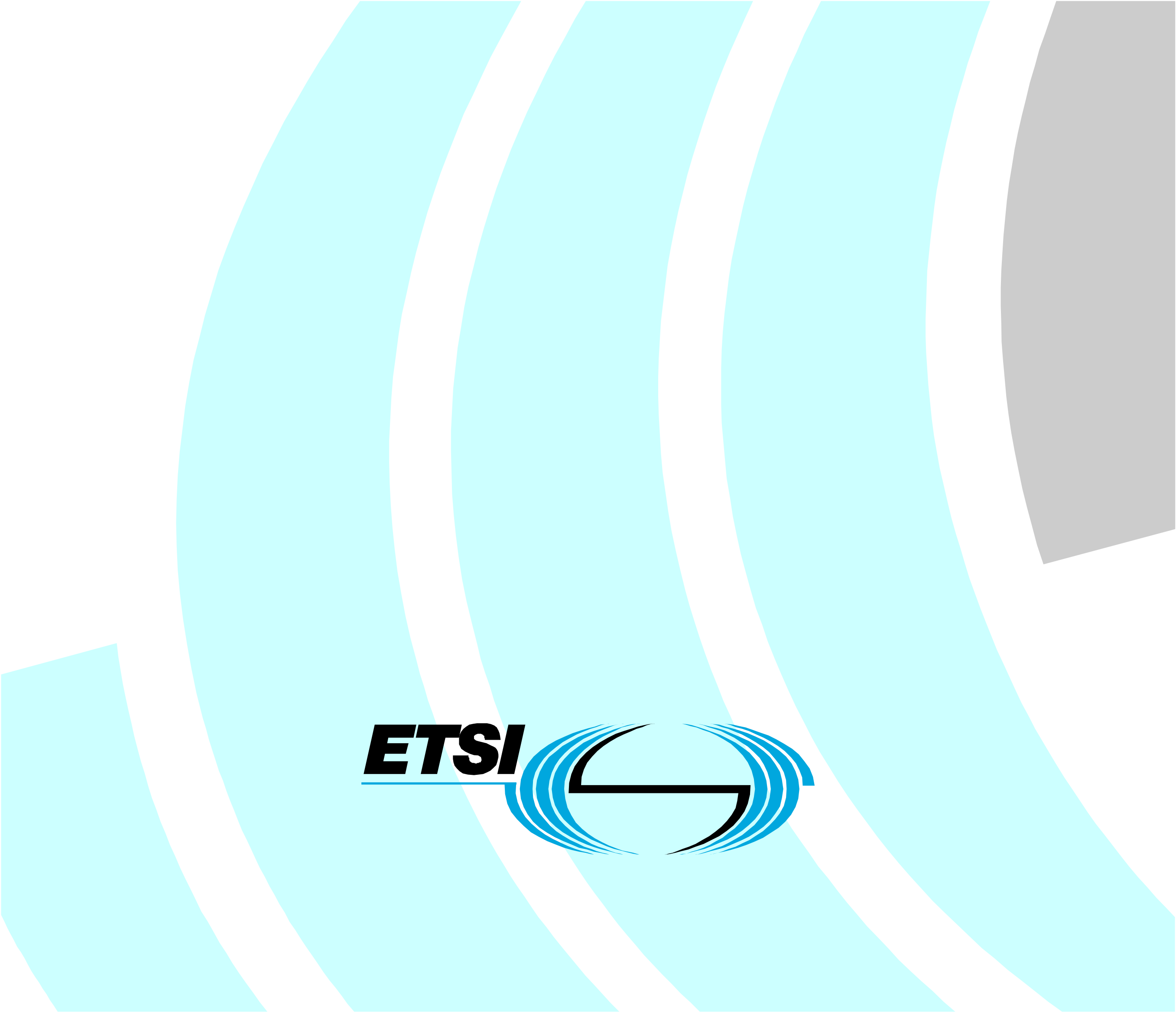
ETSI TR 102 277 V1.1.1 (2004-04)

Technical Report

Satellite Earth Stations and Systems (SES); Satellite Component of UMTS/IMT-2000; W-CDMA Radio Interface for Multimedia Broadcast/Multicast Service (MBMS)



Reference
DTR/SES-00089

Keywords
IMT-2000, radio, satellite, UMTS, WCDMA

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

Individual copies of the present document can be downloaded from:
http://www.etsi.org

The present document may be made available in more than one electronic version or in print. In any case of existing or perceived difference in contents between such versions, the reference version is the Portable Document Format (PDF). In case of dispute, the reference shall be the printing on ETSI printers of the PDF version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at
http://portal.etsi.org/tb/status/status.asp

If you find errors in the present document, send your comment to:
editor@etsi.org

Copyright Notification

No part may be reproduced except as authorized by written permission.
The copyright and the foregoing restriction extend to reproduction in all media.

© European Telecommunications Standards Institute 2004.
All rights reserved.

DECTTM, **PLUGTESTS**TM and **UMTS**TM are Trade Marks of ETSI registered for the benefit of its Members.
TIPHONTM and the **TIPHON logo** are Trade Marks currently being registered by ETSI for the benefit of its Members.
3GPPTM is a Trade Mark of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.

Contents

Intellectual Property Rights

Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

Introduction

The objective of W-CDMA Satellite Radio Interface is to ease integration of satellite and terrestrial UMTS for provision of Multimedia Broadcast/Multicast Service (MBMS). Some of the benefits to be gained from a fully integrated S-UMTS/T-UMTS system are:

- seamless service provision;
- highly integrated multi-mode terrestrial/satellite User Equipment (UE);
- re-use of terrestrial equipment: radio access infrastructure equipment (RNC, Node B, etc.).

The satellite component of MBMS may provide services:

- in areas covered by cellular terrestrial systems, for complementary services such as broadcast/multicast;
- in areas where terrestrial coverage is not available:
  - because terrestrial network have not been deployed for business attractiveness reasons; or
  - because terrestrial infrastructure has suffered environmental damages (crisis conditions).

The present document is applicable to several satellite constellation types (for LEO and MEO constellations, addition of Doppler and synchronization adaptation module).

The outline of the present document is the following:

- In clause 4 "Satellite Multimedia Broadcast/Multicast Service", the system architecture and candidate satellite constellations are presented.
- Clause 5 "W-CDMA Satellite Radio Interface" summarizes key characteristics based on the Technical Specifications defined by 3GPP.
- Clause 6 specifies test environment and equipment performance requirements.
- Clause 7 "System performances" presents link budgets and system capacity.
- Clause 8 "Technology design constraints" summarizes constraints due to satellite environment.
- The concluding clause 9 "Conclusion" is a brief summary of the results established so far.

The present document is completed with three annexes. Annex A specifies reference measurement channels. Annex B presents detailed system capacity results. Annex C is the ITU-R template used in M.1225 [2] the evaluation of the Radio Interfaces.

1 Scope

The present document evaluates the feasibility to use W-CDMA UTRA FDD as a satellite radio interface for provision of Satellite Multimedia Broadcast/Multicast Service (S-MBMS).

The Technical Specifications for the W-CDMA UTRA FDD has been developed in the framework of the third Generation Partnership project (3GPP). The analysis for applicability to satellite is based on 3GPP standards as defined from [6] to [29].

The procedure and methodology used for the evaluation of W-CDMA UTRA FDD as a Satellite Radio Interface are those defined in the Recommendations from ITU-R and which have been used for the evaluation of the radio transmission technologies candidate for the satellite component of UMTS/IMT-2000:

- ITU-R Recommendation M.1455: "Key characteristics for the radio interfaces of the International Mobile Telecommunications- 2000 (IMT-2000)" [3];
- ITU-R Recommendation M.1225: "Guidelines for evaluation of radio transmission technology for IMT-2000" [2].

2 References

For the purposes of this Technical Report (TR), the following references apply:

[1] ETSI TR 101 865: "Satellite Earth Stations and Systems (SES); Satellite component of UMTS/IMT-2000; General aspects and principles".

[2] ITU-R Recommendation M.1225: "Guidelines for evaluation of Radio Transmission technology for IMT-2000".

[3] ITU-R Recommendation M.1455: "Key characteristics for the International Mobile Telecommunications-2000 (IMT-2000) radio interfaces".

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

[5] ITU-R Recommendation M.1034-1: "Requirements for the radio interface(s) for International Mobile Telecommunications-2000 (IMT-2000)".

[6] ETSI TS 125 101: "Universal Mobile Telecommunications System (UMTS); User Equipment (UE) radio transmission and reception (FDD) (3GPP TS 25.101)".

[7] ETSI TS 125 104: "Universal Mobile Telecommunications System (UMTS); Base Station (BS) radio transmission and reception (FDD); (3GPP TS 25.104)".

[8] ETSI TS 125 201: "Universal Mobile Telecommunications System (UMTS); Physical layer - General description (3GPP TS 25.201)".

[9] ETSI TS 125 211: "Universal Mobile Telecommunications System (UMTS); Physical channels and mapping of transport channels onto physical channels (FDD) (3GPP TS 25.211)".

[10] ETSI TS 125 212: "Universal Mobile Telecommunications System (UMTS); Multiplexing and channel coding (FDD) (3GPP TS 25.212)".

[11] ETSI TS 125 213: "Universal Mobile Telecommunications System (UMTS); Spreading and modulation (FDD) (3GPP TS 25.213)".

[12] ETSI TS 125 214: "Universal Mobile Telecommunications System (UMTS); Physical layer procedures (FDD) (3GPP TS 25.214)".

[13] ETSI TS 125 215: "Universal Mobile Telecommunications System (UMTS); Physical layer; Measurements (FDD) (3GPP TS 25.215)".

[14] ETSI TS 125 301: "Universal Mobile Telecommunications System (UMTS); Radio interface protocol architecture (3GPP TS 25.301)".

[15] ETSI TS 125 302: "Universal Mobile Telecommunications System (UMTS); Services provided by the physical layer (3GPP TS 25.302)".

[16] ETSI TS 125 321: "Universal Mobile Telecommunications System (UMTS); Medium Access Control (MAC) protocol specification (3GPP TS 25.321)".

[17] ETSI TS 125 322: "Universal Mobile Telecommunications System (UMTS); Radio Link Control (RLC) protocol specification (3GPP TS 25.322)".

[18] ETSI TS 125 323: "Universal Mobile Telecommunications System (UMTS); Packet Data Convergence Protocol (PDCP) specification (3GPP TS 25.323)".

[19] ETSI TS 125 324: "Universal Mobile Telecommunications System (UMTS); Broadcast/Multicast Control (BMC) (3GPP TS 25.324).

[20] ETSI TS 125 331: "Universal Mobile Telecommunications System (UMTS); Radio Resource Control (RRC) protocol specification (3GPP TS 25.331)".

[21] ETSI TS 125 401: "Universal Mobile Telecommunications System (UMTS); UTRAN overall description (3GPP TS 25.401)".

[22] ETSI TS 125 402: "Universal Mobile Telecommunications System (UMTS); Synchronisation in UTRAN; Stage 2 (3GPP TS 25.402)".

[23] ETSI TS 125 141: "Universal Mobile Telecommunications System (UMTS); Base Station (BS) conformance testing (FDD) (3GPP TS 25.141)".

[24] ETSI TS 134 121: "Universal Mobile Telecommunications System (UMTS); Terminal Conformance Specification; Radio Transmission and Reception (FDD) (3GPP TS 34.121)".

[25] ETSI TR 125 942: "Universal Mobile Telecommunications System (UMTS); RF system scenarios (3GPP TR 25.942)".

[26] ETSI TS 122 146: "Universal Mobile Telecommunications System (UMTS); Multimedia Broadcast/Multicast Service (MBMS); Stage 1 (3GPP TS 22.146)".

[27] 3GPP TS 25.346: "Introduction of the Multimedia Broadcast/Multicast Service (MBMS) in the Radio Access Network (Stage 2)".

[28] ETSI TR 125 992: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); Multimedia Broadcast/Multicast Service (MBMS); UTRAN/GERAN requirements (3GPP TR 25.992)".

[29] 3GPP TR 23.846: "3rd Generation Partnership Project; Technical Specification Group Services and Systems Aspects; Multimedia Broadcast/Multicast Service (MBMS); Stage 2".

[30] ITU-R Recommendation SM.1541: "Unwanted emissions in the out-of-band domain".

[31] ITU-R Recommendation M.1142: "Sharing in the 1-3 GHz frequency range between geostationary space stations operating in the mobile-satellite service and the fixed service".

[32] ERC Report 65: "Adjacent band compatibility between UMTS and other services in the 2 GHz band".

[33] Satin D5: "S-UMTS Packet-based Layer 1 & 2 Functions".

[34] Satin D7: "Evaluations and Recommendation".

[35] Satin publication: "Initial synchronization procedure in S-UMTS networks for multimedia broadcast multicast services".

[36] Satin publication: "Cell search procedure in S-UMTS networks".

[37] ECC PT1 (03)79: "Sharing and compatibility studies between the satellite and terrestrial components of IMT-2000 in the 2.5 GHz range (continuation)".

[38] ECC PT1 (02)024: "First results of sharing and adjacent band compatibility studies between the terrestrial and satellite components of IMT-2000 in the 2.5 GHz range (continuation)".

[39] ITU 8F/862-E: "Parameters of a satellite based digital multimedia broadcasting (S-DMB) system to be used in compatibility studies between the terrestrial and the satellite component of IMT-2000".

[40] ETSI TR 30.20: "Universal Mobile Telecommunications System (UMTS); Technical characteristics, capabilities and limitations of mobile satellite systems applicable to the UMTS". http://www.3gpp.org/ftp/Specs/archive/30_series/30.20U/3020U-310.zip

[41] ICAP 91, Seventh International Conference on (IEE), (15-18 Apr 1991): "Aeronautical Mobile Satellite Communication propagation characteristics in flight experiment using ETS-V".

[42] ITU-T Recommendation G.726: "40, 32, 24, 16 kbit/s adaptive differential pulse code modulation (ADPCM)".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

cell: geographical area under Intermediate Module Repeater (IMR) coverage

handover: process in which the User Equipment (UE) continuously receives services while it crosses radio access areas covered with distinct radio access mode and/or radio system

rice factor: power ration between LOS component and diffuse component

spot: geographical are under beam coverage

3.2 Symbols

For the purposes of the present document, the following symbols apply:

$\frac{S-CCPCH\_E_c}{I_{or}}$	The ratio of the transmit energy per PN chip of the S-CCPCH to the total transmit power spectral density at the Node B antenna connector.
$\frac{E_b}{N_t}$	The ratio of combined received energy per information bit to the effective noise power spectral density for the P-CCPCH and S-CCPCH at the UE antenna connector. Following items are calculated as overhead: pilot, TPC, TFCI, CRC, tail, repetition, convolution coding and Turbo coding.
C_p	Primary synchronization code.
I_{oc}	The power spectral density of a band limited white noise source (simulating interference from spots, which are not defined in a test procedure) as measured at the UE antenna connector.
$\hat{I}_{or}$	The received power spectral density of the downlink as measured at the UE antenna connector.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACCH	Access Control CHannel
ACLR	Adjacent Channel Leakage Ratio

ALT	Automatic radio Link Transfer
AMR	Adaptive Multi-Rate
AWGN	Additive White Gaussian Noise
BCCH	Broadcast Control Channel
BCH	Broadcast Channel
BER	Bit Error Rate
BLER	Block Error Ratio
BMC	Broadcast/Multicast Protocol
BS	Base Station
CCCH	Common Control Channel
CCPCH	Common Control Physical Channel
CCTrCH	Code Composite Transport Channel
CDMA	Code Division Multiple Access
C/I	Carrier to Interference
CPICH	Common Pilot Channel
CRC	Cyclic Redundancy Check
CTCH	Common Traffic Channel
DCA	Dynamic Channel Allocation
DL	Downlink
DS	Direct Sequence
DTX	Discontinuous Transmission
EIRP	Effective Isotropic Radiated Power
FACH	Forward Access Channel
FDD	Frequency Duplex Division
FDM	Frequency Division Multiplex
FDMA	Frequency Division Multiple Access
FEC	Forward Error Correction
FER	Frame Error Rate
FH	Frequency Hopping
FSS	Fixed Satellite Service
FWA	Fixed Wireless Application
GEO	Geostationary Earth Orbit
GPS	Global Positioning System
GSO	Geostationary Orbit
HDFSS	High Density Fixed Satellite Service
IMR	Intermediate Module Repeater
ISDN	Integrated Service Digital Network
LEO	Low ORBIT
LES	Land Earth Station
LOS	Line Of Sight
MAC	Medium Access Control
MBMS	Multimedia Broadcast Multicast Service
MCCH	MBMS Control Channel
Mcps	Mega chip per second
MEO	Medium Earth Orbit
MOPS	Minimum Operational Performance Specification
MS	Mobile Station
MSS	Mobile Satellite Service
MTCH	MBMS Traffic Channel
MUD	Multi User Detection
NCCH	Notification Common Control Channel
NLOS	No Line Of Sight
OVSF	Orthogonal Variable Spreading Factor
PCCC	Parallel Concatenated Convolutional Code
PCCH	Paging Control Channel
P-CCPCH	Primary Common Control Physical Channel
PCH	Paging Channel
P-CPICH	Primary Common Pilot Channel
PDCP	Packet Data Convergence Protocol
PHY	Physical (layer)
PI	Paging Indicator
PICH	Paging Indicator Channel

PN	Personal Numbering
PSC	Primary Synchronization Code
QPSK	Quadrate Phase Shift Keying
RF	Radio Frequency
RLC	Radio Link Control
RNC	Radio Network Controller
RNS	Radio Network Subsystem
RRC	Radio Resource Control
RTT	Radio Transmission Technology
SAP	Satellite Access Point
S-CCPCH	Secondary Common Control Physical Channel
SCH	Synchronization Channel
S-CPICH	Secondary Common Pilot Channel
S-MBMS	Satellite Multimedia Broadcast/Multicast Service
SRC	Square Root Cosine
SRI	Satellite Radio Interface
SSC	Secondary Synchronization Code
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TFCI	Transport Format Combination Indicator
TPC	Transmit Power Control
TrCH	Transport Channel
TFS	Transport Format Set
TTI	Time Transmission Interval
T-UMTS	Terrestrial UMTS
UE	User Equipment
UL	Uplink
USRAN	UMTS Satellite Radio Access Network
UTRA	UMTS Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network
W-CDMA	Wideband Code Division Multiple Access

4 Satellite Multimedia Broadcast/Multicast Service

4.1 System architecture

The proposed system architecture is devoted to Satellite Multimedia Broadcast Multicast Services (S-MBMS), as depicted in figure 4.1.

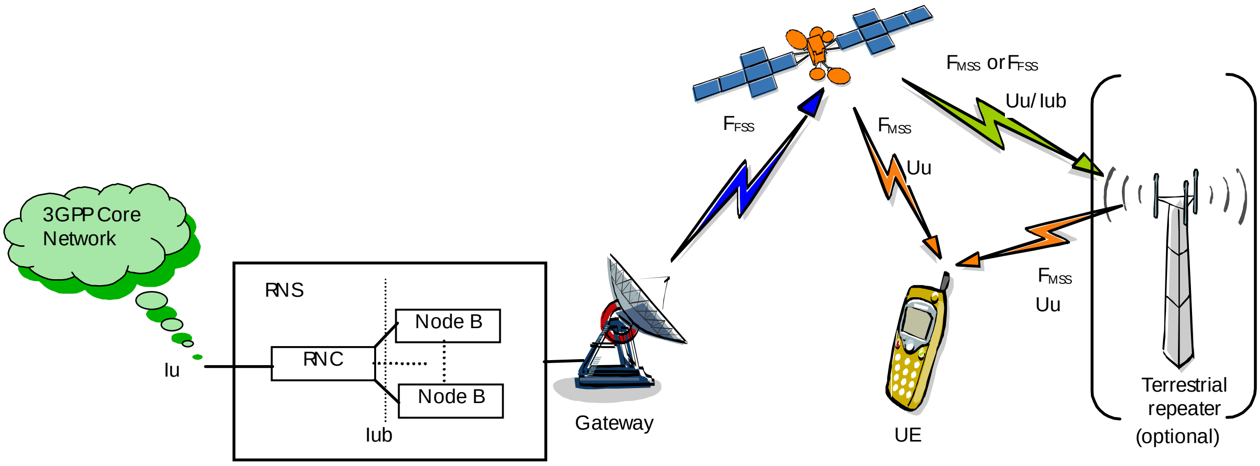


Figure 4.1: System architecture

The present document focuses on the forward link direction which is sufficient to support the broadcast service as defined by 3GPP.

The return link required for multicast sessions may be provided either by terrestrial 2G/3G network or by a satellite return link. The provision of the return link is out of the scope of the present document.

The system may provide either single or multiple satellite constellation, each satellite may provide either mono or multi-spot coverage.

An S-MBMS area may be either a spot or a group of spots for roaming users.

User Equipment (UEs) receive S-MBMS services from one or several satellites which redirect the radio signal from gateways. The system allows for either a centralized gateway or a group of geographically dispatched gateways, depending on the operators requirements. The Gateway connects the signal from the Radio Network Subsystem (RNS), i.e. Node Bs and RNC. The decision to integrate Node Bs and/or RNC inside or outside the Gateway is under manufacturers' implementation choice.

The system addresses UEs fully compatible with 3GPP UTRA FDD mode (W-CDMA), with adaptation for agility to the MSS (Mobile Satellite Services) frequency band.

In a satellite environment, signal transmission is subject to suffer from path blocking due to buildings, mountains, etc. In order to ensure coverage continuity in highly shadowed areas, the system can be completed with Intermediate Module Repeaters (IMRs) which role is to amplify and repeat the signal from the satellite to terrestrial coverage in the MSS frequency band. The feeding of IMRs by the satellite is made either in MSS or a Fixed Satellite Service (FSS) band. IMR's feeder link reception antenna is positioned in line of sight to the satellite.

On the system point of view, satellite and IMRs have the same functionality, which is reduced to signal repetition.

When IMRs are deployed, UEs are subject to receive S-MBMS services:

- from the satellite only (areas where IMRs are not deployed or situation with no signal view from IMRs);
- from IMRs only (situation where there is no view of the satellite signal);
- simultaneously from satellite and IMRs.

In the present document, the term "spot" applies to beam coverage area while the term "cell" applies to IMR coverage area.

4.2 Frequency bands

4.2.1 Service link

The S-MBMS frequency bands are allocated in the IMT-2000 MSS band.

For the space-to-earth direction and for the IMR signal repetition, the UE is able to receive S-MBMS in:

- the 2 170 MHz to 2 200 MHz band, which has been allocated by WARC-92 to MSS downlink and is the "core band";
- the 2 500 MHz to 2 520 MHz band, which has been identified by WRC-2000 for IMT-2000 MSS downlink and is the "extension band".

These frequency bands are adjacent to the terrestrial UMTS frequency bands, as depicted in figure 4.2. The exploitation of adjacent bands should ease 3GPP standardized UE reuse provided they are adapted for MSS frequency agility.

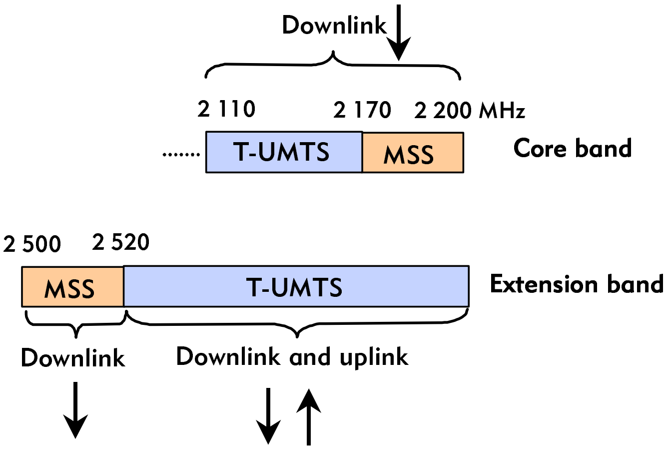


Figure 4.2: IMT-2000 spectrum allocation

NOTE: The use of extension band for S-MBMS is for further release of the present document.

4.2.2 Feeder links

The present document does not intend to specify feeder links. Nevertheless, candidate frequency bands are given for indication.

The gateway to satellite feeder link is intended to be operated in the 27,5 GHz to 30 GHz band.

Depending on the IMR configuration, the satellite to IMR link is intended to be operated either:

- "on-channel" IMR: in the service link band (2 170 MHz to 2 200 MHz). This configuration is suitable for indoor coverage;
- "non on-channel" IMR: in the HDFSS band (19,7 GHz to 20,2 GHz). This configuration is suitable for outdoor coverage.

4.3 Satellite system configuration

The system is able to cope with several satellite constellation types, i.e. LEO, HEO, MEO or GEO. It is out of the scope of the present document to restrict the satellite system configuration.

Nevertheless, in order to present realistic deployment scenario, the present document focuses on the GEO constellation type.

Several architectures are envisaged depending on throughput requirements. The examples below assume European coverage. Global beam configuration means there is a unique spot covering the entire Europe area.

Multi-beam configuration means a satellite serves several spots, for instance 1 spot per linguistic area (7 multi-beam configuration) or 1 spot per regional area (extended multi-beam configuration).

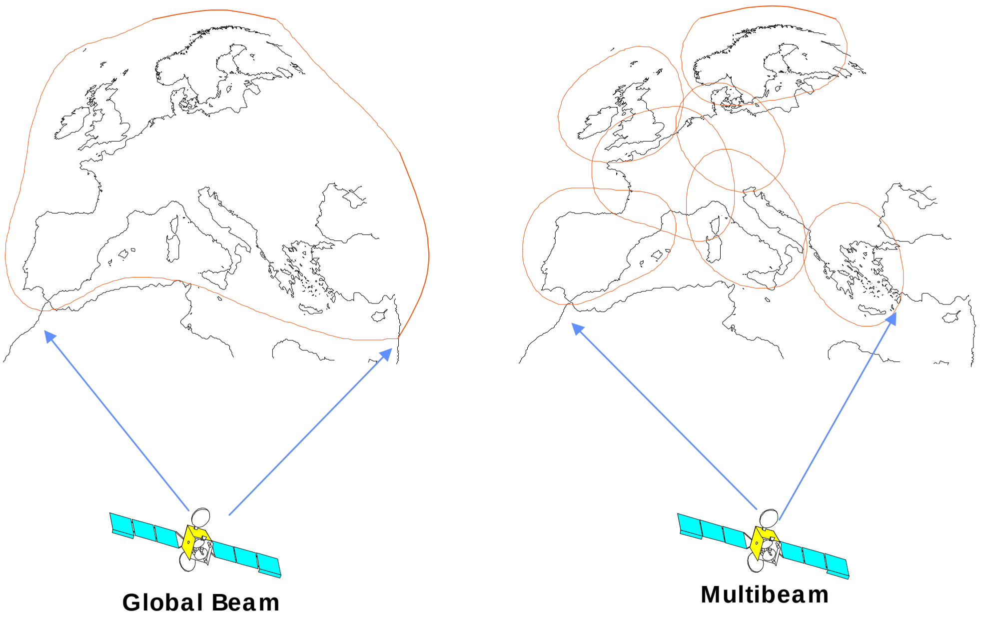


Figure 4.3: Global beam and 7 multi-beam satellite configuration

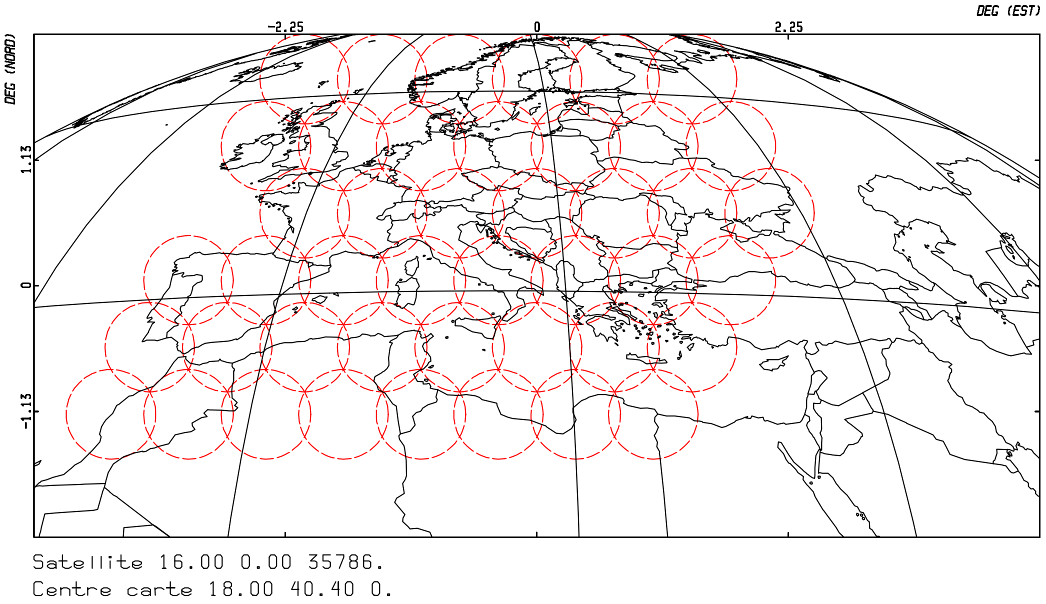


Figure 4.4: Extended multi-beam configuration

An other possible configuration is the system is built with several satellites, each satellite serving several spots.

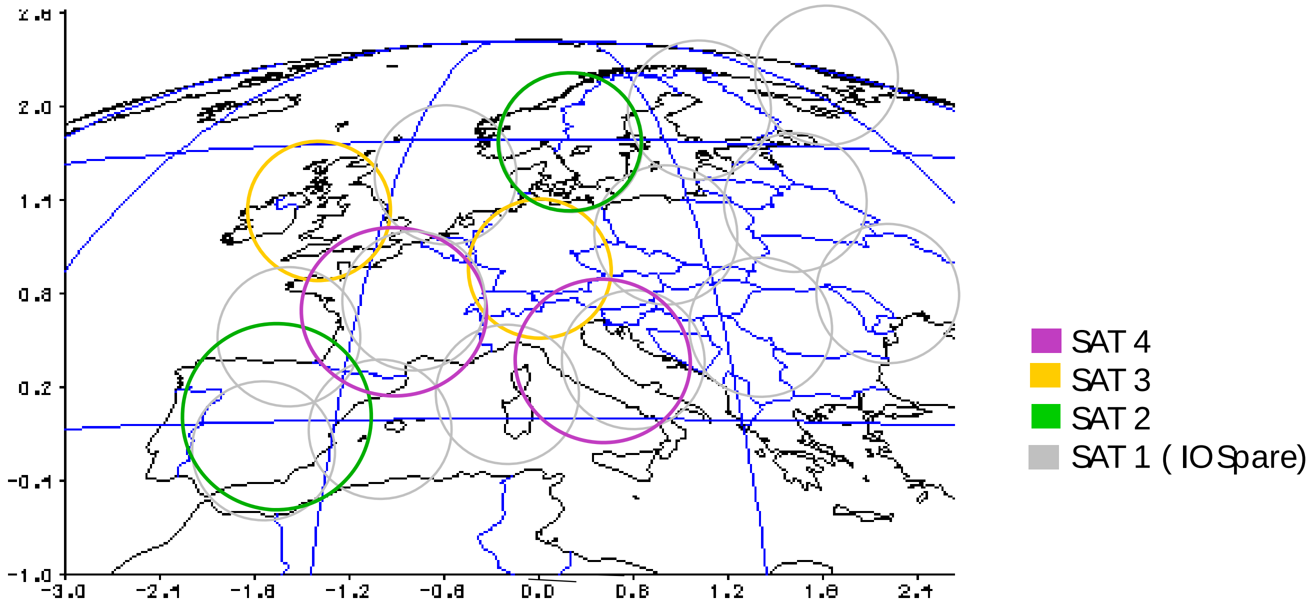


Figure 4.5: Multi-satellite and multi-beam configuration

4.3.1 Global beam architecture

The global beam architecture provides an overall throughput of 3,84 Mb/s over Europe shared among 2 FDMs, each carrying 5 channel codes at 384 kbit/s. Each FDM occupies 5 MHz bandwidth among MSS frequency band. Satellite performances are summarized in table 4.1.

Table 4.1: Satellite Global beam architecture

		Global beam
Number of spot beams		1
Downlink (satellite to UE)		
Frequency (satellite to UE)	MHz	2 170 to 2 200
Polarization		LHCP or RHCP
On board EIRP per carrier	dBW	64

4.3.2 Multi-beam architecture

Satellite performances are summarized in table 4.2.

Table 4.2: Satellite 7 multi-beam architecture

		7 Multibeam
Number of spot beams		7
Downlink (satellite to UE)		
Frequency (satellite to UE)	MHz	2 170 to 2 200
Polarization		LHCP or RHCP
On board EIRP per carrier	dBW	From 64 to 74 (see note)
NOTE: Depending on considered spot beam and frequency reuse pattern.		

4.3.3 Extended multi-beam architecture

Satellite performances are summarized in table 4.3.

Table 4.3: Satellite extended multi-beam architecture

		Extended Multibeam
Number of spot beams		30
Downlink (satellite to UE)		
Frequency (satellite to UE)	MHz	2 170 to 2 200
Polarization		LHCP or RHCP
On board EIRP per carrier	dBW	From 64 to 74 (see note)
NOTE: Depending on considered spot beam.		

4.3.4 Multi-satellite/multi-beam architecture

This configuration is addressed in the present document but not fully analysed.

4.4 User Equipment

User Equipment (UE) may be of several types:

- **3G standardized handset:** the use in satellite environment requires adaptation for frequency agility to the MSS band. The basic assumption is UE equipped with standard omni-directional antenna (e.g. antenna gain: 0 dBi).
- **Portable:** the portable configuration is built with a notebook PC to which an external antenna is appended.
- **Vehicular:** the vehicular configuration is obtained by mounting an RF module on car roof connected to the UE in the cockpit.
- **Transportable:** the transportable configuration is built with a notebook which cover contains flat patch antennas (manually pointed towards the satellite).
- **Aeronautical:** aeronautical configuration is built by mounting an antenna on top of the fuselage.

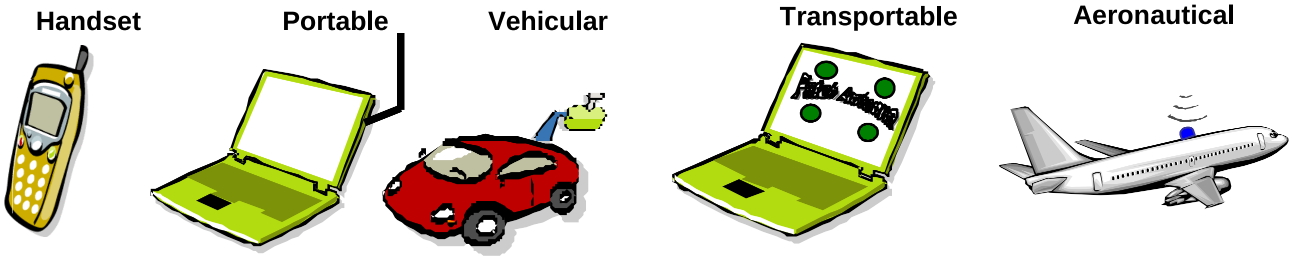


Figure 4.6: UE configurations

The gain characteristics for the four first UE configurations are summarized in table 4.4.

Table 4.4: UE maximum antenna gain

UE type	Ref. Antenna Gain
3G Handset (see [6])	0 dBi
Portable (see note)	2 dBi
Vehicular (see note)	4 dBi
Transportable (see note)	14 dBi
Aeronautical (see note)	3 dBi
NOTE: Typical values.	

4.5 Intermediate Module Repeaters (IMR)

Two kinds of architecture can be envisaged:

- "on channel" repeaters: use the same band for signal reception and retransmission. The gain is limited to around 80 dB to avoid self-oscillation and offer narrow coverage;
- "non on-channel" repeaters: use different frequency bands for signal reception and retransmission. They enable to achieve wider coverage than on-channel repeaters, but require an additional frequency band for feeding (e.g. HDFSS band).

Low-cost and low-power IMRs can be easily collocated to terrestrial UTRAN node B sites to provide the same coverage. They can also reuse some node B subsystems (e.g. sectored antennas) since frequency bands for both satellite and terrestrial components of IMT-2000 are adjacent.

IMRs RF performance are summarized in table 4.5.

Table 4.5: IMR - RF performance

Transmit frequency (MHz)	2 170 to 2 200
Transmit polarization	Vertical
Overall EIRP (dBW)	Same as 3GPP Node B
Coverage area (°)	Up to 360° (i.e. 90° per sector)

5 W-CDMA Satellite Radio Interface (SRI)

Clause 5 gives a description of W-CDMA as applicable to the S-MBMS satellite environment.

5.1 General description

5.1.1 W-CDMA key features

Listed below are the key services and operational features of the W-CDMA radio-interface:

- support of 3GPP standard MBMS services from low-data-rate (8 kbps) up to high-data-rate transmission (384 kbps) with wide-area coverage;
- high service flexibility with support of multiple parallel variable-rate services;
- built-in support for future capacity/coverage-enhancing technologies, such as adaptive antennas, advanced receiver structures, and satellite diversity;
- support of inter-frequency handover for operation with hierarchical cell structures and handover to other systems.

5.1.2 Key technical characteristics

Key technical characteristics are summarized in table 5.1.

Table 5.1: Key technical characteristics

Multiple-Access scheme	DS-CDMA
Duplex scheme	FDD
Chip rate	3,840 Mcps
Carrier spacing	5 MHz (200 kHz carrier raster)
Frame length	10 ms
Inter-spot synchronization	No accurate synchronization needed
Multi-rate/Variable-rate scheme	Variable-spreading factor + Multi-code
Channel coding scheme	Convolutional coding (rate 1/2 - 1/3) Turbo coding 1/3
Packet access	Mono mode (common channel)

5.1.3 Radio interface protocol architecture

Radio interface protocol stack is extracted from 3GPP UTRAN (see [14]).

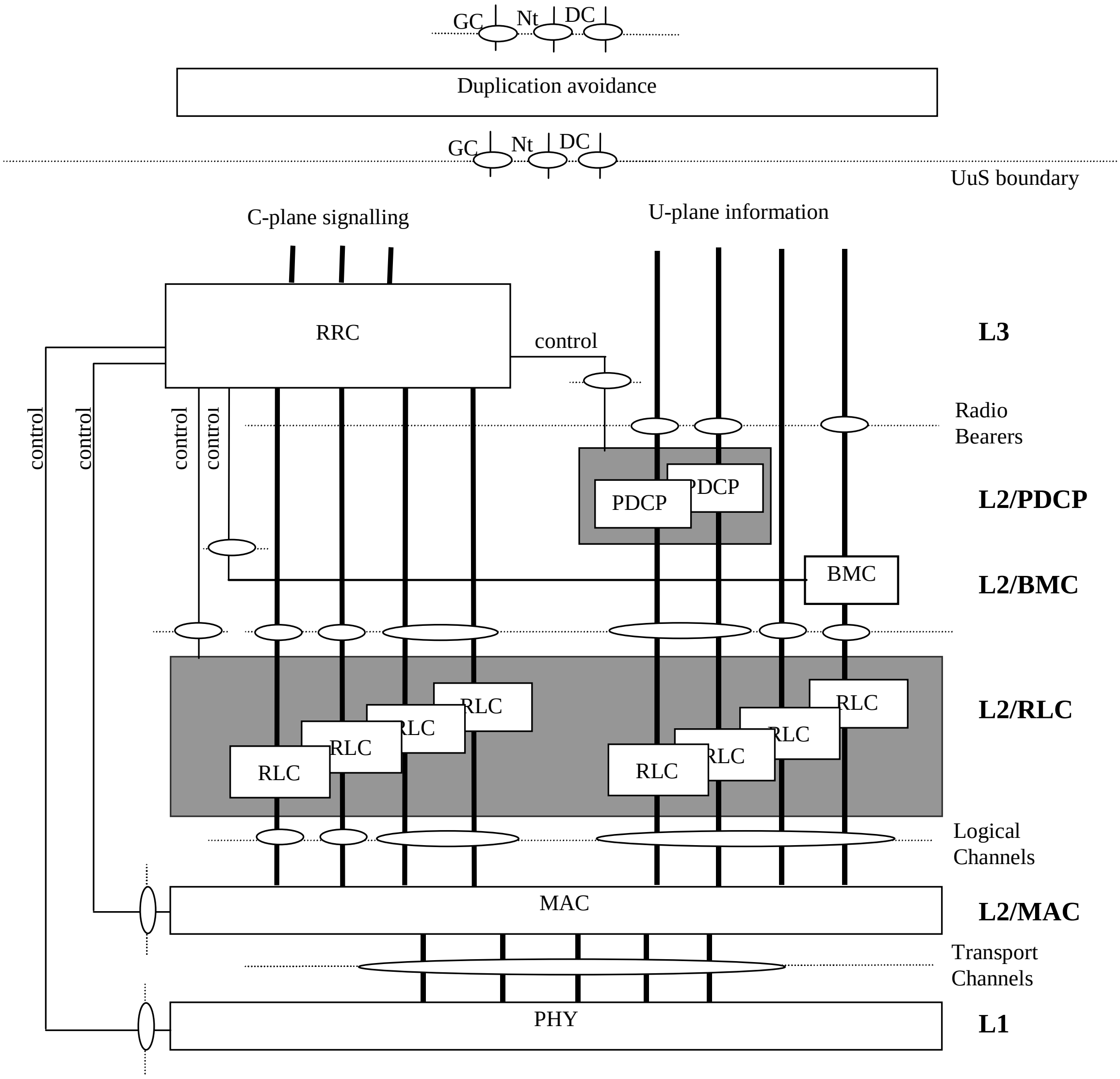


Figure 5.1: Radio interface protocol architecture

5.2 Channel structure

The channel structure is the same as in 3GPP (see [14]). It is described here for clarification, reduced to common channels required for S-MBMS services.

The MBMS channels are still under definition in 3GPP. Any change may impact clause 5.2.

5.2.1 Logical channels

All the logical channels are downlink only and point-to-multipoint. The following common logical channels are defined (see [14]):

- Broadcast Control Channel (BCCH): used to broadcast system- and spot-specific information. The BCCH is always transmitted over the entire spot;
- Paging Control Channel (PCCH): used to carry control information to UEs. The PCCH is always transmitted over the entire spot;
- Common Control Channel (CCCH): for transmitting control information to UEs;
- Common Traffic Channel (CTCH): for transfer of user information for all or a group of UEs.

The system is opened to introduction of new channels in line with 3GPP MBMS specifications progress, i.e.:

- MBMS Control Channel (MCCH): for transfer of control information related to MBMS services to UEs;
- Notifications Common Control Channel (NCCH): for transfer of notifications. This channel may replace MCCH in case only notifications would be required for control information;
- MBMS Traffic Channel (MTCH): for transfer of MBMS traffic.

In like manner of 3GPP MBMS specifications, MCCH and MTCH may be existing channels such as CCCH and CTCH.

5.2.2 Transport channels

Common transport channels are:

- Broadcast Channel (BCH): used for broadcast of system information into an entire spot;
- Paging Channel (PCH): used for broadcast of control information into an entire spot allowing efficient UE sleep mode procedures. Currently identified information types are paging and notification. Another use could be USRAN notification of change of BCCH information;
- Forward Access Channel (FACH): used for transmission of S-MBMS traffic.

To each transport channel, there is an associated transport format (for transport channels with a fixed or slow changing rate) or an associated Transport Format Set (TFS) (for transport channels with fast changing rate). A transport format is defined as a combination of encoding, interleaving, bit rate and mapping onto physical channels. A Transport Format Set is a set of Transport Formats.

5.2.3 Physical channels and signals

Physical channels and signals are:

- Primary Common Pilot Channel (P-CPICH): carries a pre-defined sequence of symbols. It is the phase reference for SCH, P-CCPCH, PICH and S-CCPCH. It is used by UEs for spot pilot synchronization, and downlink channels estimation;
- Secondary Common Pilot Channel (S-CPICH): optional. For hot spots service provision, i.e. operation with narrow antenna beams (either satellite or IMR antenna);
- Synchronization Channel (SCH): consists of two sub channels, the Primary and Secondary SCH. Used for cell search;

- Primary Common Control Physical Channel (P-CCPCH): carrying BCH;
- Secondary Common Control Physical Channel (S-CCPCH): carrying FACH and PCH;
- Paging Indicator Channel (PICH): associated to S-CCPCH. Indicates the frame number at with UE has to extract PCH from S-CCPCH.

5.2.4 Logical to transport channels mapping

The mappings as seen from the UE and UTRAN sides are shown in figures 5.2 and 5.3 respectively.

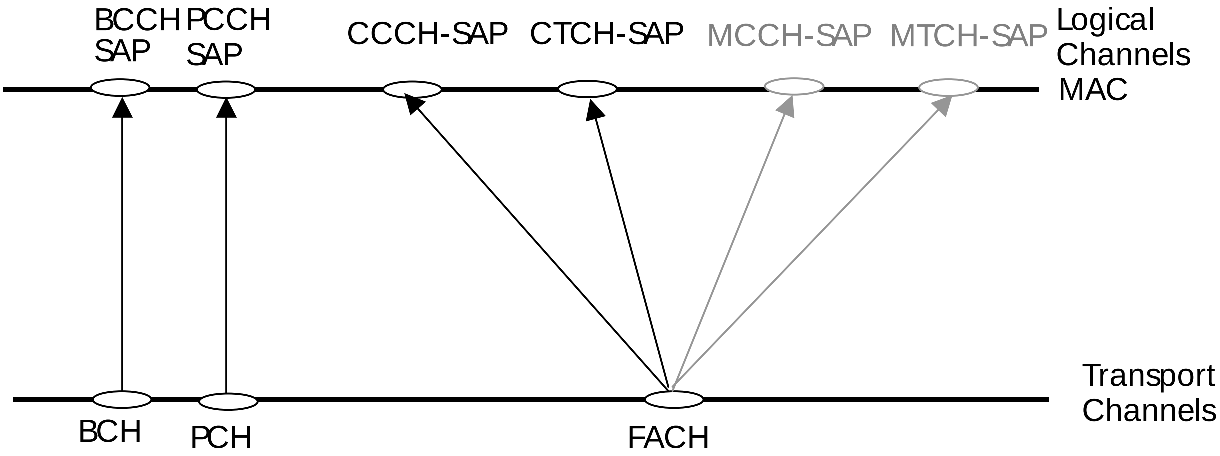


Figure 5.2: Logical channels mapped onto transport channels, seen from the UE side

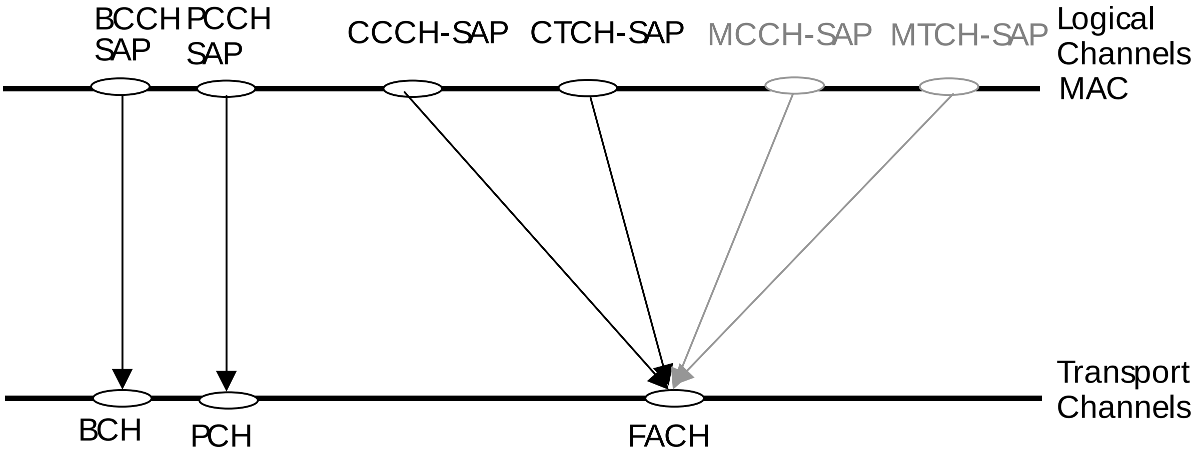


Figure 5.3: Logical channels mapped onto transport channels, seen from the UTRAN side

5.2.5 Mapping and association of physical channels

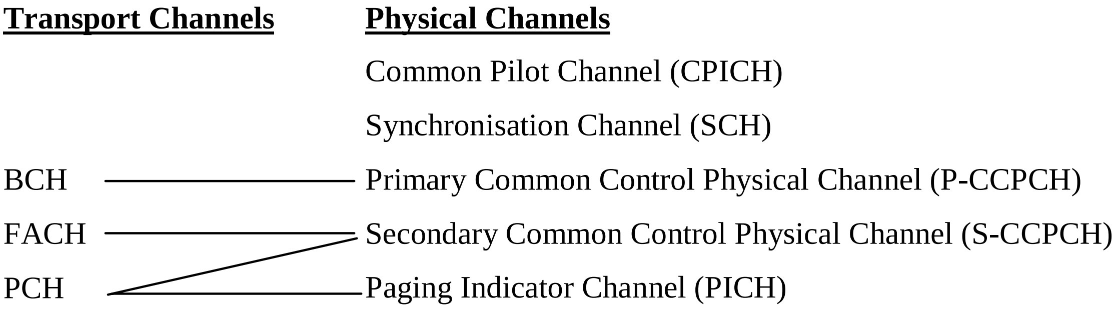


Figure 5.4: Mapping of transport channels onto physical channels

5.3 Physical channel structure

5.3.1 Common Pilot Channel (CPICH)

The Common Pilot Channel (CPICH) is a fixed rate (30 kbps, SF=256) downlink physical channel that carries a pre-defined bit/symbol sequence.

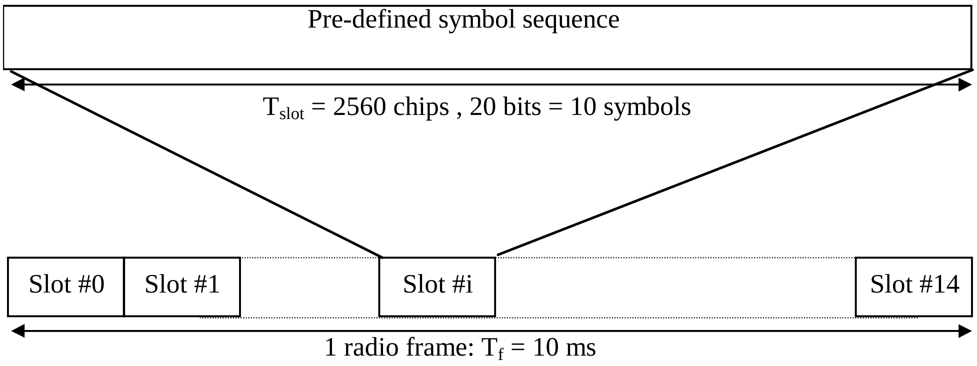


Figure 5.5: Frame structure of CPICH

There are two types of Common pilot channels, the Primary and Secondary CPICH.

5.3.1.1 Primary Common Pilot Channel (P-CPICH)

The P-CPICH characteristics are:

- the same channelization code is always used for the P-CPICH;
- the P-CPICH is scrambled by the primary scrambling code;
- there is one and only one P-CPICH per spot/cell;
- the P-CPICH is broadcast over the entire spot/cell;
- the Primary CPICH is a phase reference for the downlink physical channels.

5.3.1.2 Secondary Common Pilot Channel (S-CPICH)

The S-CPICH characteristics are:

- an arbitrary channelization code of SF=256 is used for the S-CPICH;
- a A S-CPICH is scrambled by either the primary or a secondary scrambling code;
- there may be zero, one, or several S-CPICH per spot/cell;
- a S-CPICH may be transmitted over the entire spot/cell or only over a part of the spot/cell.

5.3.2 Synchronization Channel (SCH)

The Synchronization Channel (SCH) is a downlink signal used for spot/cell search. The SCH consists of two sub-channels, the Primary and Secondary SCH. The 10 ms radio frames of the Primary and Secondary SCH are divided into 15 slots, each of length 2 560 chips.

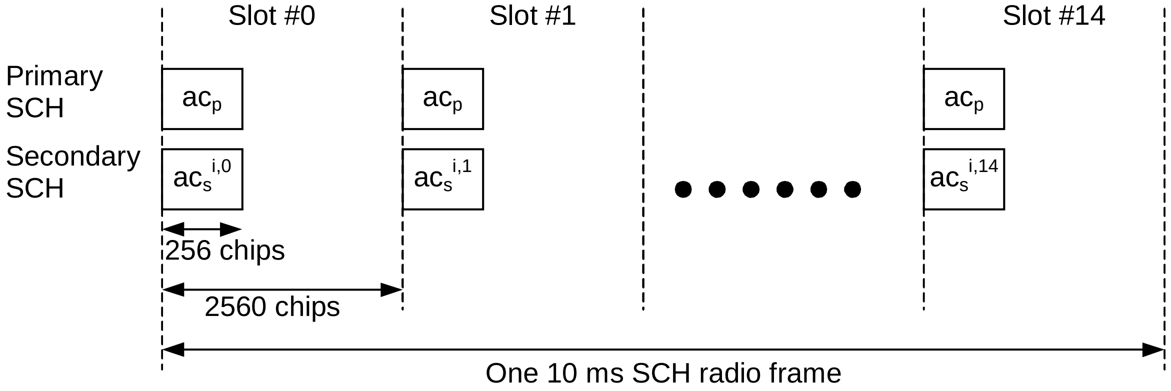


Figure 5.6: Structure of SCH

The Primary SCH consists of a modulated code of length 256 chips, the Primary Synchronization Code (PSC) denoted c_p in figure 5.6, transmitted once every slot. The PSC is the same for every spot in the system.

The Secondary SCH consists of repeatedly transmitting a length 15 sequence of modulated codes of length 256 chips, the Secondary Synchronization Codes (SSC), transmitted in parallel with the Primary SCH. The SSC is denoted $c_s^{i,k}$ in figure 5.6, where $i = 0, 1, \ldots, 63$ is the number of the scrambling code group, and $k = 0, 1, \ldots, 14$ is the slot number. Each SSC is chosen from a set of 16 different codes of length 256. This sequence on the Secondary SCH indicates which of the code groups the spot's downlink scrambling code belongs to.

5.3.3 Primary Common Control Physical Channel (P-CCPCH)

The Primary CCPCH is a fixed rate (30 kbps, SF=256) downlink physical channels used to carry the BCH transport channel.

The Primary CCPCH is not transmitted during the first 256 chips of each slot. Instead, Primary SCH and Secondary SCH are transmitted during this period.

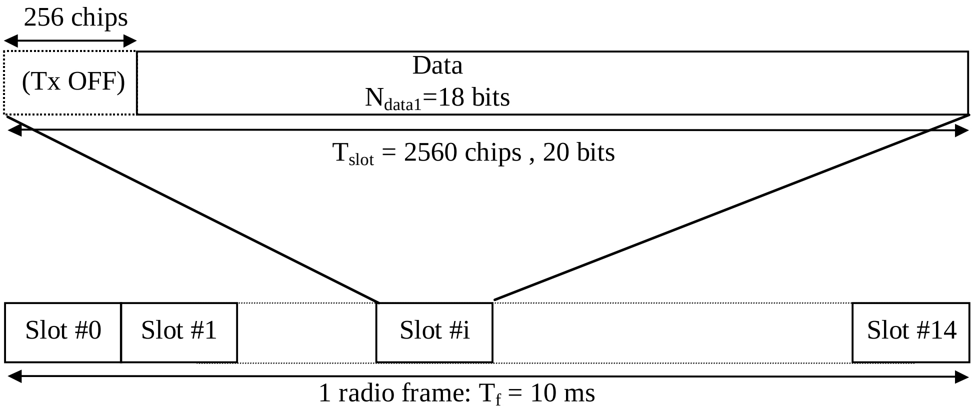


Figure 5.7: Frame structure of P-CCPCH

5.3.4 Secondary Common Control Physical Channel (S-CCPCH)

The Secondary CCPCH is used to carry the FACH and PCH. There are two types of Secondary CCPCH: those that include TFCI and those that do not include TFCI.

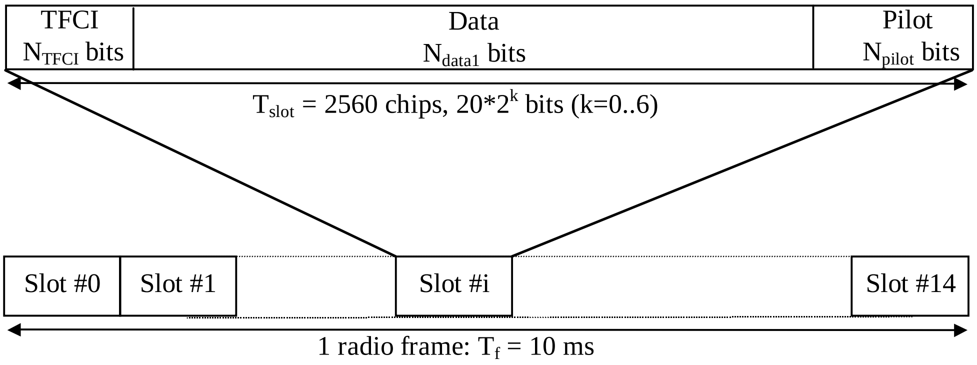


Figure 5.8: Frame structure of S-CCPCH

The parameter k in figure 5.8 determines the total number of bits per S-CCPCH slot. It is related to the spreading factor SF of the physical channel as $SF = 256/2^k$. The spreading factor range is from 256 down to 4.

The FACH and PCH can be mapped to the same or to separate S-CCPCHs. If FACH and PCH are mapped to the same Secondary CCPCH, they can be mapped to the same frame. S-CCPCH supports multiple transport format combinations using TFCI.

Table 5.2: S-CCPCH slot formats

Slot Format #i	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/Frame	Bits/ Slot	N_{data1}	N_{pilot}	N_{TFCI}
0	30	15	256	300	20	20	0	0
1	30	15	256	300	20	12	8	0
2	30	15	256	300	20	18	0	2
3	30	15	256	300	20	10	8	2
4	60	30	128	600	40	40	0	0
5	60	30	128	600	40	32	8	0
6	60	30	128	600	40	38	0	2
7	60	30	128	600	40	30	8	2
8	120	60	64	1 200	80	72	0	8
9	120	60	64	1 200	80	64	8	8
10	240	120	32	2 400	160	152	0	8
11	240	120	32	2 400	160	144	8	8
12	480	240	16	4 800	320	312	0	8
13	480	240	16	4 800	320	296	16	8
14	960	480	8	9 600	640	632	0	8
15	960	480	8	9 600	640	616	16	8
16	1 920	960	4	19 200	1 280	1 272	0	8
17	1 920	960	4	19 200	1 280	1 256	16	8

The pilot symbol pattern is as 3GPP (see [9]).

5.3.5 Paging Indicator Channel (PICH)

The Paging Indicator Channel (PICH) is a fixed rate (SF=256) physical channel used to carry the paging indicators. The PICH is always associated with an S-CCPCH to which a PCH transport channel is mapped.

One PICH radio frame of length 10 ms consists of 300 bits. Of these, 288 bits are used to carry paging indicators. The remaining 12 bits are not formally part of the PICH and are not transmitted. The part of the frame with no transmission is reserved for possible future use.

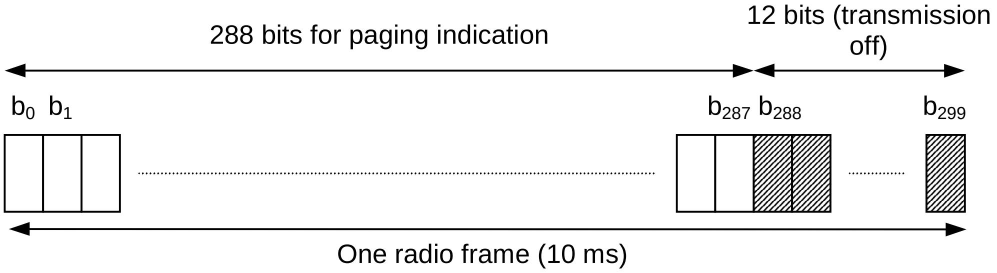


Figure 5.9: Structure of PICH

In each PICH frame, Np paging indicators {P_0, …, P_{Np-1}} are transmitted, where Np=18, 36, 72, or 144.

The PI is associated to the paging indicator P_q, where q is computed as a function of the PI computed by higher layers, the SFN of the P-CCPCH radio frame during which the start of the PICH radio frame occurs, and the number of paging indicators per frame (Np):

$$q = \left(PI + \left\lfloor \left(\left(18 \times \left(SFN + \lfloor SFN/8 \rfloor + \lfloor SFN/64 \rfloor + \lfloor SFN/512 \rfloor \right) \right) \bmod 144 \right) \times \frac{Np}{144} \right\rfloor \right) \bmod Np$$

Further, the PI calculated by higher layers is associated with the value of the paging indicator P_q. If a paging indicator in a certain frame is set to "1" it is an indication that UEs associated with this paging indicator and PI should read the corresponding frame of the associated S-CCPCH.

The PI bitmap in the PCH data frames over Iub contains indication values for all higher layer PI values possible. Each bit in the bitmap indicates if the paging indicator associated with that particular PI shall be set to 0 or 1. Hence, the calculation in the formula above is to be performed in Node B to make the association between PI and P_q.

The mapping from $\{P_0, \ldots, P_{Np-1}\}$ to the PICH bits $\{b_0, \ldots, b_{287}\}$ are according to table 5.3.

Table 5.3: Mapping of paging indicators P_q to PICH bits

Number of paging indicators per frame (Np)	$P_q = 1$	$P_q = 0$
Np=18	$\{b_{16q}, \ldots, b_{16q+15}\} = \{1, 1,\ldots, 1\}$	$\{b_{16q}, \ldots, b_{16q+15}\} = \{0, 0,\ldots, 0\}$
Np=36	$\{b_{8q}, \ldots, b_{8q+7}\} = \{1, 1,\ldots, 1\}$	$\{b_{8q}, \ldots, b_{8q+7}\} = \{0, 0,\ldots, 0\}$
Np=72	$\{b_{4q}, \ldots, b_{4q+3}\} = \{1, 1,\ldots, 1\}$	$\{b_{4q}, \ldots, b_{4q+3}\} = \{0, 0,\ldots, 0\}$
Np=144	$\{b_{2q}, b_{2q+1}\} = \{1, 1\}$	$\{b_{2q}, b_{2q+1}\} = \{0, 0\}$

5.3.6 Spreading and modulation

For all the channels excepted SCH, data modulation is QPSK where each pair of two bits are serial-to-parallel converted. Even numbered symbols are mapped to the I branch, odd numbered symbols are mapped to Q branch. Symbol number zero is defined as the first symbol in each frame. The I and Q branch are then spread to the chip rate with the same channelization code $c_{ch,SF,m}$ and subsequently scrambled by the spot/cell specific scrambling code $S_{dl,n}$.

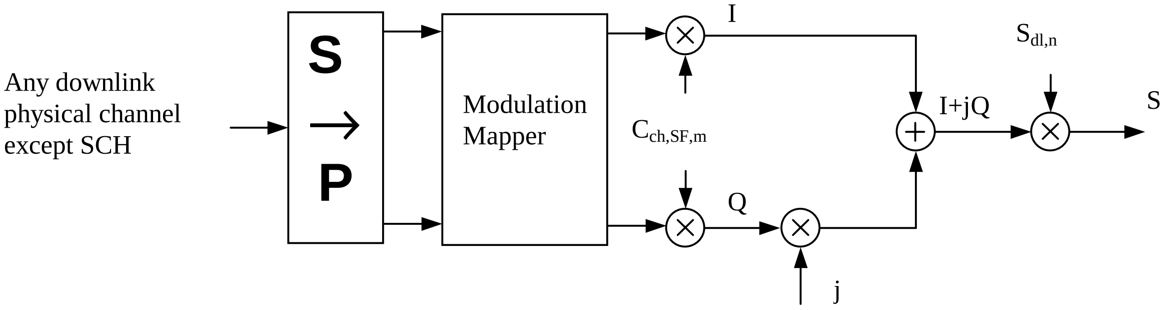


Figure 5.10: Spreading for all downlink physical channels except SCH

Figure 5.11 illustrates how different downlink channels are combined. Each complex-valued spread channel, corresponding to point S in figure 5.10, is separately weighted by a weight factor G_i. The complex-valued P-SCH and S-SCH are separately weighted by weight factors G_p and G_s. All downlink physical channels are then combined using complex addition.

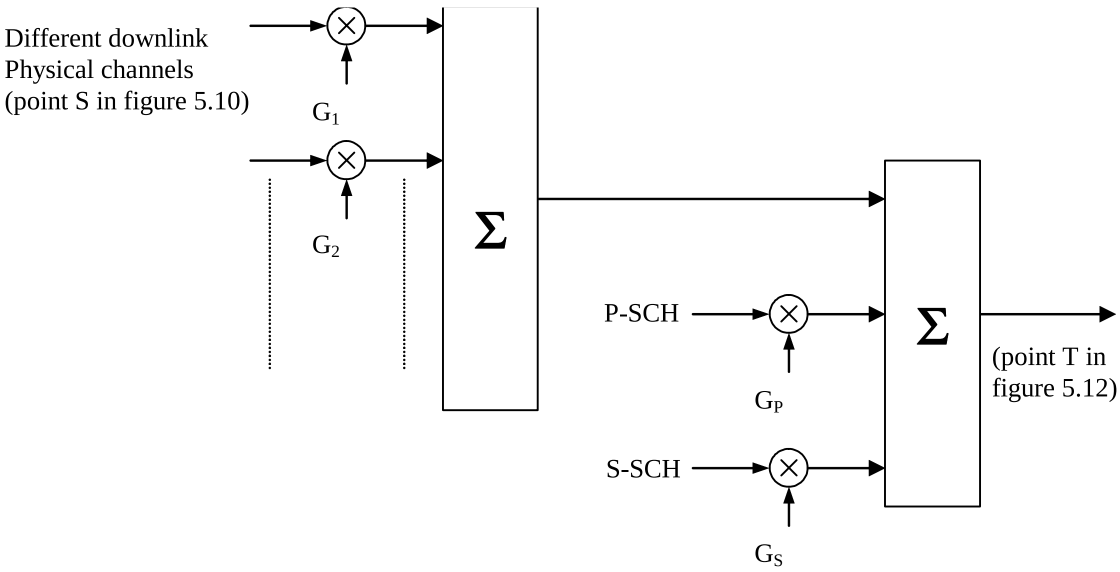


Figure 5.11: Downlink channels combination and Spreading for SCH

The modulating chip rate is 3,84 Mcps. The pulse-shaping filters are Root Raised Cosine (RRC) with roll-off α = 0,22 in the frequency domain.

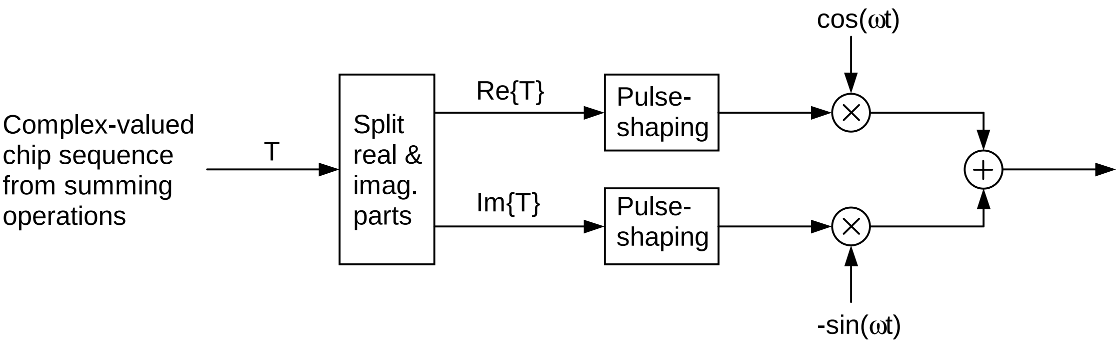


Figure 5.12: Downlink modulation

5.3.7 Code allocation

5.3.7.1 Scrambling codes

The downlink scrambling code c_{scramb} is a 38 400 chips (10 ms) segment of a length 2^{18} - 1 Gold code repeated in each frame. The scrambling codes are divided into 512 sets each of a primary scrambling code and 15 secondary scrambling codes.

The primary scrambling codes consist of scrambling codes n = 16 × i where i=0…511. The i:th set of secondary scrambling codes consists of scrambling codes 16 × i + k, where k = 1…15.

There is a one-to-one mapping between each primary scrambling code and 15 secondary scrambling codes in a set such that i:th primary scrambling code corresponds to i:th set of secondary scrambling codes.

Hence, according to the above, scrambling codes k = 0, 1, …, 8 191 are used.

The set of primary scrambling codes is further divided into 64 scrambling code groups, each consisting of 8 primary scrambling codes. The j:th scrambling code group consists of primary scrambling codes 16 × 8 × j + 16 × k, where j = 0..63 and k = 0..7.

Each spot/cell is allocated one and only one primary scrambling code. The P-CPICH, PICH, P-CCPCH and S-CCPCH carrying PCH are always transmitted using the primary scrambling code. S-CCPCH carrying FACH can be transmitted with either the primary scrambling code or a secondary scrambling code from the set associated with the primary scrambling code of the cell.

A grouping of the downlink codes is done in order to facilitate a fast spot/cell search.

5.3.7.2 Synchronization codes

The same synchronization codes as for 3GPP UTRAN are used (see [11]).

5.3.7.3 Channelization codes

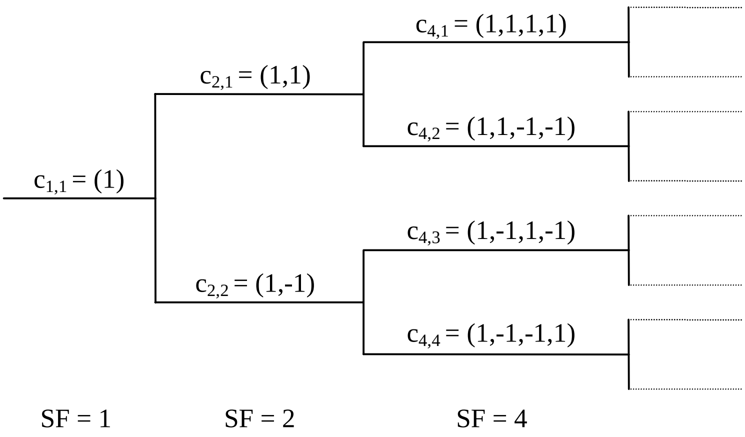


Figure 5.13: Code-tree for generation of OVSF codes

The channelization codes are Orthogonal Variable Spreading Factor (OVSF) codes that preserve the orthogonality between downlink channels of different rates and spreading factors. The OVSF codes can be defined using the code tree of figure 5.13.

Each level in the code tree defines channelization codes of length SF, corresponding to a spreading factor of SF. All codes within the code tree cannot be used simultaneously within one spot/cell. A code can be used in a spot/cell if and only if no other code on the path from the specific code to the root of the tree or in the sub-tree below the specific code is used in the same spot/cell. This means that the number of available channelization codes is not fixed but depends on the rate and spreading factor of each physical channel.

The channelization code for P-CPICH is fixed to $C_{ch,256,0}$.

The channelization code for P-CCPCH is fixed to $C_{ch,256,1}$.

The channelization codes for other physical channels are assigned dynamically by S-URAN.

5.4 Channel coding and service multiplexing

5.4.1 Channel coding/interleaving for user services

W-CDMA offers three basic service classes with respect to forward-error-correction (FEC) coding (see [10]):

- standard-services with convolutional coding;
- high-quality services with Turbo coding;
- services with service-specific coding, i.e. services for which the W-CDMA layer 1 does not apply any pre-specified channel coding.

Data arrives to the coding/multiplexing unit in form of transport block sets once every transmission time interval. The transmission time interval is transport-channel specific from the set {10 ms, 20 ms, 40 ms, and 80 ms}.

The following coding/multiplexing steps are defined (see [10]):

- add CRC to each transport block;
- transport block concatenation and code block segmentation;
- channel coding;
- radio frame equalization;
- rate matching;
- insertion of Discontinuous Transmission (DTX) indication bits;
- interleaving (two steps);
- radio frame segmentation;
- multiplexing of transport channels;
- physical channel segmentation;
- mapping to physical channels.

5.4.1.1 CRC attachment

Error detection is provided on transport blocks through a Cyclic Redundancy Check (CRC). The size of the CRC is 0, 8, 16 or 24 bits.

5.4.1.2 Transport block concatenation and code block segmentation

All transport blocks in a TTI are serially concatenated. If the number of bits in a TTI is larger than *Z*, the maximum size of a code block in question, then code block segmentation is performed after the concatenation of the transport blocks. The maximum size of the code blocks depends on whether convolutional coding, turbo coding or no coding is used.

5.4.1.3 Channel coding

The scheme of Turbo coder is a Parallel Concatenated Convolutional Code (PCCC) with two 8-state constituent encoders and one Turbo code internal interleaver.

Table 5.4: Channel coding scheme and coding rate

Type of TrCH	Coding scheme	Coding rate
BCH	Convolutional coding	1/2
PCH	Convolutional coding	1/2
FACH	Convolutional coding Turbo coding No coding	1/2,1/3 1/3

5.4.1.4 Radio frame size equalization

Radio frame size equalization is padding the input bit sequence in order to ensure that the output can be segmented in data segments of same size. Radio frame size equalization is only performed in the UL.

5.4.1.5 Radio frame segmentation

When the transmission time interval is longer than 10 ms, the input bit sequence is segmented and mapped onto consecutive radio frames. Following rate matching in the DL and radio frame size equalization in the UL the input bit sequence length is guaranteed to be an integer multiple of radio frames.

5.4.1.6 TrCH multiplexing

Every 10 ms, one radio frame from each TrCH is delivered to the TrCH multiplexing. These radio frames are serially multiplexed into a coded composite transport channel (CCTrCH).

5.4.1.7 Insertion of Discontinuous Transmission (DTX) indication bits

In the downlink, DTX is used to fill up the radio frame with bits. The insertion point of DTX indication bits depends on whether fixed or flexible positions of the TrCHs in the radio frame are used. It is up to the UTRAN to decide for each CCTrCH whether fixed or flexible positions are used during the connection. DTX indication bits only indicate when the transmission should be turned off, they are not transmitted.

5.4.1.8 Outer coding/interleaving

The current assumption for the outer Reed Salomon coding is a rate 4/5 code over the 2^8 - ary symbol alphabet.

After outer Reed Salomon coding, symbol-wise inter-frame block interleaving is applied.

5.4.1.9 Rate matching

After channel coding and service multiplexing, the total bit rate is almost arbitrary. The rate matching matches this rate to the limited set of possible bit rates of a Dedicated Physical Data Channel. Rate matching means that bits on a transport channel are repeated or punctured.

5.5 Radio resource functions

5.5.1 Initial spot/cell search

During the initial satellite spot/cell search, the UE searches for and determines the long code and frame synchronization of the spot/cell to which it has the lowest path loss. This is carried out in three steps.

5.5.1.1 Step 1: Slot synchronization

During the first step of the initial spot/cell search procedure, the UE uses the primary synchronization channel to acquire slot synchronization to the strongest spot/cell. This is done with a matched filter matched to the primary synchronization code c_p common to all spots/cell. The output of the matched filter, accumulated over a sufficient number of slot intervals, will give peaks for each ray of each spot/cell within range of the UE. Detecting the position of the strongest peak gives the timing of the strongest spot/cell modulo the slot length.

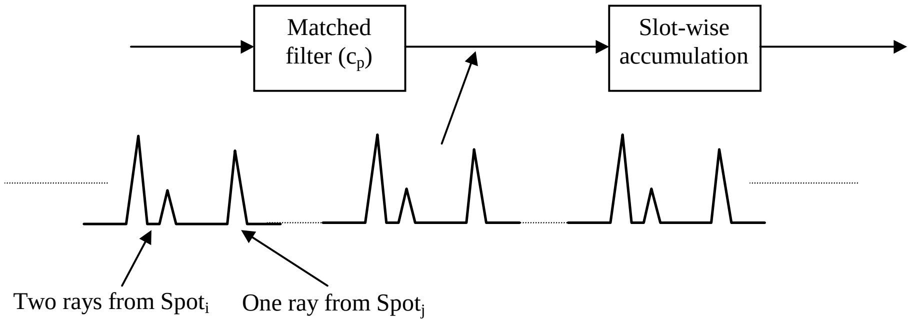


Figure 5.14: Matched-filter search for primary synchronization code

5.5.1.2 Step 2: Frame synchronization and code-group identification

During the next step of the initial spot/cell search procedure, the UE uses the secondary synchronization channel to find frame synchronization and identify the code group of the spot/cell found in the first step. This is done by correlating the received signal at the position of the secondary synchronization codes with all possible secondary synchronization codes. Note that the position of the Secondary synchronization codes are known after the first step, due to the known time offset between the primary and the secondary synchronization codes.

Furthermore, the frame synchronization is found from the modulation sequence of the secondary SCH.

5.5.1.3 Step 3: Scrambling-code identification

During the last step of the initial spot/cell search procedure, the UE determines the exact primary scrambling code used by the found spot/cell. The primary scrambling code is identified through symbol-by-symbol correlation over the CPICH with all scrambling codes within the code group identified in the second step.

After the scrambling code has been identified, the Primary CCPCH can be detected, super-frame synchronization can be acquired and the system- and spot/cell specific BCCH information can be read.

5.5.2 Radio resource allocation

5.5.2.1 Channelization codes

The channelization code for the BCCH is a predefined code which is the same for all spots/cell within the system.

The channelization code(s) used for the Secondary Common Control Physical Channel is broadcast on the BCCH.

The channelization codes for the S-CCPCH are decided by the network. The set of channelization codes may be changed during the duration of a S-MBMS service, typically as a result of a change of service or an inter-spot/cell handover. A change of downlink channelization codes is indicated to UEs on BCCH and/or PCH.

5.5.2.2 Scrambling code

The downlink scrambling code is assigned to the spot/cell at the initial deployment. The mobile station learns about the downlink scrambling code during the spot/cell search process.

5.5.2.3 IMR frequency and codes

Several radio resource allocation strategies can be adopted:

1) The first strategy, the simplest one on the point of view of resource allocation, is IMRs repeat the satellite signal as it is, i.e. on the same frequency and the same scrambling and channelization codes. This method, as explained in clause 6.1.3 "Test environment support" results in adding artificial multi-paths. Those multi-paths delays are to be restricted to the UE rake receiver window length, which is subject to introduce IMR deployment constraints for IMR signal repetition synchronization.

In order to soften the IMR synchronization constraints, other radio resource allocation strategies can be adopted, where the satellite spot coverage is considered as an umbrella cell to IMRs cell coverage.

2) Thus a second radio resource allocation strategy deals with IMRs satellite signal repetition on an other MSS frequency. Service continuity is ensured thanks to the UE hard handover capability.

3) In case of carrier frequency lack, a third radio resource allocation strategy consists in IMRs satellite signal repetition on the same frequency, but with a different scrambling code. The drawback of this strategy is additional interference for UEs in simultaneous view of satellite and IMR. It is foreseen a capacity loss of 50 %. Service continuity is ensured thanks to the UE multi-code scrambling reception capability (soft-handover).

5.5.3 Power control/balancing

The near-far effect in the satellite environment is not as influent as in terrestrial environment.

However power control has to be implemented in order not to waste system power and capacity.

Slow power level variations are due to different causes:

- satellite and UE antenna gain variations;
- shadowing;
- user speed changes;
- time varying co-channel interference.

S-MBMS is mapped to common channels, which by essence are not power controlled in line with UE radio conditions. Furthermore, due to the large coverage area (at least regional spot), it is not envisaged to implement dynamic power allocation.

Power control is limited to power balancing, i.e. power is allocated on a service and geographical priority basis:

- service priority means more power is allocated to emergency or high cost services;
- geographical priority means satellite power may be focused to hot spot areas.

Additionally, closed loop power control between layer 1 and RRC, at the network side, can be adjusted when gateway is equipped with a MSS receiver. In effect, assuming the gateway is under spot coverage, the MSS receiver measures interference, broadcast service quality reception, etc. Measurements are reported to RNC (RRC layer) which orders to Node B transmit power adaptation if required. Then spot transmit power is adjusted accordingly. This method allows for raw power control, which is not in line with each UE radio conditions under spot coverage, but which is an averaged estimation and takes into account interference variation due to broadcast traffic variation.

5.5.4 Handover

5.5.4.1 Intra-frequency handover

5.5.4.1.1 Soft handover

Soft handover deals with simultaneous service reception from several spots/cells and is applicable in case of either:

- intra-satellite spots coverage overlapping (single satellite system);
- inter-satellite spots coverage overlapping (multi satellites system);
- IMR deployment with scrambling code different from that of the satellite.

When in active broadcast reception mode, the UE continuously searches for new spots/cells on the current carrier frequency. This spot/cell search is carried out in basically the same way as the initial spot/cell search. The main difference compared to the initial spot/cell search is that an UE station has received a priority list from the network. This priority list describes in which order the downlink scrambling codes should be searched for and does thus significantly reduce the time and effort needed for the scrambling-code search (step 3). The priority list is continuously updated to reflect the changing neighbourhood of a moving UE.

During the search, the UE measures the received signal level broadcast from neighbouring spot/cell, compares them to a set of thresholds, and adds or removes satellite spot/IMR cell links from its *reception set.* The *reception set* is defined as the set of spots/cells from which the same S-MBMS traffic is received, simultaneously demodulated and coherently combined.

From the spot-search procedure, the UE knows the frame offset of the CCPCH of potential soft-handover candidates relative to that of the source spot(s)/cell(s). The frame offset between the S-CCPCH of the source and destination spots/cells at the UE receiver is depending on the maximum IMR cell radius.

5.5.4.1.2 Softer handover

Softer handover is the special case of a soft handover between sectors/spots belonging to the same gateway (Node B) site or the same IMR. Conceptually, a softer handover is similar to soft handover on the UE point of view.

5.5.4.2 Inter-frequency handover

Inter-frequency handover may typically occur in the following situations:

- handover between spots to which different number of carriers have been allocated, e.g. due to different capacity requirements (hot-spot scenarios);
- handover between spots of different overlapping orthogonal spot layers using different carrier frequencies;
- hHandover between spot and IMRs when IMRs repeat the signal on another frequency;
- handover between different operators/systems using different carrier frequencies including handover to terrestrial UMTS/GSM.

A key requirement for the support of seamless inter-frequency handover is the possibility for the UE to carry out spot search on a carrier frequency different from the current one, without affecting the ordinary data flow. W-CDMA supports inter-frequency spot search in two different ways, a dual-receiver approach and a slotted-downlink-transmission approach.

5.5.4.2.1 Dual-receiver

For a UE with receiver diversity, there is a possibility for one of the receiver branches to temporarily be reallocated from diversity reception and instead carry out reception on a different carrier, i.e. UE implements capability for simultaneous reception on distinct carriers.

5.5.4.2.2 Slotted downlink transmission

With slotted downlink transmission, it is possible for a single-receiver UE to carry out measurements on other frequencies without affecting the ordinary data flow. When in slotted mode, the information normally transmitted during a 10 ms frame is compressed in time, either by code puncturing or by reducing the spreading factor by a factor of 2. In this way, an idle time period of up to 5 ms is created within each frame. During that time, the UE receiver is idle and can be used for inter-frequency measurements.

This slotted downlink transmission may be applied periodically to all allocated S-MBMS channels.

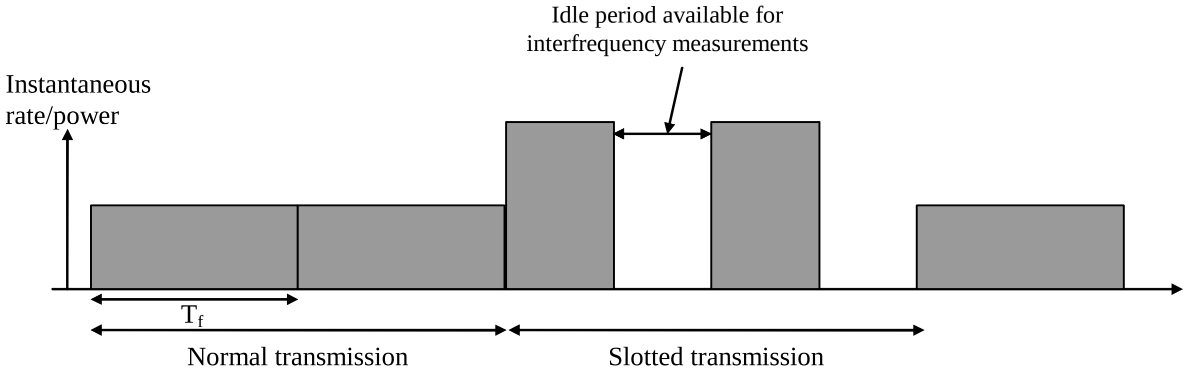


Figure 5.15: Downlink slotted transmission

5.6 Support of TDD

For further release.

6 Performance requirements

6.1 Test environment support

6.1.1 Satellite environment

UEs operate in either LOS or NLOS propagation conditions, i.e. either Rice or Rayleigh propagation channel.

Path blockage can be induced by heavy shadowing from hills, tress, bridges and buildings. The car body (vehicular UE configuration) and the head of the user (handset UE configuration) can also have a non-negligible impact. Tree shadowing can lead to 10 dB to 20 dB of excess attenuation and is often the cause for link outage.

The useful dynamic range for the received signal power is much smaller than for terrestrial environments (for which it goes up to 80 dB). This is due to the different system geometry (reduced path loss variation within each satellite beam, in the order of 3 dB to 5 dB) and to the limited satellite RF power which is insufficient to counteract path blockage.

Multi-path diversity in a single satellite system results in paths in the range of -20 dB below the main path. Multi-paths are exploited by rake receiver. Link level simulation results presented hereafter show the impact of these multi-paths on link budget, which can be dramatic for slow moving UEs.

In case the system is composed of more than one satellite, satellite diversity can be provided, including soft handover capability. Radio channels can benefit from this for link outage reduction and quality of service improvement.

Channel tap models from [2] are hereafter adopted.

Table 6.1: Channel model A (10 % delay spread values)

Tap number	Relative tap delay value (ns)	Tap amplitude distribution	Parameter of amplitude distribution (dB)	Average amplitude with respect to free space propagation	Rice factor (dB)	Doppler spectrum
1	0	LOS: Rice NLOS: Rayleigh	10 log c 10 log P_m	0,0 -7,3	10 -	Rice Classic
2	100	Rayleigh	10 log P_m	-23,6	-	Classic
3	180	Rayleigh	10 log P_m	-28,1	-	Classic

Table 6.2: Channel model B (50 % delay spread values)

Tap number	Relative tap delay value (ns)	Tap amplitude distribution	Parameter of amplitude distribution (dB)	Average amplitude with respect to free space propagation	Rice factor (dB)	Doppler spectrum
1	0	LOS: Rice NLOS: Rayleigh	10 log c 10 log P_m	0,0 -9,5	7 -	Rice Classic
2	100	Rayleigh	10 log P_m	-24,1	-	Classic
3	250	Rayleigh	10 log P_m	-25,1	-	Classic

Table 6.3: Channel model C (90 % delay spread values)

Tap number	Relative tap delay value (ns)	Tap amplitude distribution	Parameter of amplitude distribution (dB)	Average amplitude with respect to free space propagation	Rice factor (dB)	Doppler spectrum
1	0	LOS: Rice NLOS: Rayleigh	10 log c 10 log P_m	0,0 -12,1	3 -	Rice Classic
2	60	Rayleigh	10 log P_m	-17,0	-	Classic
3	100	Rayleigh	10 log P_m	-18,3	-	Classic
4	130	Rayleigh	10 log P_m	-19,1	-	Classic
5	250	Rayleigh	10 log P_m	-22,1	-	Classic

6.1.2 Intermediate Module Repeater environment (IMR)

When UEs are on view of IMRs only (no view of the satellite signal), radio environment is terrestrial, i.e. propagation conditions apply as they are specified by 3GPP standards (see [6]).

6.1.3 Combined satellite and IMR environment

When UEs are on view of both IMRs and satellite signals, IMRs introduce artificial multi-paths. The satellite and IMR paths are to be added in the rake receiver fingers set.

Satin project proposed propagation models that apply to combined satellite and IMR environment (see [33] and [34]). They are based on two IMR configurations:

- low power IMR: the cell radius is 400 m;
- high power IMR: the cell radius is 2 km.

In both cases, IMR taken as a reference is surrounded by 6 IMRs, with a regular hexagonal cellular layout. The distance of the UE from the reference IMR is 0,87 × cell radius. The path delay profiles extracted from reference [33] are depicted hereafter:

Table 6.4: Path delay profile; Low power IMR

Sat		Ref. IMR		IMR1		IMR2	
Relative delay (µs)	Avg. power (dB)	Relative delay (µs)	Avg. power (dB)	Relative delay (µs)	Avg. power (dB)	Relative delay (µs)	Avg. power (dB)
0,00	-3,8	1,99	0,0	0,32	-3,7	2,44	-13,2
		2,30	-1,0	0,63	-4,7	2,75	-14,2
		2,70	-9,0	1,03	-12,7	3,15	-22,2
		3,08	-10,0	1,41	-13,7	3,53	-23,2
		3,72	-15,0	2,05	-18,7	4,17	-28,2
		4,50	-20,0	2,83	-23,7	4,95	-33,2
IMR3		**IMR4**		**IMR5**		**IMR6**	
Relative delay (µs)	Avg. power (dB)	Relative delay (µs)	Avg. power (dB)	Relative delay (µs)	Avg. power (dB)	Relative delay (µs)	Avg. power (dB)
5,18	-17,5	6,16	-17,5	4,41	-13,2	1,30	-3,7
5,49	-18,5	6,47	-18,5	4,72	-14,2	1,61	-4,7
5,89	-26,5	6,87	-26,5	5,12	-22,2	2,01	-12,7
6,27	-27,5	7,25	-27,5	5,50	-23,2	2,39	-13,7
6,91	-32,5	7,89	-32,5	6,14	-28,2	3,03	-18,7
7,69	-37,5	8,67	-37,5	6,92	-33,2	3,81	-23,7

Table 6.5: Path delay profile; High power IMR

Sat		**Ref. IMR**		**IMR1**		**IMR2**	
Relative delay (µs)	Avg. power (dB)	Relative delay (µs)	Avg. power (dB)	Relative delay (µs)	Avg. power (dB)	Relative delay (µs)	Avg. power (dB)
0,00	-6,5	9,96	0,0	1,58	-3,7	1,58	-3,7
		10,27	-1,0	1,89	-4,7	1,89	-4,7
		10,67	-9,0	2,29	-12,7	2,29	-12,7
		11,05	-10,0	2,67	-13,7	2,67	-13,7
		11,69	-15,0	3,31	-18,7	3,31	-18,7
		12,47	-20,0	4,09	-23,7	4,09	-23,7
IMR3		**IMR4**		**IMR5**		**IMR6**	
Relative delay (µs)	Avg. power (dB)	Relative delay (µs)	Avg. power (dB)	Relative delay (µs)	Avg. power (dB)	Relative delay (µs)	Avg. power (dB)
25,91	-17,5	30,83	-17,5	22,04	-13,2	6,50	25,91
26,22	-18,5	31,14	-18,5	22,35	-14,2	6,81	26,22
26,62	-26,5	31,54	-26,5	22,75	-22,2	7,21	26,62
27,00	-27,5	31,92	-27,5	23,13	-23,2	7,59	27,00
27,64	-32,5	32,56	-32,5	23,77	-28,2	8,23	27,64
28,42	-37,5	33,34	-37,5	24,55	-33,2	9,01	28,42

Satin project proposed a set of propagation conditions for defining performance test cases inspired by those of 3GPP specifications, taking into account the presence of IMRs and of the direct path from satellite. The test propagation conditions extracted from reference [33] are depicted hereafter.

Table 6.6: Path delay profiles; Combined Satellite and IMRs test cases

S-Case 1 speed 3km/h		**S-Case 2 speed 3 km/h**		**S-Case 3 speed 120 km/h**		**S-Case 4 speed 250 km/h**		**S-Case 5 speed 120 km/h**		**S-Case 6 speed 250 km/h**	
Relative delay [ns]	Average power [dB]	Relative delay [ns]	Average power [dB]	Relative delay [ns]	Average power [dB]	Relative delay [ns]	Average power [dB]	Relative delay [ns]	Average power [dB]	Relative delay [ns]	Average power [dB]
0	0	0	0	0	0	0	0	0	-3	0	-3
1 042	-10	1 042	0	260	-3	260	-3	260	-3	260	-3
		26 563	0	521	-6	521	-6	521	-9	521	-9
				781	-9	781	-9	1 042	-3	1 042	-3
								1 302	-3	1 302	-3
								1 562	-3	1 562	-3
								1 823	0	1 823	0
								2 083	0	2 083	0
NOTE: For case 5 and case 6, tap at 0 ns is Rice distributed.											

6.1.4 Aeronautical environment

Aeronautical environment is derived from [41], for a speed of 800 km/h.

Table 6.7: Channel model; Aeronautical; 800 km/h

Tap number	**Relative delay (ns)**	**Average power (dB)**	**Rice factor (dB)**	**Doppler spectrum**
1	0	0	14	Rice
2	11 500	-18	-	

6.2 Expected performances

6.2.1 Summary of test measurement services

The reference measurement channel for the 4 test services is summarized hereafter. Detailed description is given in annex 1.

Table 6.8: Reference measurement channels

Parameter	FACH for CTCH				Unit
Information bit rate	8	64	144	384	kbps
Physical channel	15	120	240	480	ksps
Spreading factor	256	16	8	4	-
Repetition rate	-	-	-	-	%
Time Transmission Interval	20	20	20	10	ms
Type of Error Protection	Convolutional	Turbo			-
Coding Rate	1/3				-
Size of CRC	16				Bit

The CPICH must cover the entire spot area. Thus the CPICH power is adjusted in order a UE in the worst case position is able to correctly receive it. The same applies to the SCH, the P-CCPCH and the PICH.

The worst case UE position is considered as being the border of the lower spot elevation (16°).

The required power at UE receiver input is deduced from the physical common channels characteristics defined for the reception of the 4 test services as defined in TS 134 121 [24].

Table 6.9: Power at UE receiver input; Common physical channels

Physical Channel	Ec/Îor Power	Power at UE receiver input
P-CPICH	P-CPICH_$E_c/\hat{I}_{or}$ = –10 dB	-71 dBm
P-CCPCH	P-CCPCH_$E_c/\hat{I}_{or}$ = –12 dB	-73 dBm
SCH	SCH_$E_c/\hat{I}_{or}$ = –12 dB	-73 dBm
PICH	PICH_$E_c/\hat{I}_{or}$ = –15 dB	-76 dBm

6.2.2 FACH demodulation requirements

Link level simulations have been run for the test environments and services described above in order to specify the FACH receiver performance requirements.

The tables in next clauses include margin in order to take into account effects that are not modelled in simulations (imperfect channel estimation and path search, over sampling, number of floating points, and all UE hardware margin).

The results presented apply to a Block Error Ratio (BLER) of 10^{-2}.

Table 6.10: Margin applied to FACH performance

Channel	Margin	Note
AWGN	2 dB	
Case 1, Case 2 S-Case 1, S-Case 2	2,5 dB	Slow fading
Case 3,… Case 6 S-Case 3, … S-Case 6	3 dB	Fast fading
Aeronautical	4 dB	LOS
Other channels: 3 km/h, 50 km/h 120 km/h, 250 km/h	 2,5 dB 3 dB	 Slow fading Fast fading

6.2.2.1 Demodulation in static conditions

Table 6.11: FACH parameters in static propagation conditions

Parameter	Unit	
Phase reference		P-CPICH
$\hat{I}_{or}/I_{oc}$	dB	-1
I_{oc}	dBm/3,84 MHz	-60

Table 6.12: FACH requirements in static propagation conditions

Data rate	$\frac{S-CCPCH\_E_c}{I_{or}}$	$\frac{E_b}{N_t}$
8 kbps	-20,6 dB	6,3 dB
64 kbps	-13,8 dB	4 dB
144 kbps	-10,7 dB	3,6 dB
384 kbps	-6,3 dB	3,7 dB

6.2.2.2 Demodulation in ITU Channel model A conditions

The average $\frac{S-CCPCH\_E_c}{I_{or}}$ power ratio is specified for 2 UE locations: 20 % around spot centre and spot borders.

Empty compartments mean the service is not reachable (situations suffering from too high adjacent-spot interference).

Table 6.13: FACH parameters in ITU channel model A conditions

Parameter	Unit	Test 1	Test 2
Phase reference		P-CPICH	
$\hat{I}_{or}/I_{oc}$	dB	9	-3
I_{oc}	dBm/3,84 MHz	-60	
Information Data Rate	kbps	20 % spot centre	Spot border

Table 6.14: FACH requirements in ITU channel model A conditions

Data rate	Speed	$\frac{S-CCPCH\_E_c}{I_{or}}$						$\frac{E_b}{N_t}$		
		$\frac{\hat{I}_{or}}{I_{oc}} = 9dB$			$\frac{\hat{I}_{or}}{I_{oc}} = -3dB$					
		LOS	/	*NLOS*	LOS	/	*NLOS*	LOS	/	*NLOS*
8 kbps	3 km/h	-28,6 dB	/	-15,8 dB	-16,6 dB	/	-3,8 dB	7,2 dB	/	20 dB
	50 km/h	-28,5 dB	/	-24,3 dB	-16,5 dB	/	-12,3 dB	7,3 dB	/	11,5 dB
	120 km/h	-27,8 dB	/	-25,2 dB	-15,8 dB	/	-13,2 dB	8 dB	/	10,6 dB
	250 km/h	-27,4 dB	/	-18,6 dB	-15,4 dB	/	-6,6 dB	8,4 dB	/	17,2 dB
64 kbps	3 km/h	-21,8 dB	/	-8 dB	-9,8 dB	/	-	5 dB	/	18,8 dB
	50 km/h	-21,8 dB	/	-16,7 dB	-9,8 dB	/	-4,7 dB	5 dB	/	10 dB
	120 km/h	-21,3 dB	/	-18 dB	-9,3 dB	/	-6 dB	5,5 dB	/	8,8 dB
	250 km/h	-21,1 dB	/	-10,1 dB	-9,1 dB	/	-	5,7 dB	/	16,7 dB
144 kbps	3 km/h	-18,7 dB	/	-4,8 dB	-6,7 dB	/	-	4,6 dB	/	18,4 dB
	50 km/h	-18,6 dB	/	-13,5 dB	-6,6 dB	/	-1,5 dB	4,6 dB	/	9,7 dB
	120 km/h	-18,2 dB	/	-14,7 dB	-6,2 dB	/	-2,7 dB	5 dB	/	8,5 dB
	250 km/h	-18,1 dB	/	-	-6,1 dB	/	-	5,2 dB	/	24 dB
384 kbps	3 km/h	-14 dB	/	-	-2 dB	/	-	5 dB	/	20,2 dB
	50 km/h	-14,1 dB	/	-6,5 dB	-2,1 dB	/	-	4,9 dB	/	12,5 dB
	120 km/h	-13,6 dB	/	-7,5 dB	-1,6 dB	/	-	5,4 dB	/	11,4 dB
	250 km/h	-13,6 dB	/	-2,3 dB	-1,6 dB	/	-	5,4 dB	/	16,1 dB

6.2.2.3 Demodulation in ITU Channel model B conditions

The average $\frac{S-CCPCH\_E_c}{I_{or}}$ power ratio is specified for 2 UE locations: 20 % around spot centre and spot borders.

Empty compartments mean the service is not reachable (situations suffering from too high inter-spot interference).

Table 6.15: FACH parameters in ITU channel model B conditions

Parameter	Unit	Test 1	Test 2
Phase reference		P-CPICH	
$\hat{I}_{or}/I_{oc}$	dB	9	-3
I_{oc}	dBm/3,84 MHz	-60	
Information Data Rate	kbps	20 % spot centre	Spot border

Table 6.16: FACH requirements in ITU channel model B conditions

Data rate	Speed	$\frac{S-CCPCH\_E_c}{I_{or}}$		$\frac{E_b}{N_t}$
		$\frac{\hat{I}_{or}}{I_{oc}} = 9dB$	$\frac{\hat{I}_{or}}{I_{oc}} = -3dB$	
		LOS / *NLOS*	LOS / *NLOS*	LOS / *NLOS*
8 kbps	3 km/h	-28,1 dB / -17,2 dB	-16,1 dB / -5,3 dB	7,7 dB / 10,1 dB
	50 km/h	-28 dB / -24,6 dB	-16 dB / -12,7 dB	7,8 dB / 11,2 dB
	120 km/h	-27,2 dB / -25,3 dB	-15,2 dB / -13,3 dB	8,7 dB / 10,5 dB
	250 km/h	-26,8 dB / -12,4 dB	-14,8 dB / -0,5 dB	9 dB / 23,3 dB
64 kbps	3 km/h	-21,3 dB / -9,3 dB	-9,3 dB / -	5,5 dB / 8,8 dB
	50 km/h	-21,4 dB / -17,1 dB	-9,4 dB / -5,2 dB	5,4 dB / 9,6 dB
	120 km/h	-20,9 dB / -18,2 dB	-8,9 dB / -6,2 dB	5,9 dB / 8,6 dB
	250 km/h	-20,6 dB / -12,1 dB	-8,6 dB / -0,1 dB	6,1 dB / 14,6 dB
144 kbps	3 km/h	-18,1 dB / -6 dB	-6,1 dB / -	5,1 dB / 8,6 dB
	50 km/h	-18,2 dB / -13,9 dB	-6,2 dB / -1,9 dB	5,1 dB / 9,3 dB
	120 km/h	-17,7 dB / -14,9 dB	-5,7 dB / -3 dB	5,5 dB / 8,3 dB
	250 km/h	-17,7 dB / -6,6 dB	-5,7 dB / -	5,6 dB / 16,6 dB
384 kbps	3 km/h	-13,3 dB / -0,4 dB	-1,3 dB / -	5,7 dB / 9,3 dB
	50 km/h	-13,6 dB / -7,1 dB	-1,6 dB / -	5,4 dB / 11,8 dB
	120 km/h	-13,2 dB / -8,1 dB	-1,2 dB / -	5,8 dB / 10,8 dB
	250 km/h	-13,1 dB / -3,4 dB	-1,1 dB / -	5,9 dB / 15,5 dB

6.2.2.4 Demodulation in ITU Channel model C conditions

The average $\frac{S-CCPCH\_E_c}{I_{or}}$ power ratio is specified for 2 UE locations: 20 % around spot centre and spot borders.

Empty compartments mean the service is not reachable (situations suffering from too high inter-spot interference).

Table 6.17: FACH parameters in ITU channel model C conditions

Parameter	Unit	Test 1	Test 2
Phase reference		P-CPICH	
$\hat{I}_{or}/I_{oc}$	dB	9	-3
I_{oc}	dBm/3,84 MHz	-60	
Information Data Rate	kbps	20 % spot centre	Spot border

Table 6.18: FACH requirements in ITU channel model C conditions

Data rate	Speed	$\frac{S-CCPCH\_E_c}{I_{or}}$		$\frac{E_b}{N_t}$
		$\frac{\hat{I}_{or}}{I_{oc}} = 9dB$	$\frac{\hat{I}_{or}}{I_{oc}} = -3dB$	
		LOS / *NLOS*	LOS / *NLOS*	LOS / *NLOS*
8 kbps	3 km/h	-26,8 dB / -18 dB	-14,8 dB / -7,6 dB	9 dB / 0 dB
	50 km/h	-26,7 dB / -24 dB	-14,7 dB / -13,6 dB	9,1 dB / 10 dB
	120 km/h	-25,4 dB / -24,3 dB	-13,4 dB / -13,8 dB	10,4 dB / 9,8 dB
	250 km/h	-25 dB / -19,7 dB	-13 dB / -9,3 dB	10,8 dB / 14,4 dB
64 kbps	3 km/h	-19,9 dB / -10,1 dB	-8 dB / -	6,8 dB / 0 dB
	50 km/h	-20 dB / -16,5 dB	-8 dB / -6,1 dB	6,7 dB / 8,5 dB
	120 km/h	-19,6 dB / -17,2 dB	-7,6 dB / -6,8 dB	7,2 dB / 7,8 dB
	250 km/h	-19,2 dB / -13,6 dB	-7,2 dB / -3,2 dB	7,6 dB / 11,4 dB
144 kbps	3 km/h	-16,7 dB / -6,8 dB	-4,7 dB / -	6,6 dB / 0 dB
	50 km/h	-16,8 dB / -13,3 dB	-4,8 dB / -2,9 dB	6,5 dB / 8,2 dB
	120 km/h	-16,3 dB / -13,9 dB	-4,4 dB / -3,5 dB	6,9 dB / 7,5 dB
	250 km/h	-16,1 dB / -10,6 dB	-4,1 dB / -0,2 dB	7,1 dB / 10,9 dB
384 kbps	3 km/h	-11 dB / -1,6 dB	- / -	8 dB / 0 dB
	50 km/h	-11,6 dB / -7,1 dB	- / -	7,4 dB / 10,1 dB
	120 km/h	-11,3 dB / -7,9 dB	- / -	7,7 dB / 9,4 dB
	250 km/h	-11 dB / -2,7 dB	- / -	7,9 dB / 13,6 dB

6.2.2.5 Demodulation in IMR environment conditions

FACH parameters for other cell interference are specified as reference [6].

Table 6.19: FACH requirements in IMR conditions

Case 1			**Case 2**			**Case 3**		
Data rate	$\frac{S-CCPCH\_E_c}{I_{or}}$	$\frac{E_b}{N_t}$	**Data rate**	$\frac{S-CCPCH\_E_c}{I_{or}}$	$\frac{E_b}{N_t}$	**Data rate**	$\frac{S-CCPCH\_E_c}{I_{or}}$	$\frac{E_b}{N_t}$
8 kbps	-18,5 dB	17 dB	8 kbps	-9,4 dB	13,1 dB	8 kbps	-11,7 dB	11,3 dB
64 kbps	-10,3 dB	16,1 dB	64 kbps	-2,8 dB	10,7 dB	64 kbps	-7 dB	7,1 dB
144 kbps	-7,1 dB	15,8 dB	144 kbps	-5,1 dB	14,4 dB	144 kbps	-8 dB	7,1 dB
384 kbps	-2,5 dB	16,1 dB	384 kbps	-3,2 dB	7,2 dB	384 kbps	-4,7 dB	7,7 dB
Case 4			**Case 5**			**Case 6**		
Data rate	$\frac{S-CCPCH\_E_c}{I_{or}}$	$\frac{E_b}{N_t}$	**Data rate**	$\frac{S-CCPCH\_E_c}{I_{or}}$	$\frac{E_b}{N_t}$	**Data rate**	$\frac{S-CCPCH\_E_c}{I_{or}}$	$\frac{E_b}{N_t}$
8 kbps	-7,5 dB	15,3 dB	8 kbps	-12,6 dB	11,2 dB	8 kbps	-9,6 dB	13,5 dB
64 kbps	-	-	64 kbps	-10,2 dB	4,5 dB	64 kbps	-5,2 dB	8,9 dB
144 kbps	-0,4 dB	13,9 dB	144 kbps	-8,3 dB	8,8 dB	144 kbps	-6,1 dB	8,9 dB
384 kbps	-	-	384 kbps	-4,7 dB	11,1 dB	384 kbps	-1,4 dB	11 dB

6.2.2.6 Demodulation in combined satellite and IMR environment conditions

Table 6.20: FACH parameters in combined satellite and IMR environment conditions

Parameter	**Unit**				
Phase reference		P-CPICH			
$\hat{I}_{or}/I_{oc}$	dB	-3	-3	3	6
I_{oc}	dBm/3,84 MHz	-60			
Information Data Rate	kbps	12,2	64	144	384

Table 6.21: FACH requirements in combined satellite and IMR conditions

Data rate	Speed	$\frac{S-CCPCH\_E_c}{I_{or}}$ High power / Low power	$\frac{E_b}{N_t}$ High power / Low power
8 kbps	3 km/h	-12,2 dB / -11,7 dB	10,1 dB / 10,8 dB
	50 km/h	-13,9 dB / -13,6 dB	8,5 dB / 8,8 dB
	120 km/h	-13,2 dB / -12,9 dB	9,2 dB / 9,5 dB
	250 km/h	-11,6 dB / -11,1 dB	10,8 dB / 11,3 dB
64 kbps	3 km/h	-4,5 dB / -3,9 dB	8,8 dB / 9,5 dB
	50 km/h	-6,7 dB / -6,3 dB	6,7 dB / 7,1 dB
	120 km/h	-6,2 dB / -6 dB	7,1 dB / 7,4 dB
	250 km/h	-4,8 dB / -4,5 dB	8,6 dB / 8,9 dB
144 kbps	3 km/h	-4,5 dB / -3,9 dB	8,6 dB / 9,4 dB
	50 km/h	-6,8 dB / -6,5 dB	6,4 dB / 6,8 dB
	120 km/h	-6,4 dB / -6,1 dB	6,8 dB / 7,2 dB
	250 km/h	-5 dB / -4,6 dB	8,1 dB / 8,7 dB
384 kbps	3 km/h	-0,6 dB / -0,1 dB	9,3 dB / 10,1 dB
	50 km/h	-2,4 dB / -1,9 dB	7,4 dB / 8,1 dB
	120 km/h	-2,2 dB / -1,8 dB	7,7 dB / 8,3 dB
	250 km/h	-0,8 dB / -0,2 dB	9,1 dB / 9,8 dB

Performance requirements for the candidate test cases from Satin are presented hereafter (applicable to low power IMRs).

FACH parameters for other cell interference are specified as [6].

Table 6.22: FACH requirements in combined satellite and low power IMR conditions; satin test cases

S-Case 1			**S-Case 2**			**S-Case 3**		
Data rate	$\frac{S-CCPCH\_E_c}{I_{or}}$	$\frac{E_b}{N_t}$	**Data rate**	$\frac{S-CCPCH\_E_c}{I_{or}}$	$\frac{E_b}{N_t}$	**Data rate**	$\frac{S-CCPCH\_E_c}{I_{or}}$	$\frac{E_b}{N_t}$
8 kbps	-18,5 dB	17 dB	8 kbps	-9,6 dB	12,9 dB	8 kbps	-14 dB	9,1 dB
64 kbps	-10,3 dB	16,1 dB	64 kbps	-3 dB	10,5 dB	64 kbps	-7 dB	7,1 dB
144 kbps	-7,1 dB	15,8 dB	144 kbps	-5,3 dB	14,2 dB	144 kbps	-8 dB	7,1 dB
384 kbps	-1,9 dB	16,7 dB	384 kbps	-3,4 dB	6,8 dB	384 kbps	-3,7 dB	8,7 dB
S-Case 4			**S-Case 5**			**S-Case 6**		
Data rate	$\frac{S-CCPCH\_E_c}{I_{or}}$	$\frac{E_b}{N_t}$	**Data rate**	$\frac{S-CCPCH\_E_c}{I_{or}}$	$\frac{E_b}{N_t}$	**Data rate**	$\frac{S-CCPCH\_E_c}{I_{or}}$	$\frac{E_b}{N_t}$
8 kbps	-11,9 dB	11,2 dB	8 kbps	-13,8 dB	8,6 dB	8 kbps	-10,9 dB	11,4 dB
64 kbps	-5,2 dB	8,9 dB	64 kbps	-7 dB	6,4 dB	64 kbps	-4,7 dB	8,7 dB
144 kbps	-6,1 dB	8,9 dB	144 kbps	-6,4 dB	6,8 dB	144 kbps	-4,1 dB	9,1 dB
384 kbps	-1,4 dB	11 dB	384 kbps	-1,7 dB	8,2 dB	384 kbps	-	-

6.2.2.7 Demodulation in aeronautical environment

The requirements hereafter are applicable to a velocity of 800 km/h.

The average $\frac{S-CCPCH\_E_c}{I_{or}}$ power ratio is specified for 2 UE locations: 20 % around spot centre and spot borders.

Table 6.23: FACH parameters in ITU channel model C conditions

Parameter	Unit	Test 1	Test 2
Phase reference		P-CPICH	
$\hat{I}_{or}/I_{oc}$	dB	9	-3
I_{oc}	dBm/3,84 MHz	-60	
Information Data Rate	kbps	20 % spot centre	Spot border

Table 6.24: FACH requirements in aeronautical environment

Data rate	$\frac{S-CCPCH\_E_c}{I_{or}}$		$\frac{E_b}{N_t}$
	$\frac{\hat{I}_{or}}{I_{oc}}=9dB$	$\frac{\hat{I}_{or}}{I_{oc}}=-3dB$	
8 kbps	-26,3 dB	-14,3 dB	9,5 dB
64 kbps	-20 dB	-8 dB	6,7 dB
144 kbps	-17,1 dB	-5,1 dB	6,2 dB
384 kbps	-12,8 dB	-0,8 dB	6,2 dB

6.2.3 Demodulation requirements synthesis

6.2.3.1 Propagation link margin

The simulation results show that for UEs in mobile environment a link margin is to be added to the AWGN case. The most critical case is for ITU channel model A NLOS, at 3 km/h. The maximum link margins to be added to the AWGN test case is summarized in table 6.25, for 2 deployment scenarios: satellite only and satellite + IMRs.

Table 6.25: Maximum propagation link margin

Service type	**Link margin Sat. only (see note 1)**	**Link margin Sat. + IMR (see note 2)**
Audio 8 kbps	16 dB	10 dB
Data 64 kbps	14,2 dB	11,5 dB
Data 144 kbps	19,4 B	11,7 dB
Data 384 kbps	16 dB	12,5 dB
NOTE 1: ITU channel model A NLOS, 3 km/h. NOTE 2: Satin case 1.		

As shown in table 6.25, IMR deployment allows to reduce link margin. This advantage is to be added to the fact IMRs deployment solves the problem of path blockage inherent to satellite systems.

Introducing this link margin drives to the situation that the system is designed for allowing indoor penetration, as specified by ITU Recommendation for indoor satellite environment (10 dB to 15 dB margin, see [5]).

6.2.3.2 Increasing interleaving depth

Required E_b/N_t, and thus average $\frac{S-CCPCH\_E_c}{I_{or}}$ power ratio, can be decreased by increasing interleaving depth.

One drawback of increasing interleaving depth is that this requires increasing UE memory size for buffering frames. This could be sensible for high data rate services (384 kbps).

Simulations have been run with interleaving depth of 4 and 8 for all the test environments. The simulation results show a decrease of the required propagation link margin, and an homogenisation whatever the service type.

The maximum required link margin and the reduction of the required link margin to be compared to the test cases are depicted in table 6.26.

Table 6.26: Link margin gain with interleaving depth 4 and 8

Service type	TTI = 40ms		TTI = 80ms	
	Link margin	**Margin gain**	**Link margin**	**Margin gain**
Audio 8 kbps	10,7 dB	5,3 dB	8,9 dB	7,1 dB
Data 64 kbps	11,9 dB	2,3 dB	10 dB	4,2 dB
Data 144 kbps	12 dB	7,4 dB	10 dB	9,4 dB
Data 384 kbps	12,2 dB	3,8 dB	10,4 dB	2,1 dB

6.2.3.3 Spatial diversity

Reception quality can be improved with two kinds of spatial diversity: UE antenna diversity and satellite diversity.

NOTE: Satellite antenna diversity is not considered for satellite complexity reasons.

6.2.3.3.1 UE antenna diversity

UE may be equipped with two reception antennas.

Simulation results show a reduction of the required link margin regarding the propagation channel as depicted in table 6.27.

Table 6.27: Link margin reduction; UE antenna diversity

Propagation channel	Link margin reduction
AWGN	3
Case 1, S-case 1	6,5
Case 2, S-case 2	5,8
Case 3, S-case 3	3,6
Case 4	7
Case 5, S-case 5	4
Case 6, S-case 6	4
S-case 4	4,4
ITU A, B, C (LOS)	3 dB to 3,8 dB
ITU A, B (NLOS)	4 dB to 8 dB
ITU C NLOS	3 dB to 6 dB
High and low power IMR	3 dB to 3,6 dB

6.2.3.3.2 Satellite diversity

Satellite diversity can be provided when the system is built with several satellites. This is an alternative to IMRs deployment for solving:

- path blockage problem inherent to satellite systems;
- propagation margin reduction.

UEs receive simultaneously the same service from several satellites. Satellite diversity takes benefits of the UE Rake receiver capability to combine several signals.

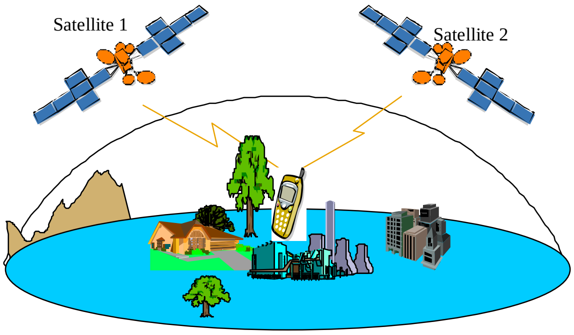


Figure 6.1: Satellite diversity

Simulations were driven for several values of the path loss difference between satellite 1 and satellite 2, in ITU channel model A (NLOS) environment for a UE velocity of 3 km/h.

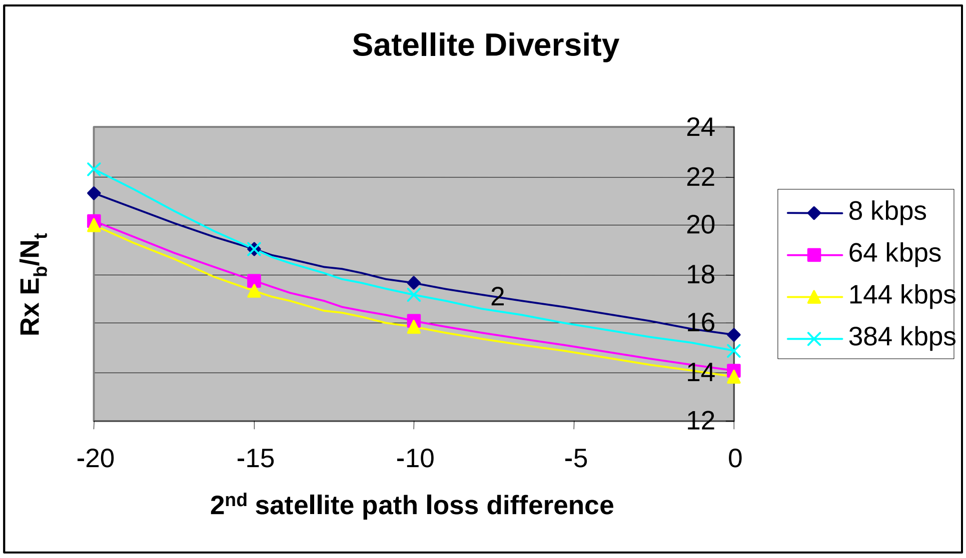


Figure 6.2: Satellite diversity; E_b/N_t as a function of satellites path loss difference, ITU channel model A, 3 km/h

Typical path loss difference between satellites is foreseen to be -10 dB in sub-urban environment and -20 dB in urban environment.

The case when satellites path loss difference is -20 dB is a path blockage situation, i.e. UE has a view on only one satellite.

6.2.4 Acquisition efficiency

Performance of initial spot synchronization was evaluated for several radio environments (see [35] and [36]). They are resumed hereafter.

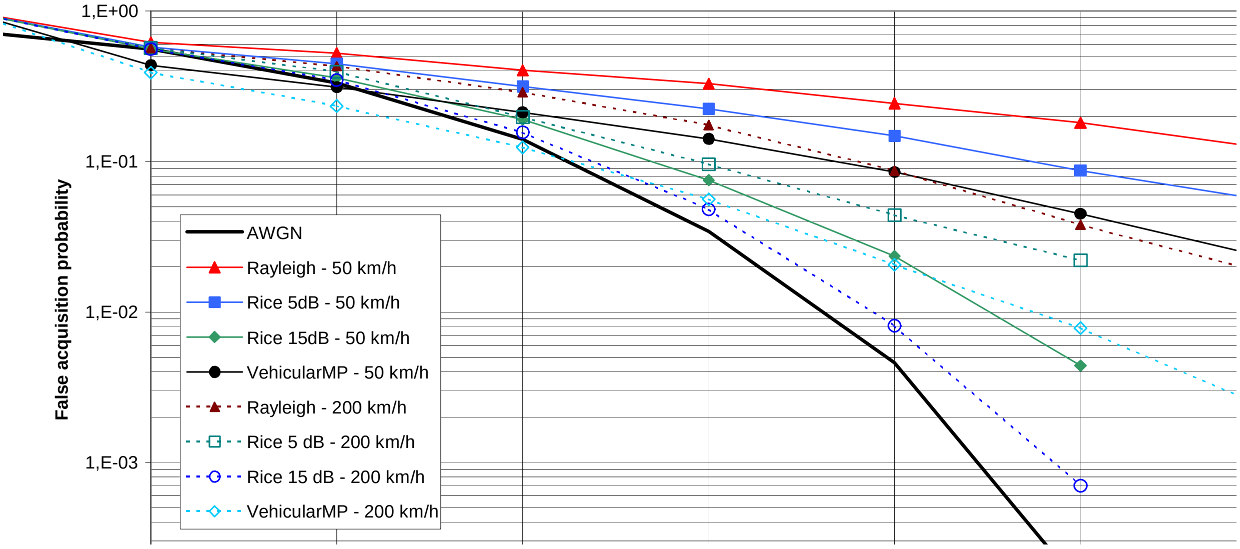


Figure 6.3: False acquisition probability vs. Ec/No, step 1

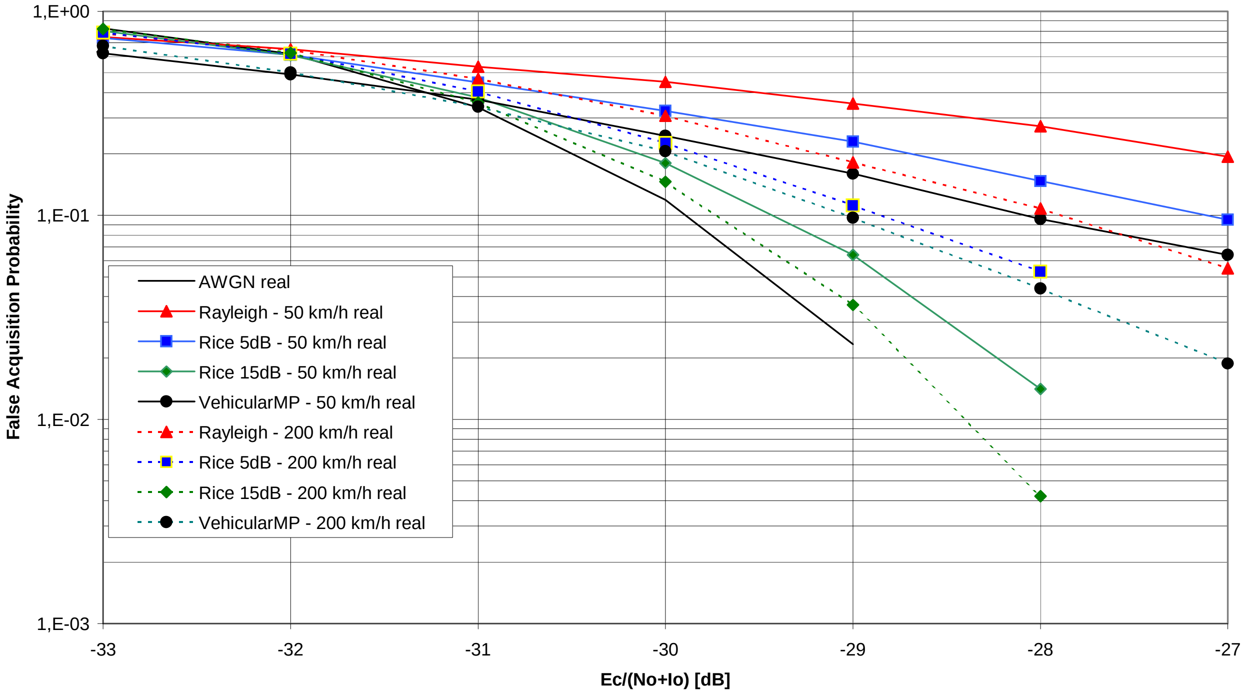


Figure 6.4: False acquisition probability vs. Ec/No, step 2

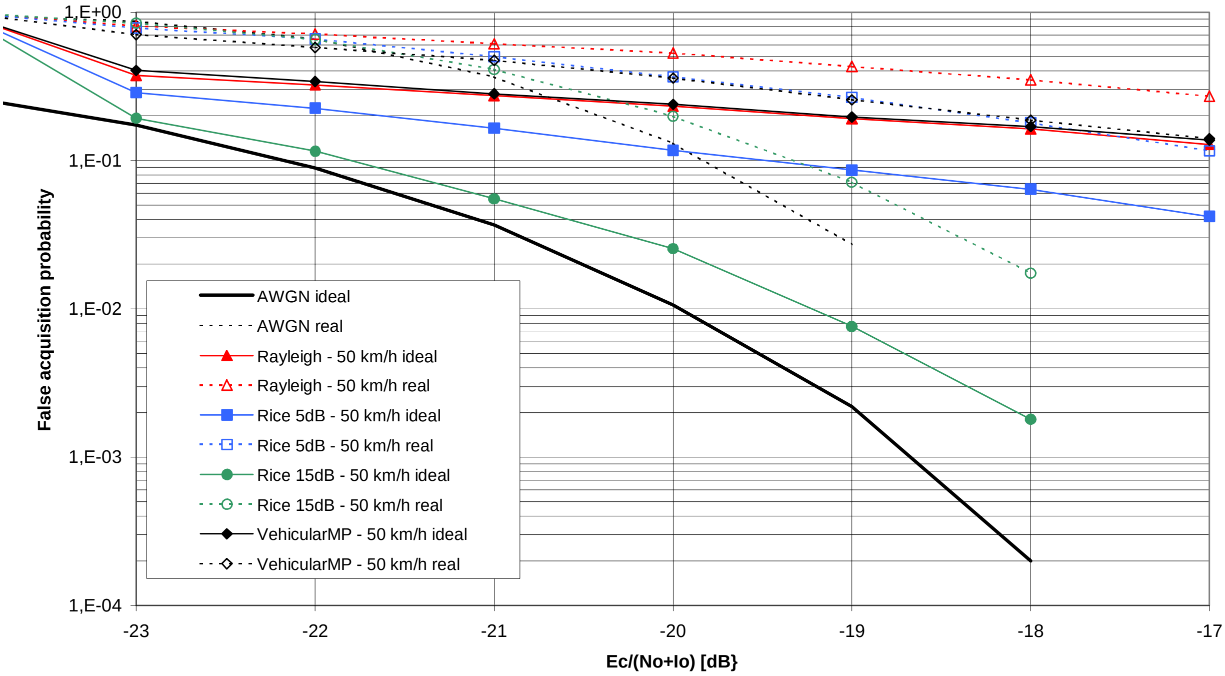


Figure 6.5: False acquisition probability vs. Ec/No, step 3, 50 km/h

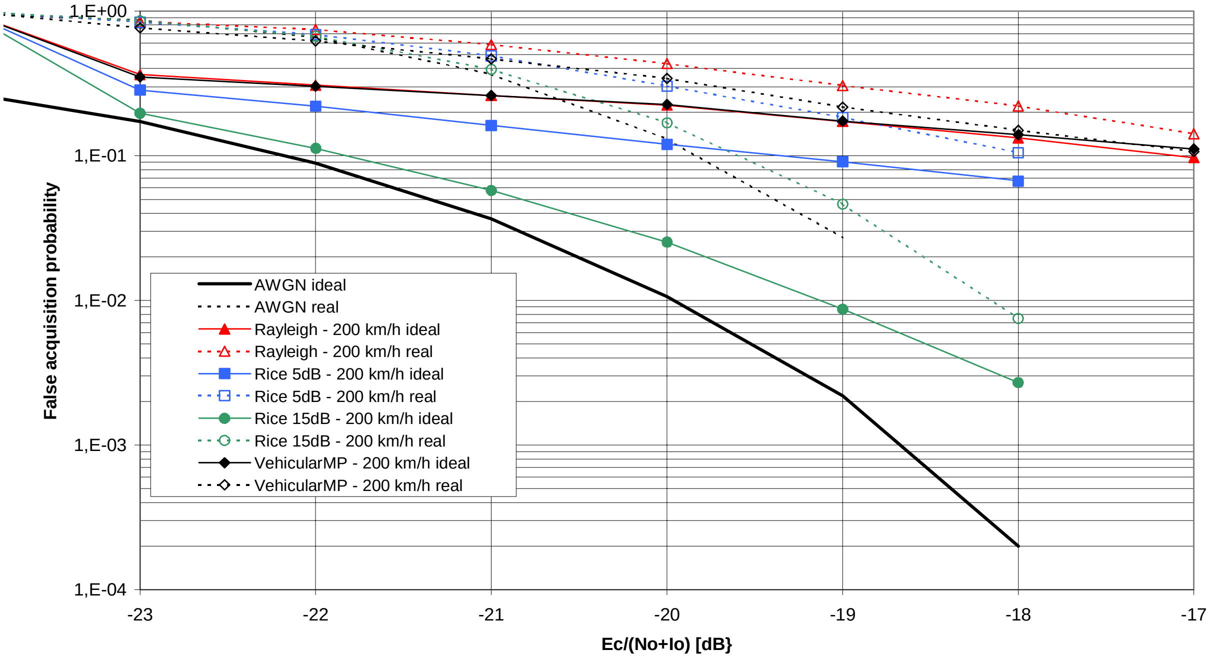


Figure 6.6: False acquisition probability vs. Ec/No, step 3, 200 km/h

6.3 Satellite transmitter characteristics

Satellite transmission in the downlink MSS band is constrained by necessity to limit interference to terrestrial UMTS.

It is assumed that the main constraint will be due to the protection of the reception by IMT-2000 UEs, in the lower adjacent terrestrial channel.

For a 74 dBW satellite EIRP, the required attenuation level in the core band compared to co-channel operation can be derived as follows:

Table 6.28: Satellite transmitter characteristics

UE receiver	Max Antenna gain	0	dB
	Feeder loss	0	dB
	Tilt angle	0,0	°down
	Rx Noise Figure	9	dB
	Rx Noise level	-134,98	dBW/MHz
	Required I/N	-10	dB
	Maximum tolerable ACI	-144,98	dBW/MHz
Satellite	Satellite altitude	36 000	Km
	Frequency	2 170	MHz
	Path loss	191,6	dB
	Maximum tolerable satellite EIRP density	46,62	dBW/MHz
	Satellite EIRP	74	dBW
	Bandwidth	3,84	MHz
	Max in-band EIRP density	68,16	dBW/MHz
	Required attenuation	21,54	dB

The satellite spectrum mask and Adjacent Channel Leakage Ratio (ACLR) are as follows:

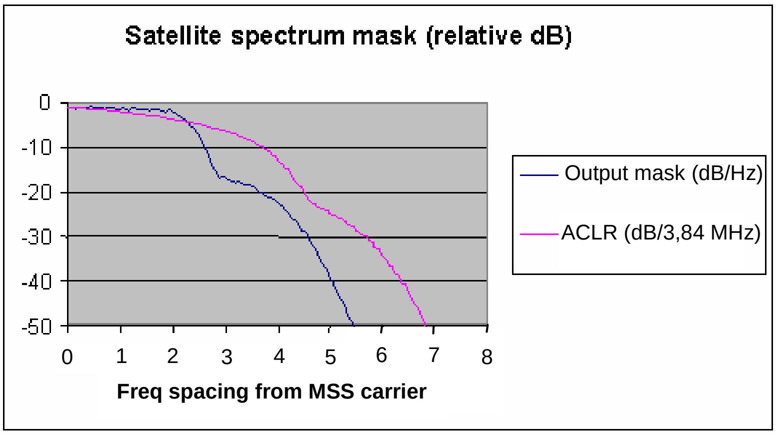


Figure 6.7: Satellite spectrum emission mask and ACLR

6.4 UE receiver characteristics

If terrestrial 3GPP UE are to be operated then their radio implementation must be upgraded for frequency agility to MSS bands. The UE RF performances are:

Table 6.29: Class 3 UE RF performance

Receive frequency (MHz)	2 170 to 2 200	
Receive polarization	Linear	
Noise figure	9 dB	
Receiver noise floor	-99 dBm	
Antenna gain	0/2/4/14 dBi	
ACS (Adjacent Channel Selectivity) as a function of carrier separation (from TS 25.101)	5 MHz	10 MHz
	33 dB	43 dB

6.5 IMR transmitter characteristics

Table 6.30: IMR power characteristics

Coverage area (°)	Up to 360° (i.e. 90° per sector)		
IMR classes	Wide area repeaters for macro-cell application	Medium range repeaters for micro-cell	Local area repeaters for pico-cell
Assumed height of IMRs (m)	30	6	6
Maximum output power (dBm)	43	30	24
Maximum Antenna gain (Tx) (dBi)	15	6	0
Transmission mask	Compliant with the 3GPP requirements for Node B in TS 125 104 [7].		
ACLR (Adjacent Channel Leakage Ratio) as a function of carrier separation - from TS 125 104 [7].	5 MHz	10 MHz	15 MHz
	45 dB	50 dB	67 dB

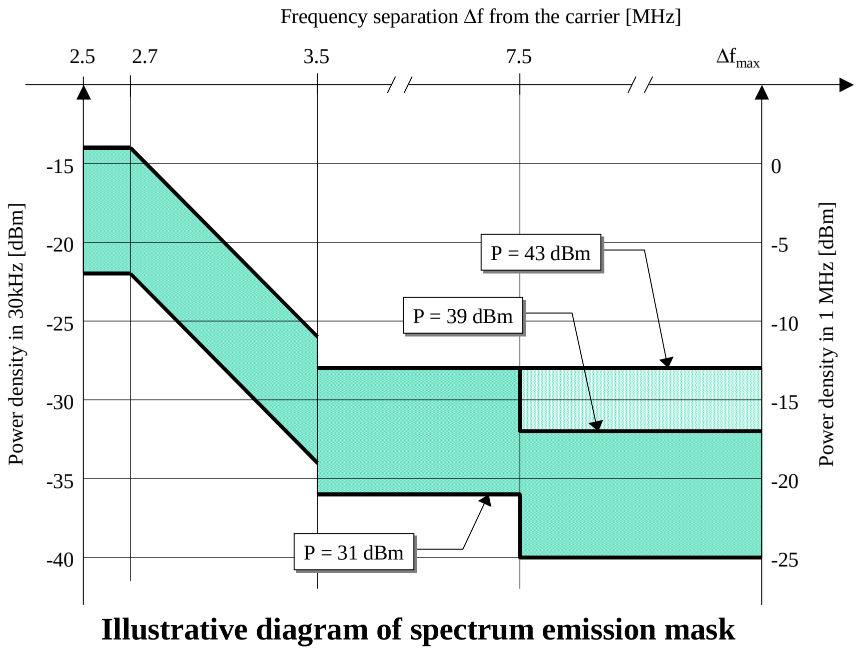


Figure 6.8: IMR transmission mask

7 System performances

7.1 Link budgets

Link budgets are evaluated for GEO constellation, extended multi-beam configuration i.e. 30 spots for a European coverage. Satellite is at an altitude in the range of 36 000 km, which means free space loss near to 192 dB.

It is assumed every spot is equally traffic loaded (uniform traffic distribution).

Satellite bus power dedicated to the W-CDMA mission is limited to 18 kW maximum Considering a 33 % efficiency for multi-carrier operation, this allows for 200 W on-board power per spot.

It is assumed the E_b/N_t feeder link degradation is kept less than 0,2 dB (see [40]).

Link budgets are calculated for a Block Error Ratio (BLER) less than 10^{-2} in AWGN channel conditions, i.e. static conditions. In case of audio 8 kbps service, an activity factor of 0,5 is assumed.

Design margin is included in E_b/N_t (see clause 6.2.2). For that reason, link budgets are calculated with a margin of 0 dB.

In case of handset terminal, body loss is taken into account (1 dB).

Link budgets were also calculated for mobile environment, i.e. taking into account propagation margin. Impact on system capacity for mobile environment is presented in clause 7.2.2.

No satellite diversity is applied, there is only one satellite in view.

The levels of power flux density (pfd) are kept below thresholds set by ITU frequency sharing recommendations (see [31]), i.e.:

- UE elevation = 42° and 30° → pfd $\leq$ -118 dBW/m^2 MHz;
- UE elevation = 16°→ pfd $\leq$ -122,5 dBW/m^2 MHz.

For adjacent spot interference calculation, it is assumed that all the spots serve an equivalent number of codes.

The downlink capacity is limited by:

- on board power:
  - the downlink interference:
  - the maximum number of downlink channelization (due to the codes tree allocation scheme) and scrambling codes (1 primary scrambling code + maximum 15 secondary scrambling codes) (see [11]).

In case secondary downlink scrambling codes are used, sets of channelization codes under different scrambling codes are not orthogonal against each other. This is taken into account for interference calculation.

Link budgets are calculated at spot borders. This means degraded case to be compared to centre spot where higher capacity is provided.

7.1.1 Link budget common parameters

It is assumed the satellite is geostationary, equipped with a 12 m diameter antenna. Polarization is circular. System temperature is 550°K.

The link budgets are evaluated with the common parameters summarized in table 7.1:

Table 7.1: Link budgets common parameters

Satellite				
Satellite Location	°E	13		
Orbital Height	Km	35786		
Average No. of Overlapping Satellites		1		
Service Downlink				
Number of FDM's		1		
Number of Satellite Beams		30		
Chip Rate	Mchip/s	3,840		
Chip SRC Roll-off Factor		0,22		
Full FDM Bandwidth	MHz	4,68		
Downlink Frequency	MHz	2185		
Availability (/year)	%	99,90		
Polarization (C/V/H)	C/V/H	Circular		
OBO (@TWTA level)	dB	1,3		
Polarization and Pointing Losses	dB	0,5		
UT System Temp.	°K	290,0		
Eb/No Losses due to Satellite Non-Lineari	dB	1,5		
UE Elevation	**deg.**	**42**	**30**	**16**
Slant Range	Km	37629,1	38611,7	39957,9
Tx Antenna Gain	dB	47,0	44,0	42,5
Satellite Antenna C/I	dB	14,0	13,0	12,0
Free Space Losses	dB	190,7	191,0	191,3

7.1.2 Audio service 8 kbps

Table 7.2: Link budget; Audio 8 kbps

FORWARD LINK BUDGET		**Handset 0 dBi**			**Portable**			**Vehicular**			**Transportable**		
UE elevation	**deg.**	**42**	**30**	**16**	**42**	**30**	**16**	**42**	**30**	**16**	**42**	**30**	**16**
Data Rate	**bit/s**	**8 000**	**8 000**	**8 000**	**8 000**	**8 000**	**8 000**	**8 000**	**8 000**	**8 000**	**8 000**	**8 000**	**8 000**
Traffic Activity Factor		0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
Required Eb/(No+Io) per Finger	**dB**	**6,30**	**6,30**	**6,30**	**6,30**	**6,30**	**6,30**	**6,30**	**6,30**	**6,30**	**6,30**	**6,30**	**6,30**
On Board Power/FACH/Beam/FDM	dBW	-4,31	-4,06	-3,81	-4,41	-4,31	-4,11	-4,51	-4,31	-4,22	-4,52	-4,47	-4,41
On Board EIRP/FACH/Beam/FDM	dBW	42,69	39,94	38,69	42,59	39,69	38,39	42,49	39,69	38,28	42,48	39,53	38,09
CPICH EIRP / Beam / FDM	dBW	53,24	50,49	49,24	53,14	50,24	48,94	53,04	50,24	48,83	53,03	50,08	48,64
P-CCPCH EIRP / Beam / FDM	dBW	51,24	48,49	47,24	51,14	48,24	46,94	51,04	48,24	46,83	51,03	48,08	46,64
SCH EIRP / Beam / FDM	dBW	51,24	48,49	47,24	51,14	48,24	46,94	51,04	48,24	46,83	51,03	48,08	46,64
PICH EIRP / Beam / FDM	dBW	48,24	45,49	44,24	48,14	45,24	43,94	48,04	45,24	43,83	48,03	45,08	43,64
Common Physical Channels Equivalent Traffic Codes	-	29,26	29,26	29,26	29,26	29,26	29,26	29,26	29,26	29,26	29,26	29,26	29,26
On Board Power / Beam / FDM	dB	23,0	23,0	23,0	23,0	23,0	23,0	23,0	23,0	23,0	23,0	23,0	23,0
On Board power Density	dB/Hz	-43,7	-43,7	-43,7	-43,7	-43,7	-43,7	-43,7	-43,7	-43,7	-43,7	-43,7	-43,7
On board EIRP / Beam / FDM	dBW	70,0	67,0	65,5	70,0	67,0	65,5	70,0	67,0	65,5	70,0	67,0	65,5
On Board Power / Beam	W	**199,9**	**199,6**	**199,7**	**200,0**	**197,7**	**199,6**	**197,6**	**199,9**	**199,9**	**200,0**	**199,8**	**199,7**
Saturated Power / Beam	W	269,6	269,2	269,4	269,8	266,6	269,2	266,6	269,6	269,7	269,8	269,5	269,4
Saturated On Board EIRP / Beam	dBW	71,3	68,3	66,8	71,3	68,3	66,8	71,3	68,3	66,8	71,3	68,3	66,8
Losses (free space, polarization, pointing and body)	dB	192,2	192,5	192,8	191,2	191,5	191,8	191,2	191,5	191,8	191,2	191,5	191,8
UE Antenna Gain	dB	0	0	0	2	2	2	4	4	4	14	14	14
UE G/T	dB/°K	-24,6	-24,6	-24,6	-22,6	-22,6	-22,6	-20,6	-20,6	-20,6	-10,6	-10,6	-10,6
Thermal Noise Density, No	dBW/Hz	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0
Interference from secondary scrambling codes	dBW	-128,5	-132,0	-134,1	-125,4	-128,8	-130,7	-123,4	-126,7	-128,6	-113,3	-116,5	-118,4
Interference from adjacent spot	dBW	-139,0	-141,2	-142,0	-136,0	-138,3	-139,0	-134,1	-136,2	-137,0	-124,0	-126,2	-127,0
Total interference per channel	dBW	-128,1	-131,5	-133,5	-125,0	-128,3	-130,1	-123,0	-126,2	-128,0	-112,9	-116,1	-117,8
-10*LOG(Spreading Bandwidth)	dB/Hz	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8
Interference Density, Io	dBW/Hz	-194,0	-197,4	-199,3	-190,8	-194,2	-196,0	-188,9	-192,1	-193,9	-178,7	-181,9	-183,7
10*log(No+Io)	dBW/Hz	-193,5	-196,5	-198,0	-190,6	-193,8	-195,3	-188,7	-191,8	-193,5	-178,7	-181,9	-183,6
Rx Power Flux Density	dBW/m²	-121,3	-124,3	-125,8	-120,4	-123,5	-125,1	-120,5	-123,5	-125,2	-120,5	-123,7	-125,4
Total Received PFD	dBW/m²/ 1 MHz	-99,8	-103,1	-104,9	-98,8	-102,1	-103,9	-98,9	-102,1	-103,9	-98,8	-102,1	-103,9
PFD max. @ UE Elev. Angle (ITU Rec.)	dBW/m²/ 1 MHz	-118,0	-118,0	-122,5	-118,0	-118,0	-122,5	-118,0	-118,0	-122,5	-118,0	-118,0	-122,5
DL Single Finger C/(No+Io)	dBHz	47,0	47,0	47,0	47,0	47,0	47,0	47,0	47,1	47,0	47,0	47,0	47,0
DL Single Finger Eb/(No+Io)	**dB**	**8,0**	**8,0**	**8,0**	**8,0**	**8,0**	**8,0**	**8,0**	**8,0**	**8,0**	**8,0**	**8,0**	**8,0**
Eb/No Losses due to Satellite Non-Linearities	dB	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
Eb/No Losses due to feeder link degradation (see TR30.20)	dB	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
Overall Link Single Finger Eb/(No+Io)	**dB**	**6,3**	**6,3**	**6,3**	**6,3**	**6,3**	**6,3**	**6,3**	**6,3**	**6,3**	**6,3**	**6,3**	**6,3**
Total C/(N+I)	**dB**	**-21,4**	**-21,4**	**-21,4**	**-21,4**	**-21,4**	**-21,4**	**-21,4**	**-21,4**	**-21,4**	**-21,4**	**-21,4**	**-21,4**
Margin for Bent-Pipe System	**dB**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**
Capacity/spot/FDM	**Mb/s**	**2,04**	**1,916**	**1,804**	**2,092**	**2,016**	**1,94**	**2,116**	**2,04**	**1,996**	**2,148**	**2,12**	**2,088**
Nb. Traffic Codes/FDM/Beam	-	510	479	451	523	504	485	529	510	499	537	530	522
Nb of codes on primary scrambling code	-	254	254	254	254	254	254	254	254	254	254	254	254
Nb of codes on secondary scrambling codes	-	256	225	197	269	250	231	275	256	245	283	276	268
Nb of Secondary Scrambling Codes/FDM/Beam	-	1	1	1	2	1	1	2	1	1	2	2	2
Satellite capacity (30 spots)	Mb/s	61,20	57,48	54,12	62,76	60,48	58,20	63,48	61,20	59,88	64,44	63,60	62,64
Spectrum efficiency as ITU	bit/s/Hz	0,435	0,409	0,385	0,447	0,430	0,414	0,452	0,435	0,426	0,459	0,453	0,446
Power efficiency as ITU	0	23,60%	23,65%	23,70%	23,60%	23,68%	23,69%	23,69%	23,34%	23,69%	23,70%	23,68%	23,69%

7.1.3 Data service 64 kbps

Table 7.3: Link budget; Data 64 kbps

FORWARD LINK BUDGET		**Handset 0 dBi**			**Portable**			**Vehicular**			**Transportable**		
UE elevation	**deg.**	**42**	**30**	**16**	**42**	**30**	**16**	**42**	**30**	**16**	**42**	**30**	**16**
Data Rate	**bit/s**	**64 000**	**64 000**	**64 000**	**64 000**	**64 000**	**64 000**	**64 000**	**64 000**	**64 000**	**64 000**	**64 000**	**64 000**
Traffic Activity Factor		1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
Required Eb/(No+Io) per Finger	**dB**	**4,00**	**4,00**	**4,00**	**4,00**	**4,00**	**4,00**	**4,00**	**4,00**	**4,00**	**4,00**	**4,00**	**4,00**
On Board Power/FACH/Beam/FDM	dBW	6,00	6,10	6,00	4,00	5,00	6,00	1,00	3,00	4,00	-1,00	-3,00	6,00
On Board EIRP/FACH/Beam/FDM	dBW	53,00	50,10	48,50	51,00	49,00	48,50	48,00	47,00	46,50	46,00	41,00	48,50
CPICH EIRP / Beam / FDM	dBW	56,75	53,85	52,25	54,75	52,75	52,25	51,75	50,75	50,25	49,75	44,75	52,25
P-CCPCH EIRP / Beam / FDM	dBW	54,75	51,85	50,25	52,75	50,75	50,25	49,75	48,75	48,25	47,75	42,75	50,25
SCH EIRP / Beam / FDM	dBW	54,75	51,85	50,25	52,75	50,75	50,25	49,75	48,75	48,25	47,75	42,75	50,25
PICH EIRP / Beam / FDM	dBW	51,75	48,85	47,25	49,75	47,75	47,25	46,75	45,75	45,25	44,75	39,75	47,25
Common Physical Channels Equivalent Traffic Codes	-	6,11	6,11	6,11	6,11	6,11	6,11	6,11	6,11	6,11	6,11	6,11	6,11
On Board Power / Beam / FDM	dB	23,0	22,9	22,6	21,0	21,9	22,8	18,0	19,9	20,8	16,1	14,0	23,0
On Board power Density	dB/Hz	-43,7	-43,8	-44,1	-45,7	-44,8	-43,9	-48,7	-46,8	-45,9	-50,6	-52,7	-43,7
On board EIRP / Beam / FDM	dBW	70,0	66,9	65,1	68,0	65,9	65,3	65,0	63,9	63,3	63,1	58,0	65,5
On Board Power / Beam	W	**199,5**	**196,0**	**183,6**	**125,9**	**155,3**	**191,5**	**63,1**	**98,0**	**120,9**	**40,6**	**25,1**	**199,5**
Saturated Power / Beam	W	269,1	264,4	247,6	169,8	209,5	258,4	85,1	132,2	163,0	54,8	33,9	269,1
Saturated On Board EIRP / Beam	dBW	71,3	68,2	66,4	69,3	67,2	66,6	66,3	65,2	64,6	64,4	59,3	66,8
Losses (free space, polarization, pointing and body)	dB	192,2	192,5	192,8	191,2	191,5	191,8	191,2	191,5	191,8	191,2	191,5	191,8
UE Antenna Gain	dB	0	0	0	2	2	2	4	4	4	14	14	14
UE G/T	dB/°K	-24,6	-24,6	-24,6	-22,6	-22,6	-22,6	-20,6	-20,6	-20,6	-10,6	-10,6	-10,6
Thermal Noise Density, No	dBW/Hz	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0
Interference from secondary scrambling codes	dBW	-128,1	-132,0	-134,7	-127,1	-129,7	-130,8	-128,1	-129,7	-130,8	-119,8	-125,3	-118,1
Interference from adjacent spot	dBW	-136,2	-138,5	-139,6	-135,2	-136,6	-136,4	-136,2	-136,6	-136,4	-128,2	-132,5	-124,3
Total interference per channel	dBW	-127,5	-131,1	-133,5	-126,5	-128,9	-129,8	-127,5	-128,9	-129,8	-119,2	-124,6	-117,2
-10*LOG(Spreading Bandwidth)	dB/Hz	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8
Interference Density, Io	dBW/Hz	-193,3	-196,9	-199,3	-192,3	-194,7	-195,6	-193,3	-194,7	-195,6	-185,0	-190,4	-183,0
10*log(No+Io)	dBW/Hz	-193,0	-196,2	-198,1	-192,0	-194,2	-195,0	-193,0	-194,2	-195,0	-185,0	-190,2	-183,0
Rx Power Flux Density	dBW/m^2	-111,0	-114,1	-116,0	-112,0	-114,2	-115,0	-115,0	-116,2	-117,0	-117,0	-122,2	-115,0
Total Received PFD	dBW/m^2/ 1 MHz	-99,8	-103,1	-105,2	-100,8	-103,2	-104,0	-103,8	-105,2	-106,0	-105,8	-111,1	-103,9
PFD max. @ UE Elev. Angle (ITU Rec.)	dBW/m^2/ 1 MHz	-118,0	-118,0	-122,5	-118,0	-118,0	-122,5	-118,0	-118,0	-122,5	-118,0	-118,0	-122,5
DL Single Finger C/(No+Io)	dBHz	53,7	53,8	53,8	53,8	53,8	53,8	53,7	53,8	53,8	53,7	53,8	53,7
DL Single Finger Eb/(No+Io)	**dB**	**5,7**	**5,7**	**5,7**	**5,7**	**5,7**	**5,7**	**5,7**	**5,7**	**5,7**	**5,7**	**5,7**	**5,7**
Eb/No Losses due to Satellite Non-Linearities	dB	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
Eb/No Losses due to feeder link degradation (see TR30.20)	dB	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
Overall Link Single Finger	**dB**	**4,0**	**4,0**	**4,0**	**4,0**	**4,0**	**4,0**	**4,0**	**4,0**	**4,0**	**4,0**	**4,0**	**4,0**
Total C/(N+I)	**dB**	**-14,7**	**-14,6**	**-14,6**	**-14,6**	**-14,7**	**-14,6**	**-14,7**	**-14,7**	**-14,6**	**-14,7**	**-14,7**	**-14,7**
Margin for Bent-Pipe System	**dB**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**
Capacity/spot/FDM	**Mb/s**	**2,816**	**2,688**	**2,56**	**2,816**	**2,752**	**2,688**	**2,816**	**2,752**	**2,688**	**2,88**	**2,816**	**2,816**
Nb. Traffic Codes/FDM/Beam	-	44	42	40	44	43	42	44	43	42	45	44	44
Nb of codes on primary scrambling	-	31	31	31	31	31	31	31	31	31	31	31	31
Nb of codes on secondary scrambling codes	-	13	11	9	13	12	11	13	12	11	14	13	13
Nb of Secondary Scrambling Codes/FDM/Beam	-	1	1	1	1	1	1	1	1	1	1	1	1
Satellite capacity (30 spots)	Mb/s	84,48	80,64	76,80	84,48	82,56	80,64	84,48	82,56	80,64	86,40	84,48	84,48
Spectrum efficiency as ITU	bit/s/Hz	0,601	0,574	0,546	0,601	0,587	0,574	0,601	0,587	0,574	0,615	0,601	0,601
Power efficiency as ITU	0	40,15%	39,59%	39,47%	39,49%	39,87%	39,67%	40,15%	39,87%	39,67%	40,03%	39,92%	40,16%

7.1.4 Data service 144 kbps

Table 7.4: Link budget; Data 144 kbps

FORWARD LINK BUDGET		Handset 0 dBi			Portable			Vehicular			Transportable		
UE elevation	**deg.**	**42**	**30**	**16**	**42**	**30**	**16**	**42**	**30**	**16**	**42**	**30**	**16**
Data Rate	**bit/s**	**144 000**	**144 000**	**144 000**	**144 000**	**144 000**	**144 000**	**144 000**	**144 000**	**144 000**	**144 000**	**144 000**	**144 000**
Traffic Activity Factor		1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
Required Eb/(No+Io) per Finger	**dB**	**3,60**	**3,60**	**3,60**	**3,60**	**3,60**	**3,60**	**3,60**	**3,60**	**3,60**	**3,60**	**3,60**	**3,60**
On Board Power/FACH/Beam/FDM	dBW	7,50	8,00	8,20	4,50	9,00	7,50	2,50	7,00	5,50	-7,50	-3,00	1,00
On Board EIRP/FACH/Beam/FDM	dBW	54,50	52,00	50,70	51,50	53,00	50,00	49,50	51,00	48,00	39,50	41,00	43,50
CPICH EIRP / Beam / FDM	dBW	55,20	52,70	51,40	52,20	53,70	50,70	50,20	51,70	48,70	40,20	41,70	44,20
P-CCPCH EIRP / Beam / FDM	dBW	53,20	50,70	49,40	50,20	51,70	48,70	48,20	49,70	46,70	38,20	39,70	42,20
SCH EIRP / Beam / FDM	dBW	53,20	50,70	49,40	50,20	51,70	48,70	48,20	49,70	46,70	38,20	39,70	42,20
PICH EIRP / Beam / FDM	dBW	50,20	47,70	46,40	47,20	48,70	45,70	45,20	46,70	43,70	35,20	36,70	39,20
Common Physical Channels Equivalent Traffic Codes	-	3,03	3,03	3,03	3,03	3,03	3,03	3,03	3,03	3,03	3,03	3,03	3,03
On Board Power / Beam / FDM	dB	21,3	21,6	21,6	18,3	22,8	21,1	16,3	20,8	19,1	6,3	10,8	14,8
On Board power Density	dB/Hz	-45,4	-45,1	-45,1	-48,4	-43,9	-45,6	-50,4	-45,9	-47,6	-60,4	-55,9	-51,9
On board EIRP / Beam / FDM	dBW	68,3	65,6	64,1	65,3	66,8	63,6	63,3	64,8	61,6	53,3	54,8	57,3
On Board Power / Beam	W	**135,1**	**145,3**	**145,5**	**67,7**	**190,9**	**129,5**	**42,7**	**120,4**	**81,7**	**4,3**	**12,0**	**30,3**
Saturated Power / Beam	W	182,3	196,0	196,3	91,4	257,5	174,7	57,6	162,5	110,2	5,8	16,2	40,8
Saturated On Board EIRP / Beam	dBW	69,6	66,9	65,4	66,6	68,1	64,9	64,6	66,1	62,9	54,6	56,1	58,6
Losses (free space, polarization, pointing and body)	dB	192,2	192,5	192,8	191,2	191,5	191,8	191,2	191,5	191,8	191,2	191,5	191,8
UE Antenna Gain	dB	0	0	0	2	2	2	4	4	4	14	14	14
UE G/T	dB/°K	-24,6	-24,6	-24,6	-22,6	-22,6	-22,6	-20,6	-20,6	-20,6	-10,6	-10,6	-10,6
Thermal Noise Density, No	dBW/Hz	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0
Interference from secondary scrambling codes	dBW	-130,0	-133,5	-136,0	-130,0	-128,7	-132,8	-130,0	-128,7	-132,8	-130,0	-128,7	-126,5
Interference from adjacent spot	dBW	-137,9	-139,8	-140,6	-137,9	-135,7	-138,1	-137,9	-135,7	-138,1	-137,9	-135,7	-132,5
Total interference per channel	dBW	-129,3	-132,6	-134,7	-129,3	-127,9	-131,7	-129,3	-127,9	-131,7	-129,3	-127,9	-125,5
-10*LOG(Spreading Bandwidth)	dB/Hz	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8
Interference Density, Io	dBW/Hz	-195,2	-198,4	-200,6	-195,2	-193,7	-197,5	-195,2	-193,7	-197,5	-195,2	-193,7	-191,3
10*log(No+Io)	dBW/Hz	-194,6	-197,4	-199,0	-194,6	-193,3	-196,6	-194,6	-193,3	-196,6	-194,6	-193,3	-191,1
Rx Power Flux Density	dBW/m²	-109,5	-112,2	-113,8	-111,5	-110,2	-113,5	-113,5	-112,2	-115,5	-123,5	-122,2	-120,0
Total Received PFD	dBW/m²/ 1 MHz	-101,5	-104,4	-106,2	-103,5	-102,3	-105,7	-105,5	-104,3	-107,7	-115,5	-114,3	-112,1
PFD max. @ UE Elev. Angle (ITU Rec.)	dBW/m²/ 1 MHz	-118,0	-118,0	-122,5	-118,0	-118,0	-122,5	-118,0	-118,0	-122,5	-118,0	-118,0	-122,5
DL Single Finger C/(No+Io)	dBHz	56,9	56,9	56,9	56,9	56,9	56,9	56,9	56,9	56,9	56,9	56,9	56,9
DL Single Finger Eb/(No+Io)	**dB**	**5,3**	**5,3**	**5,3**	**5,3**	**5,3**	**5,3**	**5,3**	**5,3**	**5,3**	**5,3**	**5,3**	**5,3**
Eb/No Losses due to Satellite Non-Linearities	dB	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
Eb/No Losses due to feeder link degradation (see TR30.20)	dB	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
Overall Link Single Finger	**dB**	**3,6**	**3,6**	**3,6**	**3,6**	**3,6**	**3,6**	**3,6**	**3,6**	**3,6**	**3,6**	**3,6**	**3,6**
Total C/(N+I)	**dB**	**-11,5**	**-11,5**	**-11,5**	**-11,5**	**-11,5**	**-11,5**	**-11,5**	**-11,5**	**-11,5**	**-11,5**	**-11,5**	**-11,6**
Margin for Bent-Pipe System	**dB**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**
Capacity/spot/FDM	**Mb/s**	**3,024**	**2,88**	**2,736**	**3,024**	**3,024**	**2,88**	**3,024**	**3,024**	**2,88**	**3,024**	**3,024**	**3,024**
Nb. Traffic Codes/FDM/Beam	-	21	20	19	21	21	20	21	21	20	21	21	21
Nb of codes on primary scrambling	-	15	15	15	15	15	15	15	15	15	15	15	15
Nb of codes on secondary scrambling codes	-	6	5	4	6	6	5	6	6	5	6	6	6
Nb of Secondary Scrambling Codes/FDM/Beam	-	1	1	1	1	1	1	1	1	1	1	1	1
Satellite capacity (30 spots)	Mb/s	90,72	86,40	82,08	90,72	90,72	86,40	90,72	90,72	86,40	90,72	90,72	90,72
Spectrum efficiency as ITU	bit/s/Hz	0,645	0,615	0,584	0,645	0,645	0,615	0,645	0,645	0,615	0,645	0,645	0,645
Power efficiency as ITU	0	43,65%	43,63%	43,61%	43,65%	43,74%	43,87%	43,65%	43,74%	43,87%	43,65%	43,74%	43,96%

7.1.5 Data service 384 kbps

Table 7.5: Link budget; Data 384 kbps

FORWARD LINK BUDGET		Handset 0 dBi			Portable			Vehicular			Transportable		
UE elevation	**deg.**	**42**	**30**	**16**	**42**	**30**	**16**	**42**	**30**	**16**	**42**	**30**	**16**
Data Rate	**bit/s**	**384 000**	**384 000**	**384 000**	**384 000**	**384 000**	**384 000**	**384 000**	**384 000**	**384 000**	**384 000**	**384 000**	**384 000**
Traffic Activity Factor		1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
Required Eb/(No+Io) per Finger	**dB**	**3,73**	**3,73**	**3,73**	**3,73**	**3,73**	**3,73**	**3,73**	**3,73**	**3,73**	**3,73**	**3,73**	**3,73**
On Board Power/FACH/Beam/FDM	dBW	10,50	8,80	11,00	7,50	12,00	8,00	5,50	10,00	12,97	-4,50	0,00	3,00
On Board EIRP/FACH/Beam/FDM	dBW	57,50	52,80	53,50	54,50	56,00	50,50	52,50	54,00	55,47	42,50	44,00	45,50
CPICH EIRP / Beam / FDM	dBW	53,70	49,00	49,70	50,70	52,20	46,70	48,70	50,20	51,67	38,70	40,20	41,70
P-CCPCH EIRP / Beam / FDM	dBW	51,70	47,00	47,70	48,70	50,20	44,70	46,70	48,20	49,67	36,70	38,20	39,70
SCH EIRP / Beam / FDM	dBW	51,70	47,00	47,70	48,70	50,20	44,70	46,70	48,20	49,67	36,70	38,20	39,70
PICH EIRP / Beam / FDM	dBW	48,70	44,00	44,70	45,70	47,20	41,70	43,70	45,20	46,67	33,70	35,20	36,70
Common Physical Channels Equivalent Traffic Codes	-	1,07	1,07	1,07	1,07	1,07	1,07	1,07	1,07	1,07	1,07	1,07	1,07
On Board Power / Beam / FDM	dB	20,5	18,4	20,6	17,5	22,0	17,6	15,5	20,0	23,0	5,5	10,0	13,0
On Board power Density	dB/Hz	-46,2	-48,3	-46,1	-49,2	-44,7	-49,1	-51,2	-46,7	-43,7	-61,2	-56,7	-53,7
On board EIRP / Beam / FDM	dBW	67,5	62,4	63,1	64,5	66,0	60,1	62,5	64,0	65,5	52,5	54,0	55,5
On Board Power / Beam	W	**113,0**	**68,8**	**114,2**	**56,7**	**159,7**	**57,3**	**35,7**	**100,7**	**199,6**	**3,6**	**10,1**	**20,1**
Saturated Power / Beam	W	152,5	92,9	154,1	76,4	215,4	77,2	48,2	135,9	269,3	4,8	13,6	27,1
Saturated On Board EIRP / Beam	dBW	68,8	63,7	64,4	65,8	67,3	61,4	63,8	65,3	66,8	53,8	55,3	56,8
Losses (free space, polarization, pointing and body)	dB	192,2	192,5	192,8	191,2	191,5	191,8	191,2	191,5	191,8	191,2	191,5	191,8
UE Antenna Gain	dB	0	0	0	2	2	2	4	4	4	14	14	14
UE G/T	dB/°K	-24,6	-24,6	-24,6	-22,6	-22,6	-22,6	-20,6	-20,6	-20,6	-10,6	-10,6	-10,6
Thermal Noise Density, No	dBW/Hz	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0	-204,0
Interference from secondary scrambling codes	dBW	-131,7	-139,7	-139,3	-131,7	-130,5	-139,3	-131,7	-130,5	-129,3	-131,7	-130,5	-129,3
Interference from adjacent spot	dBW	-138,7	-143,1	-141,7	-138,7	-136,4	-141,7	-138,7	-136,4	-134,3	-138,7	-136,4	-134,2
Total interference per channel	dBW	-130,9	-138,0	-137,3	-130,9	-129,5	-137,3	-130,9	-129,5	-128,1	-130,9	-129,5	-128,1
-10*LOG(Spreading Bandwidth)	dB/Hz	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8	-65,8
Interference Density, Io	dBW/Hz	-196,8	-203,9	-203,1	-196,8	-195,3	-203,1	-196,8	-195,3	-193,9	-196,8	-195,3	-193,9
10*log(No+Io)	dBW/Hz	-196,0	-200,9	-200,5	-196,0	-194,8	-200,5	-196,0	-194,8	-193,5	-196,0	-194,8	-193,5
Rx Power Flux Density	dBW/m^2	-106,5	-111,4	-111,0	-108,5	-107,2	-113,0	-110,5	-109,2	-108,1	-120,5	-119,2	-118,0
Total Received PFD	dBW/m^2/ 1 MHz	-102,3	-107,7	-107,3	-104,3	-103,0	-109,3	-106,3	-105,0	-103,9	-116,3	-115,0	-113,8
PFD max. @ UE Elev. Angle (ITU Rec.)	dBW/m^2/ 1 MHz	-118,0	-118,0	-122,5	-118,0	-118,0	-122,5	-118,0	-118,0	-122,5	-118,0	-118,0	-122,5
DL Single Finger C/(No+Io)	dBHz	61,3	61,3	61,3	61,3	61,3	61,3	61,3	61,3	61,2	61,3	61,3	61,2
DL Single Finger Eb/(No+Io)	**dB**	**5,4**	**5,4**	**5,4**	**5,4**	**5,5**	**5,4**	**5,4**	**5,5**	**5,4**	**5,4**	**5,5**	**5,4**
Eb/No Losses due to Satellite Non-Linearities	dB	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
Eb/No Losses due to feeder link degradation (see TR30.20)	dB	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
Overall Link Single Finger	**dB**	**3,7**	**3,7**	**3,7**	**3,7**	**3,8**	**3,7**	**3,7**	**3,8**	**3,7**	**3,7**	**3,8**	**3,7**
Total C/(N+I)	**dB**	**-7,1**	**-7,2**	**-7,1**	**-7,1**	**-7,1**	**-7,1**	**-7,1**	**-7,1**	**-7,2**	**-7,1**	**-7,1**	**-7,2**
Margin for Bent-Pipe System	**dB**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**
Capacity/spot/FDM	**Mb/s**	**3,456**	**3,072**	**3,072**	**3,456**	**3,456**	**3,072**	**3,456**	**3,456**	**3,456**	**3,456**	**3,456**	**3,456**
Nb. Traffic Codes/FDM/Beam	-	9	8	8	9	9	8	9	9	9	9	9	9
Nb of codes on primary scrambling	-	7	7	7	7	7	7	7	7	7	7	7	7
Nb of codes on secondary scrambling codes	-	2	1	1	2	2	1	2	2	2	2	2	2
Nb of Secondary Scrambling Codes/FDM/Beam	-	1	1	1	1	1	1	1	1	1	1	1	1
Satellite capacity (30 spots)	Mb/s	103,68	92,16	92,16	103,68	103,68	92,16	103,68	103,68	103,68	103,68	103,68	103,68
Spectrum efficiency as ITU	bit/s/Hz	0,738	0,656	0,656	0,738	0,738	0,656	0,738	0,738	0,738	0,738	0,738	0,738
Power efficiency as ITU	0	42,29%	42,57%	42,45%	42,29%	42,10%	42,45%	42,29%	42,10%	42,84%	42,29%	42,10%	42,81%

7.2 System capacity

System capacity is presented in a first step for static environment (AWGN channel), then for mobile environment and indoor penetration. Improvement thanks to IMRs deployment is also quantified.

On-board power consumption is indicated in order to highlight situations when spot capacity is not transmit power limited but interference limited.

Aeronautical UE configuration system capacity is similar to static environment.

7.2.1 Static environment

7.2.1.1 Audio service 8 kbps

Table 7.6: System capacity; audio 8 kbps

Data rate (kbps) 8	Capacity/ carrier/ spot (Mbps)	Nb traffic codes/spot/ carrier	Nb 2^{ndary} Scrambling codes/spot/ carrier	Satellite Capacity/ carrier (see note) (Mbps)	Spectrum efficiency as ITU (bit/s/Hz)	Power efficiency as ITU	On board Power consumption W
Handset							
Max (40°)	2,04	510	1	61,20	0,44	23,60 %	200
Average (30°)	1,92	479	1	57,48	0,41	23,65 %	200
Min (16°)	1,80	451	1	54,12	0,39	23,70 %	200
Portable							
Max (40°)	2,09	523	2	62,76	0,45	23,60 %	200
Average (30°)	2,02	504	1	60,48	0,43	23,68 %	198
Min (16°)	1,94	485	1	58,20	0,41	23,69 %	200
Vehicular							
Max (40°)	2,12	529	2	63,48	0,45	23,69 %	198
Average (30°)	2,04	510	1	61,20	0,44	23,34 %	200
Min (16°)	2,00	499	1	59,88	0,43	23,69 %	200
Transportable							
Max (40°)	2,15	537	2	64,44	0,46	23,70 %	200
Average (30°)	2,12	530	2	63,60	0,45	23,68 %	200
Min (16°)	2,09	522	2	62,64	0,45	23,69 %	200
NOTE: 30 beams configuration.							

7.2.1.2 Data service 64 kbps

Table 7.7: System capacity; data 64 kbps

Data rate (kbps) 64	Capacity/ carrier/ spot (Mbps)	Nb traffic codes/spot/ carrier	Nb 2^{ndary} Scrambling codes/spot/ carrier	Satellite Capacity/ carrier (see note) (Mbps)	Spectrum efficiency as ITU (bit/s/Hz)	Power efficiency as ITU	On board Power consumption W
Handset							
Max (40°)	2,82	44	1	84,48	0,60	40,15 %	200
Average (30°)	2,69	42	1	80,64	0,57	39,59 %	196
Min (16°)	2,56	40	1	76,80	0,55	39,47 %	184
Portable							
Max (40°)	2,82	44	1	84,48	0,60	39,49 %	126
Average (30°)	2,75	43	1	82,56	0,59	39,87 %	155
Min (16°)	2,69	42	1	80,64	0,57	39,67 %	192
Vehicular							
Max (40°)	2,82	44	1	84,48	0,60	40,15 %	63
Average (30°)	2,75	43	1	82,56	0,59	39,87 %	98
Min (16°)	2,69	42	1	80,64	0,57	39,67 %	121
Transportable							
Max (40°)	2,88	45	1	86,40	0,61	40,03 %	41
Average (30°)	2,82	44	1	84,48	0,60	39,92 %	25
Min (16°)	2,82	44	1	84,48	0,60	40,16 %	200
NOTE: 30 beams configuration.							

7.2.1.3 Data service 144 kbps

Table 7.8: System capacity; data 144 kbps

Data rate (kbps) 144	Capacity/ carrier/ spot (Mbps)	Nb traffic codes/spot/ carrier	Nb 2^{ndary} Scrambling codes/spot/ carrier	Satellite Capacity/ carrier (see note) (Mbps)	Spectrum efficiency as ITU (bit/s/Hz)	Power efficiency as ITU	On board Power consumption W
Handset							
Max (40°)	3,02	21	1	90,72	0,65	43,65 %	135
Average (30°)	2,88	20	1	86,40	0,61	43,63 %	145
Min (16°)	2,74	19	1	82,08	0,58	43,61 %	146
Portable							
Max (40°)	3,02	21	1	90,72	0,65	43,65 %	68
Average (30°)	3,02	21	1	90,72	0,65	43,74 %	191
Min (16°)	2,88	20	1	86,40	0,61	43,87 %	130
Vehicular							
Max (40°)	3,02	21	1	90,72	0,65	43,65 %	43
Average (30°)	3,02	21	1	90,72	0,65	43,74 %	120
Min (16°)	2,88	20	1	86,40	0,61	43,87 %	82
Transportable							
Max (40°)	3,02	21	1	90,72	0,65	43,65 %	4
Average (30°)	3,02	21	1	90,72	0,65	43,74 %	12
Min (16°)	3,02	21	1	90,72	0,65	43,96 %	30
NOTE: 30 beams configuration.							

7.2.1.4 Data service 384 kbps

Table 7.9: System capacity; data 384 kbps

Data rate (kbps) 384	Capacity/ carrier/ spot (Mbps)	Nb traffic codes/spot/ carrier	Nb 2^{ndary} Scrambling codes/spot/ carrier	Satellite Capacity/ carrier (see note) (Mbps)	Spectrum efficiency as ITU (bit/s/Hz)	Power efficiency as ITU	On board Power consumption W
Handset							
Max (40°)	3,46	9	1	103,68	0,74	42,29 %	113
Average (30°)	3,07	8	1	92,16	0,66	42,57 %	69
Min (16°)	3,07	8	1	92,16	0,66	42,45 %	114
Portable							
Max (40°)	3,46	9	1	103,68	0,74	42,29 %	57
Average (30°)	3,46	9	1	103,68	0,74	42,10 %	160
Min (16°)	3,07	8	1	92,16	0,66	42,45 %	57
Vehicular							
Max (40°)	3,46	9	1	103,68	0,74	42,29 %	36
Average (30°)	3,46	9	1	103,68	0,74	42,10 %	101
Min (16°)	3,46	9	1	103,68	0,74	42,84 %	200
Transportable							
Max (40°)	3,46	9	1	103,68	0,74	42,29 %	4
Average (30°)	3,46	9	1	103,68	0,74	42,10 %	10
Min (16°)	3,46	9	1	103,68	0,74	42,81 %	20
NOTE: 30 beams configuration.							

7.2.2 Mobile environment and/or indoor penetration

Considering the link level simulation results, system capacity is evaluated for a link budget margin of 15 dB. This link margin covers following situations:

- indoor penetration in the absence of IMRs deployment; or
- mobile environment.

Grey compartments mean the 15 dB link margin is not reached. Nevertheless, interleaving depth can be increased for reaching the 15 dB link margin.

Table 7.10 applies to the average case, i.e. for UE at 30° elevation. System capacity for maximum and minimum elevations (respectively 40° and 16°) can be found in clause B.1.

Table 7.10: System capacity; mobile environment/indoor penetration; 30° elevation

Data rate (kbps)	Capacity/ carrier/ spot (kbps)	Nb traffic codes/spot/ carrier	Satellite Capacity/ carrier (see note) (Mbps)	Spectrum efficiency as ITU (bit/s/Hz)	Power efficiency as ITU dB	Link Margin dB	On board Power consumption W
Handset							
8 kbps	92	23	2,76	0,02	0,75 %	15,0	200
64 kbps	64	1	1,92	0,01	1,83 %	13,4	200
144 kbps	144	1	4,32	0,03	2,33 %	12,7	200
384 kbps	384	1	11,52	0,08	3,19 %	11,2	200
Portable							
8 kbps	200	50	6,00	0,04	0,75 %	15,0	200
64 kbps	64	1	1,92	0,01	1,35 %	14,7	200
144 kbps	144	1	4,32	0,03	1,72 %	14,0	200
384 kbps	384	1	11,52	0,08	2,37 %	12,5	200
Vehicular							
8 kbps	272	68	8,16	0,06	0,75 %	15,0	198
64 kbps	64	1	1,92	0,01	1,25 %	15,0	159
144 kbps	144	1	4,32	0,03	1,50 %	14,6	200
384 kbps	384	1	11,52	0,08	2,06 %	13,1	200
Transportable							
8 kbps	500	125	15,00	0,11	0,75 %	15,0	198
64 kbps	192	3	5,76	0,04	1,26 %	15,0	58
144 kbps	144	1	4,32	0,03	1,39 %	15,0	29
384 kbps	384	1	11,52	0,08	1,59 %	14,3	200
NOTE: 30 beams configuration.							

7.2.3 Combined satellite and IMR environment

IMRs deployment allow to reduce the required link margin.

The link margin improvement is particularly sensible for low UE speed (3 km/h).

The required link margin in case of IMR deployment is:

- 8 kbps: 10 dB;
- 64 kbps: 11,5 dB;
- 144 kbps: 11,7 dB;
- 384 kbps: 12,5 dB.

Table 7.11 applies to the average case, i.e. for UE at 30° elevation. System capacity for maximum and minimum elevations (respectively 40° and 16°) can be found in clause B.2.

Grey compartments mean the link margin is not reached. Nevertheless, interleaving depth can be increased for reaching the link margin if supported by standard 3GPP equipment.

Table 7.11: System capacity; IMR deployment

Data rate (kbps)	Capacity/ carrier/ spot (kbps)	Nb traffic codes/spot/ carrier	Satellite Capacity/ carrier (see note) (Mbps)	Spectrum efficiency as ITU (bit/s/Hz)	Power efficiency as ITU dB	Link Margin dB	On board Power consumption W
Handset							
8 kbps	624	156	18,72	0,13	2,37 %	10,0	200
64 kbps	320	5	9,60	0,07	2,85 %	11,5	200
144 kbps	288	2	8,64	0,06	2,94 %	11,7	196
384 kbps	384	1	11,52	0,08	3,19 %	11,2	200
Portable							
8 kbps	1 000	250	30,00	0,21	2,36 %	10,0	200
64 kbps	512	8	15,36	0,11	2,80 %	11,5	178
144 kbps	432	3	12,96	0,09	2,96 %	11,7	141
384 kbps	384	1	11,52	0,08	2,37 %	12,5	200
Vehicular							
8 kbps	1 036	259	31,08	0,22	2,37 %	10,0	200
64 kbps	704	11	21,12	0,15	2,85 %	11,5	196
144 kbps	576	4	17,28	0,12	2,93 %	11,7	137
384 kbps	384	1	11,52	0,08	2,38 %	12,5	125
Transportable							
8 kbps	1 068	267	32,04	0,23	2,34 %	10,0	200
64 kbps	1 024	16	30,72	0,22	2,84 %	11,5	176
144 kbps	1 008	7	30,24	0,22	2,98 %	11,7	100
384 kbps	768	2	23,04	0,16	2,41 %	12,5	122
NOTE: 30 beams configuration.							

7.2.4 Hierarchical services structure

At this moment, it is recommended to structure broadcast services hierarchically: high priority data is mapped to low data rate channels (for example: 8 kbps or 64 kbps) while low priority data is mapped to high data rate channel. An illustrative example is: textual essential data sent over 8 kbps channel, images sent over 384 kbps.

UE equipment decodes the low or high data rate channel depending on its reception capabilities and its radio environment (see system capacity evaluation).

8 Technology design constraints

8.1 Doppler frequency shift

8.1.1 Doppler shift due to satellite movement

Considering GEO satellite configuration, a speed of 3m/s for the movement of the satellite (stabilization of the North-South inclination of about 0,07°) and $\cos(\alpha) = 1$, the maximum doppler frequency shift is calculated at upper limit of MSS core frequency band.

Table 8.1: Maximum doppler frequency shift due to satellite movement (GEO case)

	Core band MSS downlink
Maximum Doppler frequency shift	22 Hz

The Doppler frequency shift due to the GEO satellite movement is negligible to be compared to the one due to UE movement (see clause 8.1.2). Thus it can easily be compensated with standard 3GPP chipsets.

For LEO/HEO/MEO constellations, it is envisaged to append a dedicated Doppler compensation module to UE.

8.1.2 Doppler shift due to UE movement

Depending on the maximum UE speed, the maximum Doppler frequency shift is as follows (at upper limit of MSS core frequency band):

Table 8.2: Maximum Doppler frequency shift due to UE movement

UE velocity	Core Band MSS downlink
5 000 km/h (aeronautical future)	10 185 Hz
1 000 km/h (aeronautical)	2 037 Hz
500 km/h	1 018 Hz
120 km/h	244 Hz
3 km/h	6,1 Hz

The most constraining is aeronautical environment concerning Doppler frequency shift. This constraints may drive to add a Doppler compensation module to the UE and the gateway for use in aeronautical environment.

8.2 Interoperability

8.2.1 Dual mode UEs

To use W-CDMA UTRA FDD with satellite environment means essential parameters are made common between satellite and terrestrial systems. Consequently, most of RF and base-band circuits in the UE can be shared by the two operation modes. The UE antenna is also shared by the two operation modes for the handset configuration. This allows for small and light-weight dual mode UEs.

Dual mode UEs with 2nd generation systems, e.g. GSM or GMR and 2nd generation services are also supported.

8.2.2 Intermediate Module Repeaters (IMR)

IMR can be built with UTRAN Node B equipment. Co-location with terrestrial Node Bs is possible for system deployment integration.

Inter-system handover:

The proposed radio interface eases inter-system handover:

- with 2nd generation systems (e.g. GSM or GMR) thanks to compressed mode;
- with terrestrial UMTS thanks to the use of the same radio interface (same waveform, same protocol architecture).

8.2.3 Compatibility with existing systems

Since the radio interface is not new but based on terrestrial UMTS, it is highly recommended to re-use terrestrial UMTS components.

Furthermore, it presents no problem for connection to terrestrial 3GPP infrastructure thanks to the use of standardized transport interfaces: Iub, Iur and Iu interfaces are kept unchanged from 3GPP standards.

8.3 Performance enhancement features

For the space segment, communication payload on-board satellite may implement techniques that enhance system performance, e.g.:

- transparent analogue connectivity between spots and/or frequency channels: this allows connectivity between coverage areas, thus allowing to easily dispatch S-MBMS services to spots;
- regenerative payload: on-board base band processing signal demodulation/re-modulation and decoding/re-encoding may be implemented in order to increase link level performance. Link budget calculations (see clause 7.1) are based on the assumption that the feeder link has little impact on link level performance. Thus regenerative payload seems to be of interest in case on-board connectivity only.

For the terrestrial segment, candidate techniques for system performance enhancement are:

- additionally to Multi User Detection (MUD) which feasibility is commonly agreed for the uplink direction, applicability to the downlink direction is being considered. In effect, implementing interference cancellation at the UE receiver means to inform the UE about scrambling code, thus allowing for adjacent spot and/or secondary scrambling code interference cancellation. A major focus is to be pointed on the UE implementation cost;
- receiver diversity at the UE level, i.e. dual antenna at UE, for portable, vehicular and transportable configurations;
- time diversity;
- higher level modulation for the downlink direction can be considered, with restriction due to satellite power capacity constraints;
- optimized code allocation strategy.

8.4 System flexibility

The radio interface allows for system flexibility such as:

- dynamic spot redirection: a spot coverage may be redirected to a regional area where more capacity is required;
- dynamic spot power redistribution: satellite power can be redistributed between spots according to varying capacity requirement;
- satellite diversity.

9 Conclusion

The present document has presented the feasibility of using W-CDMA as a satellite radio interface. Satellite Multimedia Broadcast/Multicast Service enlarges capacity of terrestrial networks. The main system characteristics can be summarized as:

- UMTS terrestrial networks interoperability;
- large area coverage, particularly convenient for services such as broadcast/multicast services;
- suitable to complement terrestrial coverage in areas where:
    - terrestrial systems have not been deployed for business attractiveness reasons; or
    - terrestrial coverage requires capacity complement; or
    - terrestrial system has suffered environmental damages (crisis conditions);

- in the absence of Intermediate Module Repeaters, possibility to operate under obstructed environment and some indoor penetration;
- intermediate Module Repeaters can extend system capacity in urban and indoor coverage areas, in the MSS frequency band;
- re-use of terrestrial equipment, which allows economies of scale.

The only adaptation expected from 3GPP equipment for operation in satellite environment is RF agility to MSS frequency band.

Annex A:
Downlink reference measurement channels

Test services adopted hereafter are similar to 3GPP ones, i.e. audio 8 kbps and data 64/144/384 kbps (see [6] and [7]), with the difference that they are mapped to FACH.

A.1 Audio 8 kbps service

This test service concerns broadcasting of basic audio service. The parameters for the 8 kbps audio broadcast service are specified in table A.1 the channel coding for information is shown in figure A.1.

Table A.1: Parameters for 8 kbps test service

Parameter	
Information bit rate	8 kbps
S-CCPCH	15 ksps
Slot format #i	2
TFCI	On
TFCI/pilot to data fields power offsets	0 dB
Puncturing	2,17 %
Transport channel number	1
Transport block size	160 bits
Transport block set size	160 bits
Transmission time interval	20 ms
Type of error protection	Convolution Coding
Coding rate	1/3
Rate matching attribute	256
Size of CRC	16
Position of TrCH in radio frame	Fixed

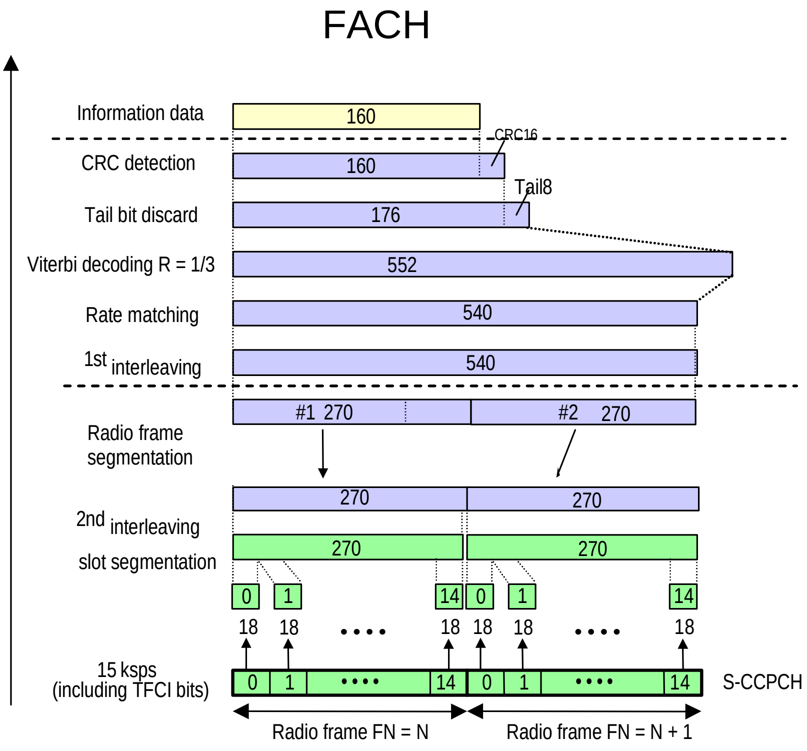


Figure A.1: Channel coding and multiplexing example for 8 kbps data

A.2 Data 64 kbps service

The parameters for the 64 kbps data service are specified in table A.2. The channel coding for information is shown in figure A.2.

Table A.2: Parameters for 64 kbps test service

Parameter	
Information bit rate	64 kbps
S-CCPCH	120 ksps
Slot format #i	11
TFCI	On
TFCI/pilot to data fields power offsets	0 dB
Repetition	11,1 %
Transport channel number	1
Transport block size	1 280
Transport block set size	1 280
Transmission time interval	20 ms
Type of error protection	Turbo Coding
Coding rate	1/3
Rate matching attribute	256
Size of CRC	16
Position of TrCH in radio frame	Fixed

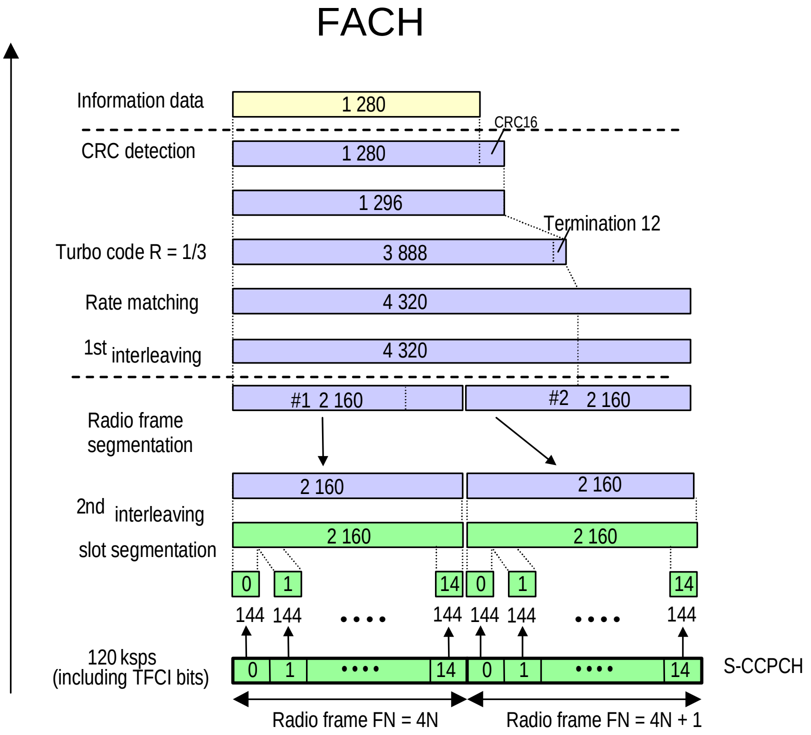


Figure A.2: Channel coding and multiplexing example for 64 kbps data

A.3 Data 144 kbps service

The parameters for the 144 kbps data service are specified in table A.3. The channel coding for information is shown in figure A.3.

Table A.3: Parameters for 144 kbps test service

Parameter	
Information bit rate	144 kbps
S-CCPCH	240 ksps
Slot format #i	13
TFCI	On
TFCI/pilot to data fields power offsets	0 dB
Repetition	2,2 %
Transport channel number	1
Transport block size	2 880
Transport block set size	2 880
Transmission time interval	20 ms
Type of error protection	Turbo Coding
Coding rate	1/3
Rate matching attribute	256
Size of CRC	16
Position of TrCH in radio frame	fixed

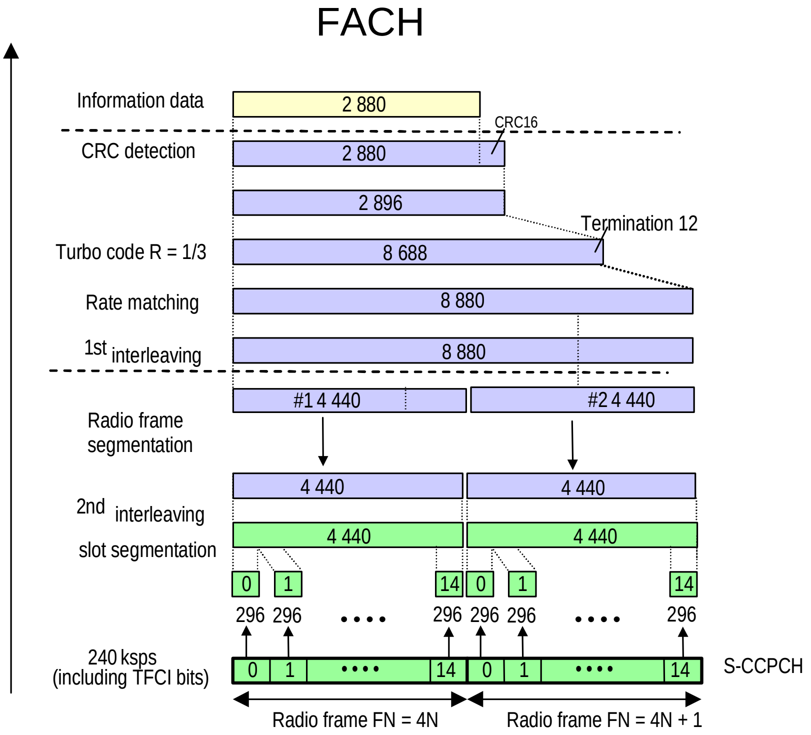


Figure A.3: Channel coding and multiplexing example for 144 kbps data

A.4 Data 384 kbps service

The parameters for the 384 kbps data service are specified in table A.4. The channel coding for information is shown in figure A.4.

Table A.4: Parameters for 384 kbps test service

Parameter	
Information bit rate	384 kbps
S-CCPCH	480 ksps
Slot format #i	15
TFCI	On
TFCI/pilot to data fields power offsets	0 dB
Puncturing	20,1 %
Transport channel number	1
Transport block size	3 840
Transport block set size	3 840
Transmission time interval	10 ms
Type of error protection	Turbo Coding
Coding rate	1/3
Rate matching attribute	256
Size of CRC	16
Position of TrCH in radio frame	fixed

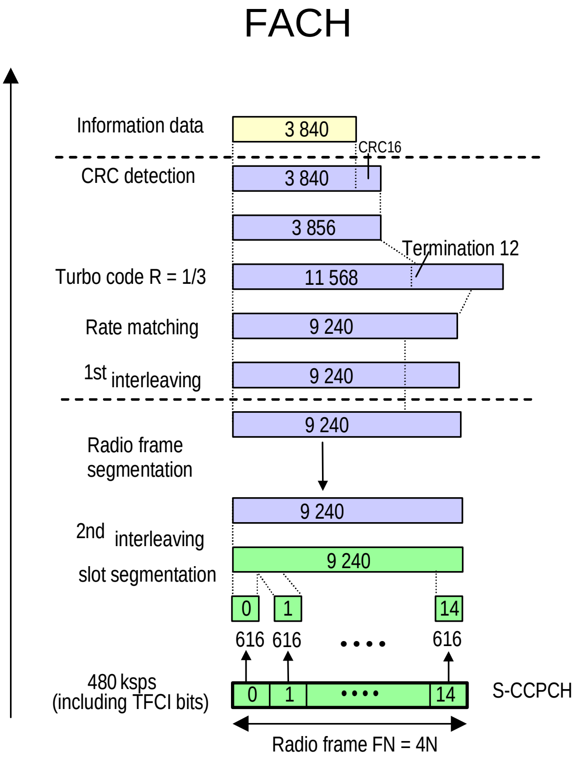


Figure A.4: Channel coding and multiplexing example for 384 kbps data

Annex B: System capacity - detailed results

B.1 Mobile environment and/or indoor penetration

Annex B presents system capacity in mobile environment and/or indoor penetration, i.e. for a 15 dB target link margin.

Grey compartments mean the 15 dB link margin is not reached for the corresponding UE configuration and elevation.

B.1.1 Audio service 8 kbps

Table B.1: System capacity; Mobile environment/indoor penetration; audio 8 kbps

Data rate (kbps) 8	**Capacity/ carrier/ spot (Mbps)**	**Nb traffic codes/spot/ carrier**	**Satellite capacity/ carrier (see note) (Mbps)**	**Spectrum efficiency as ITU (bit/s/Hz)**	**Power efficiency as ITU**	**On board power consumption W**
Handset						
Max (40°)	256	64	7,68	0,05	0,75 %	199
Average (30°)	92	23	2,76	0,02	0,75 %	200
Min (16°)	20	5	0,60	0,00	0,75 %	197
Portable						
Max (40°)	400	100	12,00	0,09	0,74 %	200
Average (30°)	200	50	6,00	0,04	0,75 %	200
Min (16°)	100	25	3,00	0,02	0,75 %	199
Vehicular						
Max (40°)	492	123	14,76	0,11	0,75 %	198
Average (30°)	272	68	8,16	0,06	0,75 %	198
Min (16°)	156	39	4,68	0,03	0,75 %	197
Transportable						
Max (40°)	708	177	21,24	0,15	0,75 %	199
Average (30°)	500	125	15,00	0,11	0,75 %	198
Min (16°)	344	86	10,32	0,07	0,75 %	200
NOTE: 30 beams configuration.						

B.1.2 Data service 64 kbps

Table B.2: System capacity; Mobile environment/indoor penetration; data 64 kbps

Data rate (kbps) 64	Capacity/ carrier/ spot (Mbps)	Nb traffic codes/spot/ carrier	Satellite capacity/ carrier (see note) (Mbps)	Spectrum efficiency as ITU (bit/s/Hz)	Power efficiency as ITU	Link margin dB	On board power consumption W
Handset							
Max (40°)	64	1	1,92	0,01	1,26 %	15,0	159
Average (30°)	64	1	1,92	0,01	1,83 %	13,4	200
Min (16°)	64	1	1,92	0,01	2,54 %	12,0	200
Portable							
Max (40°)	192	3	5,76	0,04	1,27 %	15,0	155
Average (30°)	64	1	1,92	0,01	1,35 %	14,7	200
Min (16°)	64	1	1,92	0,01	1,82 %	13,4	200
Vehicular							
Max (40°)	256	4	7,68	0,05	1,25 %	15,0	160
Average (30°)	64	1	1,92	0,01	1,25 %	15,0	159
Min (16°)	64	1	1,92	0,01	1,56 %	14,1	200
Transportable							
Max (40°)	384	6	11,52	0,08	1,25 %	15,0	76
Average (30°)	192	3	5,76	0,04	1,26 %	15,0	58
Min (16°)	64	1	1,92	0,01	1,27 %	15,0	57
NOTE: 30 beams configuration.							

B.1.3 Data service 144 kbps

Table B.3: System capacity; Mobile environment/indoor penetration; data 144 kbps

Data rate (kbps) 144	Capacity/ carrier/ spot (Mbps)	Nb traffic codes/spot/ carrier	Satellite capacity/ carrier (see note) (Mbps)	Spectrum efficiency as ITU (bit/s/Hz)	Power efficiency as ITU	Link Margin dB	On board power consumption W
Handset							
Max (40°)	144	1	4,32	0,03	1,46 %	14,7	200
Average (30°)	144	1	4,32	0,03	2,33 %	12,7	200
Min (16°)	144	1	4,32	0,03	3,23 %	11,3	200
Portable							
Max (40°)	144	1	4,32	0,03	1,39 %	15,0	116
Average (30°)	144	1	4,32	0,03	1,72 %	14,0	200
Min (16°)	144	1	4,32	0,03	2,32 %	12,7	200
Vehicular							
Max (40°)	288	2	8,64	0,06	1,40 %	15,0	159
Average (30°)	144	1	4,32	0,03	1,50 %	14,6	200
Min (16°)	144	1	4,32	0,03	1,99 %	13,4	200
Transportable							
Max (40°)	432	3	12,96	0,09	1,40 %	15,0	85
Average (30°)	144	1	4,32	0,03	1,39 %	15,0	29
Min (16°)	144	1	4,32	0,03	1,47 %	14,7	200
NOTE: 30 beams configuration.							

B.1.4 Data service 384 kbps

Table B.4: System capacity; Mobile environment/indoor penetration; data 384 kbps

Data rate (kbps) 384	Capacity/ carrier/ spot (Mbps)	Nb traffic codes/spot/ carrier	Satellite capacity/ carrier (see note) (Mbps)	Spectrum efficiency as ITU (bit/s/Hz)	Power efficiency as ITU	Link margin dB	On board power consumption W
Handset							
Max (40°)	384	1	11,52	0,08	2,01 %	13,2	200
Average (30°)	384	1	11,52	0,08	3,19 %	11,2	200
Min (16°)	384	1	11,52	0,08	4,44 %	9,8	200
Portable							
Max (40°)	384	1	11,52	0,08	1,62 %	14,2	200
Average (30°)	384	1	11,52	0,08	2,37 %	12,5	200
Min (16°)	384	1	11,52	0,08	3,19 %	11,2	200
Vehicular							
Max (40°)	384	1	11,52	0,08	1,47 %	14,6	200
Average (30°)	384	1	11,52	0,08	2,06 %	13,1	200
Min (16°)	384	1	11,52	0,08	2,73 %	11,9	200
Transportable							
Max (40°)	384	1	11,52	0,08	1,25 %	15,3	200
Average (30°)	384	1	11,52	0,08	1,59 %	14,3	200
Min (16°)	384	1	11,52	0,08	2,02 %	13,2	200
NOTE: 30 beams configuration.							

B.2 IMR deployment

Clause B.2 presents system capacity in case of IMR deployment.

B.2.1 Audio service 8 kbps

The required link margin is 10 dB.

Table B.5: System capacity; IMR deployment; audio 8 kbps

Data rate (kbps) 8	Capacity/ carrier/ spot (Mbps)	Nb traffic codes/spot/ carrier	Satellite capacity/ carrier (see note) (Mbps)	Spectrum efficiency as ITU (bit/s/Hz)	Power efficiency as ITU	On board power consumption W
Handset						
Max (40°)	1 028	257	30,84	0,22	2,35 %	198
Average (30°)	624	156	18,72	0,13	2,37 %	200
Min (16°)	392	98	11,76	0,08	2,37 %	199
Portable						
Max (40°)	1 056	264	31,68	0,23	2,36 %	193
Average (30°)	1 000	250	30,00	0,21	2,36 %	200
Min (16°)	680	170	20,40	0,15	2,37 %	200
Vehicular						
Max (40°)	1 068	267	32,04	0,23	2,37 %	200
Average (30°)	1 036	259	31,08	0,22	2,37 %	200
Min (16°)	888	222	26,64	0,19	2,37 %	199
Transportable						
Max (40°)	1 084	271	32,52	0,23	2,36 %	198
Average (30°)	1 068	267	32,04	0,23	2,34 %	200
Min (16°)	1 048	262	31,44	0,22	2,32 %	160
NOTE: 30 beams configuration.						

B.2.2 Data service 64 kbps

The required link margin is 11,5 dB.

Table B.6: System capacity; IMR deployment; Data 64 kbps

Data rate (kbps) 64	Capacity/ carrier/ spot (Mbps)	Nb traffic codes/ spot/ carrier	Satellite capacity/ carrier (see note) (Mbps)	Spectrum efficiency as ITU (bit/s/Hz)	Power efficiency as ITU	On board power consumption W
Handset						
Max (40°)	704	11	21,12	0,15	2,83 %	188
Average (30°)	320	5	9,60	0,07	2,85 %	200
Min (16°)	64	1	1,92	0,01	2,82 %	167
Portable						
Max (40°)	960	15	28,80	0,20	2,84 %	176
Average (30°)	512	8	15,36	0,11	2,80 %	178
Min (16°)	320	5	9,60	0,07	2,85 %	200
Vehicular						
Max (40°)	1 152	18	34,56	0,25	2,85 %	200
Average (30°)	704	11	21,12	0,15	2,85 %	196
Min (16°)	384	6	11,52	0,08	2,85 %	160
Transportable						
Max (40°)	1 408	22	42,24	0,30	2,82 %	177
Average (30°)	1 024	16	30,72	0,22	2,84 %	176
Min (16°)	704	11	21,12	0,15	2,79 %	171
NOTE: 30 beams configuration.						

B.2.3 Data service 144 kbps

The required link margin is 11,7 dB.

Table B.7: System capacity; IMR deployment; Data 144 kbps

Data rate (kbps) 144	Capacity/ carrier/ spot (Mbps)	Nb traffic codes/spot/ carrier	Satellite capacity/ carrier (see note) (Mbps)	Spectrum efficiency as ITU (bit/s/Hz)	Power efficiency as ITU	On board power consumption W
Handset						
Max (40°)	720	5	21,60	0,15	2,96 %	193
Average (30°)	288	2	8,64	0,06	2,94 %	196
Min (16°)	144	1	4,32	0,03	3,23 %	200
Portable						
Max (40°)	1 008	7	30,24	0,22	2,95 %	196
Average (30°)	432	3	12,96	0,09	2,96 %	141
Min (16°)	288	2	8,64	0,06	2,93 %	196
Vehicular						
Max (40°)	1 152	8	34,56	0,25	2,94 %	196
Average (30°)	576	4	17,28	0,12	2,93 %	137
Min (16°)	432	3	12,96	0,09	2,98 %	200
Transportable						
Max (40°)	1 440	10	43,20	0,31	2,98 %	116
Average (30°)	1 008	7	30,24	0,22	2,98 %	100
Min (16°)	720	5	21,60	0,15	2,93 %	197
NOTE: 30 beams configuration.						

B.2.4 Data service 384 kbps

The required link margin is 12,5 dB.

Table B.8: System capacity; IMR deployment; Data 384 kbps

Data rate (kbps) 384	Capacity/ carrier/ spot (Mbps)	Nb traffic codes/spot/ carrier	Satellite capacity/ carrier (see note) (Mbps)	Spectrum efficiency as ITU (bit/s/Hz)	Power efficiency as ITU	On board power consumption W
Handset						
Max (40°)	384	1	11,52	0,08	2,40 %	134
Average (30°)	384	1	11,52	0,08	3,19 %	200
Min (16°)	384	1	11,52	0,08	4,44 %	200
Portable						
Max (40°)	768	2	23,04	0,16	2,40 %	199
Average (30°)	384	1	11,52	0,08	2,37 %	200
Min (16°)	384	1	11,52	0,08	3,19 %	200
Vehicular						
Max (40°)	768	2	23,04	0,16	2,39 %	128
Average (30°)	384	1	11,52	0,08	2,38 %	125
Min (16°)	384	1	11,52	0,08	2,73 %	200
Transportable						
Max (40°)	768	2	23,04	0,16	2,36 %	13
Average (30°)	768	2	23,04	0,16	2,41 %	122
Min (16°)	384	1	11,52	0,08	2,37 %	37
NOTE: 30 beams configuration.						

Annex C: "W-CDMA" Radio transmission technologies description template

C.1 Test environment support

A1.1	Test environment support
A1.1.1	In what test environments will the RTT operate? **Answer:** The RTT will operate in the satellite test environment. Indoor test environment can be achieved either with Intermediate Module Repeaters (IMR) deployment or with a reduced radio system capacity.
A1.1.2	If the RTT supports more than one test environment, what test environment does this technology description template address? **Answer:** This template addresses the satellite test environment and the combined satellite/terrestrial environment in case of Intermediate Module Repeaters deployment. With IMR when satellite signal is totally obstructed, terrestrial environment applies.
A1.1.3	Does the RTT include any features in support of FWA application? Provide detail about the impact of those features on the technical parameters provided in this template, stating whether the technical parameters provided apply for mobile as well as for FWA applications. **Answer:** The proposed RTT can accommodate fixed, portable, vehicular and personal (handheld) satellite terminals. The proposed RTT is flexible enough to accommodate a wide range of bearer services up to 384 kbit/s.

C.2 Technical parameters

A1.2	Technical parameters NOTE: Parameters for both forward link and reverse link should be described separately, if necessary.
A1.2.1	What is the minimum frequency band required to deploy the system (MHz)? **Answer:** The minimum required band is 5 MHz for the satellite to terminals links (downlink). Additional bandwidth is needed for the satellite to LES link (feeder links) in FSS band.
A1.2.2	What is the duplex method: TDD or FDD? **Answer:** The duplex method is FDD.
A1.2.2.1	What is the minimum up/down frequency separation for FDD? **Answer:** Not applicable (this RTT only addresses downlink).
A1.2.2.2	What is requirement of transmit/receive isolation? Does the proposal require a duplexer in either the Mobile Station (MS) or BS? **Answer:** No duplexer is required (only forward link direction is considered in this RTT).
A1.2.3	Does the RTT allow asymmetric transmission to use the available spectrum? Characterize. **Answer:** Not applicable (this RTT only addresses downlink).
A1.2.4	What is the RF channel spacing (kHz)? In addition, does the RTT use an interleaved frequency plan? NOTE: The use of the second adjacent channel instead of the adjacent channel at a neighbouring cluster cell is called "interleaved frequency planning". If a proponent is going to employ an interleaved frequency plan, the proponent should state so in clause A1.2.4 and complete clause A1.2.15 with the protection ratio for both the adjacent and second adjacent channel. **Answer:** The channel spacing is 4,68 MHz (chip rate: 3,84 Mcps, roll-off factor: 0,22). No interleaved frequency allocation is needed.
A1.2.5	What is the bandwidth per duplex RF channel (MHz) measured at the 3 dB down points? It is given by (bandwidth per RF channel) × (1 for TDD and 2 for FDD). Provide detail. **Answer:** 4,68 MHz (3,84 Mcps + Root Raised Cosinus roll-off 0,22).
A1.2.5.1	Does the proposal offer multiple or variable RF channel bandwidth capability? If so, are multiple bandwidths or variable bandwidths provided for the purposes of compensating the transmission medium for impairments but intended to be feature transparent to the end user? **Answer:** Not applicable.
A1.2.6	What is the RF channel bit rate (kbit/s)? NOTE: The maximum modulation rate of RF (after channel encoding, adding of in-band control signalling and any overhead signalling) possible to transmit carrier over an RF channel, i.e. independent of access technology and of modulation schemes. **Answer:** Downlink: the spreading factor is variable in the range 4 to 512, the RF channel bit rates provided are: 15, 30…1 920 kbps. Multiple codes can be allocated for higher transmission rates.

A1.2.7	*Frame structur*e: Describe the frame structure to give sufficient information such as: - frame length; - the number of time slots per frame; - guard time or the number of guard bits; - user information bit rate for each time slot; - channel bit rate (after channel coding); - channel symbol rate (after modulation); - Associated Control Channel (ACCH) bit rate; - power control bit rate. NOTE 1: Channel coding may include Forward Error Correction (FEC), Cyclic Redundancy Checking (CRC), ACCH, power control bits and guard bits. Provide detail. NOTE 2: Describe the frame structure for forward link and reverse link, respectively. NOTE 3: Describe the frame structure for each user information rate. **Answer:** - Frame length: 10 ms. - Number of time slots per frame: 15. - Guard time: No guard time needed. - User information bit rate for each time slot: the user bit rate is variable on a frame by frame. basis. The user information rate may vary from few hundred bits/s to 384 kbps. - Channel bit rate (after channel coding and rate matching): 15/30/60/120 etc. 1 920 kbps. - Channel symbol rate (after modulation): 3,840 Mchip/s. See system description for more details.
A1.2.8	Does the RTT use frequency hopping? If so, characterize and explain particularly the impact (e.g. improvements) on system performance. **Answer:** No frequency hopping is employed in the RTT proposal.
A1.2.8.1	What is the hopping rate? **Answer:** Not applicable.
A1.2.8.2	What is the number of the hopping frequency sets? **Answer:** Not applicable.
A1.2.8.3	Are BSs synchronized or non-synchronized? **Answer:** With the baseline scrambling code allocation strategy, LESs (and spots) do not need to be tightly synchronized. Accuracy in the order of 10 ms is adequate, to support system procedures like inter-spot handoff. Different scrambling code allocation strategies, envisaging the use of different offsets of the same scrambling code by different spots will require tighter synchronization (in the order of 1 ms).
A1.2.9	Does the RTT use a spreading scheme? **Answer:** The RTT uses direct sequence spreading.
A1.2.9.1	What is the chip rate (Mchip/s)? Rate at input to modulator. **Answer:** The chip rate is 3,840 Mchip/s.
A1.2.9.2	What is the processing gain? 10 log (chip rate/information rate). **Answer:** Considering the standard test services: audio 8 kbps, data 64 kbps to 384 kbps, the processing gain is ranging from 10 dB to 26,8 dB. For lower bit rates (see system description), i.e. 2,4 kbps, the processing gain is up to 32 dB.
A1.2.9.3	Explain the uplink and downlink code structures and provide the details about the types (e.g. personal numbering (PN) code, Walsh code) and purposes (e.g. spreading, identification, etc.) of the codes. **Answer:** Channelization codes: Orthogonal Variable Spreading Factor (OVSF) codes. Spreading factor: 4 to 512. Scrambling code: Primary scrambling code: 18 bit scrambling codes (Gold sequence) limited to 512 codes. Secondary scrambling code: 18 bit scrambling codes (Gold sequence). Synchronization channel Scrambling code: code word with 256 chips from 16-chip sequence, not modulated. See System description for further detail.
A1.2.10	Which access technology does the proposal use: TDMA, FDMA, CDMA, hybrid, or a new technology? In the case of CDMA, which type of CDMA is used: Frequency Hopping (FH) or Direct Sequence (DS) or hybrid? Characterize. **Answer:** Direct sequence CDMA is employed.

A1.2.11	What is the base-band modulation technique? If both the data modulation and spreading modulation are required, describe in detail. What is the peak to average power ratio after base-band filtering (dB)? **Answer:** Modulation is QPSK. Square root raised cosine filtering with roll-off 0,22 is applied. See System description for further details.
A1.2.12	What is the channel coding (error handling) rate and form for both the forward and reverse links? E.g. does the RTT adopt: - FEC or other schemes? - Unequal error protection? Provide details. - Soft decision decoding or hard decision decoding? Provide details. - Iterative decoding (e.g. turbo codes)? Provide details. - Other schemes? **Answer:** Different classes of bearer services are supported. Depending on the quality bearer services: convolutional code with rate 1/2 or 1/3, k = 9, Rate 1/3. Turbo codes, or no FEC coding (in that case, error handling is directly provided by the application). Puncturing or unequal bit repetition is exploited to adapt the bearer service rate to the channel rate (rate matching feature).
A1.2.13	What is the bit interleaving scheme? Provide detailed description for both uplink and downlink. **Answer:** Default bit interleaving work perform block interleaving on a single signal frame (10 ms). 1st interleaving: on FEC blocks (inter frames interleaving) - depth: 20,40 or 80 ms. 2nd interleaving: on 10 ms frame (intra frame interleaving = bit interleaving).
A1.2.14	Describe the approach taken for the receivers (MS and BS) to cope with multi-path propagation effects (e.g. via equalizer, Rake receiver, etc.). **Answer:** The UE will utilize RAKE receivers. Usefulness of RAKE receiver in the satellite environment lies in the possibility to implement soft/softer handover as well as in the capability to exploit satellite diversity to improve the system power efficiency by decreasing the required link margins for a given service outage probability. Multi-path satellite channels also play a role. RAKE receiver detection threshold at -25 dB is recommended.
A1.2.14.1	Describe the robustness to inter-symbol interference and the specific delay spread profiles that are best or worst for the proposal. **Answer:** Inter-symbol interference plays a minor role in the performance of the proposed RTT being significantly attenuated by the de-spreading process. The performances of the RTT is influenced by the particular wide-band channel model (channel A, B and C) proposed for the satellite component.
A1.2.14.2	Can rapidly changing delay spread profile be accommodated? Describe. **Answer:** Rake receiver is designed to adapt to changing delay spread profile.
A1.2.15	What is the adjacent channel protection ratio? NOTE: In order to maintain robustness to adjacent channel interference, the RTT should have some receiver characteristics that can withstand higher power adjacent channel interference. Specify the maximum allowed relative level of adjacent RF channel power (dBc). Provide detail how this figure is assumed. **Answer:** The recommended adjacent channel protection ratio in a homogeneous environment is about 23 dB. Lower values may result in a graceful degradation of performances and/or capacity. Somewhat higher protection ratios may be required in a non-uniform environment as a consequence of the band sharing between different operators utilizing satellite constellation having different characteristics.
A1.2.16	Power classes
A1.2.16.1	*Mobile terminal emitted power:* What is the radiated antenna power measured at the antenna? For terrestrial component, give (dBm). For satellite component, the mobile terminal emitted power should be given in E.I.R.P. (effective isotropic radiated power) (dBm).
A1.2.16.1.1	What is the maximum peak power transmitted while in active or busy state? **Answer:** Not applicable (this RTT only addresses downlink).
A1.2.16.1.2	What is the time average power transmitted while in active or busy state? Provide detailed explanation used to calculate this time average power. **Answer:** Not applicable (this RTT only addresses downlink).

A1.2.17	What is the maximum number of voice channels available per RF channel that can be supported at one BS with 1 RF channel (TDD systems) or 1 duplex RF channel pair (FDD systems), while still meeting ITU-T Recommendation G.726 performance requirements? **Answer:** Up to 256 orthogonal codes are available for each downlink scrambling code, per sub-beam. Reserving three codes for the CCPCHs and the acquisition aid pilot, up to a maximum of 253 channels is available per sub-beam, plus 256 channelization code with a secondary scrambling code. See system description for detailed capacity evaluation. NOTE: A sub-beam is here defined as a single RF frequency channel associated to a single satellite spot, i.e. it is the intersection of a satellite spot beam and an RF channel.
A1.2.18	*Variable bit rate capabilities*: Describe the ways the proposal is able to handle variable baseband transmission rates. For example, does the RTT use: - Adaptive source and channel coding as a function of RF signal quality? - Variable data rate as a function of user application? - Variable voice/data channel utilization as a function of traffic mix requirements? Characterize how the bit rate modification is performed. In addition, what are the advantages of your system proposal associated with variable bit rate capabilities? **Answer:** Source coding is not part of this RTT. - For speech, Adaptive Multi-Rate (AMR) technique can be used every 20 ms speech frame to adapt air interface loading and speech connections quality. - Different frame format and data rates can be specified via the Transport Format Control Indicator (TFCI) associated to each transmitted data frame. Different channel coding parameters can also be associated to the different frame formats (see System Description). However, variation of the frame format and data rate has to be managed at higher protocol layer (MAC layer) than the physical layer. - Orthogonal Variable Spreading Factor (OVSF) codes are used to adapt the channel bit rate to the user requirements. Moreover, data rate can change on a frame by frame basis without any specific rate negotiation between the two communication entities thanks to a Transport Format Combination Indicator (TFCI) associated to each channel or thanks to Blink Detection. - Multiple spreading codes can be assigned for user information bit rates exceeding 384 Kbit/s.
A1.2.18.1	What are the user information bit rates in each variable bit rate mode? **Answer:** See system description.
A1.2.19	What kind of voice coding scheme or codec is assumed to be used in the proposed RTT? If the existing specific voice coding scheme or codec is to be used, give the name of it. If a special voice coding scheme or codec (e.g. those not standardized in standardization bodies such as ITU) is indispensable for the proposed RTT, provide detail, e.g. scheme, algorithm, coding rates, coding delays and the number of stochastic code-books. **Answer:** This RTT does not envisage any specific voice coding technique. Different voice coding techniques can be supported, including AMR.
A1.2.19.1	Does the proposal offer multiple voice coding rate capability? Provide detail. **Answer:** This RTT provide multiple bit rate capability that will allow fitting multiple voice coding standards like G.729, G.723.1, GSM (full and half rate), IS-54, IS-96. Also, it will support voice activation (DTX) and AMR.
A1.2.20	*Data services*: Are there particular aspects of the proposed technologies which are applicable for the provision of circuit-switched, packet-switched or other data services like asymmetric data services? For each service class (A, B, C and D) a description of RTT services should be provided, at least in terms of bit rate, delay and BER/Frame Error Rate (FER). NOTE 1: See ITU-R Recommendation M.1224 for the definition of: "circuit transfer mode"; "packet transfer mode"; "connectionless service"; and for the aid of understanding "circuit switched" and "packet switched" data services. NOTE 2: See ITU-T Recommendation I.362 for details about the service classes A, B, C and D. **Answer:** The proposed RTT is able to provide all type of services: circuit-switched and packet switched with the attention that services are unidirectional, i.e. downlink only. Bearer services with different BER and delay requirements can be set up thanks to the possibility of specifying different coding strategies and different interleaving depth.

A1.2.20.1	For delay constrained, connection oriented (Class A). **Answer:** All bit rates in the range 2,4 Kbit/s to 384 Kbit/s can be provided with BER <1.E-3, BLER <1 E-2. Lower BER options are also available and can be negotiated at call set-up. BER of 1E-6 or lower, however, requires Turbo Codes and the associated delay is compatible only with the higher bit rates (32 Kbit/s and more). Transmission delay is strongly dependent on the satellite constellation characteristics, which is not part of this RTT.
A1.2.20.2	For delay constrained, connection oriented, variable bit rate (Class B). **Answer:** Connection oriented, variable bit rate services are supported. In particular, very large flexibility in data rate has been introduced directly at the physical layer. BER/BLER performances and delay as in clause A1.2.20.1 can be achieved.
A1.2.20.3	For delay unconstrained, connection oriented (Class C). **Answer:** As for the other service class, Quality of Service can be negotiated at call set-up. Lacking strict constraints on delay, concatenated coding schemes can be used with longer interleaving thus allowing to achieve BER lower than 1^{E}-6 independently from the user data rate.
A1.2.20.4	For delay unconstrained, connectionless (Class D). **Answer:** Connectionless services have the same Quality of Service of delay unconstrained, connection oriented service (see clause A1.20.3).
A1.2.21	Simultaneous voice/data services: is the proposal capable of providing multiple user services simultaneously with appropriate channel capacity assignment? **Answer:** Simultaneous multiple user services is supported. The different services can have independent bit rate, BER, delay, etc. and can have different transfer modes (packet/circuit-switched).
A1.2.22	*Power control characteristics*: Is a power control scheme included in the proposal? Characterize the impact (e.g. improvements) of supported power control schemes on system performance. **Answer:** Power control is semi-static and controlled by the gateway.
A1.2.22.1	What is the power control step size (dB)? **Answer:** Step size can be chosen in the range 1 dB to 3 dB.
A1.2.22.2	What is the number of power control cycles per second? **Answer:** Not applicable.
A1.2.22.3	What is the power control dynamic range (dB)? **Answer:** Not applicable.
A1.2.22.4	What is the minimum transmit power level with power control? **Answer:** Not applicable.
A1.2.22.5	What is the residual power variation after power control when RTT is operating? Provide details about the circumstances (e.g. in terms of system characteristics, environment, deployment, MS-speed, etc.) under which this residual power variation appears and which impact it has on the system performance. **Answer:** Not applicable.
A1.2.23	*Diversity combining in MS and BS:* Are diversity combining schemes incorporated in the design of the RTT?

A1.2.23.1	Describe the diversity techniques applied in the MS and at the BS, including micro diversity and macro diversity, characterizing the type of diversity used, for example: - time diversity: repetition, Rake-receiver, etc.; - space diversity: multiple sectors, multiple satellite, etc.; - frequency diversity: FH, wide-band transmission, etc.; - code diversity: multiple PN codes, multiple FH code, etc.; - other scheme. Characterize the diversity combining algorithm, for example, switch diversity, maximal ratio combining, equal gain combining. Additionally, provide supporting values for the number of receivers (or demodulators) per cell per mobile user. State the dB of performance improvement introduced by the use of diversity. For the MS: what is the minimum number of RF receivers (or demodulators) per mobile unit and what is the minimum number of antennas per mobile unit required for the purpose of diversity reception? These numbers should be consistent to that assumed in the link budget template of annex 2 and that assumed in the calculation of the "capacity" defined at clause A1.3.1.5. **Answer:** The RTT supports space diversity and time diversity respectively through the use of multiple satellite and channel coding/interleaving. Maximal ratio combining is supported. Up to 8 fingers can be required in the UE depending on the satellite constellation and the channel delay profile (Intermediate Module Repeater environment).
A1.2.23.2	What is the degree of improvement expected (dB)? Also indicate the assumed conditions such as BLER and FER. **Answer:** For a BLER of 10^{-2}, and in ITU channel model A at 3km/h (the most unfavourable case), satellite diversity improvement is estimated in the range 2 dB to 5 dB depending on radio environment (ITU channel model A). UE antenna diversity improvement is estimated around 9 dB. See system description for further details.
A1.2.24	*Handover/Automatic radio Link Transfer (ALT):* Do the radio transmission technologies support handover? Characterize the type of handover strategy (or strategies) which may be supported, e.g. MS assisted handover. Give explanations on potential advantages, e.g. possible choice of handover algorithms. Provide evidence whenever possible. **Answer:** Soft and softer handover is supported. The following handoff types are the most common in the system. ***Beam hand-off*** The UE always measures the level of the pilot C/(N+I) coming from adjacent beams. The LES may decide to transmit the same channel through two different beams (soft beam hand-off) and command the UE to add a finger to demodulate the additional signal. ***Inter-satellite handoff*** The procedure is analogous to that of inter-beam hand-off. The only difference is that the UE has also to search for different satellite specific pilot scrambling codes. If a new, strong enough, pilot scrambling code is detected. Differently from the previous case, there is now a path diversity advantage and it is useful that all strong enough diversity paths are exploited. Maximal ratio combining can then be performed. ***Inter-frequency handoff*** Only hard inter-frequency, handoff is supported. This hand-off can be either intra-gateway or inter-gateway. Inter-frequency handoff is generally not needed. This hand-off is decided by the LES.
A1.2.24.1	What is the break duration (s) when a handover is executed? In this evaluation, a detailed description of the impact of the handover on the service performance should also be given. Explain how the estimate was derived. **Answer:** Soft handover allows no service break time.

A1.2.24.2	For the proposed RTT, can handover cope with rapid decrease in signal strength (e.g. street corner effect)? Give a detailed description of: - the way the handover detected, initiated and executed; - how long each of this action lasts (minimum/maximum time (ms)); - the time-out periods for these actions. **Answer:** Multiple satellites diversity will minimize the outage probability due to the Line Of Sight (LOS) blockage (or heavy shadow). Limitation in the number of available fingers in the UE receiver and the fact that explicit resources have to be allocated, can limit the number of satellites used for diversity. Although diversity can actually reduce the normalized power and increase bandwidth efficiency (according to the evaluation procedure suggested in ITU-R Recommendation M.1225 [2] annex 2), it is believed that it can provide an acceptable outage probability in land mobile application without imposing the use of too large link margins to counteract deep shadowing. An other alternative is IMRs deployment. See clause A1.2.24 for a description of handover detection and execution. Because of the soft handover characteristic, there is no specific time out.
A1.2.25	Characterize how the proposed RTT reacts to the system deployment (e.g. necessity to add new cells and/or new carriers) particularly in terms of frequency planning. **Answer:** This RTT supports full frequency reuse (frequency reuse factor equal to 1). Hence no ad-hoc planning is required to, for example, enlarge the satellite constellation and or increase the frequency band utilized apart for the normal co-ordination procedure with the other systems, or deploy Intermediate Module Repeaters.
A1.2.26	*Sharing frequency band capabilities:* To what degree is the proposal able to deal with spectrum sharing among IMT-2000 systems as well as with all other systems: - spectrum sharing between operators; - spectrum sharing between terrestrial and satellite IMT-2000 systems; - spectrum sharing between IMT-2000 and non-IMT-2000 systems; - other sharing schemes. **Answer:** Use of a spread spectrum transmission technique actually simplifies band sharing between different operators. Spread spectrum techniques will in fact significantly reduce the requirement for Adjacent Channel Protection that may instead penalize other access techniques. Spectrum sharing between terrestrial and satellite IMT-2000 systems has not been specifically considered in this proposal. However, its feasibility is not unreasonable if the access scheme of the two components is consistent.
A1.2.27	*Dynamic channel allocation:* characterize the Dynamic Channel Allocation (DCA) schemes which may be supported and characterize their impact on system performance (e.g. in terms of adaptability to varying interference conditions, adaptability to varying traffic conditions, capability to avoid frequency planning, impact on the reuse distance, etc.). **Answer:** No DCA strategy is required.
A1.2.28	Mixed cell architecture: How well do the technologies accommodate mixed cell architectures (pico, micro and macro-cells)? Does the proposal provide pico, micro and macro cell user service in a single licensed spectrum assignment, with handoff as required between them? (terrestrial component only) NOTE: Cell definitions are as follows: Pico - cell hex radius (r) < 100 m. Micro - 100 m < (r) < 1 000 m. Pico - (r) > 1 000 m. **Answer:** This RTT focuses on satellite component with possibility of global beam or multi-beam configuration. In case of use of IMRs, mixed cell architecture is accommodated. Then pico/micro/macro and satellite cell services are assigned to the same frequency carrier. Seamless handover is possible between the cell layers.
A1.2.29	Describe any battery saver/intermittent reception capability. **Answer:** During circuit switched operation the transmitter is continuously on, but discontinuous transmission allow to minimize the required power of the UE receivers. With packet traffic, depending on the packet-access mode, the receiver can be used periodical, i.e. switched off until data is available for reception.

A1.2.29.1	*Ability of the MS to conserve standby battery power:* Provide details about how the proposal conserves standby battery power. **Answer:** In stand-by the receiver will only listen to the broadcast and paging channels, periodically searching new pilot signals. This is slotted reception, UEs are powered-on only in time to receive the assigned slot for any possible pages or messages.
A1.2.30	*Signalling transmission scheme*: If the proposed system will use RTTs for signalling transmission different from those for user data transmission, describe the details of the signalling transmission scheme over the radio interface between terminals and base (satellite) stations. **Answer:** For layers above layer 2, the proposed system will use for signalling the same RTT as for data transmission: user data and signalling is time multiplexed on Layer 1.
A1.2.30.1	Describe the different signalling transfer schemes which may be supported, e.g. in connection with a call, outside a call. Does the RTT support: - new techniques? Characterize. - Signalling enhancements for the delivery of multimedia services? Characterize. **Answer:** Because signalling uses the same RTT as the user data, the system is open to any signalling technique. Signalling can be multiplexed with data on a unique physical channel. Special features, like rate indication, are however specifically supported by the physical layer to better cope with variable rate services, like multimedia services.
A1.2.31	Does the RTT support a bandwidth on demand (BOD) capability? BOD refers specifically to the ability of an end-user to request multi-bearer services. Typically, this is given as the capacity in the form of bits per second of throughput. Multi-bearer services can be implemented by using such technologies as multi-carrier, multi-time slot or multi-codes. If so, characterize these capabilities. NOTE: BOD does not refer to the self-adaptive feature of the radio channel to cope with changes in the transmission quality (see clause A1.2.5.1). **Answer:** Multiple bearer services are available in the proposed system. Bit rate may vary from few hundreds bit/s up to 384 Kbit/s. The BOD possibility is implemented by multiplexing the multi-bearer traffic on a single L1 traffic stream to be carried by the variable rate physical channel (for higher rates, combination of variable spreading factor and multi-code transmission).
A1.2.32	Does the RTT support channel aggregation capability to achieve higher user bit rates? **Answer:** Channel aggregation (i.e. multiple codes) can be used to achieve higher bit rates (up to 2 Mbps).

C.3 Expected performances

A1.3	Expected performances
A1.3.2	For satellite test environment only
A1.3.2.1	What is the required C/N0 to achieve objective performance defined in annex 2? **Answer:** Results are dependent on the satellite characteristics and constellation characteristics. Assuming a GEO constellation (36 000 Km height) with 30 beams satellites, C/No is from -21,4 dB (8kbps) up to -7,1 dB (384 kbps). See Link Budget examples.
A1.3.2.2	What are the Doppler compensation method and residual Doppler shift after compensation? **Answer:** With a GEO constellation, Doppler shift due to the satellite movement is 22 Hz in the Core Band. This is negligible to be compared to Doppler shift due to UE motion. For the Doppler shift due to UE velocity, in aeronautical environment (max UE speed: 5 000 km/h) an additional Doppler shift of up to 10 185 Hz in the Core Band. Compensation methods are similar to the ones for 3G standardized terrestrial products for UE speeds up to 500 km/h. An adaptation is to be implemented for aeronautical environment (UE speed up to 5 000 km/h).
A1.3.2.3	*Capacity:* The spectrum efficiency of the radio transmission technology has to be evaluated assuming the deployment models described in annex 2.
A1.3.2.3.1	What is the voice information capacity per required RF bandwidth (bit/s/Hz)? **Answer:** Results are dependent on the constellation and satellite characteristics. Also a trade-off is possible between power and bandwidth efficiency. A typical value is 0,46 bit/s/Hz. See system description for detailed capacity evaluation.

A1.3.2.3.2	What is the voice plus data information capacity per required RF bandwidth (bit/s/Hz)? **Answer:** Results are dependent on the constellation and satellite characteristics. Also a trade-off is possible between power and bandwidth efficiency. Typical value ranges between 0,5 bit/s/Hz and 0,75 bit/s/Hz depending on data rate. See system description for detailed capacity evaluation.
A1.3.2.4	*Normalized power efficiency:* The power efficiency of the radio transmission technology has to be evaluated assuming the deployment models described in annex 2.A1.3.2.4.1 What is the supported information bit rate per required carrier power-to-noise density ratio for the given channel performance under the given interference conditions for voice? **Answer:** Results are dependent on the satellite characteristics and constellation characteristics. It typically ranges from 23,7 % (8kbps) up to 43 % (384 kbps). See system description for detailed evaluation.
A1.3.2.4.2	What is the supported information bit rate per required carrier power-to-noise density ratio for the given channel performance under the given interference conditions for voice plus data? **Answer:** See system description.
A1.3.3	*Maximum user bit rate (for data):* Specify the maximum user bit rate (kbit/s) available in the deployment models described in annex 2. **Answer:** 384 Kbit/s (multi-beam).
A1.3.4	What is the maximum range (m) between a user terminal and a BS (prior to hand-off, relay, etc.) under nominal traffic loading and link impairments as defined in annex 2? **Answer:** The maximum range is constellation dependent (ex: GEO = ≈ 2 × 36 000 km). See example for GEO in link budgets.
A1.3.5	Describe the capability for the use of repeaters. **Answer:** The system is designed to be able to cope with repeaters deployment. See system description.
A1.3.6	*Antenna systems:* Fully describe the antenna systems that can be used and/or have to be used; characterize their impacts on systems performance, (terrestrial only); e.g. does the RTT have the capability for the use of: - remote antennas: describe whether and how remote antenna systems can be used to extend coverage to low traffic density areas; - distributed antennas: describe whether and how distributed antenna designs are used, and in which IMT-2000 test environments; - Smart antennas (e.g. switched beam, adaptive, etc.): describe how smart antennas can be used and what is their impact on system performance; - other antenna systems. **Answer:** See Link Budget examples and textual description.
A1.3.7	Delay (for voice) **Answer:** The delay will depend mainly on the selected satellite constellation characteristics and on the source coding technique. The delay introduced by the radio part is typically 20 ms. (with 20 ms. Interleaving depth). In case of GEO constellation the delay introduced by the transmission path is up to 250 ms.
A1.3.7.1	What is the radio transmission processing delay due to the overall process of channel coding, bit interleaving, framing, etc., not including source coding? This is given as transmitter delay from the input of the channel coder to the antenna plus the receiver delay from the antenna to the output of the channel decoder. Provide this information for each service being provided. In addition, a detailed description of how this parameter was calculated is required for both the uplink and the downlink. **Answer:** It depends on the selected interleaving depth. Minimum interleaving depth is one frame (10 ms). Maximum interleaving depth is 8 frames (80 ms). With a 1/3 FEC, the processing delay is 3 × 80 = 240 ms.

A1.3.7.2	What is the total estimated round trip delay (ms) to include both the processing delay, propagation delay (terrestrial only) and vocoder delay? Give the estimated delay associated with each of the key attributes described in Fig. 6 that make up the total delay provided. **Answer:** Source coding is not includes in this RTT. Source coding which may find use with this RTT like G729, IS-96 QCELP and G723.1 have total delay respectively of 25 ms., 45 ms and 67,5 ms. Interleaving delay are given in clause A1.3.7.1. Propagation delay is satellite constellation dependent.
A1.3.7.3	Does the proposed RTT need echo control? **Answer:** Not applicable (this RTT only addresses downlink).
A1.3.8	What is the MOS level for the proposed codec for the relevant test environments given in annex 2? Specify its absolute MOS value and its relative value with respect to the MOS value of ITU-T Recommendation G.711 (64 k PCM) and ITU-T Recommendation G.726 [42] (32 k ADPCM). NOTE: If a special voice coding algorithm is indispensable for the proposed RTT, the proponent should declare detail with its performance of the codec such as MOS level. (See clause A1.2.19). **Answer:** Speech coding is not part of this proposal.
A1.3.9	Description of the ability to sustain quality under certain extreme conditions.
A1.3.9.2	*Hardware failures:* Characterize system behaviour and performance in such conditions. Provide detailed explanation on any calculation. **Answer:** System behaviour is implementation dependent. The possibility to exploit satellite diversity makes the system less sensitive to isolated faults in a given satellite.
A1.3.9.3	*Interference immunity:* Characterize system immunity or protection mechanisms against interference. What is the interference detection method? What is the interference avoidance method? **Answer:** The system is inherently robust against interference thanks to the CDMA access. Further, the proposed RTT supports interference mitigation techniques like linear Multi-User Detection (MUD) receiver which may be optionally exploited to reduce interference, with the drawback of increasing UE cost.
A1.3.10	Characterize the adaptability of the proposed RTT to different and/or time-varying conditions (e.g. propagation, traffic, etc.) that are not considered in the above attributes of clause A1.3. **Answer:** See system description.

C.4 Technology design constraints

A1.4	Technology design constraints
A1.4.1	*Frequency stability:* Provide transmission frequency stability (not oscillator stability) requirements of the carrier (include long term, 1 year, frequency stability requirements (ppm)).
A1.4.1.2	For MS transmission. **Answer:** Not applicable (this RTT only addresses downlink).
A1.4.2	*Out-of-band and spurious emissions:* Specify the expected levels of base or satellite and mobile transmitter emissions outside the operating channel, as a function of frequency offset. **Answer:** - Mobile**:** not applicable (this RTT only addresses downlink). - Satellite: see satellite transmission mask (clause 6.3). - IMR: see IMR transmission mask (clause 6.5).
A1.4.3	*Synchronization requirements:* Describe RTT's timing requirements, e.g.: - Is BS-to-BS or satellite land earth station (LES)-to-LES synchronization required? Provide precise information, the type of synchronization, i.e. synchronization of carrier frequency, bit clock, spreading code or frame, and their accuracy. **Answer:** No synchronization required apart for a time accuracy in the order of 10 ms to ease soft handoff procedures. - State short-term frequency and timing accuracy of BS (or LES) transmit signal. **Answer:** Frequency accuracy within ±0,05 ppm over one time slot period. Timing accuracy: TBC. - State source of external system reference and the accuracy required, if used at BS (or LES) (for example: derived from wireline network, or GPS receiver). **Answer:** A reference clock can be derived from the RNC or from GPS. - State free run accuracy of MS frequency and timing reference clock. **Answer:** Short term accuracy: ±0,1 ppm over 1 time slot period. - State base-to-base bit time alignment requirement over a 24 h period (ms). **Answer:** A specific requirement is needed only if inter-LES handover has to be supported. In that case 10 ms of time accuracy is sufficient.
A1.4.4	*Timing jitter:* For BS (or LES) and MS give: - the maximum jitter on the transmit signa; - the maximum jitter tolerated on the received signal. Timing jitter is defined as r.m.s. value of the time variance normalized by symbol duration. **Answer:** It is expected that timing jitter less than 3 % of the chip duration will not produce any significant signal degradation.
A1.4.5	*Frequency synthesizer:* What is the required step size, switched speed and frequency range of the frequency synthesizer of MSs? **Answer:** - Step size: 200 kHz. - Switched speed: No strict requirement (<10 ms.) - Frequency range: 15 MHz (for MSS bandwidth).
A1.4.6	Does the proposed system require capabilities of fixed networks not generally available today? **Answer:** No.
A1.4.6.1	Describe the special requirements on the fixed networks for the handover procedure. Provide handover procedure to be employed in proposed RTT in detail. **Answer:** No special requirement on the fixed network is required.
A1.4.7	Fixed network feature transparency
A1.4.7.1	Which service(s) of the standard set of ISDN bearer services can the proposed RTT pass to users without fixed network modification. **Answer:** 64 Kbit/s bearer services are supported. Extension to 384 Kbit/s is also feasible.
A1.4.8	Characterize any radio resource control capabilities that exist for the provision of roaming between a private (e.g. closed user group) and a public IMT-2000 operating environment. **Answer:** This RTT proposal only addresses physical layer issues. Higher layer signalling is required for that purpose.

A1.4.9	Describe the estimated fixed signalling overhead (e.g. broadcast control channel, power control messaging). Express this information as a percentage of the spectrum which is used for fixed signalling. Provide detailed explanation on your calculations. **Answer:** For each downlink spot beam a pilot channel (CPICH), a Synchronization Channel (SCH) and a broadcast channel are needed. Channel data rate on the primary CCPCH (broadcast channel bringing system specific information) is 30 kbps. A secondary CCPCH may also be active for paging. These three channels consume 3 channelization codes out of 256 available. Common physical fixed signalling channels equivalent number of traffic codes was calculated in link budgets (see system description), taking into account common channels to traffic channels power ratio. In static environment, percentage of the spectrum/power used for fixed signalling is from 6 % (8 kbps audio traffic) to 12 % (data 384 kbps) up to 14 % (data 64 and 144 kbps). Percentage of satellite power: XX.
A1.4.13	What are the signal processing estimates for both the hand-portable and the BS? - MOPS (millions of operations per second) value of parts processed by DSP (digital signal processing); - gate counts excluding DSP; - ROM size requirements for DSP and gate counts (kbytes); - RAM size requirements for DSP and gate counts (kbytes). NOTE 1: At a minimum the evaluation should review the signal processing estimates (MOPS, memory requirements, gate counts) required for demodulation, equalization, channel coding, error correction, diversity processing (including Rake receivers), adaptive antenna array processing, modulation, A-D and D-A converters and multiplexing as well as some IF and baseband filtering. For new technologies, there may be additional or alternative requirements (such as FFTs etc.). NOTE 2: The signal processing estimates should be declared with the estimated condition such as assumed services, user bit rate and etc. **Answer:** Signal processing estimates are similar to terrestrial UMTS equipment.
A1.4.14	*Dropped calls:* Describe how the RTT handles dropped calls. Does the proposed RTT utilize a transparent reconnect procedure - that is, the same as that employed for handoff? **Answer:** This RTT proposal supports the transparent reconnect procedure.
A1.4.15	Characterize the frequency planning requirements: - frequency reuse pattern: given the required C/I and the proposed technologies, specify the frequency cell reuse pattern (e.g. 3-cell, 7-cell, etc.) and, for terrestrial systems, the sectorization schemes assumed; - characterize the frequency management between different cell layers; - does the RTT use an interleaved frequency plan? - are there any frequency channels with particular planning requirements? - all other relevant requirements. NOTE: The use of the second adjacent channel instead of the adjacent channel at a neighbouring cluster cell is called "interleaved frequency planning". If a proponent is going to employ an interleaved frequency plan, the proponent should state so in clause A1.2.4 and complete clause A1.2.15 with the protection ratio for both the adjacent and second adjacent channel. **Answer:** - Full frequency reuse is supported. - There are not multiple cell layers within the satellite segment. - There is no need for interleaved frequency plan nor frequency channel with particular planning requirements
A1.4.16	Describe the capability of the proposed RTT to facilitate the evolution of existing radio transmission technologies used in mobile telecommunication systems migrate toward this RTT. Provide detail any impact and constraint on evolution. **Answer:** The proposed RTT has been designed to simplify the implementation of dual-mode terminals (terrestrial, satellite UMTS). In particular, the most relevant radio parameters, modulation, spreading and scrambling have been designed to have the maximum commonality with the 3GPP W-CDMA proposal for the terrestrial IMT-2000 environments.

C.5 Information required for terrestrial link budget template

Not applicable.

C.6 Satellite system configuration

A1.6	*Satellite system configuration* (applicable to satellite component only): Configuration details in this clause are not to be considered as variables. They are for information only.
A1.6.1	Configuration of satellite constellation
A1.6.1.1	GSO, HEO, MEO, LEO or combination? **Answer:** The proposed RTT has not been designed specifically for a satellite constellation. It can be used with all type, or combination, of constellations. Constellations providing multi-satellite visibility will however better exploit the capability of the proposed RTT to take advantage of satellite diversity for minimizing the outage probability.
A1.6.1.2	What is the range of height where satellites are in active communication? **Answer:** It depends on the constellation type which is not part of this proposal.
A1.6.1.3	What is the orbit inclination angle? **Answer:** It depends on the constellation type which is not part of this proposal.
A1.6.1.4	What are the number of orbit planes? **Answer:** It depends on the constellation type which is not part of this proposal.
A1.6.1.5	What are the number of satellites per orbit plane? **Answer:** It depends on the constellation type which is not part of this proposal.
A1.6.2	What is the configuration of spot beams/cell layout pattern? **Answer:** It is not defined by this RTT. The RTT proposal is however extremely flexible in this regard. In particular it also supports adaptive digital beam-forming configurations able to generate an independent beam per user. This feature may be particularly attractive for the downlink implementation, where implementation complexity issues are more manageable and where maximum power efficiency improvement is of paramount importance.
A1.6.3	What is the frequency reuse plan among spot beams? **Answer:** Full frequency reuse is supported.
A1.6.4	What is the service link G/T of satellite beam (average, minimum)? **Answer:** It depends on the constellation and satellite characteristics, which are not defined in this proposal. See example in the Link budget.
A1.6.5	What is the service link saturation EIRP of each beam (average, minimum), when configured to support "hot spot"? **Answer:** It depends on the satellite characteristics which are not defined in this proposal.
A1.6.6	What is the service link total saturation E.I.R.P. per satellite? **Answer:** It depends on the satellite characteristics which are not defined in this proposal.
A1.6.7	Satellite E.I.R.P. per RF carrier for satellite component.
A1.6.7.1	What is the maximum peak E.I.R.P. transmitted per RF carrier? **Answer:** It depends on the particular constellation and satellite beam configuration.
A1.6.7.2	What is the average E.I.R.P. transmitted per RF carrier? **Answer:** It depends on the particular constellation and satellite beam configuration. See example in the Link budget.
A1.6.8	What is the feeder link information? **Answer:** Feeder link architecture is not constrained by the proposed RTT.
A1.6.9	What is the slot timing adjustment method (mainly applicable to TDMA system)? **Answer:** Not applicable for the proposed access.
A1.6.10	What is the satellite diversity method, if applicable? **Answer:** The proposed RTT support maximal ratio combining of all the signals coming from visible satellites on both forward and reverse links. In the reverse link same satellite beam diversity can also be exploited to further reduce the UE E.I.R.P. required to close the link.

History

Document history		
V1.1.1	April 2004	Publication