific references to the corresponding GSM or 3GPP specification.

- If a GMR specification does not exist, the corresponding GSM or 3GPP specification may or may not apply. The applicability of the GSM specifications is defined in TS 101 376-1-2 [2].

1 Scope

The present document is an introduction to Release 3 of the GMR-1 system (GMR-1 3G) and the associated Release 3 of the air interface specification. It is intended to point out some of the differences between the cellular 3GPP and GSM system and the mobile satellite GMR-1 system.

The GMR-1 system is designed to provide mobile services via a single geostationary satellite as compared to the thousands of geographically separated cell sites that are used by a typical GSM system. This offers both challenges to be overcome and opportunities for enhanced services and features.

GMR-1 3G is an extension of the published ETSI TS 101 376 and TIA (S-J-STD-782) specifications for mobile satellite communications, GMR-1, to support IMT-2000 services. GMR-1 is currently used in mobile satellite systems covering Europe, Africa, Asia and Middle East. GMR-1 3G is currently being deployed in North America.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

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2.1 Normative references

The following referenced documents are necessary for the application of the present document.

In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document in Release 7 or to the latest version of that document in the latest release less than 7.

In the case of a reference to a GMR-1 3G document, a non-specific reference implicitly refers to the latest version of that document in the same Release as the present document.

[1] ETSI TS 101 376-1-1: "GEO-Mobile Radio Interface Specifications (Release 2) General Packet Radio Service; Part 1: General specifications; Sub-part 1: Abbreviations and acronyms; GMPRS-1 01.004".

NOTE: This is a reference to a GMR-1 Release 2 specification. See the Introduction for more details.

[2] ETSI TS 101 376-1-2: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 1: General specifications; Sub-part 2: Introduction to the GMR-1 family; GMR-1 3G 41.201".

[3] Void.

[4] Void.

[5] ETSI TS 101 376-4-8: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 4: Radio interface protocol specifications; Sub-part 8: Mobile Radio Interface Layer 3 Specifications; GMR-1 3G 44.008".

[6] ETSI TS 101 376-5-2: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 2: Multiplexing and Multiple Access; Stage 2 Service Description; GMR-1 3G 45.002".

[7]   ETSI TS 101 376-5-3: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 3: Channel Coding; GMR-1 3G 45.003".

[8]   ETSI TS 101 376-5-4: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 4: Modulation; GMR-1 3G 45.004".

[9]   ETSI TS 101 376-5-5: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 5: Radio Transmission and Reception; GMR-1 3G 45.005".

[10]   ETSI TS 101 376-5-6: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 6: Radio Subsystem Link Control; GMR-1 3G 45.008".

[11]   ETSI TS 101 376-5-7: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 7: Radio Subsystem Synchronization; GMR-1 3G 45.010".

[12]   ETSI TS 101 376-4-12: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 4: Radio interface protocol specifications; Sub-part 12: Mobile Earth Station (MES) - Base Station System (BSS) interface; Radio Link Control/Medium Access Control (RLC/MAC) protocol; GMR-1 3G 44.060".

[13]   ETSI TS 101 376-4-13: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 4: Radio interface protocol specifications; Sub-part 13: Radio Resource Control (RRC) protocol; Iu Mode; GMR-1 3G 44.118".

[14]   ETSI TS 144 018: "Digital cellular telecommunications system (Phase 2+); Mobile radio interface layer 3 specification; Radio Resource Control (RRC) protocol (3GPP TS 44.018)".

[15]   ETSI TS 144 118: "Digital cellular telecommunications system (Phase 2+); Mobile radio interface layer 3 specification, Radio Resource Control (RRC) protocol; Iu mode (3GPP TS 44.118)".

[16]   ETSI TS 101 376-4-15: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 4: Radio interface protocol specifications; Sub-part 15: Packet Data Convergence Protocol (PDCP) specification; GMR-1 3G 25.323".

[17]   ETSI TS 101 376-4-14: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 4: Radio interface protocol specifications; Sub-part 14: Mobile Earth Station (MES) - Base Station System (BSS) interface; Radio Link Control/Medium Access Control (RLC/MAC) protocol; Iu Mode; GMR-1 3G 44.160".

[18]   ITU-R Recommendation M.1457-6: "Detailed specifications of the radio interfaces of International Mobile Telecommunications (IMT-2000)".

2.2   Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1]   IETF RFC 2236: "Internet Group Management Protocol, Version 2".

3   Abbreviations

For the purposes of the present document, the abbreviations given in TS 101 376-1-1 [1] and the following apply:

APSK   Amplitude and Phase Shift Keying
BPSK   Binary Phase Shift Keying
DC12   twelve-slot Downlink Control
DCH   Dedicated CHannel
DTCH   Dedicated Traffic CHannel
EDGE   Enhanced Data rates for GSM Evolution
FDD   Frequency Division Duplex
GBCH3   GPS Broadcast Channel 3
GERAN   GSM EDGE Radio Access Network
GMM/SM   GPRS Mobility Management and Session Management
GMPRS-1   GEO-Mobile Packet Radio Service - 1
GMR-1 3G   GEO-Mobile Radio interface - 1 Third Generation
GRA   GERAN Registration Area
GTP   GPRS Tunnelling Protocol
GTP-U   GPRS Tunnelling Protocol - User plane
IMS   IP Multimedia System
IP   Internet Protocol
IPv6   Internet Protocol version 6
Iu   Interface between BSS and core network
Iu-PS   Interface between BSS and core network - Packet Switched
ksps   kilo symbols per second
L1 bis   Layer 1 bis
L2   Layer 2
LAPSAT   Link Access Protocol for SATellite
LDPC   Low Density Parity Check
LLC   Logical Link Control
MSS   Mobile Satellite Service
MTP-1   Message Transfer Part - 1
MTP-2   Message Transfer Part - 2
MTP-3   Message Transfer Part - 3
NAS   Non Access Stratum
Nwk   Network
PAPR   Peak to Average Power Ratio
PDA   Personal Digital Assistant
PDCP   Packet Data Convergence Protocol
PDTCH/D   Packet Data Traffic Channel/Downlink
PDTCH/U   Packet Data Traffic Channel/Uplink
PSD   Power Spectral Density
QPSK   Quaternary Phase Shift Keying
RACH3   Random Access Channel - 3
RR   Radio Resource
RRC   Radio Resource Control
SBSS   Serving Base Station Subsystem
SES   Satellite Earth Stations and Systems
TCP   Transmission Control Protocol
TDM   Time Division Multiplex
UDP   User Datagram Protocol
UL   UpLink
VoIP   Voice over Internet Protocol

4 Introduction to the GMR-1 3G specifications

4.1 History of the GMR-1 air interface

The GMR-1 3G air interface is an evolutionary third generation (3G) Mobile Satellite System (MSS) air interface that is built upon the earlier Release 1 and Release 2 of the GMR-1 air interface.

The GMR-1 development and standardization path follows the evolution of GSM/EDGE Radio Access Network or GERAN as shown in figure 1.
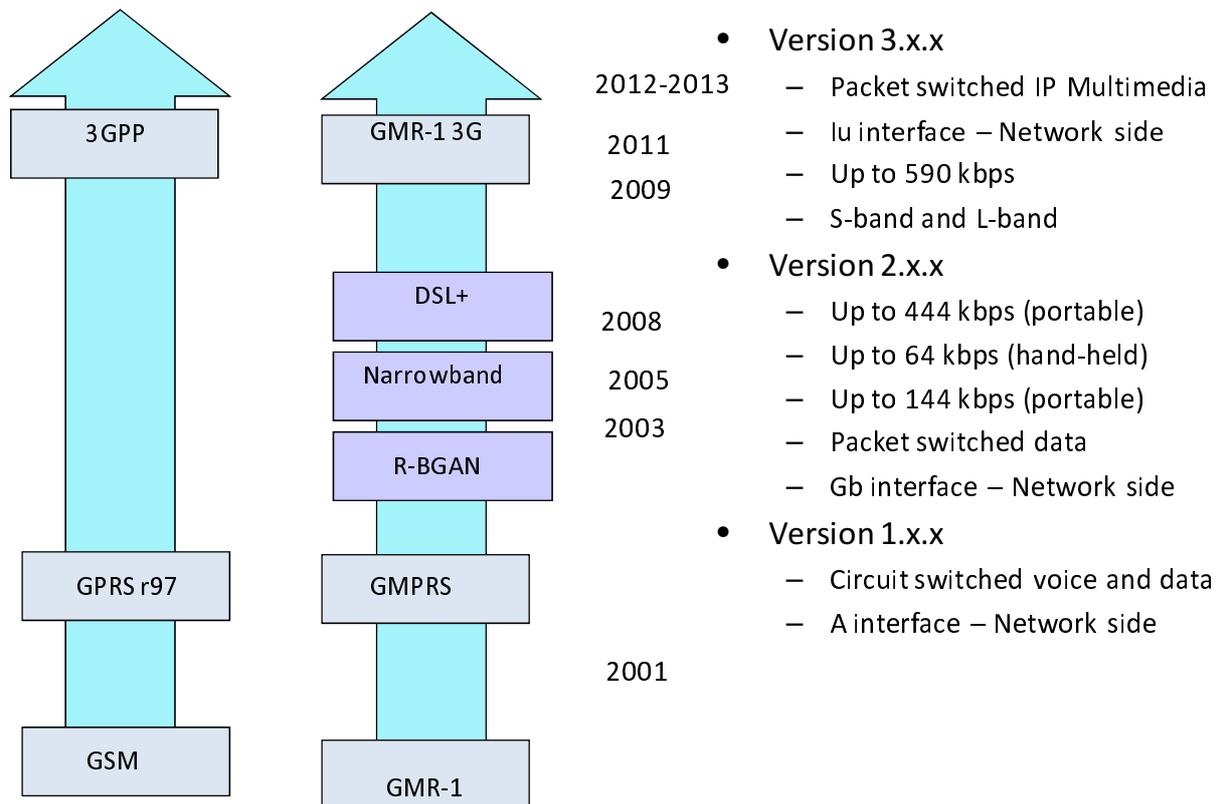

Figure 1: Evolution of GMR-1 specifications

The GMR-1 air interface specifications were first published in 2001 (GMR-1 Release 1) based on the GSM protocol architecture with satellite specific optimizations.

The GMR-1 Release 1 radio interface supports compatible services to GSM and reuses the GSM network infrastructure (see figure 2). It is designed to be used with dual-mode terminals (satellite/terrestrial) allowing the user to roam between GMR-1 satellite networks and GSM terrestrial networks. Features include spectrally efficient voice, delay tolerant fax, reliable non-transparent data services up to 9,6 kbps, SMS, cell broadcast services, position-based services, SIM roaming, high penetration alerting and single-satellite hop terminal-to-terminal calls. A system based on GMR-1 Release 1 is being widely used today in Europe, Africa, Asia and Middle East.

The GMR-1 Release 1 specifications have been revised and updated two additional times in 2002 (Version 1.2.1) and again in 2005 (Version 1.3.1).
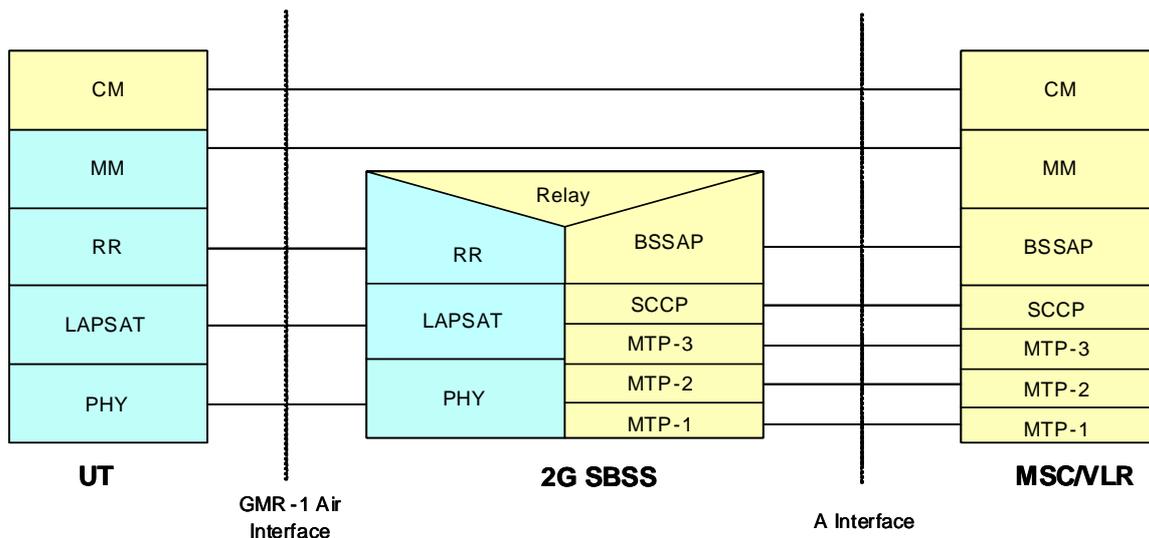
Figure 2: Protocol architecture for control plane (A interface)

In 2003, the GMR-1 air interface was enhanced with the addition of a packet switched data capability and the revised air interface published as GMR-1 Release 2 or GMPRS-1 (GEO-Mobile Packet Radio System-1). GMPRS-1 provides IP data services to transportable terminals using GPRS technology with a Gb interface to the core network. Figures 3 and 4 illustrate protocol architecture of the GMPRS-1 air interface for user plane and control plane using Gb interface towards core network. A number of satellite specific enhancements were introduced at PHY and MAC layers of the protocol stack to provide improved throughputs and better spectral efficiencies.
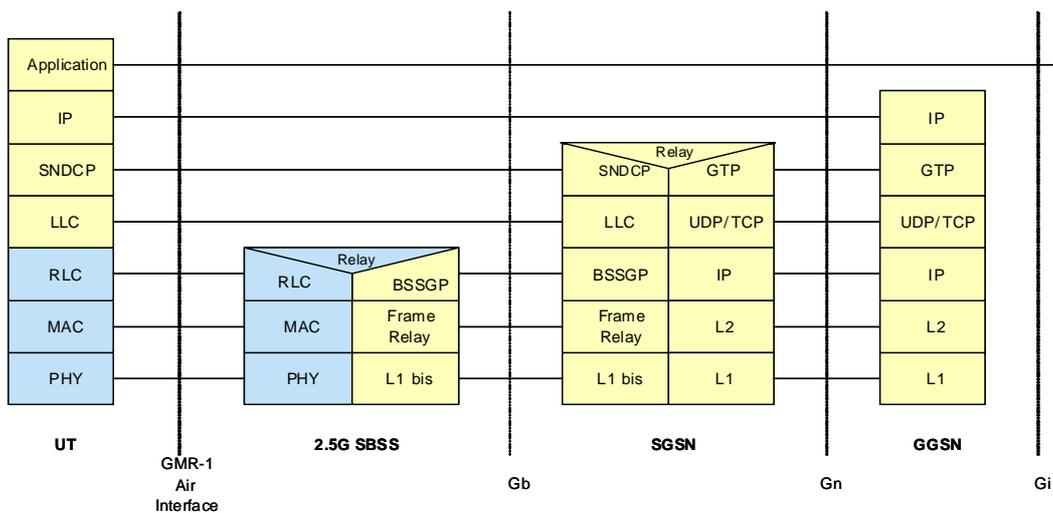
Figure 3: Protocol architecture for user plane (Gb interface)
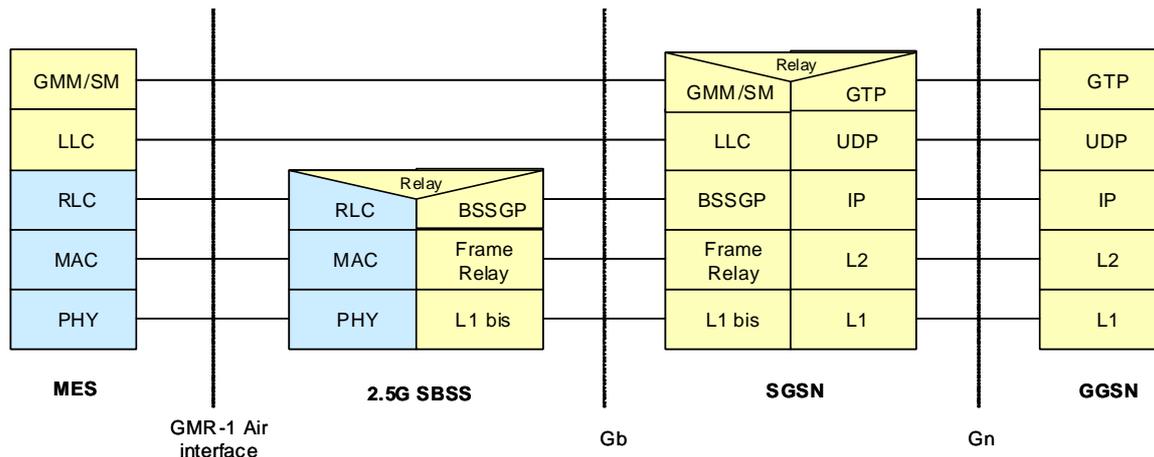
Figure 4: Protocol architecture for control plane (Gb interface)

GMPRS-1 Version 2.1.1 supports bidirectional packet data rates up to 144 kbps, QoS differentiation across users, and dynamic link adaptation. GMPRS-1 Version 2.2.1, published in 2005, adds support for narrow band packet data services to handheld terminals that permit up to 64 kbps on the forward link (downlink) and 28,8 kbps on the return link (uplink). GMPRS-1 Version 2.3.1, published in 2008, adds support for wideband packet services that increase the packet data rates to 444 kbps on the forward link and 202 kbps on the return link for A5 size transportable terminals. The system also permits data rates up to 400 kbps on the return link with an external antenna. This latest set of specifications uses the state-of-the art techniques in the physical (PHY) layer such as LDPC codes and 32-APSK modulation and can provide bi-directional streaming services.

A system using the GMR-1 Release 2 specifications has been successfully deployed in the field and is being extensively used in Europe, Africa, Asia and Middle East.

The present document describes the latest enhancement to the GMR-1 air interface specifications. This corresponds to a new Release 3 of the GMR-1 specifications, also known as GMR-1 3G. GMR-1 3G was first published in 2009 (version 3.1.1) and again in 2011 (version 3.2.1). GMR-1 3G is based on the adaptation to the satellite environment of the ETSI TDMA EDGE radio air interface (see ITU-R Recommendation M.1457-6 [18] TDMA Single-Carrier). GMR-1 3G is therefore the satellite equivalent to EDGE. The protocol architecture is based on 3GPP Release 6 and beyond, but the air interface is an evolution of the GMR-1 Release 2 air interface. In line with ETSI 3GPP specifications, the satellite base-station is therefore equivalent to a GERAN. GMR-1 3G is designed to meet the requirements of the satellite component of the third generation (3G) wireless communication systems.

Systems based on GMR-1 3G air interface specifications are currently being developed for MSS operators around the world operating in the MSS bands at both L-band and S-band frequencies as defined in TS 101 376-5-5 [9].

4.2 Key features of the GMR-1 3G air interface

The GMR-1 3G specification uses the Iu-PS interface between radio network and core network. The objective is to allow MSS operators to provide forward-looking IP Multimedia System (IMS) based services. Key features included in this air interface are:

- Spectrally efficient multi-rate VoIP with zero byte header compression.

- V.44 Data Compression.

- TCP/IP, UDP/IP and RTP/UDP/IP header compression.

- Robust waveforms for link closure with terrestrial form-factor MESs.

- Up to 590 kbps throughput.

- Multiple carrier bandwidth operation.

- Multiple terminal types - Hand-held terminals, PDA, vehicular, portable, fixed, maritime and aeronautical.

- IP Multimedia Services.

- Differentiated QoS across users and applications.

- Dynamic Link Adaptation.

- IPv6 compatibility.

- Terrestrial/Satellite handovers.

- Beam-to-Beam Handovers.

- Unmodified Non-Access Stratum (NAS) protocols and core network.

- High Penetration Alerting.

- GPS assist including either Earth Centered Earth Fixed coordinates or Keplerian coordiates.

- Cell Broadcast.

- Capability to multiplex support multiple VOIP sessions for one MES.

- Resource efficient Multicast.

- Resource and Delay Efficient Push-To-Talk.

- Regional beams and spot beam operation with or without overlay.

- Flexible traffic-only beam support.

Figures 5 and 6 illustrate the protocol architecture of the GMR-1 3G air interface for user plane and control plane using the Iu-PS interface towards the core network.
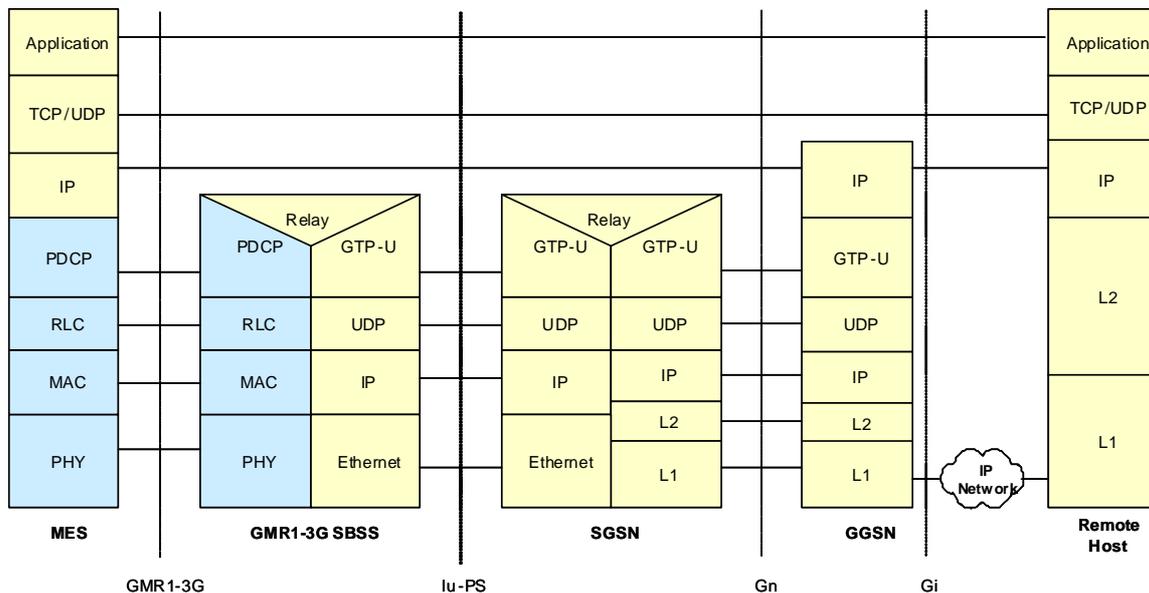
Figure 5: Protocol architecture for user plane (Iu interface)
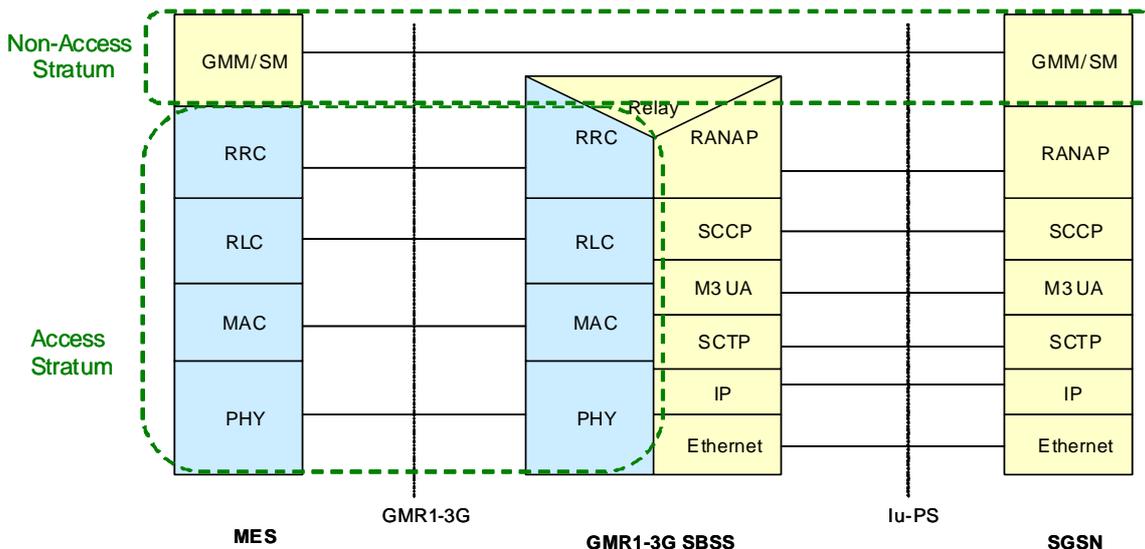
Figure 6: Protocol architecture for control plane (Iu interface)

End-to-end architectures using the GMR-1 3G air interface with different core network interfaces are shown in figure 7. A given operator may choose an individual architecture option (A, Gb, Iu-PS) or a combination thereof.

In this description, the term "GMR-1" is used to refer to attributes of the air interface and system that uses the A-interface and/or the Gb-interface. Where a particular attribute is only applicable to A-interface or Gb-interface, it will be referred to as GMR-1 (A mode) or GMR-1 (Gb mode), respectively. The term GMR-1 3G is used to refer to attributes of the air interface and system that uses the Iu-PS interface, and will be referred to as GMR-1 3G (Iu mode). If no interface is referenced the attribute is common to all interfaces.
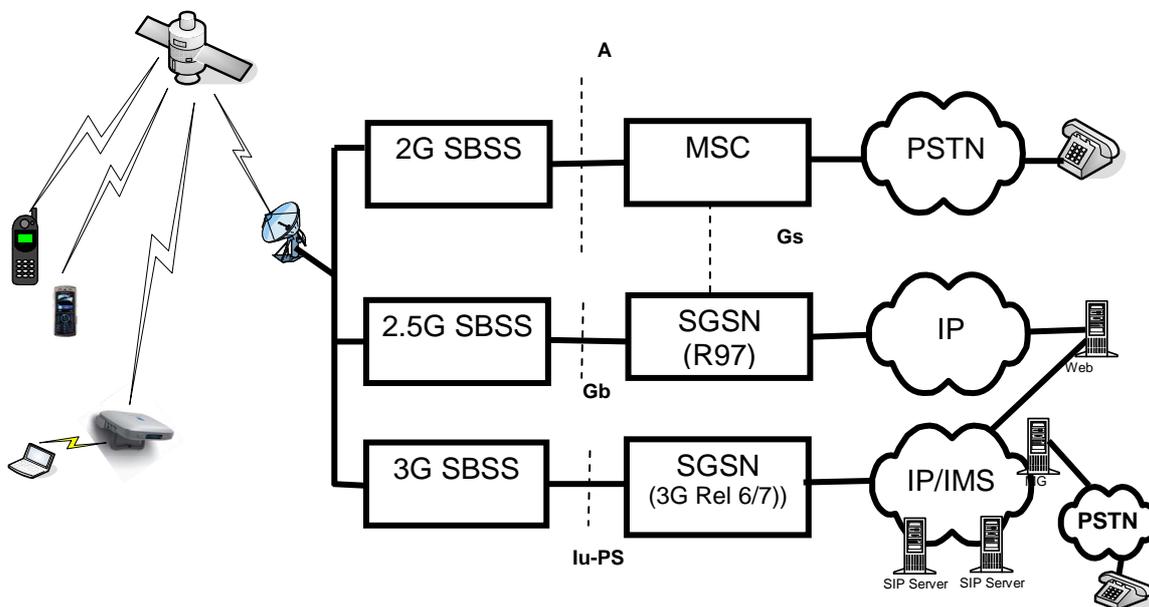
Figure 7: End-to-end architectures

GMR-1 3G operates in Frequency Division Duplex (FDD) mode with RF channel bandwidths from 31,25 kHz up to 312,5 kHz. It provides finer spectrum granularity yielding an easier spectrum sharing among different systems.

GMR-1 3G provides a wide range of bearer services from 1,2 kbit/s up to 590 kbit/s. High-quality telecommunication services can be supported including voice quality telephony and data services in a global coverage satellite environment.

The implementation of efficient multicast is shown in figure 8. Terminals use Internet Group Management Protocol (IGMPv2) (see RFC 2236 [i.1]) to join multicast sessions. The core network functions as defined in 3GPP specifications. The SBSS merges the multiple streams onto a single multicast TFI stream per beam. Details are provided in TS 144 118 [15] and TS 101 376-4-12 [12].

The implementation of efficient multicast is shown in figure 8. Terminals use Internet Group Management Protocol (IGMPv2) (see RFC 2236 [i.1]) to join multicast sessions.
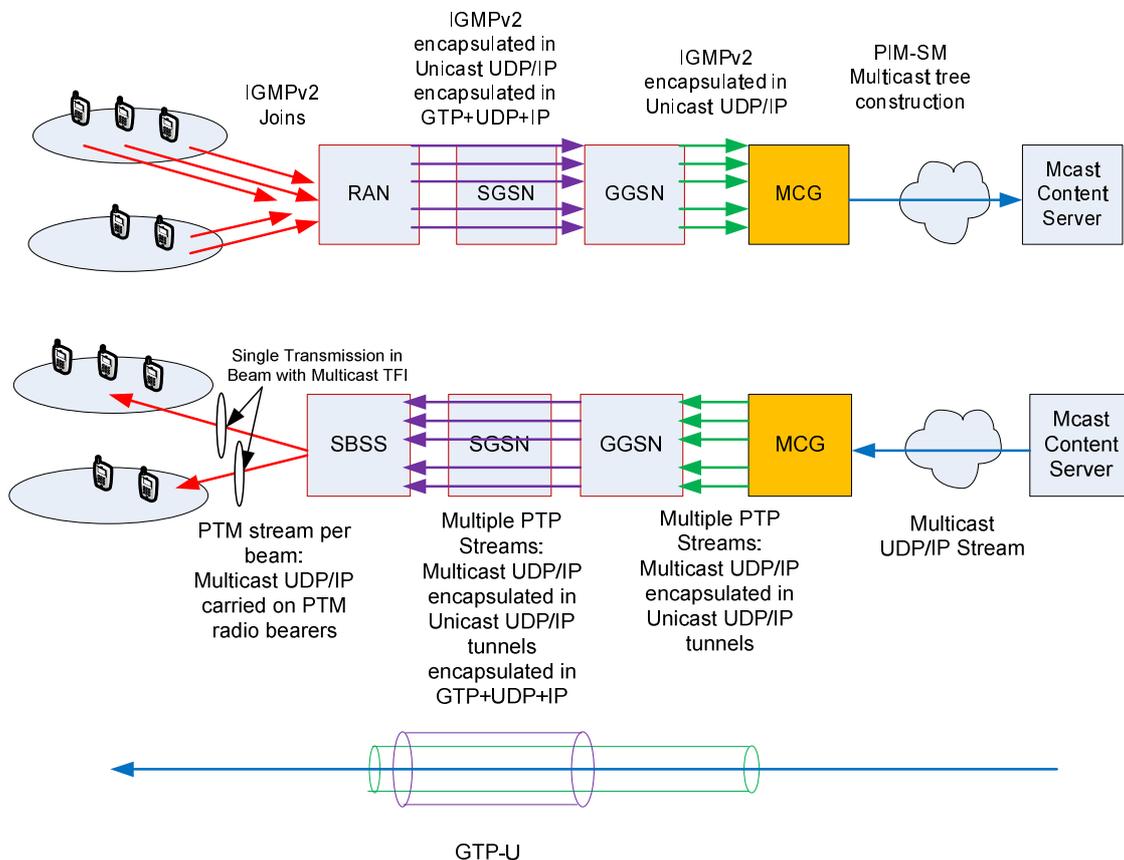
Figure 8: Efficient multicast implementation

An example of flexible beam coverage support is shown in figure 9. GMR-1 3G is deployed in systems which use a variety of beam types in the same system. Figure 9 shows a regional beam overlay, a spot beam overlay and flexible traffic-only beams superimposed on the same coverage area. In this example, regional beams might be large with relatively low G/T and EIRP properties suitable for support of aeronautical terminals with high-gain antennas. Spot beam might be very small with much higher G/T and EIRP designed to support high capacity and very small handheld terminals with electrically small, low gain antennas. Traffic-only beams might be stationary or steerable and configured to support spot traffic needs. With the advances in satellite/ground technology including ground based beam formers, steerable antennas and array architectures, the GMR-1 3G air interface does not constrain satellite or system design.
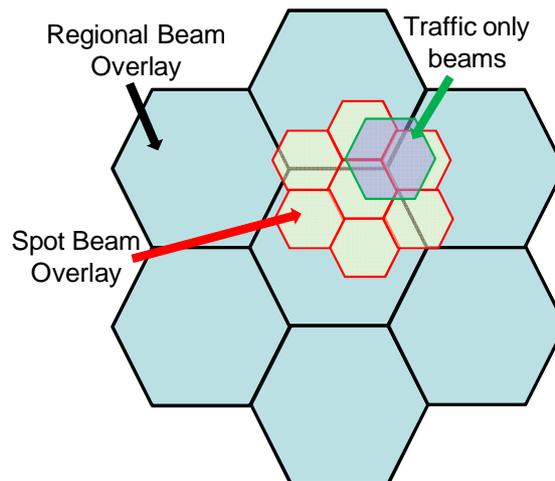
Figure 9: Example of a flexible satellite beam architecture

5   Description of the air interface

5.1   Frame structure

See TS 101 376-5-2 [6] and TS 101 376-5-7 [11] for more details.

GMR-1 uses Frequency Division Duplex (FDD) of the forward and return links, with time division multiplex (TDM) on the forward link and Time Division Multiple Access (TDMA) on the return link.

The air interface frame structure is shown in figure 10. The same frame structure is used on both the forward link and the return link: in this description all references to "TDMA Frames" apply equally to TDM frames on the forward link and TDMA frames on the return link.

The timeslots within a TDMA frame are numbered from 0 to 23 and a particular timeslot is referred to by its Timeslot Number (TN). TDMA frames are numbered by a Frame Number (FN). The frame number is cyclic and has a range of 0 to FN_MAX = $(16 \times 4 \times 4\,896) - 1 = 313\,343$. The frame number is incremented at the end of each TDMA frame. The complete cycle of TDMA frame numbers from 0 to FN_MAX is defined as a hyperframe. Other combinations of frames include:

- **Multiframes:** A multiframe consists of 16 TDMA frames. Multiframes are aligned so that the FN of the first frame in a multiframe, modulo 16, is always 0.

- **Superframes:** A superframe consists of four multiframes. Superframes are aligned so that the FN of the first frame in a superframe, modulo 64, is always 0.

- **System information cycle:** The system information cycle has the same duration as a superframe. However, the first frame of the system information cycle is delayed an integer number of frames (0 to 15) from the start of a superframe. The actual delay is intentionally varied from spot beam to spot beam to reduce the satellite's peak power requirements. The FCCH and BCCH are used to achieve system information cycle synchronization at the MES.

1 hyperframe = 4 896 superframes = 19 584 multiframes = 313 344 TDMA frames (3h 28mn 53 s 760ms)

1 superframe = 4 multiframes = 64 TDMA frames (2,56 s)

1 multiframe = 16 TDMA frames (640 ms)

1 TDMA frame = 24 timeslots (40 ms)

1 timeslot = 78 bit durations (5/3 ms)

(1 bit duration = 5/234 ms)
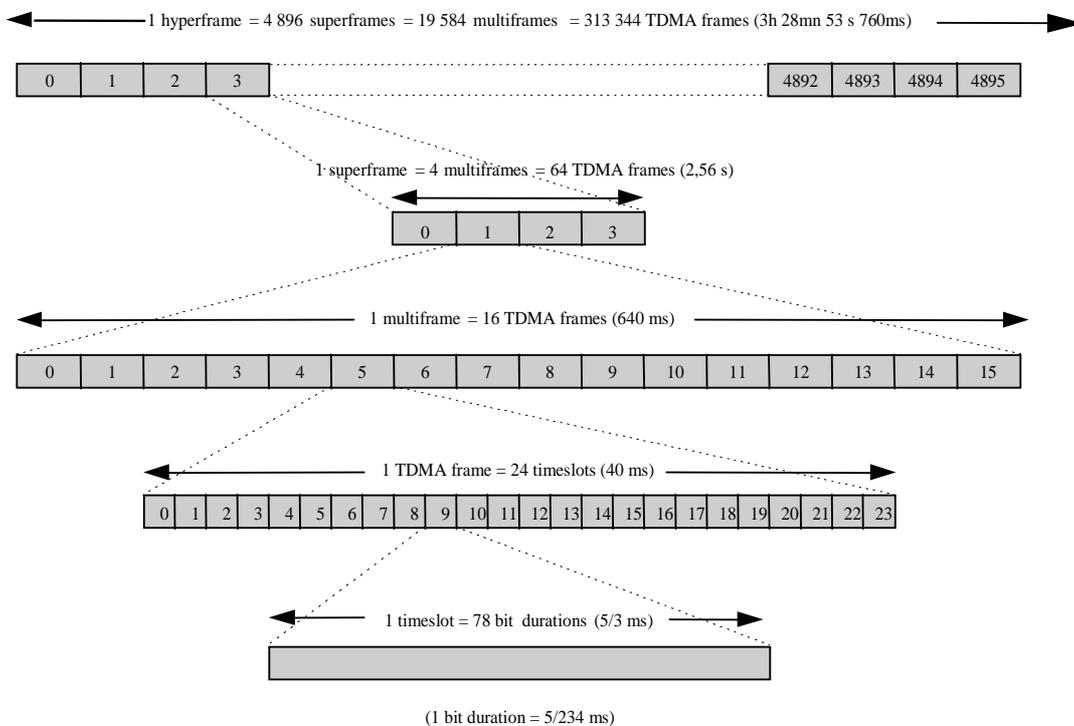
Figure 10: Frame structure

5.2 Channels

See TS 101 376-5-2 [6] for more details.

The radio subsystem is required to support a certain number of logical channels that can be separated into two overall categories.

- Traffic Channels (TCHs);

- Control Channels (CCHs).

5.2.1 Traffic channels

Circuit switched or A-mode traffic channels include those listed in table 1. These traffic channels are bidirectional.

Table 1: Circuit switched Traffic Channels

Channel type	User information capability	Gross data transmission rate	Modulation	Channel coding
TCH3	Encoded speech	5,85 kbit/s	π/4 CQPSK	Convolutional Code
TCH6	User data: 4,8 kbit/s Fax: 2 kbit/s; 4 kbit/s or 4,8 kbit/s	11,70 kbit/s	π/4 CQPSK	Convolutional Code
TCH9	User data: 9,6 kbit/s Fax: 2 kbit/s; 4 kbit/s; 4,8 kbit/s or 9,6 kbit/s	17,55 kbit/s	π/4 CQPSK	Convolutional Code

Packet channels are defined which provide data rates between 8,8 kbps and 587,2 kbps.

A packet data traffic channel (PDTCH) corresponds to the resource allocated to a single MES on one physical channel for user data transmission. Different logical channels may be dynamically multiplexed on to the same PDTCH. The PDTCH uses π/2 BPSK, π/4 QPSK, 16 APSK, or 32 APSK modulation. All packet data traffic channels are unidirectional, either uplink (PDTCH/U), for a mobile-originated packet transfer or downlink (PDTCH/D) for a mobile-terminated packet transfer.

PDTCHs are used to carry packet data traffic in either Gb or Iu mode. Those applicable to Gb mode are listed in table 2 and those applicable to Iu mode are listed in table 3. Different PDTCHs are defined by the suffix (m, n) where m indicates the bandwidth of the physical channel in which the PDTCH is mapped, m × 31,25 kHz, and n defines the number of timeslots allocated to this physical channel. Tables 2 and 3 summarize different types of packet traffic data channels, PDTCH (m, 3), (m = 1, 4, 5 and 10), where the burst duration is 5 ms , PDTCH (m, 6), (m = 1, 2), where the burst duration is 10 ms, and PDTCH (m, 12), (m = 5), where the burst duration is 20 ms.

A Dedicated Traffic Channel (DTCH) is used to carry user traffic when a dedicated channel (DCH) is allocated to the terminal in packet dedicated mode. A DTCH is unidirectional. DTCH/U is used for the uplink and a DTCH/D is used for the downlink. A DTCH may support either 2,45 kbps or 4,0 kbps encoded speech. Table 3 summarizes different types of packet traffic data channels, DTCH (m, 3), (m = 1, 4, 5 and 10), where the burst duration is 5 ms, DTCH (m, 6), (m = 1, 2), where the burst duration is 10 ms, and DTCH (m, 8), (m = 1), where the burst duration is 13,333 ms.

Table 2: Packet Data Traffic Channels (PDTCH and PDTCH2)

Channels	Direction (U: Uplink, D: Downlink)	Trans-mission symbol rate (ksps)	Channel Coding	Modulation	Trans-mission bandwidth (kHz)	Peak payload transmission rate (without CRC) (kbps)	Peak payload transmission rate (with CRC) (kbps)
PDTCH (4,3)	U/D	93,6	Conv	π/4-QPSK	125,0	113,6	116,8
PDTCH (5,3)	U/D	117,0	Conv	π/4-QPSK	156,25	145,6	148,8
PDTCH (1,6)	U/D	23,4	Conv	π/4-QPSK	31,25	27,2	28,8
PDTCH (2,6)	D/D	46,8	Conv	π/4-QPSK	62,5	62,4	64,0
PDTCH2 (5,12)	D	117,0	LDPC	π/4-QPSK	156,25	199,2	199,6
PDTCH2 (5,12)	D	117,0	LDPC	16-APSK	156,25	354,8	355,2
PDTCH2 (5,12)	D	117,0	LDPC	32-APSK	156,25	443,6	444,0
PDTCH2 (5,12)	U	117,0	LDPC	π/4-QPSK	156,25	199,2	199,6
PDTCH2 (5,12)	U	117,0	LDPC	16-APSK	156,25	399,2	399,6
PDTCH2 (5,3)	U/D	117,0	LDPC	π/4-QPSK	156,25	169,6	171,2
PDTCH2 (5,3)	U/D	117,0	LDPC	16-APSK	156,25	342,4	344,0
PDTCH2 (5,3)	U/D	117,0	LDPC	32-APSK	156,25	380,8	382,4

Table 3: Dedicated Traffic Channels (DTCH) and Packet Data Traffic Channels (PDTCH3)

Channels	Direction (U: Uplink, D: Downlink)	Trans-mission symbol rate (ksps)	Channel Coding	Modulation	Trans-mission bandwidth (kHz)	Peak payload transmission rate (without CRC) (kbps)	Peak payload transmission rate (with CRC) (kbps)
DTCH (1,3)	U/D	23,4	Conv	π/4-QPSK	31,25	28,8	32,0
DTCH (1,6)	U/D	23,4	Conv	π/2-BPSK	31,25	14,4	16,0
DTCH (1,6)	U/D	23,4	Conv	π/4-QPSK	31,25	8,8	10,4
DTCH (1,8)	U/D	23,4	Conv	π/2-BPSK	31,25	10,8	12,0
PDTCH3(1,6)	U/D	23,4	Conv.	π/4-QPSK	31,25	27,2	28,8
PDTCH3(2,6)	U/D	46,8	Conv.	π/4-QPSK	62,5	62,4	64,0
PDTCH3 (2,6)	U/D	46,8	Turbo	π/4-QPSK	62,5	62,4	64,0
PDTCH3 (5,3)	U/D	117,0	Turbo	π/4-QPSK	156,25	156,8	160,0
PDTCH3 (5,3)	D	117,0	Turbo	16-APSK	156,25	252,8	256,0
PDTCH3 (5,12)	U/D	117,0	Turbo	π/4-QPSK	156,25	185,2	186,0
PDTCH3(5,12)	U/D	117,0	Turbo	16-APSK	156,25	257,6	259,2
PDTCH3 (5,12)	D	117,0	Turbo	16-APSK	156,25	294,4	296,0
PDTCH3 (10,3)	D	234,0	Turbo	π/4-QPSK	312,50	344,0	347,2
PDTCH3 (10,3)	D	234,0	Turbo	16-APSK	312,50	587,2	590,4

A complete listof supported modulation and coding schemes is found in TS 101 376-4-12 [12].

5.2.1.1   Cell Broadcast Channels

Traffic can be broadcast on a per spot beam basis using the Cell Broadcast CHannel (CBCH). This channel is downlink only and used to broadcast Short Message Service Cell Broadcast (SMSCB) information to MESs. When the FCCH is used the CBCH is broadcast using a DC6 burst structure and when the FCCH3 is used the CBCH is broadcast using a DC12 burst structure.

5.2.2   PUI and PRI

A MAC/RLC block consists of PUI (Public User Information) and PRI (Private User Information) as shown in figure 11. Downlink blocks may include an extended PUI which contains an uplink allocation mapping or ULMAP. This field allows multiple uplink assignments to different MES using the same downlink burst. See TS 101 376-4-12 [12] and TS 101 376-5-2 [6] for more detailed information.

PUI	PRI
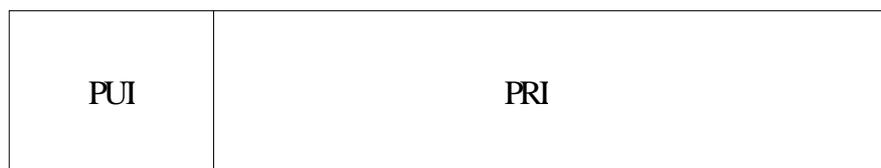
Figure 11: Public User Information (PUI) and Private User Information (PRI)

The payload is the Private Information (PRI) delivered to the physical layer by the link layer. The PRI includes the MAC header and the other higher layer overhead. The peak payload transmission rate (without CRC) is defined as the maximum attainable PRI data rate with continuous transmission, i.e. using all 24 timeslots in a frame. The above peak-rates are achieved with rate 3/4 coding for PDTCH (4,3) and PDTCH (5,3) and are achieved with rate 4/5 for PDTCH (1,6) and PDTCH (2,6). The peak rates of LDPC coded PDTCH2 (5,12) and LDPC coded PDTCH2 (5,3) are achieved for different modulation schemes with the following coding rate combinations:

- Downlink: 32 APSK Rate 4/5, 16 APSK Rate 4/5, π/4 QPSK Rate 9/10.

- Uplink: 16 APSK Rate 9/10, π/4 QPSK Rate 9/10.

The peak rates of Turbo coded PDTCH3 (5,12) and PDTCH3 (5,3) are achieved for different modulation schemes with the following coding rate combinations:

- Downlink: 16 APSK Rate 2/3, π/4 QPSK Rate 5/6.

- Uplink: π/4 QPSK Rate 5/6, for PDTCH3 (5,3), and

- Uplink: 16 APSK Rate 4/7 for PDTCH3 (5,12).

The peak rates of Turbo coded PDTCH3 (10,3) are achieved for different modulation schemes with the following coding rate combinations:

- Downlink: 16 APSK Rate 2/3, π/4 QPSK Rate 5/6.

5.2.3 Control channels

See TS 101 376-5-2 [6] for more details.

Control channels are intended to carry signalling or synchronization data. Three categories of control channels are defined: broadcast, common and dedicated. Specific channels within these categories are defined. As with traffic channels, some control channels are applicable to A, Gb and Iu modes and some are specific to a subset of modes. Where no mode is indicated, the control channel is applicable to both. Two sets of control channels are defined. Depending on available satellite EIRP one set may be preferred over the other. All broadcast and common control channels are transmitted on a 31,25 kHz carrier.

5.2.3.1 Broadcast Channels

5.2.3.1.1 FCCH or FCCH3

The Frequency Correction CHannel (FCCH or FCCH3) carries information for frequency correction of the Mobile Earth Station (MES). This frequency correction is only required for operation of the radio subsystem. The FCCH is also used for system information cycle synchronization of the MES. The FCCH is downlink only.

The FCCH burst is a real chirp signal spanning three slots. The complex envelope of the transmitted burst is defined as follows (see TS 101 376-5-4 [8] for more details):

$$x(t) = p(t) \left[e^{j\varphi_o} \sqrt{2} \cos\!\left(0,64\pi(t - 58,5T)^2 / (117T^2)\right) \right] \qquad \text{(Eq.1)}$$

where φ_o is a random phase and $p(t)$ is the ramp function as defined in TS 101 376-5-4 [8]. This signal defines the chirp sweeping range as (-7,488 kHz to 7,488 kHz).

The FCCH3 burst is a real chirp signal spanning twelve slots. The complex envelope of the transmitted burst is defined as follows:

$$x(t) = p(t) \left[e^{j\varphi_o} \sqrt{2} \cos\!\left(0,32\pi(t - 234T)^2 / (468T^2)\right) \right] \qquad \text{(Eq.2)}$$

where φ_o is a random phase and $p(t)$ is the ramp function as defined in TS 101 376-5-4 [8]. This signal defines the chirp sweeping range as (-3,744 kHz to 3,744 kHz).

5.2.3.1.2 GBCH or GBCH3

The GPS Broadcast control CHannel (GBCH or GBCH3) carries global positioning system (GPS) time information and GPS satellite ephemeris information to the MESs. (The PCH described below may also contain almanac data.) The GBCH is downlink only.

Each GBCH burst contains 108 bits of information and is broadcast using the two-slot DC2 burst. The DC2 burst uses π/4 CQPSK modulation is encoded using a convolutional code. The GBCH3 contains the same information as the GBCH but is formatted to fit a DC12 burst structure. The DC12 burst structure uses π/2 BPSK modulation and convolutional coding. Each GBCH3 burst contains 192 bits of information.

5.2.3.1.3 BCCH

The Broadcast Control CHannel (BCCH) broadcasts system information to the MESs and is downlink only. The BCCH system information parameters are described in TS 101 376-4-8 [5]. Each BCCH burst contains 192 bit of information. The BCCH is broadcast using either the BCCH burst structure or the DC12 burst structure. The BCCH burst structure is six-slot long and is broadcast using π/4 CQPSK modulation is encoded using a convolutional code.

5.2.3.2 Common Control Channels (CCCH)

5.2.3.2.1 PCH

The Paging CHannel (PCH) is a downlink only channel that is used to page MESs. Each PCH burst contains 192 bits of information and is broadcast using either the six-slot DC6 burst or the DC12 burst. The DC6 burst is broadcast using π/4 CQPSK modulation is encoded using a convolutional code.

5.2.3.2.2 RACH or RACH3

The Random Access CHannel (RACH or RACH3) is an uplink only channel that is used to request the allocation of traffic channel resources.

5.2.3.2.3 AGCH

The Access Grant CHannel (AGCH) is a downlink only channel that is used to allocate traffic channel resources to the terminal. Each AGCH burst contains 192 bits of information and is broadcast using either the six-slot DC6 burst or the DC12 burst.

5.2.3.2.4 BACH

The Basic Alerting CHannel (BACH) is a downlink only channel that is used to alert MESs. The BACH is transmitted using either the BACH burst or the BACH3 burst as described in TS 101 376-5-2 [6]. Each BACH burst is two-time slot duration and is broadcast using 6PSK modulation. Each BACH3 burst occupies six timeslots and is modulated with π/2 BPSK modulation.

5.2.3.2 Dedicated Control Channels

A suite of dedicated control channels are available to support both circuit switched and packet switched services. These are described in TS 101 376-5-2 [6].

5.3 FEC

See TS 101 376-5-3 [7] for more details.

Table 4 lists the FEC schemes supported by GMR-1 3G.

Table 4: FEC schemes

FEC Code	FEC block size (Info. Bits)	Comments
Convolutional Code	Between 20 bits and 1 000 bits	Constraint length K = 5, 6, 7, and 9. Mother code of rate 1/4, 1/3, and 1/2. Various rates by puncturing. Tail biting for small FEC block.
Turbo Code	Between 200 bits and 6 000 bits	Turbo code. Various Rates by puncturing.
Reed Solomon Code	Blocks of 9 information symbols of 4 bits	Systematic (15,9) Reed-Solomon.
Extended Golay Code	12 bit information bits	(12,24) extended Golay code.
LDPC (Low Density Parity Check) Code	Between 500 bits and 9 000 bits	Optimized for small FEC block size.
CRC (Cyclic Redundancy Check) Code	Between 20 bits and 9 000 bits	3 bit, 5 bit, 8 bit, 12 bit or 16 bit CRC for error detection.

The FEC coded bits are additionally punctured, interleaved and scrambled before modulation. Details can be found in TS 101 376-5-3 [7].

5.4   Modulation

GMR-1 3G adopts power and spectrally efficient modulations as specified in TS 101 376-5-4 [8]. The specified modulation schemes are:

- Dual Chirp;

- π/2-BPSK, π/4-QPSK, 16 APSK, and 32 APSK.

Dual chirp is a constant envelope frequency modulated signal that is used for MES initial timing and frequency acquisition of FCCH (Frequency Correction Channel). The dual chirp waveform is shown in figure 12.
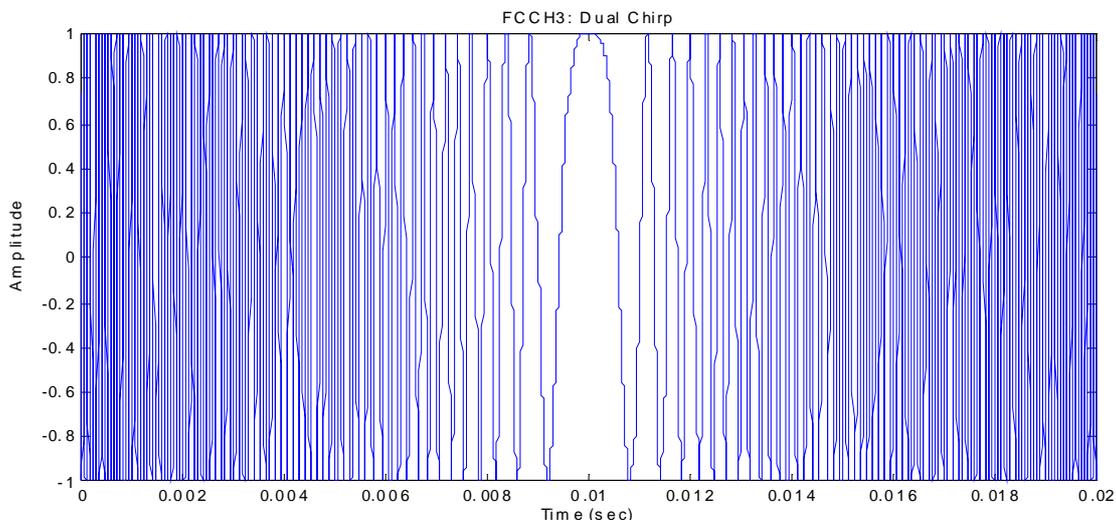
**Figure 12: Dual chirp waveform**

Control channels use either π/2-BPSK or π/4-QPSK, and traffic channels use π/2-BPSK, π/4-QPSK, 16 APSK, or 32 APSK depending on data rate. The signal constellations for π/2-BPSK, and π/4-QPSK are shown in figure13, and the signal constellations for 16 APSK, and 32 APSK are shown in figure 14.
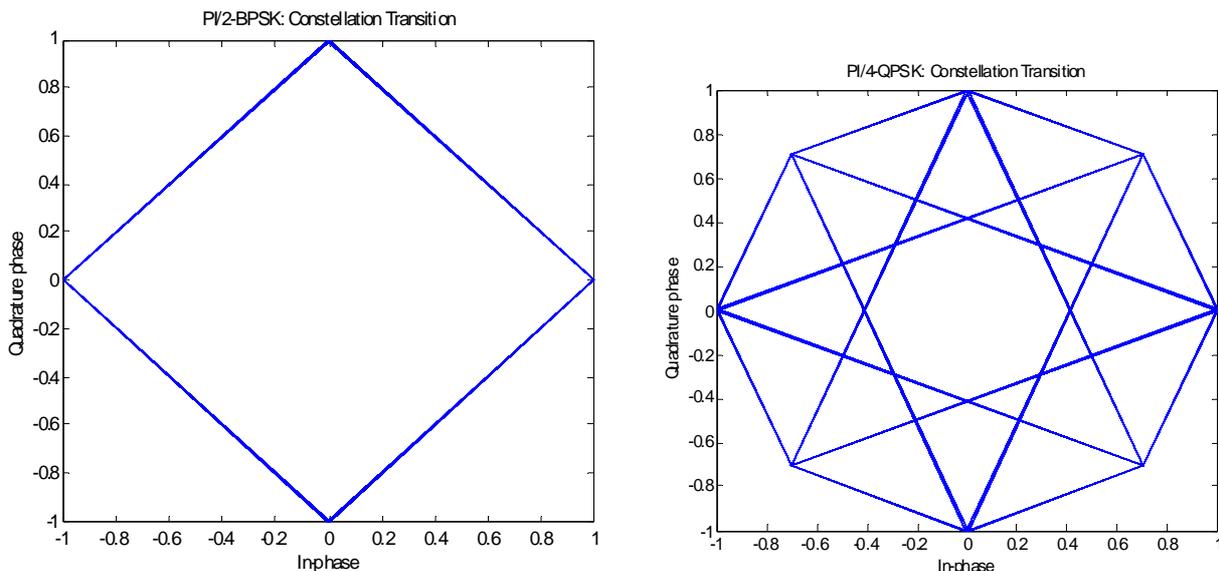

Figure 13: Signal constellations for π/2-BPSK and π/4-QPSK
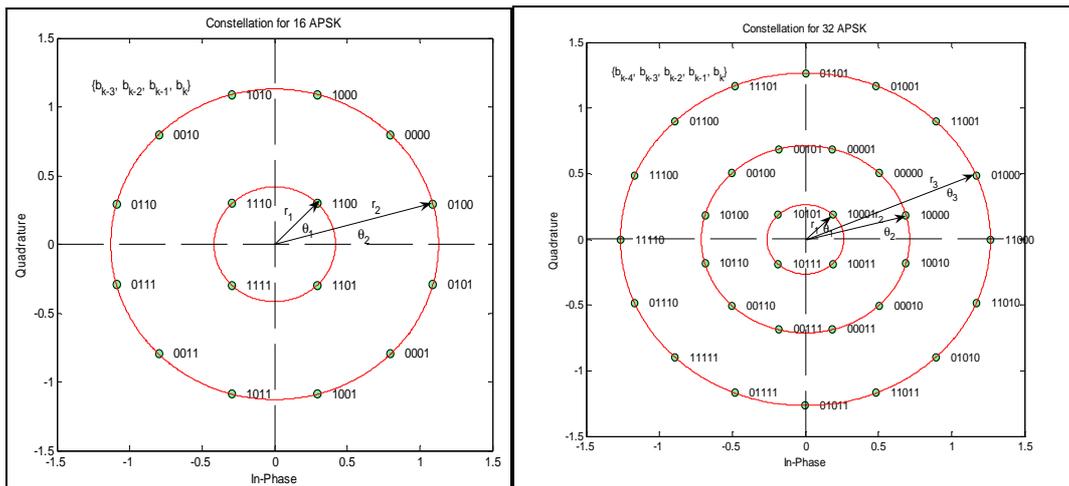
Figure 14: Signal constellations for 16 APSK and 32 APSK

The modulated signal is pulse-shaped by the SQRC (square root raised cosine) filter with a roll-off factor 0,35. As an example, the PSD (Power Spectral Density) of π/4-QPSK modulated PNB3(5,3) is shown in figure15.
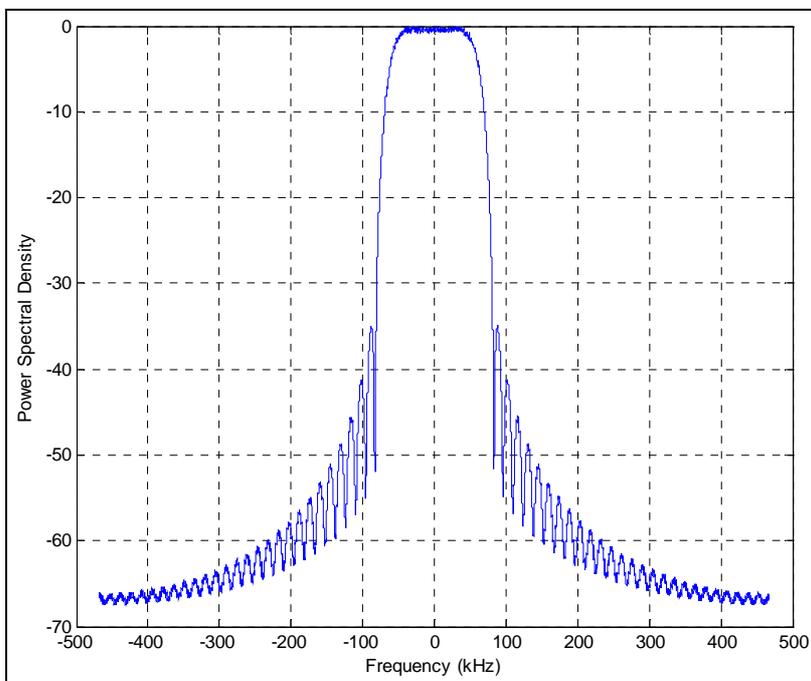
Figure 15: Example Power Spectral Density (PSD)

Table 5 lists the PAPR (peak-to-average-power-ratio) for different modulation schemes. The adopted GMR-1 3G modulation schemes such as π/2-BPSK, π/4-QPSK, or16 APSK have much smaller PAPR than conventional BPSK, QPSK, and 16 QAM.

Table 5: Peak-to-Average Power-Ratio (PAPR)

Modulation	π/2-BPSK	BPSK	QPSK	π/4-QPSK	16 QAM	16 APSK	32 APSK
PAPR (dB)	1,84	3,86	3,86	3,17	6,17	4,72	5,91

5.5   Power Control and Link Adaptation

5.5.1   General

GMR-1 3G supports power control and link adaptation, as specified in TS 101 376-5-6 [10]. The power control and link adaptation allows the system to manage the radio resources optimally according to the user's channel quality.

The objective of the modulation-code rate adaptation is:

- To adjust the transmission throughput according to each user's unique channel environment while maintaining a reliable transmission.

For the mobile return link, the objectives of power control are to:

- Reduce co-channel interference at the satellite receiver by ensuring that all signals from different MESs are received at approximately the same level at the satellite.

- Minimize MES power drain by using the minimum EIRP necessary to close the link for a given channel condition.

5.5.2   Link Adaptation

See TS 101 376-5-6 [10] for more details.

Packet data services use coding rate and modulation scheme control procedures both over the forward and return link.

The network selects the coding rate/modulation scheme for both the forward and return directions based on the signal quality and power level information available at the network or reported by the terminals.

The terminal identifies the coding rate and modulation selected by the network by reading the Physical Layer Header (PUI) on each forward burst.

5.5.3   Power Control

See TS 101 376-5-6 [10] for more details.

Dedicated channel utilizes power control for both return and forward link. In packet data service, power control is used in the return direction. The transmit power at the MES is regulated so as to achieve expected, but not excessive, signal quality at the network end. The power transmitted by the terminal can be changed over a range of 24 dB below the maximum power with 0,4 dB resolution.

Both closed loop and open loop power control are supported.

In the closed-loop power control, the MES' transmit power is controlled based upon measurements of the received signal quality made at the network. Due to the round trip time, for the closed-loop, the reaction speed to channel variation is slow. Closed-loop control is intended to mitigate shadowing events. The network makes the selection of the terminal power control based on signal quality measurement made by the network physical layer over the transmitted bursts from MES.

In the open loop power control, the measurements of received signal quality at the MES are processed and are used to quickly adjust the MES' transmit power should the signal quality suddenly deteriorate. This approach assumes that there is some degree of statistical correlation between the receive and transmit shadowing. This approach is used at the MESs to speed the power control response to abrupt shadowing events.

5.6   Control channel organization

A mobile satellite may use either the three-slot FCCH or the twelve-slot FCCH3 burst for synchronization. The choice would depend on the available EIRP for the satellite. Table 6 lists the burst types used for the broadcast and common control channels for the cases where the FCCH is used and table 7 lists the burst types used for the broadcast and common control channels for the case where the FCCH3 is used.

An MES would scan for either the FCCH or the FCCH3 and would be able to receive the other control channels depending on which version of the frequency correction channel it received.

**Table 6: Available burst types when FCCH is used**

Control channel	Burst type
FCCH	FCCH
BCCH	BCCH
GBCH	DC2
PCH	DC6
AGCH	DC6
BACH	BACH

Table 7: Available burst types when FCCH3 is used

Control channel	Burst type
FCCH3	FCCH3
BCCH	DC12
GBCH3	DC12
PCH	DC12
AGCH	DC12
BACH	BACH3

The organization of control channel broadcast on the 31,25 kHz BCCH/CCCH channel when the FCCH is used is shown in figure 16. Note that the FCCH is a three-slot burst and the BCCH and PCH are six-slot bursts. When the FCCH is used 6 out of the 24 time slots in each frame are dedicated to broadcast of the control channels. The twenty-four-slot frame is shown in figure 17. Note the GBCH is broadcast two time slots later than the BCCH/CCCH within each frame. The unused time slots from time slot 12 to time slot 23 within the frame may be used for traffic. The Physical Channel Relative Timeslot Number (PCRTN) and the System Information Relative Frame Number are described in TS 101 376-5-2 [6]. The number after PCH and BACH refer to the paging and alerting groups. This is described in TS 101 376-5-2 [6].

The return link allocation in both figures 17 and 19 show a 12-slot RACH window. In very large spot or regional beams where the timing uncertainty is large, GMR-1 3G allows the RACH window to be extended arbitrarily up to the full 24 time slots leaving the remainder for traffic. The forward link traffic can accommodate broadcast, multicast or dedicated traffic depending on the needs of the system.

S I R F N	PC6d PCRTN						S I R F N	PC6d PCRTN						S I R F N	PC6d PCRTN						S I R F N	PC6d PCRTN					
	0	1	2	3	4	5		0	1	2	3	4	5		0	1	2	3	4	5		0	1	2	3	4	5
0	FCCH			CICH			16	FCCH			CICH			32	FCCH			CICH			48	FCCH			CICH		
1	BACH #0		BACH #0		BACH #0		17	BACH #0		BACH #0		BACH #0		33	BACH #0		BACH #0		BACH #0		49	BACH #0		BACH #0		BACH #0	
2	BCCH						18	BCCH						34	BCCH						50	BCCH					
3	BACH #4		BACH #4		BACH #4		19	BACH #4		BACH #4		BACH #4		35	BACH #4		BACH #4		BACH #4		51	BACH #4		BACH #4		BACH #4	
4	PCH#0						20	PCH#0						36	PCH#0						52	PCH#0					
5	BACH #0		BACH #0		BACH #0		21	BACH #1		BACH #1		BACH #1		37	BACH #2		BACH #2		BACH #2		53	BACH #3		BACH #3		BACH #3	
6	BACH #1		BACH #1		BACH #1		22	BACH #1		BACH #1		BACH #1		38	BACH #1		BACH #1		BACH #1		54	BACH #1		BACH #1		BACH #1	
7	BACH #5		BACH #5		BACH #5		23	BACH #5		BACH #5		BACH #5		39	BACH #5		BACH #5		BACH #5		55	BACH #5		BACH #5		BACH #5	
8	FCCH			CICH			24	FCCH			CICH			40	FCCH			CICH			56	FCCH			CICH		
9	BACH #2		BACH #2		BACH #2		25	BACH #2		BACH #2		BACH #2		41	BACH #2		BACH #2		BACH #2		57	BACH #2		BACH #2		BACH #2	
10	BCCH						26	BCCH						42	BCCH						58	BCCH					
11	BACH #6		BACH #6		BACH #6		27	BACH #6		BACH #6		BACH #6		43	BACH #6		BACH #6		BACH #6		59	BACH #6		BACH #6		BACH #6	
12	PCH#1						28	PCH#1						44	PCH#1						60	PCH#1					
13	BACH #7		BACH #7		BACH #7		29	BACH #7		BACH #7		BACH #7		45	BACH #7		BACH #7		BACH #7		61	BACH #7		BACH #7		BACH #7	
14	BACH #3		BACH #3		BACH #3		30	BACH #3		BACH #3		BACH #3		46	BACH #3		BACH #3		BACH #3		62	BACH #3		BACH #3		BACH #3	
15	BACH #4		BACH #4		BACH #4		31	BACH #5		BACH #5		BACH #5		47	BACH #6		BACH #6		BACH #6		63	BACH #7		BACH #7		BACH #7	

Figure 16: Control Channel Organization when FCCH is used

Forward link Frame when FCCH is used

BCCH/CCCH		GBCH		Available for traffic																			
0	1																						23

Time slots

Return link Frame when FCCH is used

RACH window												Available for traffic											
0	1																						23

Figure 17: Frames when FCCH is used

Figure 18 shows the control channel transmission order and organization when the FCCH3 is used. As can be seen from figure 19, the first twelve time slots of the twenty-four time slot frame are used to transmit the control channels and the remaining twelve time slots are available for traffic.

SIRFN	PC12d PCRTN 0 1 2 3 4 5 6 7 8 9 10 11		SIRFN	PC12d PCRTN 0 1 2 3 4 5 6 7 8 9 10 11		SIRFN	PC12d PCRTN 0 1 2 3 4 5 6 7 8 9 10 11		SIRFN	PC12d PCRTN 0 1 2 3 4 5 6 7 8 9 10 11	
0	FCCH3		16	FCCH3		32	FCCH3		48	FCCH3	
1	GBCH3		17	GBCH3		33	GBCH3		49	GBCH3	
2	BCCH		18	BCCH		34	BCCH		50	BCCH	
3	PCH#0		19	PCH#0		35	PCH#0		51	PCH#0	
4	BACH#4	BACH#2	20	BACH#4	BACH#2	36	BACH#4	BACH#2	52	BACH#4	BACH#2
5	GBCH3		21	GBCH3		37	GBCH3		53	GBCH3	
6	BACH#0	BACH#6	22	BACH#0	BACH#6	38	BACH#0	BACH#6	54	BACH#0	BACH#6
7			23			39			55		
8	FCCH3		24	FCCH3		40	FCCH3		56	FCCH3	
9	GBCH3		25	GBCH3		41	GBCH3		57	GBCH3	
10	BCCH		26	BCCH		42	BCCH		58	BCCH	
11	PCH#1		27	PCH#1		43	PCH#1		59	PCH#1	
12	BACH#1	BACH#5	28	BACH#3	BACH#7	44	BACH#1	BACH#5	60	BACH#1	BACH#5
13	GBCH3		29	GBCH3		45	GBCH3		61	GBCH3	
14	BACH#3	BACH#7	30	BACH#1	BACH#5	46	BACH#3	BACH#7	62	BACH#3	BACH#7
15	BACH#1	BACH#5	31	BACH#3	BACH#7	47	BACH#0	BACH#6	63	BACH#4	BACH#2

Figure 18: Control Channel Organization when FCCH3 is used

Forward link Frame when FCCH3 is used

BCCH/CCCH/GBCH3	Available for traffic
0 1	23

Time slots

Return link Frame when FCCH3 is used

| RACH window	Available for traffic
0 1	23
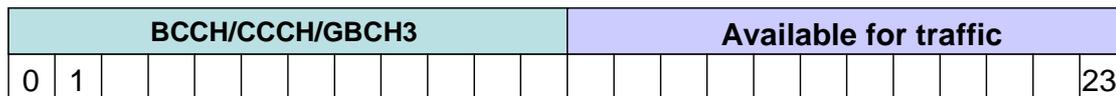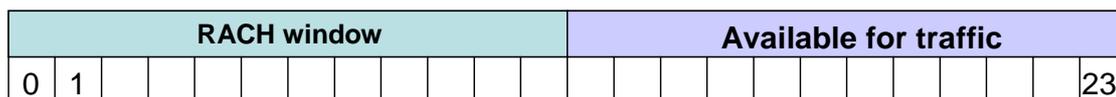
Figure 19: Frames when FCCH3 is used

5.7 MAC/RLC Layer Design

See TS 101 376-4-12 [12] for more details.

The MAC/RLC layer design is based on the 3GPP GPRS/EDGE MAC (see also TS 101 376-4-14 [17]) with satellite specific optimizations to mitigate impacts of long delay. These optimizations are geared to improve throughput by minimizing chattiness of protocols and maximally utilizing bandwidth provided by the physical layer.

The MAC provides the following functions:

- Configuring the mapping between logical channels and basic channels.

- Selecting logical channels for signalling radio bearer.

- Selecting logical channels for user radio bearer.

- Assignment, reconfiguration and release of shared resources for a TBF.

- MES measurement reporting and control of reporting.

- Broadcasting/listening of BCCH and CCCH.

- Ciphering and deciphering for Transparent Mode in Iu Mode.

- Identification of different traffic flows of one or more MESs on the shared channel.

- Multiplexing/demultiplexing of higher layer PDUs.

- Multiplexing/demultiplexing of multiple TBFs on the same PDTCH.

- Scheduling of RLC/MAC data and control PDUs delivered to the physical channel on a shared channel.

- Splitting/recombining RLC/MAC PDUs onto/from several shared logical channels.

- Mapping multicast bearers to shared TFIs.

The RLC operates in Acknowledge mode (AM) or UnAcknowledged mode (UM). Functions include:

- Segmentation of upper layer PDUs into RLC data blocks.

- Concatenation of upper layer PDUs into RLC data blocks.

- Padding to fill out RLC data block.

- Reassembly of RLC data blocks into upper layer PDU.

- In-sequence delivery of upper layer PDUs.

- Link Adaptation.

- Ciphering and deciphering in Iu Mode.

- Sequence number check to detect lost RLC blocks.

For Iu mode of operation, RLC can also operate in Transparent Mode for carrying spectrally efficient VoIP.

In addition to the above, RLC provides the following functions when operating in ACK mode:

- Backward Error Correction (BEC) procedure enabling the selective retransmission of RLC data blocks.

- Discard of RLC SDUs not yet segmented into RLC PDUs, according to the delay requirements of the associated Radio Bearers.

5.8   RRC Layer Design

See TS 101 376-4-13 [13] for more details.

The Radio Resource Control (RRC) layer design is based on the 3GPP GERAN Iu mode RRC specifications
(see TS 144 018 [14] andTS 144 118 [15]) with satellite specific optimizations to cater to long delay environments and
achieve better spectral efficiency.

The RRC state model is based on RRC states defined in TS 144 018 [14] and is illustrated in figure 20.
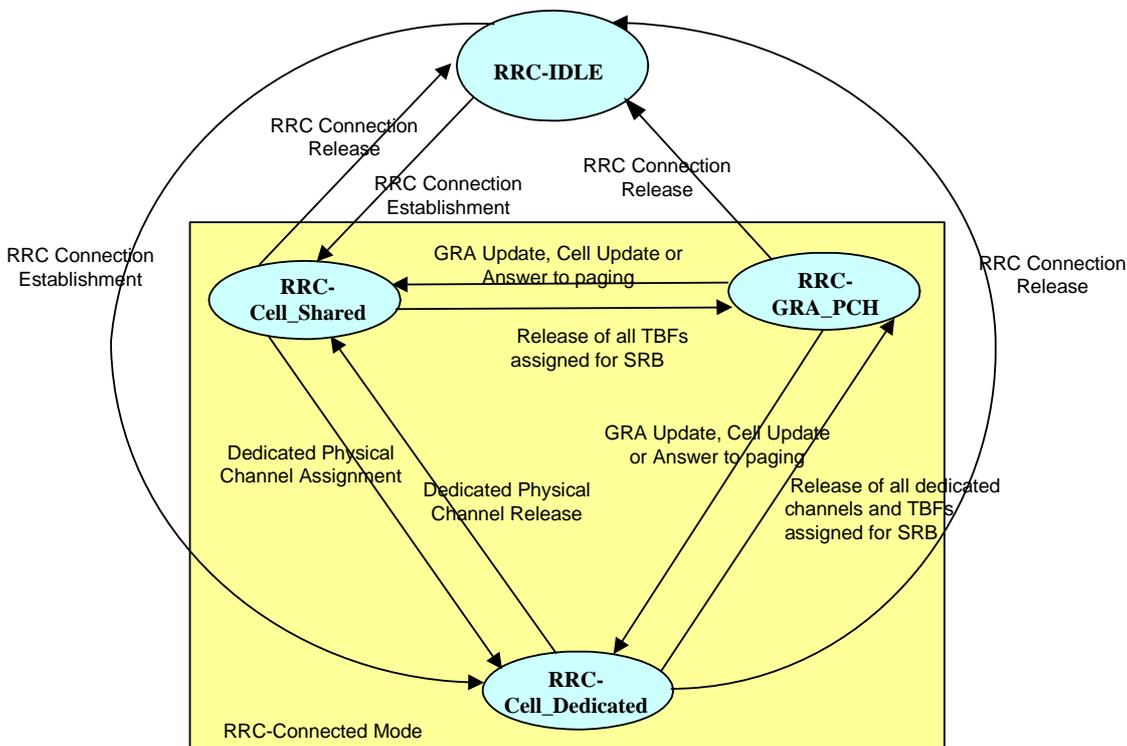

Figure 20: Radio Resource Control (RRC) state model

RRC functions include:

- Assignment, reconfiguration, and release of radio resources for the RRC connection.

- Establishment, reconfiguration, and release of Radio Bearers.

- Release of signalling connections.

- Paging.

- Routing of higher layer PDUs.

- Control of requested QoS.

- Control of Ciphering and Integrity Protection.

- Integrity Protection.

- Support for Location Services.

- Timing advance control.

Satellite specific enhancements in RRC layer includes:

- Enhancements to Cell Update procedure to reduce number of round-trips.

- Fast RRC Connection Setup using RACH.

- Fast GRA Update using RACH/PRACH.

- Fast RRC Connection Reject/Connection Release using AGCH.

- RAB Binding procedure to identify PTT bearers.

- RAB Binding procedure to identify multicast bearer.

- RB Reconfiguration procedure for intra-beam carrier relocation.

5.9   PDCP Layer Design

The Packet Data Convergence Protocol (PDCP) layer design is based on TS 101 376-4-15 [16] with satellite specific enhancements. The PDCP structure is shown in figure 21.
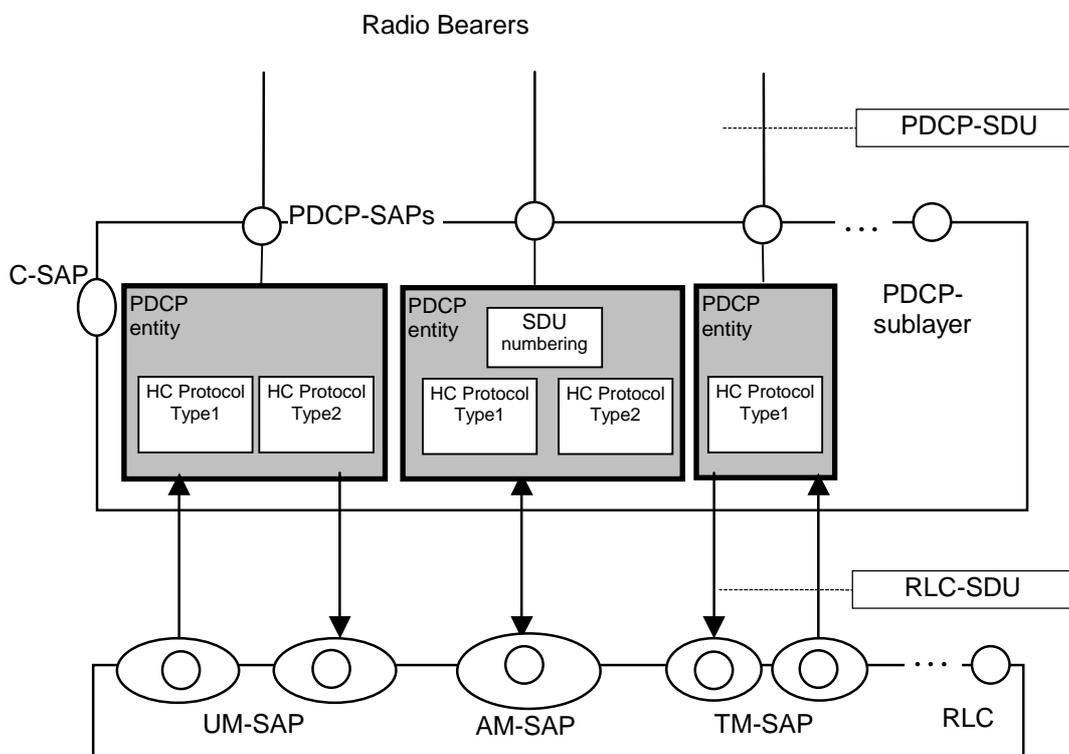

Figure 21: Packet Data Convergence Protocol (PDCP) structure

The Packet Data Convergence Protocol performs the following functions:

- Header compression and decompression of IP data streams (e.g. TCP/IP and RTP/UDP/IP headers for IPv4 and IPv6) at the transmitting and receiving entity, respectively.

- Transfer of user data. This function is used for conveyance of data between users of PDCP services.

- Maintenance of PDCP sequence numbers.

- Data compression using V.44.

PDCP uses the services provided by the Radio Link Control (RLC) sublayer.

Satellite specific optimizations include:

- Early context establishment procedures.

- Zero byte header compression.

- Efficient handling of RTCP packets.

- Efficient handling of IPv6 RTP/UDP/IP headers.

- Interaction with TCP Performance Enhancing Proxy.

Benefits of PDCP layer functions include:

- Improve spectral efficiency and decrease satellite power usage.

- Improve capacity.

- Improve MES battery life.

- Improve interactive response time.

- Reduce packet loss rate.

5.10   Terminal types

GMR-1 3G supports a wide range of terminal types from small handheld terminals to large high gain fixed or transportable terminals. Both 2,45 kbps and 4 kbps voice rates are supported using zero-byte header compression, as well as IP data traffic with bandwidths dependent on terminal type. The following terminal characteristics are supported.

- GMR-1 3G terminal type identifier (signalling code point) - see TS 101 376-5-2 [6].

- Multislot class (limitations on burst transmissions for small terminals) - see TS 101 376-5-2 [6].

- Power class - see TS 101 376-5-5 [9].

- Supported channel types (FCCH and/or FCCH3) - see TS 101 376-5-2 [6].

- Supported traffic channel types based on terminal capability.

- Transmission capability (half or full duplex).

- Mode of use (handheld, fixed, etc.).

- Antenna type (internal or external, linearly or circularly polarized, etc.).

- Network interfaces supported (A, Gb or Iu mode).

- Operating band (S-band, L-band) - see TS 101 376-5-5 [9].

Annex A (informative):
Bibliography

GMR-1 3G 23.003 (ETSI TS 101 376-3-3): "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 3: Network specifications; Sub-part 3: Numbering, addressing and identification".

GMR-1 3G 43.022 (ETSI TS 101 376-3-10): "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 3: Network specifications; Sub-part 10: Functions related to Mobile Earth Station (MES) in idle mode".

History

Document history		
V3.1.1	July 2009	Publication
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