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Technical Report

Satellite Earth Stations and Systems (SES); Satellite Component of UMTS/IMT-2000; Considerations on possible harmonization between A, C and G family Satellite Radio Interface features

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Contents

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Foreword

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

1 Scope

The present document identifies all differences and commonalities between the A, C and G family satellite radio interfaces (ITU-R Recommendation M.1457 [i.13]) in order to asses harmonization.

It also includes a synthetic view of new features proposed by SAT-CDMA and SW-CDMA vs W-CDMA radio interface and what are their expected benefits, with respect to the context (type of constellation and service requirements)

2 References

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2.1 Normative references

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Not applicable.

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area**.** For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] ETSI TS 101 851-1-2: "Satellite Earth Stations and Systems (SES); Satellite Component of UMTS/IMT-2000; Part 1: Physical channels and mapping of transport channels into physical channels; Sub-part 2: A-family (S-UMTS-A 25.211)".

[i.2] ETSI TS 101 851-2-2: "Satellite Earth Stations and Systems (SES); Satellite Component of UMTS/IMT-2000; Part 2: Multiplexing and channel coding; Sub-part 2: A-family (S-UMTS-A 25.212)".

[i.3] ETSI TS 101 851-3-2: "Satellite Earth Stations and Systems (SES); Satellite Component of UMTS/IMT-2000; Part 3: Spreading and modulation; Sub-part 2: A-family (S-UMTS-A 25.213)".

[i.4] ETSI TS 101 851-4-2: "Satellite Earth Stations and Systems (SES); Satellite Component of UMTS/IMT-2000; Part 4: Physical layer procedures; Sub-part 2: A-family (S-UMTS-A 25.214)".

[i.5] ETSI TS 101 851-1-1: "Satellite Earth Stations and Systems (SES); Satellite Component of UMTS/IMT-2000; Part 1: Physical channels and mapping of transport channels into physical channels; Sub-part 1: G-family (S-UMTS-G 25.211)".

[i.6] ETSI TS 101 851-2-1: "Satellite Earth Stations and Systems (SES); Satellite Component of UMTS/IMT-2000; Part 2: Multiplexing and channel coding; Sub-part 1: G-family (S-UMTS-G 25.212)".

[i.7] ETSI TS 101 851-3-1: "Satellite Earth Stations and Systems (SES); Satellite Component of UMTS/IMT-2000; Part 3: Spreading and modulation; Sub-part 1: G-family (S-UMTS-G 25.213)".

[i.8] ETSI TS 101 851-4-1: "Satellite Earth Stations and Systems (SES); Satellite Component of UMTS/IMT-2000; Part 4: Physical layer procedures; Sub-part 1: G-family (S-UMTS-G 25.214)".

[i.9] TTAS.KO-06.0090: "IMT-2000 SAT-CDMA - Physical channel and mapping of transport channels onto physical channels (Release A) (TTAE-3G-SAT-25.211)".

[i.10] TTAS.KO-06.0091: "IMT-2000 SAT-CDMA - Multiplexing and channel coding (Release A) (TTAE-3G-SAT-25.212)".

[i.11] TTAS.KO-06.0092: "IMT-2000 SAT-CDMA - Spreading and modulation (Release A) (TTAE-3G-SAT-25.213)".

[i.12] TTAS.KO-06.0093: "IMT-2000 SAT-CDMA - Physical layer procedure (Release A) (TTAE-3G-SAT-25.214)".

[i.13] ITU-R Recommendation M.1457-6: "Detailed specifications of the radio interfaces of International Mobile Telecommunications-2000 (IMT-2000)".

[i.14] ETSI TR 102 058: "Satellite Earth Stations and Systems (SES); Satellite Component of UMTS/IMT-2000; Evaluation of the W-CDMA UTRA FDD as a Satellite Radio Interface".

[i.15] ETSI TS 125 331:" Universal Mobile Telecommunications System (UMTS); RRC Protocol Specification (3G TS 25.331 version 3.3.0 Release 1999)".

[i.16] IEEE Journal on Selected Areas in Communications, Vol. 19, No. 2, February 2001.

[i.17] IEEE Journal on Selected Areas in Communications, Vol. 7, No.18, July 2000.

[i.18] IEEE Journal on Selected Areas in Communications, Vol. 17, No. 2, February 1999.

[i.19] ETSI TS 125 213: "Universal Mobile Telecommunications System (UMTS); Spreading and modulation (FDD) (3GPP TS 25.213)".

[i.20] ETSI TS 125 214: "Universal Mobile Telecommunications System (UMTS); Physical layer procedures (FDD) (3GPP TS 25.214)".

[i.21] TTAS.KO-06.0094: "Physical layer - measurements (Release A) (TTAE-3G-SAT-25.215)".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

SW-CDMA: satellite radio interface referenced as SRI-A of IMT-2000 satellite component at ITU-R Recommendation M.1457 [i.13]

NOTE: The SW-CDMA radio interface was produced by the ETSI SES Technical Committee as S-UMTS A-family standard.

W-CDMA: satellite radio interface referenced at SRI-G of IMT-2000 satellite component at ITU-R Recommendation M.1457 [i.13]

NOTE: The W-CDMA radio interface was produced by the ETSI SES Technical Committee as S-UMTS G-family standard.

SAT-CDMA: satellite radio interface referenced at SRI-C of IMT-2000 satellite component at ITU-R Recommendation M.1457 [i.13]

NOTE 1: The SAT-CDMA was produced by TTA of Korea.

NOTE 2: These radio interfaces are based on the FDD mode of UTRA defined by 3GPP Technical Specifications and adapted for operation over satellite transponders.

3.2 Symbols

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

r	code rate
K	constraint length
R	number of rows for a block interleaver
C	number of columns for a block interleaver

3.3 Abbreviations

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

AI	Acquisition Indicator
AICH	Acquisition Indicator Channel
AP	Access Preamble
APA	aAccess Preamble Acquisition
APA/CD/CA-ICH	Access Preamble Acquisition/Collision Detection/Channel Assignment-Indicator Channel
API	Access Preamble acquisition Indicator
BCH	Broadcast CHannel
BSDT	Beam Selection Diversity Transmission
CA	Channel Assignment
CAI	Channel Assignment Indicator
CCC	CPCH Control Command
CCTrCH	Coded Composite Transport CHannel
CD	Collision Detection
CDI	Collision Detection Indicator
CDP	Collision Detection Preamble
CLPC	Closed Loop Power Control
CPCH	Common Packet CHannel
CPCH-CCPCH	CPCH-Common Control Physical CHannel
CPICH	Common Pilot Channel
CRC	Cyclic Redundancy Check
CSICH	CPCH Status Indicator Channel

DL	Downlink
DPCCH	Dedicated Physical Control Channel
DPCH	Dedicated Physical Channel
DPDCH	Dedicated Physical Data Channel
DS	Direct Spread
DTX	Discontinuous Transmission
FACH	Forward Access Channel
FBI	FeedBack Information
FSW	Frame Synchronization Word
GEO	Geostationary Earth Orbit
GNSS	Global Navigation Satelliite System
I	I-branch
LC	Long Code
LEO	Low Earth Orbit
MAC	Medium Access Control
MUD	MultiUser Detection
MSS	Mobile Satellite Service
NACK	Negative ACKnowledgment
NI	Notification Indicator
OLPC	Open Loop Power Control
OVSF	Orthogonal Variable Spreading Factor
P-CCPCH	Primary Common Control Physical Channel
PCH	Paging Channel
PCPCH	Physical Common Packet Channel
PDSCH	Physical Downlink Shared Channel
PG	Processing Gain
PhCH	Physical Channel
PHPPCH	Physical High Penetration Paging Channel
PI	Paging Indicator
PICH	Paging Indicator Channel
PRACH	Physical Random Access Channel
PSC	Primary Synchronization Code
RAN	Radio Access Network
RLC	Radio Link Control
RRC	Radio Resource Control
RSSI	Received Signal Strength Indicator
RTD	Round Trip Delay
SC	Short Code
S-CCPCH	Secondary Common Control Physical Channel
SCH	Synchronization Channel
SF	Spreading Factor
SFN	System Frame Number
SI	CPSH Status Indicator
SIR	Signal to Interference Ratio
SSC	Secondary Synchronization Code
SSDT	Site Selection Diversity Transmission
TF	Transport Format
TFC	Transport Format Combination
TFCI	Transport-Format Combination Indicator
TG	Transmission Gap
TPC	Transmit Power Control
TrBk	Transport Block
TrCH	Transport Channel
TTI	Transmission Time Interval
UE	User Equipment
UL	Uplink

4 Presentation of (S)W-CDMA and SAT-CDMA

4.1 SW-CDMA

SW-CDMA is a satellite radio interface designed to meet the requirements of the satellite component of the third generation (3G) wireless communication systems. The SW-CDMA radio interface was produced by TS 101 851.

SW-CDMA is based on the adaptation to the satellite environment of the IMT-2000 CDMA Direct Spread terrestrial radio interface (UTRA FDD or WCDMA). The intention is to reuse the same core network and reuse the radio interface specifications for the Iu and Cu interface. Only the Uu interface will be adapted to the satellite environment.

SW-CDMA operates in FDD mode with RF channel bandwidth of either 2,350 MHz or 4,700 MHz for each transmission direction.

SW-CDMA provides a wide range of bearer services from 1,2 kbit/s up to 144 kbit/s. High-quality telecommunication service can be supported including voice quality telephony and data services in a global coverage satellite environment. SW-CDMA deviation from the above-mentioned terrestrial radio interface are summarized hereafter:

- Maximum bit rate supported limited to 144 kbit/s.
- Permanent softer handover forward link operations for constellations providing satellite diversity.
- Permanent reverse link satellite diversity combining for constellations providing satellite diversity.
- Feeder link (gateway-satellite) and satellite to user link beam centre Doppler pre-compensation.
- Two-steps (instead of three-steps as terrestrial) forward link acquisition procedure.
- Introduction of a high-power paging channel for in-building penetration.
- Optional (not standard) use of pilot symbols in the communication channels.
- Reduced power control rate with multi-level predictive power control loop to cope with longer propagation delay.
- Shorter scrambling sequence length (2 560 chips) in the forward link.
- Optional use in the forward link of a short scrambling sequence (256 chips) to allow CDMA interference mitigation.
- Single user terminal level.
- Longer random access preamble sequence.

SW-CDMA offers a great degree of commonality with the terrestrial radio interface making the interoperability between the IMT-2000 terrestrial and the satellite components easier.

For the comparison, the present document refers to Technical Specification (TS) describing the SRI as follows:

- ETSI TS 101 851-1-2 [i.1].
- ETSI TS 101 851-2-2 [i.2].
- ETSI TS 101 851-3-2 [i.3].
- ETSI TS 101 851-4-2 [i.4].

4.2 W-CDMA

This satellite radio interface is also based on the W-CDMA UTRA FDD radio interface already standardized in 3GPP. Mobile satellite systems intending to use this interface will address user equipment fully compatible with 3GPP UTRA FDD W-CDMA, with adaptation for agility to the Mobile Satellite Service (MSS) frequency band.

The use of a 3GPP standardized technology as well as a satellite IMT-2000 frequency band adjacent to a terrestrial IMT-2000 frequency band allows to accommodate these MSS system's features in 3G handsets with no waveform modification and consequently low cost impact. This optimizes considerably the market entry and penetration.

The key service and operational features of the W-CDMA radio interface are following:

- Support for low data rate services (e.g. 1,2 kbps) up to high data rate transmission (384 kbps) with wide area coverage.
- High service flexibility with support of multiple parallel variable-rate services on each connection.
- Efficient packet access.
- Built-in Support for future capacity/coverage-enhancing technologies, such as adaptive antennas, advanced receiver structures, and transmitter diversity.
- Support of inter-frequency handover for operation with hierarchical cell structures and handover to other systems, including handover to GSM.

For the comparison, the present document refers to Technical Specification (TS) describing the SRI as followed:

- ETSI TS 101 851-1-1 [i.5].
- ETSI TS 101 851-2-1 [i.6].
- ETSI TS 101 851-3-1 [i.7].
- ETSI TS 101 851-4-1 [i.8].

4.3 SAT-CDMA

The SAT-CDMA is a satellite radio interface to provide the various advanced mobile telecommunications services defined for the IMT-2000 satellite environment with maximum data rate, 384 kbit/s. This system could be applied for LEO and GEO satellite for the global international communications.

The major technical scheme in SAT-CDMA is also wideband code division multiple access (W-CDMA) whose chip rate is 3.84 Mchip/s.

The system has a high degree of commonality with the terrestrial ratio specification, IMT-2000 Direct Spread (DS), but it also has a number of different features. Those features, which are necessary to reflect the satellite-specific characteristics, such as long round trip delay and high Doppler shift, are implemented in the form of downlink synchronization, uplink packet access, and closed loop power control.

For the comparison, the present document refers to Technical Specification (TS) describing the SRI as followed:

- TTAS.KO-06.0090 [i.9].
- TTAS.KO-06.0091 [i.10].
- TTAS.KO-06.0092 [i.11].
- TTAS.KO-06.0093 [i.12].

5 Commonalties and differences

5.1 Introduction

This clause provides a short list with all the points of divergence identified in the analysis of the (S)W-CDMA and SAT-CDMA specifications. This list is intended as a guide to the more detailed comments provided in clauses 2 and 3. This means practically that in many cases an item covers several points of clauses 2 and 3. Additionally, this list is a pure description of the differences; where appropriate, a short technical discussion and a possible way of harmonization, are included in the comments of clause 2.

The following tables show the differences and commonalties between the draft specifications of (S)W-CDMA and SAT-CDMA, item-by-item.

5.2 Commonalties and differences between SW-CDMA and SAT-CDMA

5.2.1 Physical channel structure

Table 1-1: Commonality in radio frame structure

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
1.1.1	Radio frame	· 10 ms = 15 slots = 38 400 chips	· 10 ms = 15 slots = 38 400 chips	· There is no difference.	High
1.1.2	Time slot	· 2 560 chips	· 2 560 chips	· There is no difference.	High
Abbreviations					

Table 1-2: Commonality in the type of physical channels

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
1.2.1	Uplink dedicated	DPDCH DPCCH	DPDCH DPCCH	· There is no difference.	High
1.2.2	Uplink common	PRACH	PRACH PCPCH	· SAT-CDMA offers the PCPCH for fast uplink packet-mode transmission.	Medium
1.2.3	Downlink dedicated	DPCH - DPDCH and DPCCH	DPCH - DPDCH and DPCCH	· There is no difference	High
1.2.4	Downlink common	SCH CPICH P-CCPCH S-CCPCH PDSCH PICH HPPICH	SCH CPICH P-CCPCH S-CCPCH CPCH-CCPCH PDSCH PICH AICH APA/CD/CA-ICH CSICH	· SAT-CDMA offers secondary SCH and AICH to assist mobile's beam search and uplink RACH transmission, respectively · SW-CDMA defines HPPICH for high penetration paging. · SAT-CDMA defines the indicator channels and the CPCH-CCPCH for supporting the uplink PCPCH.	Medium
Abbreviations AICH - Acquisition Indicator Channel APA/CD/CA-ICH - Access Preamble Acquisition/Collision Detection/Channel Assignment - Indicator Channel CPCH-CCPCH - CPCH - Common Control Physical Channel CPICH - Common Pilot Channel CSICH - CPCH Status Indicator Channel DPCH - Dedicated Physical Channel DPCCH - Dedicated Physical Control Channel DPDCH - Dedicated Physical Data Channel PCPCH - Physical Common Packet Channel PDSCH - Physical Downlink Shared Channel PICH - Paging Indicator Channel PHPPCH - Physical High Penetration Paging Channel PRACH - Physical Random Access Channel P-CCPCH - Primary Common Control Physical Channel SCH - Synchronization Channel S-CCPCH - Secondary Common Control Physical Channel					

Comment 1.2.2 and 1.2.4-1: In SAT-CDMA, the AICH can reduce the retransmission delay of the PRACH preamble and message because a quick acknowledgement is possible at physical layer by transmitting an acquisition indicator corresponding to the PRACH preamble signature. Although the preamble is successfully acquired it is possible that the message part may not be received successfully. However, generally, message detection probability is high if the preamble is detected.

Comment 1.2.2 and 1.2.4-1: There are some potential problems in the use of AICH, and, generally, Slotted transmission; this can be however modified if an analysis shows there are no problems.

Comment 1.2.2 and 1.2.4-2: The PCPCH is required for uplink packet-mode transmission with medium length (e.g. several or several tens of frames). CPCH-CCPCH for CPCH transmission control and power control is suggested in SAT-CDMA. In 3GPP specifications, each PCPCH is associated with a DL DPCCH for CPCH which is a downlink dedicated channel, while in the SAT-CDMA all of PCPCHs in a CPCH set are associated with a CPCH-CCPCH which is a downlink common control channel. In satellite environment, the common control channel is more efficient because the deviation of the propagation loss to each user is relatively little in a beam coverage, compared to the terrestrial case. This implies that power control is not mandatory for the associated common control channel.

Comment 1.2.2 and 1.2.4-2: The PCPCH and the downlink indicator channels might be deleted in SAT-CDMA because PCPCH have not been used in a real implementation, as close as possible to those in the 3GPP. PCPCH as applied in 3GPP specifications is not viable for satellite systems.

Comment 1.2.4-1: In SAT-CDMA, a hierarchical search procedure should be necessary for fast acquisition of the downlink primary scrambling code as in the 3GPP cell search procedure. Even if the synchronization codes are not differentially encoded at the transmitter, the differential detection can be employed in order to overcome the large frequency offset of the downlink carrier at the receiver.

Comment 1.2.4-1: An issue is the maximum timing uncertainty resolution, that may not be sufficient for satellite. A slightly modified three-step approach can be agreed, keeping the UW for time ambiguity resolution in SW-CDMA.

Comment 1.2.4-2: In SW-CDMA, an additional paging channel is required for the users whose positions are out of normal coverage area. The power of user terminals will be saved if the high-penetration paging channel could support the sleep-mode operation as the PICH.

Table 1-3: Commonality in dedicated uplink physical channel

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
1.3.1	Multiplexing	· DPDCH and DPCCH are I-Q/code multiplexed	· DPDCH and DPCCH are I-Q/code multiplexed	· There is no difference.	High
1.3.2	DPDCH	· Slot = Data field · SF = 256/2^k = 256~4 (k=0…6)	· Slot = Data field · SF = 256/2^k = 256~4 (k=0…6)	· There is no difference.	High
1.3.3	DPCCH	· Slot = Pilot + TFCI/TPC · SF = 256	· Slot = Pilot + TPC + TFCI + FBI · SF = 256	· SAT-CDMA defines the FBI field for the support of BSDT. · SW-CDMA uses the combined TFCI/TPC field, while SAT-CDMA uses them separately.	Medium
1.3.4	Pilot field	· 8 bits per slot · FSW used	· 3, 4, 5, 6, 7 or 8 bits per slot · FSW used	· SAT-CDMA defines the several pilot bit patterns as well as 8-bit pattern.	Medium
1.3.5	TFCI / TPC field	· TFCI and TPC bits: encoded together · TPC/TFCI field: 2 bits per slot · 1 TPC command per frame	· TFCI and TPC bits: encoded separately · TPC field: 2 bits per slot · TFCI field: 2, 3 or 4 bits per slot · 1 TPC command per frame	· In SW-CDMA, the TFCI and TPC bits are encoded together. · In SAT-CDMA, the TFIC and TPC bits are independently encoded and mapped to the separated fields	Medium
1.3.6	FBI field	· Not defined	· 0 or 1 bit per slot	· SAT-CDMA uses 1 bit per slot as the FBI field for BSDT	Low
1.3.7	DPCCH preamble	· Power control preamble - ength: Npcp slots - Slot format: identical to the DPCCH slot	· Initial transmission preamble - Length: Nitp frames - Slot format: identical to the DPCCH slot	· The length of the DCPCCH preamble is N_{pcp} slots in SW-CDMA, while N_{itp} frames in SAT-CDMA.	Medium
Abbreviations SF: Spreading Factor TFCI: Transport-format combination indicator TPC: Transmit power control			FSW: Frame synchronization word BSDT: Beam Selection Diversity Transmission		

Comment 1.3.3 and 1.3.5: For the case when the TFCI bits and the TPC command bits are encoded together by the (32,10) RM code, the number of bits allocated for TFCI in 10 input bits to RM encoder is restricted to be smaller than 10 due to the portion of TPC command bits. This results in the limitation of TFC types come from higher layers. The detection performances of both, moreover, will be correlated mutually. Therefore, the TFCI bits and the TPC command in SAT-CDMA are separately encoded and distributed into the slots of the radio frame without modifying the 10-bit space reserved for TFCI bits. In this case, the same slot formats as in 3GPP can be used.

Comment 1.3.3 and 1.3.5: The idea in SW-CDMA is to reduce overhead related to unnecessary for slot power control. The proposed approach in SW-CDMA is expected to be sufficient to support the required flexibility.

Comment 1.3.6: In SAT-CDMA, BSDT can reduce additional downlink interference and power consumption in soft handover mode as with the terrestrial site selection diversity transmission (SSDT). Furthermore, the update period to select the primary satellite beam does not need to be as short as that in terrestrial case. In SAT-CDMA, one primary beam ID is transmitted to Satellite-RAN via the FBI fields in a radio frame regardless of non-compressed mode or compressed mode.

Comment 1.3.6: SW-CDMA is open to accept the points of SAT-CDMA, and the matter needs further work.

Comment 1.3.7: In SW-CDMA, the power control preamble with the length of Npcp slots is transmitted before DPCCH transmission and the preamble has the same slot format as the DPCCH. This is not consistent with the description in [i.4] due to the different 3GPP version used for the specification. This can be changed for the future release.

Table 1-4: Commonality in physical random access channel (PRACH)

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
1.4.1	Random-access transmission	· ALOHA approach · Transmission = 1 PRACH preamble (9 * 4 096 = 36 864 chips) + 1 PRACH message (10/20 ms)	· ALOHA approach with fast acquisition indication · Transmission = 1 PRACH preamble (Np * 4 096) + 1 PRACH message (10/20 ms)	· In SAT-CDMA, DL AICH is used for fast acquisition indication of the PRACH transmission.	Medium
1.4.2	Access slot or frame	· Not defined	· Access frame = 2 radio frames	· SAT-CDMA defines a timing structure consisted of the access frames.	Low
1.4.3	PRACH preamble part	· Preamble: 8 * 256 repetitions of a signature of length of 16 chips + an unique word of length 16 QPSK symbols (SF=256) differentially encoded. Unique word Value=0x78DB) · Length = 9 * 4 096 = 36 864 chips	· Preamble: Np repetitions of sub-preambles · Sub-preamble = 256 repetitions of a signature of length of 16 chips. · Invert the sign of the last sub-preamble · Length = Np * 4 096 chips	· In S-UMTS, the number of repetition is fixed, while in SAT-CDMA it is signalled by higher layers. · S-UMTS defines a unique word, while SAT-CDMA uses the last sub-preamble with inverse sign.	Medium
1.4.4	PRACH message part	· Data and Control are I-Q/code multiplexed · Length = 10 ms or 20 ms	· Data and Control are I-Q/code multiplexed · Length = 10 or 20 ms	· There is no difference	High
1.4.5	Data part of the RACH message	· Slot = Data field · SF = $256/2^k$ = 256~32 (k=0…3)	· Slot = Data field · SF = $256/2^k$ = 256~32 (k=0…3)	· There is no difference.	High
1.4.6	Control part of the RACH message	· Slot = Pilot (8 bits) + TFCI (2 bits) · SF = 256	· Slot = Pilot (8 bits) + TFCI (2 bits) · SF = 256	· There is no difference.	High
Abbreviations					

Comment 1.4.2: In SAT-CDMA, random-access transmission starts at the beginning of access frames. Each access frame has a length of two radio frames. Considering typical beam sizes and satellite altitude for LEO, MEO and GEO systems, the deviation of delays among users in a beam ranges within 20 ms. In the downlink AICH, the access frame of length 20 ms is also defined as the period of acquisition indicator transmission as well as the AICH frame.

Comment 1.4.2: This difference is related to the access procedure for RACH. SW-CDMA does not define access slots, as it has doubts on their suitability for satellite.

Comment 1.4.3: In SAT-CDMA, the number of sub-preamble repetitions is not fixed and signalled by higher layers. Generally, the repetition number depends on the detection scheme and the amount of the Doppler shift. Thus in specification it should not be optimized for a specific detection scheme and a satellite constellation. The last sub-preamble with the inverted sign and the same structure can inform the detector of the end time of the preamble or the beginning time of the message part, instead of the insertion of symbols modulated by a method different from the modulation method used for the preamble. The structure of signature repetition makes differential detection possible although the symbols are not differentially encoded. If the receiver has already detected and acquired the preamble using a matched filter with a differential detection scheme, the timing of the preamble scrambling code has been acquired and thus it is not required to detect the UW for a bit and/or a message packet synchronization.

Comment 1.4.3: The change in the place where the number of repetition is fixed can be accepted in SW-CDMA. Concerning the unique word/sub-preamble, SW-CDMA would like to have some quantitative analysis.

Comment 1.4.4: This difference is due to a change in 3GPP specifications. This will be changed in SW-CDMA for the future release.

Table 1-5: Commonality in physical common packet channel (PCPCH)

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
1.5.1	Random-access transmission	· Not defined	· DSMA-CD approach · Transmission = 1 AP/CDP part + 1 message part	· SAT-CDMA defines the PCPCH for fast packet transmission on uplink.	Low
1.5.2	Access slot or frame	· Not defined	· Access frame = 2 radio frames	· The timing of the PCPCH transmission is aligned to the access frame, as with the PRACH transmission	Low
1.5.3	PCPCH preamble part	· Not defined	· Preamble = 1 AP + 1 CD · AP =N_p * 256 repetitions of a signature of length of 16 chips. · CD = 256 repetitions of a signature of length of 16 chips · Length = (N_p+1) * 4 096 chips	· The PCPCH preamble consists of a pair of the access preamble and the collision detection preamble. · The access preamble has the same structure as with the PRACH preamble	Low
1.5.4	PCPCH initial transmission preamble	· Not defined	· CPCH Initial Transmission Preamble - Length: L_{itp} slots - Slot format: identical to the slot format of PCPCH message control part	· To help the detection at Satellite-RAN, the initial transmission preamble can be transmitted prior to the message part.	Low
1.5.5	PCPCH message part	· Not defined	· Data and Control are I-Q/code multiplexed · Length = N_{max_frames} frames	·	Low
1.5.6	Data part of the message	· Not defined	· Slot = Data field · SF = 256/2^k = 256 ~ 4 (k=0…6)	· The PCPCH message part is transmitted after the successful preamble acquisition indication.	Low

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
1.5.7	Control part of the message	· Not defined	· Slot = Pilot (8 bits) + TFCI (2 bits) · SF = 256	· The control part does not have any TPC field because the power of the corresponding downlink channel is not controlled by an inner-loop power control procedure.	Low
Abbreviations AP - Access Preamble			CDP - Collision Detection Preamble		

Comment 1.5: SAT-CDMA defines the PCPCH for fast packet transmission on uplink. The PCPCH and the downlink indicator channels are designed as close as possible to those in the 3GPP. However, in PCPCH transmission in SAT-CDMA, the access preamble and the collision detection preamble are successively transmitted as a pair in order to reduce the access delay.

Table 1-6: Commonality in downlink dedicated physical channel (downlink DPCH)

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
1.6.1	Characteristics	· DPDCH and DPCCH are time multiplexed · Slot = TFCI/TPC + Data + Pilot · SF = $512/2^k$ = 512 ~ 4 (k=0…7)	· DPDCH and DPCCH are time multiplexed · Slot = Data1 +TFCI +TPC + Data2 + Pilot · SF = $512/2^k$ = 512 ~ 4 (k=0…7)	· SAT-CDMA defines one or two data fields as the DPDCH portion. · SW-CDMA uses the combined TFCI/TPC field	Medium
1.6.2	DPDCH	· One data field per slot	· One or two data fields per slot	· In SAT-CDMA, there are one or two data fields per slot according to slot format.	Medium
1.6.3	DPCCH	· TFCI/TPC and Pilot fields	· TPC, TFCI and Pilot fields	· SW-CDMA uses the combined TFCI/TPC field.	Medium
1.6.4	TFCI / TPC field	· TFCI and TPC bits: encoded together · TPC/TFCI field: 2 bits per slot · 1 TPC command per frame	· TFCI and TPC bits: encoded separately · TPC field: 2 bits per slot · TFCI field: 2, 3 or 4 bits per slot · 1 TPC command per frame	· In SW-CDMA, the TFCI and TPC bits are coded together. · In SAT-CDMA, the TFIC and TPC bits are independently encoded and mapped to the separated fields	Medium
1.6.5	Pilot field	· 0, 2, 4, 8, 16 bits per slot · FSW used	· 2, 4, 8, 16 bits per slot · FSW used	· In SW-CDMA, the slot format without dedicated pilot bits is also defined.	High
Abbreviations TFCI: Transport-format combination indicator TPC: Transmit power-control			FSW: Frame synchronization word		

Comment 1.6.1: See comments 1.3.3 and 1.3.5.

Comment 1.6.1: The idea behind a common TPC/TFCI field is covered before.

Comment 1.6.5: In SW-CDMA, this is an important possibility to improve S-UMTS efficiency as there is no need for user dedicated pilot channel (user steerable antenna is not likely to happen) but exploiting the beam common pilot for channel estimation.

Table 1-7: Commonality in common pilot channel (CPICH)

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
1.7.1	Characteristics	· Carrying a pre-defined symbol sequence · SF = 256 (fixed) · Type: Primary CPICH and Secondary CPICH	· Carrying a pre-defined symbol sequence · SF = 256 (fixed) · Type: Primary CPICH and Secondary CPICH	· There is no difference.	High
1.7.2	Primary CPICH	· Only one P-CPICH per cell · Channelization: by the pre-defined code · Scrambling: by the primary scrambling code	· Only one P-CPICH per cell · Channelization: by the pre-defined code · Scrambling: by the primary scrambling code	· There is no difference.	High
1.7.3	Secondary CPICH	· Zero, one or several S-CPICH per cell · Channelization: by an arbitrary code · Scrambling: by the primary or secondary scrambling code	· Zero, one or several S-CPICH per cell · Channelization: by an arbitrary code · Scrambling: by the primary or secondary scrambling code	· There is no difference.	High
Abbreviations					

Table 1-8: Commonality in common control physical channel (CCPCH)

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
1.8.1	Type	· Primary-CCPCH · Secondary-CCPCH	· Primary-CCPCH · Secondary-CCPCH	· There is no difference.	High
1.8.2	Primary-CCPCH	· Carrying BCH · SF = 256 (fixed) · Slot = Tx OFF + Frame Sync + Data · Tx OFF: 256 chips. · Frame Sync field: differentially encoded 4 QPSK symbols · Data: 10 bits	· Carrying BCH · SF = 256 (fixed) · Slot = Tx OFF + Data · Tx OFF: 256 chips · Data: 18 bits	· S-UMTS transmits the predefined QPSK symbols of the Frame Synchronization word after Tx OFF.	Medium
1.8.3	Secondary-CCPCH	· Carrying PCH and/or FACH · SF = $256/2^k$ = 256 ~ 4 (k=0…6) · Slot = TFCI + Data + Pilot · TFCI field: 0, 2, 8 bits per slot · Data field: 10 ~ 1 272 bits per slot · Pilot field: 0, 8, 16 bits per slot	· Carrying PCH and/or FACH · SF = $256/2^k$ = 256 ~ 4 (k=0…6) · Slot = TFCI + Data + Pilot · TFCI field: 0, 2, 8 bits per slot · Data field: 10 ~ 1 272 bits per slot · Pilot field: 0, 8, 16 bits per slot	· There is no difference.	High

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
1.8.4	CPCH-CCPCH	· Not defined	· To control the uplink PCPCH · SF = 256 (fixed) · Slot = TPC + CCC + Pilot · TPC field: 8 bits · CCC field: 8 bits · Pilot field: 4 bits	· SAT-CDMA uses a common control channel to support the power and transmission control for the uplink PCPCH	Low
Abbreviations BCH - Broadcast Channel FACH - Forward Access Channel			PCH - Paging Channel CCC - CPCH control command		

Comment 1.8.2: SW-CDMA inserted a frame sync field to allow path diversity from different satellites with differential delay exceeding the T-UMTS conditions.

Comment 1.8.4: See comments 1.2.2 and 1.2.4-2 about the CPCH-CCPCH in SAT-CDMA.

Comment 1.8.4: The reason for not using CPCH in SW-CDMA is already mentioned.

Table 1-9: Commonality in synchronization channel (SCH)

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
1.9.1	Type	· Primary SCH	· Primary SCH and Secondary SCH	· SAT-CDMA offers a Secondary SCH to support UE's hierarchical cell search.	Medium
1.9.2	Primary SCH	· Slot = PSC (256 chips) + Tx OFF (2 304 chips) · PSC: complex valued sequence of 256-chip length · Used the same PSC in every cell	· Slot = PSC (256 chips) + Tx OFF (2 304 chips) · PSC: complex valued sequence of 256-chip length · Used the same PSC in every cell	· There is no difference.	High
1.9.3	Secondary SCH	-	· Slot = SSC sequence (256 chips) + Tx OFF (2 304 chips) · SSC sequence: a set of 16 different codes of length 256 chips · 64 different SSC sequences	· SW-CDMA does not define any Secondary SCH.	Low
Abbreviations PSC: Primary Synchronization Code			SSC: Secondary Synchronization Code		

Comment 1.9.1: See comments 1.2.4-1 and 1.8.2 about the secondary SCH of SAT-CDMA.

Comment 1.9.1 and 1.9.3: The inclusion of the secondary SCH in SW-CDMA could be considered for a future release for the sake of T-UMTS commonality, although it has not been identified as strictly required.

Table 1-10: Commonality in other physical downlink channels

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
1.10.1	PDSCH	· Code-sharing between users · Slot = only data field · SF = $256/2^k$ = 256 ~ 4 (k=0…6) · Associated with a DL DPCH	· Code-sharing between users · Slot = only data field · SF = $256/2^k$ = 256 ~ 4 (k=0…6) · Associated with a DL DPCH	· There is no difference.	High
1.10.2	PICH	· SF = 256 · Frame = 288-bit PI part + 12-bit Tx OFF	· SF = 256 · Frame = 288-bit PI part + 12-bit Tx OFF	· There is no difference.	High
1.10.3	AICH	-	· Carrying AI for RACH · SF = 256 · AICH frame = 20 ms · 15 access slots per AICH frame · First access slot = AI part (4 096 chips) + Tx OFF (1 024 chips)	· SAT-CDMA transmits AIs corresponding the PRACH preambles for the purpose of fast acquisition indication.	Low
1.10.4	APA/CD/CA-ICH	-	· Carrying API and CDI/CAI for CPCH · SF = 256 · A pair of two access slots = API part (4 096 chips) + Tx OFF (1 024 chips) + CDI/CAI part (4 096 chips) + Tx OFF (1 024 chips) · Use 7 access slot pairs except the first access slot in a AICH frame	· SAT-CDMA transmits indicators corresponding the PCPCH preambles for the purpose of CPCH admission or channel assignment	Low
1.10.5	CSICH	-	· Carrying SI for CPCH status information · SF = 256 · Access slots = Tx OFF (4 096 chips) + SI part (1 024 chips) · 8 * 15 bits in a AICH frame	· SAT-CDMA transmits status indicators for CPCH availability broadcast.	Low
1.10.6	PHPPCH	· Unspread BPSK signal packet of length 10 ms · Channel rate = 15 k symbol/s · Packet = Preamble (24 bits) + UW (12 bits) + data (114 bits).	· Not defined	· SAT-CDMA does not define a deep paging channel.	Low
Abbreviations AI: Acquisition Indicator CAI: Channel Assignment Indicator		API: Access Preamble acquisition Indicator SI: CPCH Status Indicator		PI: Paging Indicator CDI: Collision Detection Indicator	

Comment 1.10.4: In SAT-CDMA, the PCPCH preamble consists of a pair of an access preamble and a CD preamble. Therefore, the corresponding indicators are also transmitted as a pair in the associated downlink indicator channel. The APA/CD/CA-ICH is designed by combining the AP-AICH with CD/CA-ICH. The structures of acquisition indicators and CSICH are identical to those of 3GPP's.

Comment 1.10.3-5: SW-CDMA have reservation about the approach applicability to satellite due to the propagation delays.

Comment 1.10.6: see comment 1.2.4-2 about PHPPCH.

Comment 1.10.6: SW-CDMA considers that this functionality should be there since this specific function is important for the satellite component.

5.2.2 Channel coding and multiplexing

Table 2-1: Commonality in processing steps of channel coding and multiplexing

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
2.1.1	Uplink processing steps	· CRC attachment · TrBk concatenation/Code block segmentation · Channel coding · Radio frame equalization · 1st interleaving · Radio frame segmentation · Rate matching · TrCH multiplexing · PhCH segmentation · 2nd interleaving · PhCH mapping	· CRC attachment · TrBk concatenation/Code block segmentation · Channel coding · Radio frame equalization · 1st interleaving · Radio frame segmentation · Rate matching · TrCH multiplexing · PhCH segmentation · 2nd interleaving · PhCH mapping	· There is no difference.	High
2.1.2	Downlink processing steps	· CRC attachment · TrBk concatenation/Code block segmentation · Channel coding · Rate matching · 1st insertion of DTX indication · 1st interleaving · Radio frame segmentation · TrCH multiplexing · 2nd insertion of DTX indication · PhCH segmentation · 2nd interleaving · Scrambling · PhCH mapping	· CRC attachment · TrBk concatenation/Code block segmentation · Channel coding · Rate matching · 1st insertion of DTX indication · 1st interleaving · Radio frame segmentation · TrCH multiplexing · 2nd insertion of DTX indication · PhCH segmentation · 2nd interleaving · PhCH mapping	· There is no difference except that S-UMTS adds an optional scrambling before physical channel mapping.	High
Abbreviations CRC: Cyclic Redundancy Check TrBk: Transport block TrCH: Transport channel PhCH: Physical channel DTX: Discontinuous transmission					

Comment 2.1.2: When an interference mitigation is envisaged, the physical downlink scrambling process is expected to obtain an additional scrambling effect only for the bits in the TFCI/TPC field because the bits in data fields have already been scrambled in higher layers and the pilot bits is excluded from the scrambling.

Thus in SAT-CDMA the additional scrambling is not essential by considering small portion of TFCI/TPC field. Additionally, if the data scrambling was used along with the downlink short scrambling code, we would have a negative opinion of these processes.

Comment 2.1.2: SW-CDMA have found experimentally that is important to randomize data even for small fields in the frame; and being optional we feel there is no harm. The concerns from SAT-CDMA are not completely clear, a more detailed analysis could be necessary.

Table 2-2: Commonality in error detection and channel coding

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
2.2.1	Error detection	· Using CRC attachment · CRC length: 24, 16, 12, 8 or 0 bits	· Using CRC attachment · CRC length: 24, 16, 12, 8 or 0 bits	· There is no difference.	High
2.2.2	Channel coding scheme	· Convolutional coding r=1/2 or 1/3, K=9 · Turbo coding: r=1/3, 8-state constituent code	· Convolutional coding r=1/2 or 1/3, K=9 · Turbo coding: r=1/3, 8-state constituent code	· There is no difference.	High
Symbols r: code rate			K: constraint length		

Table 2-3: Commonality in interleaving

Item ref.	Item	S-UMTS A	SAT-CDMA	Difference	Commonality
2.3.1	1st interleaving	· Block interleaver with inter-column permutations · Interleaving bit sequence for each TrCH before the TrCH multiplexing · Writing input bits row by row · Reading output bits column by column · R = variable · C =1, 2, 4 or 8	· Block interleaver with inter-column permutations · Interleaving bit sequence for each TrCH before the TrCH multiplexing · Writing input bits row by row · Reading output bits column by column · R = variable · C =1, 2, 4 or 8	· There is no difference.	High
2.3.2	2nd interleaving	· Block interleaver with inter-column permutations · Interleaving bit sequence in one radio frame for each PhCH after the PhCH segmentation · Writing input bits row by row · Reading output bits column by column · R = variable · C = 30	· Block interleaver with inter-column permutations · Interleaving bit sequence in one radio frame for each PhCH after the PhCH segmentation · Writing input bits row by row · Reading output bits column by column · R = variable · C = 30	· There is no difference.	High
Symbol R: number of rows for a block interleaver			C: number of columns for a block interleaver		

Table 2-4: Commonality in rate matching and data scrambling

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
2.4.1	Uplink rate matching	· To match the bit rate of a CCTrCH to the bit rate of the allocated PhCH(s) · Depending on the TFC used in each radio frame · A radio frame is either completely filled with bits or not used · Supporting the compressed mode	· To match the bit rate of a CCTrCH to the bit rate of the allocated PhCH(s) · Depending on the TFC used in each radio frame · A radio frame is either completely filled with bits or not used · Supporting the compressed mode	· There is no difference.	High
2.4.2	Downlink rate matching	· Depending on the TF of each TrCH in each TTI and the number of the assigned channelization codes · Using DTX to fill up the radio frame with bits · Supporting the fixed or flexible positions of the TrCHs in the radio frame · Supporting the compressed mode	· Depending on the TF of each TrCH in each TTI and the number of the assigned channelization codes · Using DTX to fill up the radio frame with bits · Supporting the fixed or flexible positions of the TrCHs in the radio frame · Supporting the compressed mode	· There is no difference.	High
Abbreviations CCTrCH: Coded Composite Transport Channel TF: Transport Format TFC: Transport Format Combination TTI: Transmission Time Interval DTX: Discontinuous Transmission					

Table 2-5: Commonality in transport format detection

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
2.5.1	Transport format detection methods	· TFCI based detection · Explicit blind detection · Guided detection	· TFCI based detection · Explicit blind detection · Guided detection	· There is no difference.	High
2.5.2	TFCI coding or TFCI/TPC coding	· TFCI/TPC coding in normal mode - 10-bit TFCI/TPC per frame - Using a (32, 10) sub-code of the second order Reed Muller code - Code word: Linear combination of 10 basis sequences · TFCI/TPC coding in split mode - A pair of 5-bit TFCI/TPC - using two (16,5) bi-orthogonal codes - Code word: Linear combination of 5 basis sequences	· TFCI coding in normal mode - 10-bit TFCI per frame - Using a (32, 10) sub-code of the second order Reed Muller code - Code word: Linear combination of 10 basis sequences · TFCI coding in split mode - A pair of 5-bit TFCI - using two (16,5) bi-orthogonal codes - Code word: Linear combination of 5 basis sequences	· S-UMTS combines TFCI bits with TPC command bits and encodes together.	Low

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
2.5.3	Compressed mode	· Transmission gap for inter-frequency measurements · TG position: decided by network · Frame structure types - Type A: maximizing the TG - Type B: Optimizing for power control · Compressing method - Puncturing - Reducing the spreading factor by 2 - Higher layer scheduling	· Transmission gap for inter-frequency measurements · TG position: decided by network · Frame structure types - Type A: maximizing the TG · Compressing method - Puncturing - Reducing the spreading factor by 2 - Higher layer scheduling	· There is no difference except that SAT-CDMA uses only Type A as the frame structure.	High
2.5.4	TPC coding	·	· 2-bit TPC per frame · Using a (16,2) subcode of the bi-orthogonal code · Code word: Linear combination of 2 basis sequences	· SAT-CDMA encodes the TPC command bits using the (16, 2) bi-orthogonal code.	Low
Abbreviations TFCI: Transport Format Combination Indicator TG: Transmission Gap					

Comment 2.5.3: In 3GPP two kinds of frame structure are required in compressed mode since the slot-by-slot power control is employed. However, there is no need of Type B in SAT-CDMA since the power control period is one radio frame in satellite specifications.

Comment 2.5.3: Type B could be dropped in SW-CDMA for future releases in a harmonization effort.

Table 2-6: Commonality in downlink data scrambling

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
2.6.1	Data scrambling	· Optional for downlink when interference mitigation is used. · Prior to physical channel mapping · By a ML sequence with polynomial $1+X^{14}+X^{15}$ · Rate: 30 kbit/s	· Not defined	· SAT-CDMA does not define the data scrambling in physical layer.	Medium (in SW-CDMA scrambling is enabled by the upper layers. Upper layers could disable the scrambling to allow interoperability)
Abbreviations TFCI: Transport Format Combination Indicator TG: Transmission Gap					

Comment 2.6.1: See comment 2.1.1.

Comment 2.6.1: Already covered before.

5.2.3 Spreading and Modulation

Table 3-1: Commonality in the uplink spreading and modulation

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
3.1.1	Uplink modulation	· Dual channel QPSK · I-Q/code multiplexing · Chip rate: 3,84 Mchip/s	· Dual channel QPSK · I-Q/code multiplexing · Chip rate: 3,84 Mchip/s	· There is no difference.	High
3.1.2	Uplink spreading	· Channelization: different Walsh covering on I and Q braches · Scrambling: complex scrambling by long or short codes · Multi-code transmission: Up to 6 codes for DPDCH	· Channelization: different Walsh covering on I and Q braches · Scrambling: complex scrambling by long or short codes · Multi-code transmission: Up to 6 codes for DPDCH	· There is no difference.	High
3.1.3	Uplink channelization code	· OVSF Walsh code · Length: 4~256 chips	· OVSF Walsh code · Length: 4~256 chips	· There is no difference.	High
3.1.4	Uplink long scrambling code	· Gold code · Length: 38 400 chips (one radio frame) · Generator polynomials: $X^{25}+X^3+1$, $X^{25}+X^3+X^2+X+1$	· Gold code · Length: 38 400 chips (one radio frame) · Generator polynomials: $X^{25}+X^3+1$, $X^{25}+X^3+X^2+X+1$	· There is no difference.	High
3.1.5	Uplink short scrambling code	· Extended S(2) code · Length: 256 chips · Generator polynomials: $g_0(x)=x^8+x^5+3x^3+x^2+2x+1$, $g_1(x)=x^8+x^7+x^5+x+1$, $g_2(x)=x^8+x^7+x^5+x^4+1$	· Extended S(2) code · Length: 256 chips · Generator polynomials: $g_0(x)=x^8+x^5+3x^3+x^2+2x+1$, $g_1(x)=x^8+x^7+x^5+x+1$, $g_2(x)=x^8+x^7+x^5+x^4+1$	· There is no difference.	High
Abbreviations OVSF: Orthogonal Variable Spreading Factor UL: Uplink DL: Downlink					

Table 3-2: Commonality in downlink spreading and modulation

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
3.2.1	Downlink modulation	· QPSK · Time multiplexed · Chip rate: 3,84 Mchip/s	· QPSK · Time multiplexed · Chip rate: 3,84 Mchip/s	· There is no difference.	High
3.2.2	Downlink spreading	· Channelization: same Walsh covering on I and Q braches · Scrambling: complex scrambling by primary or secondary scrambling codes	· Channelization: same Walsh covering on I and Q braches · Scrambling: complex scrambling by primary or secondary scrambling codes	· There is no difference.	High

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
3.2.3	Downlink channelization code	· OVSF Walsh code · Length: 4~512 chips	· OVSF Walsh code · Length: 4~512 chips	· There is no difference.	High
3.2.4	Downlink scrambling code	· Gold code · Grouping: 512 sets · Generator polynomial: $1+X^7+X^{18}$, $1+X^5+X^7+X^{10}+X^{18}$	· Gold code · Grouping: 512 sets · Generator polynomial: $1+X^7+X^{18}$, $1+X^5+X^7+X^{10}+X^{18}$	· There is no difference.	High
3.2.5	Downlink optional short scrambling code	· Short Gold-like code · Length: 256 chips · Total number of codes: 255 · Generator polynomial: $1+X^4+X^9$, $1+X+X^3+X^4+X^9$	· Not defined	· SW-CDMA defines an optional short code (when downlink multi-user detection is envisaged)	Low
Abbreviations OVSF: Orthogonal Variable Spreading Factor LC: Long Code SC: Short Code I: I-branch Q: Q-branch					

Comment 3.2.5: In SAT-CDMA, the downlink multi-user detection (MUD) scheme is not defined since it will cause expensive and complex user terminals, especially in the case of dual-mode terminal for accessing both satellite and terrestrial systems. In order to support the MUD, the system should scramble all downlink channels with the short scrambling code when the terminals with and without the MUD scheme coexist in a satellite system. Accordingly, all users should descramble the downlink channels with the short codes, and users without the MUD will suffer from performance degradation.

Comment 3.2.5: About complexity of MUD, in SW-CDMA, it has shown that this item can be done with limited demodulator complexity increase (see "VLSI Implementation of a CDMA Blind Adaptive Interference-Mitigating Detector," L. Fanucci, E. Letta, R. De Gaudenzi,F. Giannetti, M. Luise, IEEE Journal on Sel. Areas in Communic., Vol. 19, No. 2, February 2001 [i.16]), by using an improved single user detector (not a MUD).

Please note that interference mitigation advantages are noticeable (see "On Antenna Design and Capacity Analysis for the Forward Link of a Multi-beam Power Controlled CDMA Network", J. Romero, R. De Gaudenzi, IEEE Journal on Selected Areas in Comm., Vol. 7, No.18, July 2000 [i.17]) particularly evident for broadcasting applications (see "Capacity of a Multi-beam, Multi-Satellite CDMA Radio Network with Interference-Mitigating Receiver," R. De Gaudenzi, F. Giannetti, M. Luise, IEEE Journal on Selected Areas in Comm., Vol. 17, No. 2, February 1999 [i.18]).

5.2.4 Physical layer procedure

Table 4-1: Commonality in the synchronization procedure for common physical channels

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
4.1.1	Cell search	· Slot synchronization: Using SCH with a matched filter · Frame synchronization: Using differentially encoded FSW on the P-CCPCH	· Slot synchronization: Using SCH's primary synchronization code · Frame synchronization: Using SCH's secondary synchronization code · Scrambling-code identification: Using the CPICH	· SW-CDMA uses the cell search procedure with two steps, while SAT-CDMA does that with three steps. · In SW-CDMA, frame synchronization is performed using differentially encoded FSW on the P-CCPCH.	Low

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
4.1.2	Common physical channel synchronization	· P-CCPCH frame timing: Found during cell search · All common physical channel timing: Related to P-CCPCH timing	· P-CCPCH frame timing: Found during cell search · All common physical channel timing: Related to P-CCPCH timing		High
Abbreviations					

Comment 4.1.1: The two-step procedure in SW-CDMA could be considered for the next release, although some quantitative analysis is needed before convergence.

Table 4-2: Commonality in the synchronization procedure for dedicated physical channels

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
4.2.1	Downlink synchronization primitives	· Primitives: CPHY-Sync-IND, CPHY-Out-of Sync-IND · Primitives are used as in TS 125 331 [i.15].	· Primitives: CPHY-Sync-IND, CPHY-Out-of-Sync-IND · First phase - During the first 160 ms - Report the in-sync to higher layer - Criteria: using DPCCH quality and threshold Q_{int} · Second phase - After the first 160 ms - Report the in-sync or out-of- sync to higher layer - Criteria: using DPCCH quality or CRC checks, and thresholds of Q_{in} and Q_{out}	· SAT-CDMA defines the same synchronization primitives as the 3GPP specification · In SW-CDMA according to TS 101 851-4 v1.1.1, primitives are used as in TS 125 331 [i.15]:.	**High**
4.2.2	Uplink synchronization primitives	· Primitives: CPHY-Sync-IND, CPHY-Out-of-Sync-IND · Indicate the sync status to the RL Failure/Restored triggering function in the Node B · Criteria - not subject to specification	· Primitives: CPHY-Sync-IND, CPHY-Out-of-Sync-IND · Indicate the sync status to the RL Failure/Restored triggering function in the Node B · Criteria - not subject to specification	· SAT-CDMA explains the same synchronization primitives as the 3GPP specification	High

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
4.2.3	Initial radio link establishment	· Network: Start the transmission of DL DCH (including Doppler pre-compensation at DL Tx frequency). · UE: Establish DL ship and frame synchronization · UE: Start the transmission of the $N_{preambles}$ repetition of the RACH preamble and the UL DPCCH (including Doppler pre-compensation at UL Tx frequency) · Network: Establish UL chip and frame synchronization (Conforming S_R successive frame sync)	· Satellite-RAN: Start the transmission of the DL DPCCH (including Doppler pre-compensation at DL Tx frequency). · UE: Establish DL chip and frame synchronization · UE: Start the transmission of the initial transmission preamble and the UL DPCCH (including Doppler pre-compensation at UL Tx frequency) · Satellite-RAN: Establish UL chip and frame synchronization	· At the start of uplink transmission, SW-CDMA repeats the preamble having the same format as the RACH preamble. · In SAT-CDMA transmits an initial preamble having the same format as the followed DPCCH.	Medium
4.2.4	Additional radio link establishment	· DPCCH/DPDCH diversity path synchronization	· Satellite-RAN - Start the transmission of the new DL DPCCH/DPDCH (within T_0±148 chips prior to the UL frame at UE) - Establish UL chip and frame synchronization · UE - Establish DL chip and frame synchronization of the new RL	· S-UMTS does not explain the procedure in detail. · SAT-CDMA uses the procedure similar to that of the 3GPP specification	Low
4.2.6	Radio link monitoring	· Not defined	· DL radio link failure: Indicating in-sync and out-of-sync to higher layers · UL radio link failure: after N_OUTSYNC_IND successive out-of-sync indications and the time period of T_RLFAILURE · UL radio link restore: after N_INSYNC_IND successive in-sync indications	· S-UMTS does not explain in detail · SAT-CDMA uses the procedure similar to that of the 3GPP specification	Low
4.2.7	Transmission timing adjustment	· Not defined	· When the time between reception of DL DPCCH and transmission of UL DPCCH lies outside a valid range at UE	· S-UMTS does not explain in detail · SAT-CDMA uses the procedure similar to that of the 3GPP specification	Low
Abbreviations					

Comment 4.2: The above synchronization procedures in SW-CDMA can be defined as closely as possible to 3GPP as with SAT-CDMA. However, there are some concerns about the timing relationship in SW-CDMA.

Table 4-3: Commonality in the power control procedure

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
4.3.1	UL PRACH power control	· Open-loop power control to calculate the initial transmit power · No inner loop · Control the control/data part relative power using gain factors β_c and β_d	· No inner loop · Control the control/data part relative power using gain factors β_c and β_d	· There is no difference except that in S-UMTS the equation to calculate the initial transmit power of the PRACH is explained. This must be under the control of RRC layer.	High
4.3.2	UL DPCCH/ DPDCH power control	· Keep the SNIR at a target, $SNIR_{target}$ · One command per frame · 2-bit TPC command · 4-level adjustment · Network: Generating TPC commands using the additional adjustment averaged over N_d frames	· Keep the SIR at a target, SIR_{target} · One command per frame · 2-bit TPC command · 4-level adjustment · Power controls in soft handover and compressed mode	· The power control measure is SNIR in S-UMTS, while it is SIR in SAT-CDMA. · S-UMTS uses the power adjustment averaged in the past frames to generate the current TPC command. · SAT-CDMA defines the power controls in soft handover and compressed mode.	Medium
4.3.3	UL PCPCH power control	· Not defined	· PCPCH message part: the same rule as for DPDCH/DPCCH	· S-UMTS does not define the PCPCH.	Low
4.3.4	DL DPCCH/ DPDCH power control	· Power offset between DPCCH and DPDCH fields, determined by the network · TPC command generating rule: the same as for UL DPDCH/DPCCH	· Power offset between DPCCH and DPDCH fields, determined by the network · UE: the same rule as for UL DPDCH/DPCCH · Satellite-RAN: power balancing · Beam Selection Diversity TPC	· In SAT-CDMA, power balancing procedure is added to the inner loop PC in Satellite-RAN behavior. · In SAT-CDMA, BSDT is defined for soft handover mode.	Low
4.3.5	PDSCH	· Based on the PC commands sent by the MS on UL DPCCH	· Based on the PC commands sent by the UE on UL DPCCH	· There is no difference.	High
4.3.6	P-CCPCH	· Slow power control · Transmit power: determined by network and signalled on BCH	· Not defined	· In SAT-CDMA, the power control for P-CCPCH is not explained.	Low
4.3.7	S-CCPCH	· Set by network (time varying)	· Power offset of TFCI and pilot fields (time varying)	· There is no difference.	High
4.3.8	CPCH-CCPCH	· Not defined	· Inform the relative power compared to P-CPICH power	· S-UMTS does not define the CPCH-CCPCH.	Low
4.3.9	AICH	· Not defined	· Inform the relative power compared to P-CPICH power	· In S-UMTS, the AICH is not defined.	Low
4.3.10	PICH	· Not defined	· Inform the relative power compared to P-CPICH power	· In S-UMTS, the power control for PICH is not explained.	Low
4.3.11	CSICH	· Not defined	· Inform the relative power compared to P-CPICH power	· In S-UMTS, the CSICH is not defined.	Low
Abbreviations TPC: Transmit Power Control BSDT: Beam Selection Diversity Transmission CPCH-CCPCH: Common Packet Channel - Common Control Physical Channel					

Comment 4.3.1: The contents on open loop and outer loop power controls are subject to higher layers (e.g. RRC).

Comment 4.3.2: It is not subject to specification how the network (satellite or gateway) generates TPC commands but subject to network operator. However, it is subject to specification how a UE should calculate the uplink transmit power adjustment from the TPC commands generated and transmitted by the network adjustment.

Comment 4.3.2: The generation of TPC commands in SW-CDMA will be shifted to an annex, and also converged onto a common name for SNIR/SIR. The averaging of power control commands tries to minimize the impact of PC loop delay that in satellite is large. The performance improvement is large and shall be considered by SAT-CDMA. SW-CDMA will also include the description of power control commands for compressed mode.

Comment 4.3.4: See comment 1.3.6 about BSDT.

Table 4-4: Commonality in the random access procedure

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
4.4.1	Step 1	· Select one preamble spreading code	· Select one access frame	· S-UMTS does not define transmission timing in detail. · SAT-CDMA define the access frame time at UE.	Low
4.4.2	Step 2	· Correct the Tx frequency for Doppler pre-compensation	· Select one signature	· S-UMTS does not perform any signature selection.	Low
4.4.3	Step 3	· Set the preamble power	· Set the Retrans Counter	-	-
4.4.4	Step 4	· Perform the dynamic persistence check	· Set the preamble power	· In S-UMTS, the dynamic persistence check is performed at physical layer.	Low
4.4.5	Step 5	· Set the Retrans Counter	· Select one transmission time offset	· In SAT-CDMA, RACH is transmitted with a time offset from the start of the access frame.	Low
4.4.6.	Step 6	· Transmit the RACH preamble and message	· Transmit the RACH preamble and message (including the Doppler pre-compensation)		High
4.4.7	Step 7	· If the acquisition indication on the FACH is not detected after a predefined interval - Increase the transmission power - Decrease the Retrans Counter - Repeat from step 3 if Retrans Counter > 0	· If the acquisition indication on the AICH is not detected after a predefined interval - Select the next access frame - Select a new signature - Increase the transmission power - Decrease the Retrans Counter - Repeat from step 5 if Retrans Counter > 0	· In S-UMTS, the acquisition indication is received via FACH at the level of higher layer, while in SAT-CDMA it is done via AICH at the level of physical layer.	Low
4.4.8	Step 8		· If the Nack on the AICH is detected, report to higher layer and stop	· In SAT-CDMA, the negative acknowledgement is used.	Low
Abbreviations MAC: Medium Access Control			Nack: Negative acknowledgement		

Comment 4.4: See comments 1.2.2 and 1.2.4-1.

Comment 4.4.4: The dynamic persistence check is subject to the MAC sub-layer.

Comment 4.4.7: In SW-CDMA, every retransmission during a power ramping period must pass through the persistence check. This may cause the additional access delay.

Comment 4.4: In SW-CDMA the whole random access procedure can be open for discussion.

Table 4-5: Commonality in the access procedure for CPCH

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
4.5.1	Step 1	·	· Check the CPCH status information on the CSICH	· S-UMTS does not define the PCPCH.	-
4.5.2	Step 2	·	· Set the preamble power and retransmission counter	·	-
4.5.3	Step 3	·	· Select an access frame, a AP signature, a time offset	·	-
4.5.4	Step 4	·	· Select a time offset	·	-
4.5.5	Step 5	·	· Select a CD signature	·	-
4.5.6	Step 6	·	· Transmit the AP and CDP	·	-
4.5.7	Step 7	·	· If no ack on APA/CD/CA-ICH - Select the next access frame - Select the new CD signature - Increase the transmit power - Decrease the retrans counter - Repeat from step 4 if Retrans Counter > 0	·	-
4.5.8	Step 8	·	· If Nack on APA/CD/CA-ICH - Report to MAC and stop	·	-
4.5.9	Step 9	·	· If Ack on APA/CD/CA-ICH - Transmit the CPCH initial preamble and the CPCH message	·	-
4.5.10	Step 10	·	· If no Start of Message Indicator in the first $N_{Start\_Message}$ frames of the CPCH-CCPCH - Halt the transmission and report to MAC	·	-
4.5.11	Step 11	·	· Perform the inner loop power control during the CPCH message transmission	·	-

Item ref.	Item	SW-CDMA	SAT-CDMA	Difference	Commonality
4.5.12	Step 12	·	· If Emergency Stop command on the CPCH-CCCH - Halt the transmission and report to MAC	·	-
Abbreviations AP: Access Preamble APA: Access Preamble Acquisition CD: Collision Detection CD P: Collision Detection Preamble CA: Channel Assignment CPCH-CCPCH: Common Packet Channel - Common Control Physical Channel					

Comment 4.5: See comments 1.2.2 and 1.2.4-2.

Comment 4.5: In SW-CDMA, the whole random access procedure can be open for discussion.

5.3 Commonalties and differences between W-CDMA and SAT-CDMA

5.3.1 Physical channel structure

Table 5-1: Commonality in radio frame structure

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
5.1.1	Radio frame	· 10 ms = 15 slots = 38 400 chips	· 10 ms = 15 slots = 38 400 chips	· There is no difference.	High
5.1.2	Time slot	· 2 560 chips	· 2 560 chips	· There is no difference.	High
Abbreviations					

Table 5-2: Commonality in the type of physical channels

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
5.2.1	Uplink dedicated	DPDCH DPCCH	DPDCH DPCCH	· There is no difference.	High
5.2.2	Uplink common	PRACH	PRACH PCPCH	· SAT-CDMA offers the PCPCH for fast uplink packet-mode transmission.	Medium
5.2.3	Downlink dedicated	DPCH - DPDCH and DPCCH	DPCH - DPDCH and DPCCH	· There is no difference	High

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
5.2.4	Downlink common	SCH CPICH **P-CCPCH** S-CCPCH PICH AICH CSICH	SCH CPICH **P-CCPCH** S-CCPCH CPCH-CCPCH PDSCH PICH AICH APA/CD/CA-ICH CSICH	· SAT-CDMA defines the indicator channels and the CPCH-CCPCH for supporting the uplink PCPCH. · SAT-CDMA defines one channel for the indications of AP and CD/CA.	Medium

Abbreviations AICH - Acquisition Indicator Channel APA/CD/CA-ICH - Access Preamble Acquisition/Collision Detection/Channel Assignment - Indicator Channel CPCH-CCPCH - CPCH - Common Control Physical Channel CPICH - Common Pilot Channel CSICH - CPCH Status Indicator Channel DPCH - Dedicated Physical Channel DPCCH - Dedicated Physical Control Channel DPDCH - Dedicated Physical Data Channel	PCPCH - Physical Common Packet Channel PDSCH - Physical Downlink Shared Channel PICH - Paging Indicator Channel PHPPCH - Physical High Penetration Paging Channel PRACH - Physical Random Access Channel P-CCPCH - Primary Common Control Physical Channel SCH - Synchronization Channel S-CCPCH - Secondary Common Control Physical Channel

Comment 5.2.2 and 5.2.4: The PCPCH, which might be deleted in SAT-CDMA because PCPCH has not been used in a real implement, is required for uplink packet-mode transmission with medium length (e.g. several or several tens of frames). The CPCH-CCPCH is suggested for CPCH transmission control and power control. In 3GPP specifications, each PCPCH is associated with a DL DPCCH for CPCH which is a downlink dedicated channel, while in the SAT-CDMA all of PCPCHs in a CPCH set are associated with a CPCH-CCPCH which is a downlink common control channel. In satellite environment, the common control channel is more efficient because the deviation of the propagation loss to each user is relatively little in a beam coverage, compared to the terrestrial case. This implies that power control is not mandatory for the associated common control channel.

Comment 5.2.4: In SAT-CDMA, only one channel for the indications of AP and CD/CA is needed for the fast access because satellite environment has a long round trip delay unlikely in 3GPP.

Table 5-3: Commonality in dedicated uplink physical channel

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
5.3.1	Multiplexing	· DPDCH and DPCCH are I-Q/code multiplexed	· DPDCH and DPCCH are I-Q/code multiplexed	· There is no difference.	High
5.3.2	DPDCH	· Slot = Data field · SF = $256/2^k$ = 256~4 (k=0…6)	· Slot = Data field · SF = $256/2^k$ = 256~4 (k=0…6)	· There is no difference.	High
5.3.3	DPCCH	· Slot = Pilot + TPC + TFCI + FBI · SF = 256	· Slot = Pilot + TPC + TFCI + FBI · SF = 256	· There is no difference.	High

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
5.3.4	Pilot field	· 4,5,6,7 or 8 bits per slot · Pilot bit pattern depending on slot format	· 4, 5, 6, 7 or 8, 9 bits per slot · FSW used	· SAT-CDMA defines the several pilot bit patterns as well as 9-bit pattern.	Medium
5.3.5	TFCI / TPC field	· TFCI and TPC bits: encoded separately · TPC field: 1 or 2 bits per slot depending on slot format · TFCI field: 2, 3 or 4 bits per slot · 1 TPC command per frame	· TFCI and TPC bits: encoded separately · TPC field: 1 bits per slot · TFCI field: 2, 3 or 4 bits per slot · 1 TPC command per frame	· SAT-CDMA reduces TPC filed to 1 bit	Medium
5.3.6	FBI field	· 0,1 or 2 bits per slot	· 0 or 1 bit per slot	· SAT-CDMA uses 1 bit per slot as the FBI field for only BSDT	Medium
5.3.7	DPCCH preamble	· Power control preamble - Length: N_{pcp} frames - Slot format: identical to the DPCCH slot	· Initial transmission preamble - Length: N_{itp} frames - Slot format: identical to the DPCCH slot	· The length of the DCPCCH preamble is N_{pcp} slots in S-UMTS, while N_{itp} frames in SAT-CDMA.	Medium
Abbreviations SF: Spreading Factor TFCI: Transport-format combination indicator TPC: Transmit power control			FSW: Frame synchronization word BSDT: Beam Selection Diversity Transmission		

Comment 5.3.4 and 5.3.5: Because one radio frame corresponds to one power-control period in two RTTs, usage of 2 bits per slot for TPC field is wasteful differently from 3GPP. Additionally, in SAT-CDMA, 1 bit expansion of pilot filed makes channel estimation more correct.

Comment 5.3.6: In SAT-CDMA compared to W-CDMA, FBI field is reduced to 1bit due to no use of closed loop transmit diversity. Therefore, The FBI bits are used to support techniques requiring feedback the UE to the Satellite-RAN Access Point including Beam Selection diversity transmission (BDST).

Table 5-4: Commonality in physical random access channel (PRACH)

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
5.4.1	Random-access transmission	· Slotted ALOHA approach with fast acquisition indication · Transmission = 1 PRACH preamble, and then, 1 PRACH message	· ALOHA approach with fast acquisition indication · Transmission = 1 PRACH preamble + 1 PRACH message	· In SAT-CDMA, one preamble and one message is transmitted together.	Low
5.4.2	Access slot or frame	· Access slot= 2 slots	· Access frame = 2 radio frames	· SAT-CDMA defines a timing structure consisted of the access frames.	Low
5.4.3	PRACH preamble part	· Preamble: 8 * 256 repetitions of a signature of length of 16 chips · Length = 9 * 4 096 = 36 864 chips	· Preamble: Np repetitions of sub-preambles · Sub-preamble = 256 repetitions of a signature of length of 16 chips. · Invert the sign of the last sub-preamble · Length = Np * 4 096 chips	· In S-UMTS, the number of repetition is fixed, while in SAT-CDMA it is signalled by higher layers. · S-UMTS defines a unique word, while SAT-CDMA uses the last sub-preamble with inverse sign.	Low

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
5.4.4	PRACH message part	· Data and Control are I-Q/code multiplexed · Length = 10 or 20 ms	· Data and Control are I-Q/code multiplexed · Length = 10 or 20 ms	· There is no difference.	High
5.4.5	Data part of the RACH message	· Slot = Data field · SF = $256/2^k$ = 256~32 (k=0…3)	· Slot = Data field · SF = $256/2^k$ = 256~32 (k=0…3)	· There is no difference.	High
5.4.6	Control part of the RACH message	· Slot = Pilot (8 bits) + TFCI (2 bits) · SF = 256	· Slot = Pilot (8 bits) + TFCI (2 bits) · SF = 256	· There is no difference.	High
Abbreviations					

Comment 5.4.1: In SAT-CDMA, transmission of preamble with message and AICH can reduce the retransmission delay of the PRACH preamble and message because a quick acknowledgement is possible at physical layer by transmitting an acquisition indicator corresponding to the PRACH preamble signature. Although the preamble is successfully acquired, it is possible that the massage part may not be received successfully. However, generally, message detection probability is high if the preamble is detected.

Comment 5.4.2: In SAT-CDMA, random-access transmission is started at the beginning of access frames. Each access frame has a length of two radio frames. Considering typical beam sizes and satellite heights for LEO, MEO and GEO systems, the deviation of delays among users in a beam have values within 20 ms. In the downlink AICH, the access frame of length 20 ms is also defined as the period of acquisition indicator transmission as well as the AICH frame.

Comment 5.4.3: In SAT-CDMA, the number of sub-preamble repetitions is not fixed and signalled by higher layers. Generally, the repetition number depends on the detection scheme and the amount of the Doppler shift. Thus in specification it should not be optimized for a specific detection scheme and a satellite constellation. In addition, the last sub-preamble with the inverted sign and the same structure can inform the detector of the end time of the preamble or the beginning time of the message part, instead of the insertion of symbols modulated by a method different from the modulation method used for the preamble. The structure of signature repetition makes differential detection possible although the symbols are not differentially encoded. If the receiver has already detected and acquired the preamble using a matched filter with a differential detection scheme, the timing of the preamble scrambling code has been acquired and thus it is not required to detect the UW for a bit and/or a message packet synchronization.

Table 5-5: Commonality in physical common packet channel (PCPCH)

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
5.5.1	CPCH Random-access transmission	· Not defined	· DSMA-CD approach · Transmission = 1 AP/CDP part + 1 message part	· SAT-CDMA defines one channel for the indications of AP and CD/CA.	Low
5.5.2	Access slot or frame	· Not defined	· Access frame = 2 radio frames	· The timing of the PCPCH transmission is aligned to the access frame, as with the PRACH transmission in SAT-CDMA	Low
5.5.3	PCPCH preamble part	· Not defined	· Preamble = 1 AP + 1 CD · AP =N_p * 256 repetitions of a signature of length of 16 chips. · CD = 256 repetitions of a signature of length of 16 chips · Length = (N_p+1) * 4 096 chips	· The PCPCH preamble in SAT-CDMA consists of a pair of the access preamble and the collision detection preamble. · The access preamble has the same structure as with the PRACH preamble.	Low

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
5.5.4	PCPCH initial transmission preamble	· Not defined	· CPCH Initial Transmission Preamble - Length: L_{itp} slots - Slot format: identical to the slot format of PCPCH message control part	· To help the detection at Satellite-RAN, the initial transmission preamble or power control preamble can be transmitted prior to the message part.	Medium
5.5.5	PCPCH message part	· Not defined	· Data and Control are I-Q/code multiplexed · Length = Nmax_frames frames	· There is no difference.	High
5.5.6	Data part of the message	· Not defined	· Slot = Data field · SF = 256/2k = 256 ~ 4 (k=0…6)	· There is no difference.	High
5.5.7	Control part of the message	· Not defined	· Slot = Pilot (8 bits) + TFCI (2 bits) · SF = 256	· There is no difference.	High
Abbreviations AP - Access Preamble			CDP - Collision Detection Preamble		

Comment 5.5.1: In SAT-CDMA, the PCPCH and the downlink indicator channels, which might be deleted in two satellite radio interfaces because PCPCH have not been used in a real implement, as close as possible to those in the 3GPP. However, in the PCPCH transmission, the access preamble and the collision detection preamble are successively transmitted as a pair in order to reduce the access delay.

Table 5-6: Commonality in downlink dedicated physical channel (downlink DPCH)

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
1.6.1	Characteristics	· DPDCH and DPCCH are time multiplexed · Slot = Data1 +TPC +TPC + Data2 + Pilot · SF = $512/2^k$ = 512 ~ 4 (k=0…7)	· DPDCH and DPCCH are time multiplexed · Slot = Data1 +TPC +TPC + Data2 + Pilot · SF = $512/2^k$ = 512 ~ 4 (k=0…7)	· There is no difference	High
1.6.2	DPDCH	· One or two data fields per slot	· One or two data fields per slot	· There is no difference	High
1.6.3	DPCCH	· TPC, TFCI and Pilot fields	· TPC, TFCI and Pilot fields	· There is no difference	High
1.6.4	TFCI / TPC field	· TFCI and TPC bits: encoded separately · TPC field: 2, 4 or 8 bits per slot · TFCI field:0, 2 or 4 bits per slot · 1 TPC command per frame	· TFCI and TPC bits: encoded separately · TPC field: 1, 2 or 4 bits per slot · TFCI field:0, 2 or 4 bits per slot · 1 TPC command per frame	· In SAT-CDMA, there is 1/2 reduction of bits for TPC field and expansion of bits for Data 2.	Medium
1.6.5	Pilot field	· 2, 4, 8 or 16 bits per slot · Pilot bit pattern depending on slot format	· 2, 4, 8 or 16 bits per slot · FSW used	· There is no difference	High
Abbreviations TFCI: Transport-format combination indicator TPC: Transmit power-control			FSW: Frame synchronization word		

Comment 5.6.4: Because one radio frame corresponds to one power-control period in two RTTs, usage of 2 bits per slot for TPC field is wasteful differently from 3GPP. Additionally, in SAT-CDMA, 1 bit expansion of data field makes data transmission efficiency, which is one of important issues in downlink, increased.

Comment 5.6: In clause 5.3.1 of W-CDMA [i.5], each frame of length 10,s is split into 15 slots, each of length T_{slot}=2 560 chips, corresponding to one power control period. This is not consistent with the description as 1 TPC command per frame in W-CDMA

Table 5-7: Commonality in common pilot channel (CPICH)

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
5.7.1	Characteristics	· Carrying a pre-defined symbol sequence · SF = 256 (fixed) · Type: Primary CPICH and Secondary CPICH	· Carrying a pre-defined symbol sequence · SF = 256 (fixed) · Type: Primary CPICH and Secondary CPICH	· There is no difference.	High
5.7.2	Primary CPICH	· Only one P-CPICH per cell · Channelization: by the pre-defined code · Scrambling: by the primary scrambling code	· Only one P-CPICH per cell · Channelization: by the pre-defined code · Scrambling: by the primary scrambling code	· There is no difference.	High
5.7.3	Secondary CPICH	· Zero, one or several S-CPICH per cell · Channelization: by an arbitrary code · Scrambling: by the primary or secondary scrambling code	· Zero, one or several S-CPICH per cell · Channelization: by an arbitrary code · Scrambling: by the primary or secondary scrambling code	· There is no difference.	High
Abbreviations					

Table 5-8: Commonality in common control physical channel (CCPCH)

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
5.8.1	Type	· Primary-CCPCH · Secondary-CCPCH	· Primary-CCPCH · Secondary-CCPCH	· There is no difference.	High
5.8.2	Primary-CCPCH	· Carrying BCH · SF = 256 (fixed) · Slot = Tx OFF + Data · Tx OFF: 256 chips · Data: 18 bits	· Carrying BCH · SF = 256 (fixed) · Slot = Tx OFF + Data · Tx OFF: 256 chips · Data: 18 bits	· There is no difference	High
5.8.3	Secondary-CCPCH	· Carrying PCH and/or FACH · SF = 256/2k = 256 ~ 4 (k=0…6) · Slot = TFCI + Data + Pilot · TFCI field: 0, 2 or 8 bits per slot · Data field: 10 ~ 1 272 bits per slot · Pilot field: 0, 8 or 16 bits per slot	· Carrying PCH and/or FACH · SF = 256/2k = 256 ~ 4 (k=0…6) · Slot = TFCI + Data + Pilot · TFCI field: 0, 2 or 8 bits per slot · Data field: 10 ~ 1 272 bits per slot · Pilot field: 0, 8 or 16 bits per slot	· There is no difference.	High

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
5.8.4	CPCH-CCPCH	· Not defined	· To control the uplink PCPCH · SF = 256 (fixed) · Slot = TPC + CCC + Pilot · TPC field: 8 bits · CCC field: 8 bits · Pilot field: 4 bits	· SAT-CDMA uses a common control channel to support the power and transmission control for the uplink PCPCH	Low
Abbreviations BCH - Broadcast Channel FACH - Forward Access Channel			PCH - Paging Channel CCC - CPCH control command		

Comment 5.8.1: See Comment 1.2.2 and 1.2.4 about the CPCH-CCPCH.

Table 5-9. Commonality in synchronization channel (SCH).

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
5.9.1	Type	· Primary SCH and Secondary SCH	· Primary SCH and Secondary SCH	· There is no difference.	High
5.9.2	Primary SCH	· Slot = PSC (256 chips) + Tx OFF (2 304 chips) · PSC: complex valued sequence of 256-chip length · Used the same PSC in every cell	· Slot = PSC (256 chips) + Tx OFF (2 304 chips) · PSC: complex valued sequence of · 256-chip length · Used the same PSC in every cell	· There is no difference.	High
5.9.3	Secondary SCH	· Slot = SSC sequence (256 chips) + Tx OFF (2 304 chips) · SSC sequence: a set of 16 different codes of length 256 chips · 64 different SSC sequences	· Slot = SSC sequence (256 chips) + Tx OFF (2 304 chips) · SSC sequence: a set of 16 different codes of length 256 chips · 64 different SSC sequences	· There is no difference.	High
Abbreviations PSC: Primary Synchronization Code			SSC: Secondary Synchronization Code		

Table 5-10: Commonality in other physical downlink channels

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
5.10.1	PDSCH	· Not defined	· Code-sharing between users · Slot = only data field · SF = $256/2^k$ = 256 ~ 4 (k=0…6) · Associated with a DL DPCH	· In S-UMTS G, PDSCH is not defined.	Low
5.10.2	PICH	· SF = 256 · Frame = 288-bit PI part + 12-bit Tx OFF	· SF = 256 · Frame = 288-bit PI part + 12-bit Tx OFF	· There is no difference.	High

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
5.10.3	AICH	· Carrying AI for RACH · SF = 256 · AICH frame = 20 ms · 15 access slots per AICH frame · First access slot = AI part (4 096 chips) + Tx OFF (1 024 chips)	· Carrying AI for RACH · SF = 256 · AICH frame = 20 ms · 15 access slots per AICH frame · First access slot = AI part (4 096 chips) + Tx OFF (1 024 chips)	· There is no difference.	High
5.10.4	APA/CD/CA-ICH	· Not defined	· Carrying API and CDI/CAI for CPCH · SF = 256 · A pair of two access slots = API part (4 096 chips) + Tx OFF (1 024 chips) + CDI/CAI part (4 096 chips) + Tx OFF (1 024 chips) · Use 7 access slot pairs except the first access slot in a AICH frame	· SAT-CDMA transmits indicators corresponding the PCPCH preambles for the purpose of CPCH admission or channel assignment at the same time.	Low
5.10.5	CSICH	· Not defined	· Carrying SI for CPCH status information · SF = 256 · Access slots = Tx OFF (4 096 chips) + SI part (1 024 chips) · 8 * 15 bits in a AICH frame	· In S-UMTS, CPCH is not implemented.	Low
5.10.6	CD/CA-ICH	· Carrying CDI/CAI for CPCH · SF = 256 · A pair of two access slots = CDI/CAI part (4 096 chips) + Tx OFF (1 024 chips)	· Not defined	· SRI-G has CD/CA-ICH for separately transmitting AI preambles and CD/CA preamble.	Low
Abbreviations AI: Acquisition Indicator CAI: Channel Assignment Indicator	API: Access Preamble acquisition Indicator SI: CPCH Status Indicator	PI: Paging Indicator CDI: Collision Detection Indicator			

Comment 5.10.1: In W-CDMA, PDSCH is not defined because the need for increasing the downlink data rate for a very short time in addition to dedicated channels is not shown.

Comment 5.10.4: In SAT-CDMA, the PCPCH preamble consists of a pair of an access preamble and a CD preamble. Therefore, the corresponding indicators are also transmitted as a pair in the associated downlink indicator channel. The APA/CD/CA-ICH is designed by combining the AP-AICH with CD/CA-ICH. The structures of acquisition indicators and CSICH are identical to those of 3GPP's.

5.3.2 Channel coding and multiplexing

Table 6-1: Commonality in processing steps of channel coding and multiplexing

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
6.1.1	Uplink processing steps	· CRC attachment · TrBk concatenation/Code block segmentation · Channel coding · Radio frame equalization · 1st interleaving · Radio frame segmentation · Rate matching · TrCH multiplexing · PhCH segmentation · 2nd interleaving · PhCH mapping	· CRC attachment · TrBk concatenation/Code block segmentation · Channel coding · Radio frame equalization · 1st interleaving · Radio frame segmentation · Rate matching · TrCH multiplexing · PhCH segmentation · 2nd interleaving · PhCH mapping	· There is no difference.	High
6.1.2	Downlink processing steps	· CRC attachment · TrBk concatenation/Code block segmentation · Channel coding · Rate matching · 1st insertion of DTX indication · 1st interleaving · Radio frame segmentation · TrCH multiplexing · 2nd insertion of DTX indication · PhCH segmentation · 2nd interleaving · PhCH mapping	· CRC attachment · TrBk concatenation/Code block segmentation · Channel coding · Rate matching · 1st insertion of DTX indication · 1st interleaving · Radio frame segmentation · TrCH multiplexing · 2nd insertion of DTX indication · PhCH segmentation · 2nd interleaving · PhCH mapping	· There is no difference except that S-UMTS adds an optional scrambling before physical channel mapping.	High
Abbreviations CRC: Cyclic Redundancy Check TrBk: Transport block TrCH: Transport channel PhCH: Physical channel DTX: Discontinuous transmission					

Table 6-2: Commonality in error detection and channel coding

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
6.2.1	Error detection	· Using CRC attachment · CRC length: 24, 16, 12, 8 or 0 bits	· Using CRC attachment · CRC length: 24, 16, 12, 8 or 0 bits	· There is no difference.	High
6.2.2	Channel coding scheme	· Convolutional coding r=1/2 or 1/3, K=9 · Turbo coding: r=1/3, 8-state constituent code	· Convolutional coding r=1/2 or 1/3, K=9 · Turbo coding: r=1/3, 8-state constituent code	· There is no difference.	High
Symbols r: code rate			K: constraint length		

Table 6-3: Commonality in interleaving

Item ref.	Item	S-UMTS G	SAT-CDMA	Difference	Commonality
6.3.1	1st interleaving	· Block interleaver with inter-column permutations · Interleaving bit sequence for each TrCH before the TrCH multiplexing · Writing input bits row by row · Reading output bits column by column · R = variable · C =1, 2, 4 or 8	· Block interleaver with inter-column permutations · Interleaving bit sequence for each TrCH before the TrCH multiplexing · Writing input bits row by row · Reading output bits column by column · R = variable · C =1, 2, 4 or 8	· There is no difference.	High
6.3.2	2nd interleaving	· Block interleaver with inter-column permutations · Interleaving bit sequence in one radio frame for each PhCH after the PhCH segmentation · Writing input bits row by row · Reading output bits column by column · R = variable · C = 30	· Block interleaver with inter-column permutations · Interleaving bit sequence in one radio frame for each PhCH after the PhCH segmentation · Writing input bits row by row · Reading output bits column by column · R = variable · C = 30	· There is no difference.	High
Symbol R: number of rows for a block interleaver			C: number of columns for a block interleaver		

Table 6-4: Commonality in rate matching and data scrambling

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
6.4.1	Uplink rate matching	· To match the bit rate of a CCTrCH to the bit rate of the allocated PhCH(s) · Depending on the TFC used in each radio frame · A radio frame is either completely filled with bits or not used · Supporting the compressed mode	· To match the bit rate of a CCTrCH to the bit rate of the allocated PhCH(s) · Depending on the TFC used in each radio frame · A radio frame is either completely filled with bits or not used · Supporting the compressed mode	· There is no difference.	High
6.4.2	Downlink rate matching	· Depending on the TF of each TrCH in each TTI and the number of the assigned channelization codes · Using DTX to fill up the radio frame with bits · Supporting the fixed or flexible positions of the TrCHs in the radio frame · Supporting the compressed mode	· Depending on the TF of each TrCH in each TTI and the number of the assigned channelization codes · Using DTX to fill up the radio frame with bits · Supporting the fixed or flexible positions of the TrCHs in the radio frame · Supporting the compressed mode	· There is no difference.	High
Abbreviations CCTrCH: Coded Composite Transport Channel TF: Transport Format TFC: Transport Format Combination TTI: Transmission Time Interval DTX: Discontinuous Transmission					

Table 6-5: Commonality in transport format detection

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
6.5.1	Transport format detection methods	· TFCI based detection · Explicit blind detection · Guided detection	· TFCI based detection · Explicit blind detection · Guided detection	· There is no difference.	High
6.5.2	TFCI coding or TFCI/TPC coding	· TFCI coding in normal mode - 10-bit TFCI per frame - Using a (32, 10) sub-code of the second order Reed Muller code - Code word: Linear combination of 10 basis sequences · TFCI coding in split mode - A pair of 5-bit TFCI - using two (16,5) bi-orthogonal codes - Code word: Linear combination of 5 basis sequences	· TFCI coding in normal mode - 10-bit TFCI per frame - Using a (32, 10) sub-code of the second order Reed Muller code - Code word: Linear combination of 10 basis sequences · TFCI coding in split mode - A pair of 5-bit TFCI - using two (16,5) bi-orthogonal codes - Code word: Linear combination of 5 basis sequences	· There is no difference.	High

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
6.5.3	Compressed mode	· Transmission gap for inter-frequency measurements · TG position: decide by network · Frame structure types - Type A: maximizing the TG - Type B: Optimizing for power control · Compressed method - Puncturing - Reducing the spreading factor by 2 - Higher layer scheduling	· Transmission gap for inter-frequency measurements · TG position: decide by network · Frame structure types - Type A: maximizing the TG · Compressed method - Puncturing - Reducing the spreading factor by 2 · - Higher layer scheduling	· There is no difference except that SAT-CDMA uses only Type A as the frame structure.	
6.5.4	TPC coding	· 1-bit TPC command per frame · if all TPC bit patterns in a slot are 1, TPC command is 1. · If all TPC bit patterns in a slot are 0, TPC command is 0.	· 2-bit TPC command per frame · Using a (16,2) bi-orthogonal code · Code word: Linear combination of 2 basis sequences	· SAT-CDMA encoded the TPS command bits using the (16,2) bi-orthogonal code	Low
Abbreviations TFCI: Transport Format Combination Indicator			TG: Transmission Gap		

Comment 6.5.3: In 3GPP, two kinds of frame structure are required in compressed mode since the slot-by-slot power control is employed. Therefore, there is no need of Type B in SAT-CDMA since the power control period is one radio frame in satellite specification.

Comment 6.3.4: SAT-CDMA defines TPC coding for 2-bit TPC command per frame. In SAT-DMA, 2-bit command per frame helps power control algorithm adapted fast to channel attenuation. Because power control period is a radio frame in SAT-CDMA and W-CDMA, mapping of TPC bit pattern for 2 bit TPC command is sufficiently achieved over one radio frame unlikely in 3GPP where all TPC bit pattern for TPC command should be transmitted in one slot.

5.3.3 Spreading and Modulation

Table 7-1: Commonality in the uplink spreading and modulation

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
7.1.1	Uplink modulation	· Dual channel QPSK · I-Q/code multiplexing · Chip rate: 3,84 Mchip/s	· Dual channel QPSK · I-Q/code multiplexing · Chip rate: 3,84 Mchip/s	· There is no difference.	High
7.1.2	Uplink spreading	· Channelization: different Walsh covering on I and Q braches · Scrambling: complex scrambling by long or short codes · Multi-code transmission: Up to 6 codes for DPDCH	· Channelization: different Walsh covering on I and Q braches · Scrambling: complex scrambling by long or short codes · Multi-code transmission: Up to 6 codes for DPDCH	· There is no difference.	High
7.1.3	Uplink channelization code	· OVSF Walsh code · Length: 4~256 chips	· OVSF Walsh code · Length: 4~256 chips	· There is no difference.	High

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
7.1.4	Uplink long scrambling code	· Gold code · Length: 38 400 chips (one radio frame) · Generator polynomials: $X^{25}+X^3+1$, $X^{25}+X^3+X^2+X+1$ · One or several preamble code: the repetition of the first preamble code.	· Gold code · Length: 38 400 chips (one radio frame) · Generator polynomials: $X^{25}+X^3+1$, $X^{25}+X^3+X^2+X+1$ · Access preamble code: the repetition of the first sub-preamble code except the final sub-preamble and the conjugate of it in the final sub-preamble	· SAT-CDMA defines one access preamble code which consists of N_p-1 repetitions and one conjugate code of the first sub-preamble code.	Medium
7.1.5	Uplink short scrambling code	· Extended S(2) code · Length: 256 chips · Generator polynomials: $g_0(x)=x^8+x^5+3x^3+x^2+2x+1$, $g_1(x)=x^8+x^7+x^5+x+1$, $g_2(x)=x^8+x^7+x^5+x^4+1$	· Extended S(2) code · Length: 256 chips · Generator polynomials: $g_0(x)=x^8+x^5+3x^3+x^2+2x+1$, $g_1(x)=x^8+x^7+x^5+x+1$, $g_2(x)=x^8+x^7+x^5+x^4+1$	· There is no difference.	High
Abbreviations OVSF: Orthogonal Variable Spreading Factor	UL: Uplink			DL: Downlink	

Comment 7.1.4: See Comment 1.4.3.

Table 7-2: Commonality in downlink spreading and modulation

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
7.2.1	Downlink modulation	· QPSK · Time multiplexed · Chip rate: 3,84 Mchip/s	· QPSK · Time multiplexed · Chip rate: 3,84 Mchip/s	· There is no difference.	High
7.2.2	Downlink spreading	· Channelization: same Walsh covering on I and Q braches · Scrambling: complex scrambling by primary or secondary scrambling codes	· Channelization: same Walsh covering on I and Q braches · Scrambling: complex scrambling by primary or secondary scrambling codes	· There is no difference.	High
7.2.3	Downlink channelization code	· OVSF Walsh code · Length: 4~512 chips	· OVSF Walsh code · Length: 4~512 chips	· There is no difference.	High
7.2.4	Downlink scrambling code	· Gold code · Grouping: 512 sets · Generator polynomial: $1+X^7+X^{18}$, $1+X^5+X^7+X^{10}+X^{18}$	· Gold code · Grouping: 512 sets · Generator polynomial: $1+X^7+X^{18}$, $1+X^5+X^7+X^{10}+X^{18}$	· There is no difference.	High

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
7.2.5	Downlink optional short scrambling code	· Short Gold-like code · Length: 256 chips · Total number of codes: 255 · Generator polynomial: $1+X^4+X^9$, $1+X+X^3+X^4+X^9$	· Not defined	· SRI-G may define an optional short code (when downlink multi-user detection is envisaged) like TS 125 213 [i.19]	Low?
7.2.6	Synchronization code	· one so-called generalized hierarchical Golay sequence.	· Two so-called generalized hierarchical Golay sequences for LEO based SAT-CDMA · One so-called generalized hierarchical Golay sequences for GEO based SAT-CDMA	· LEO base SAT-CDMA defines new codes for better performance because mobility of LEO satellites makes the performance of coherent code detection very poor.	Medium
Abbreviations OVSF: Orthogonal Variable Spreading Factor LC: Long Code SC: Short Code I: I-branch Q: Q-branch					

Comment 7.2.5: In SAT-CDMA, the downlink multi-user detection (MUD) scheme will cause expensive and complex user terminals, especially in the case of dual-mode terminal for accessing both satellite and terrestrial systems. In order to support the MUD, the system should scramble all downlink channels with the short scrambling code when the terminals with and without the MUD scheme coexist in a satellite system. Accordingly, all users should descramble the downlink channels with the short codes, and users without the MUD will suffer from performance degradation.

Comment 7.2.6: A coherent code detection of length 256 chips on the synchronization code as in 3GPP has poor performance under very large frequency offset corresponding to mobility of LEO satellites. Therefore, two new codes, so-called generalized hierarchical Golay sequences, are needed for appropriate performance of LEO based SAT-CDMA. However, GEO based SAT-CDMA has a good performance with the sequences of 3GPP Release 1999 because a frequency offset of GEO based SAT-CDMA is as small as that of TS 125 213 [i.19].

5.3.4 Physical layer procedure

Table 8-1: Commonality in the synchronization procedure for common physical channels

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
8.1.1	Cell search	· Slot synchronization: Using SCH's primary synchronization code · Frame synchronization: Using SCH's secondary synchronization code Scrambling-code identification: Using the CPICH	· Slot synchronization: Using SCH's primary synchronization code · Frame synchronization: Using SCH's secondary synchronization code · Scrambling-code identification: Using the CPICH	· There is no difference.	High
8.1.2	Common physical channel synchronization	· P-CCPCH frame timing: Found during cell search · All common physical channel timing: Related to P-CCPCH timing	· P-CCPCH frame timing: Found during cell search · All common physical channel timing: Related to P-CCPCH timing	· There is no difference.	High
Abbreviations					

Table 8-2: Commonality in the synchronization procedure for dedicated physical channels

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
8.2.1	Downlink synchronization primitives	· Primitives: CPHY-Sync-IND, CPHY-Out-of-Sync-IND · First phase - During the first 160 ms - Report the in-sync to higher layer - Criteria: using DPCCH quality and threshold Q_{int} · Second phase - After the first 160 ms - Report the in-sync or out-of-sync to higher layer - Criteria: using DPCCH quality or CRC checks, and thresholds of Q_{in} and Q_{out}	· Primitives: CPHY-Sync-IND, CPHY-Out-of-Sync-IND · First phase - During the first 160 ms - Report the in-sync to higher layer - Criteria: using DPCCH quality and threshold Q_{int} · Second phase - After the first 160 ms - Report the in-sync or out-of- sync to higher layer - Criteria: using DPCCH quality or CRC checks, and thresholds of Q_{in} and Q_{out}	· It is expected that SRI-G defines the same synchronization primitives as TS 125 214 [i.20] and SAT-CDMA.	High
8.2.2	Uplink synchronization primitives	· Primitives: CPHY-Sync-IND, CPHY-Out-of-Sync-IND · Indicate the sync status to the RL Failure/Restored triggering function in the Node B · Criteria - not subject to specification	· Primitives: CPHY-Sync-IND, CPHY-Out-of-Sync-IND · Indicate the sync status to the RL Failure/Restored triggering function in the Node B · Criteria - not subject to specification	· It is expected that SRI-G defines the same synchronization primitives as TS 125 214 [i.20]and SAT-CDMA.	High
8.2.3	Initial radio link establishment	· Satellite-RAN: Start the transmission of the DL DPCCH (including Doppler pre-compensation at DL Tx frequency). · UE: Establish DL chip and frame synchronization · UE: Start the transmission of the power control preamble and the UL DPCCH (including Doppler pre-compensation at UL Tx frequency) · Satellite-RAN: Establish UL chip and frame synchronization	· Satellite-RAN: Start the transmission of the DL DPCCH (including Doppler pre-compensation at DL Tx frequency). · UE: Establish DL chip and frame synchronization · UE: Start the transmission of the initial transmission preamble and the UL DPCCH (including Doppler pre-compensation at UL Tx frequency) · Satellite-RAN: Establish UL chip and frame synchronization	· There is no difference.	High

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
8.2.4	Additional radio link establishment	· Satellite-RAN - Start the transmission of the new DL DPCCH/DPDCH (within T_0±148 chips prior to the UL frame at UE) - Establish UL chip and frame synchronization · UE - Establish DL chip and frame synchronization of the new RL	· Satellite-RAN - Start the transmission of the new DL DPCCH/DPDCH (within T_0±148 chips prior to the UL frame at UE) - Establish UL chip and frame synchronization · UE - Establish DL chip and frame synchronization of the new RL	· There is no difference.	High
8.2.6	Radio link monitoring	· DL radio link failure: Indicating in-sync and out-of-sync to higher layers · UL radio link failure: after N_OUTSYNC_IND successive out-of-sync indications and the time period of T_RLFAILURE · UL radio link restore: after N_INSYNC_IND successive in-sync indications	· DL radio link failure: Indicating in-sync and out-of-sync to higher layers · UL radio link failure: after N_OUTSYNC_IND successive out-of-sync indications and the time period of T_RLFAILURE · UL radio link restore: after N_INSYNC_IND successive in-sync indications	· There is no difference.	High
8.2.7	Transmission timing adjustment	· When the time between reception of DL DPCCH and transmission of UL DPCCH lies outside a valid range at UE	· When the time between reception of DL DPCCH and transmission of UL DPCCH lies outside a valid range at UE	· There is no difference.	High
Abbreviations					

Table 8-3: Commonality in the power control procedure

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
8.3.1	UL PRACH power control	· No inner loop · Control the control/data part relative power using gain factors β_c and β_d	· No inner loop · Control the control/data part relative power using gain factors β_c and β_d	· There is no difference.	High
8.3.2	UL DPCCH/ DPDCH power control	· Not recommend to activate inner loop power control for GEO. · Keep the SIR at a target, SIR_{target} · One command per frame · 1-bit TPC command · 4-level adjustment · Power control in soft handover · Algorithms 1 or 2 for processing 1 bit TPC command. · Power control in compressed mode: - $\Delta_{DPCCH\_cmp} = \Delta_{DPCCH} + \Delta_{pilot}$	· Keep the SIR at a target, SIR_{target} · One command per frame · 2-bit TPC command · 4-level adjustment · OPLC in option · Power control in soft handover · Generating TPC commands using prediction algorithm. · Algorithm 1 for processing 2 bit TPC command · Power control in compressed mode: - $\Delta_{DPCCH\_cmp} = \Delta_{DPCCH}$	· In SAT-CDMA, 2 bit TPC command is defined. · 4 level adjustment by 2 bit TPC command in SAT-CDMA, and 1 bit TPC command and high layer parameter in S-UMTS G. · In S_UMTS G, algorithm 2 for processing TPC command is defined. · In SAT-CDMA, UE do not reflect Δ_{pilot} for power control in compressed mode.	Low
8.3.3	UL PCPCH power control	· Not defined	· PCPCH message part: the same rule as for DPDCH/DPCCH	· In S-UMTS, PCPCH is not implemented.	Low
8.3.4	DL DPCCH/ DPDCH power control	· Power offset between DPCCH and DPDCH fields, determined by the network · UE: the same rule as for UL DPDCH/DPCCH · Satellite-RAN: power balancing · Spot Selection Diversity TPC	· Power offset between DPCCH and DPDCH fields, determined by the network · UE: the same rule as for UL DPDCH/DPCCH · Satellite-RAN: power balancing · Beam Selection Diversity TPC	· In SAT-CDMA, power balancing procedure is added to the inner loop PC in Satellite-RAN behavior. · In SAT-CDMA, BSDT is defined for soft handover mode.	High
8.3.5	PDSCH	· Not defined	· Based on the PC commands sent by the UE on UL DPCCH	· In S-UMTS G, PDSCH is not implemented.	Low
8.3.7	S-CCPCH	· Power offset of TFCI and pilot fields (time varying)	· Power offset of TFCI and pilot fields (time varying)	· There is no difference.	High
8.3.8	CPCH-CCPCH	· Not defined	· Inform the relative power compared to P-CPICH power	· In S-UMTS G, PCH is not implemented.	Low
8.3.9	AICH	· Inform the relative power compared to P-CPICH power	· Inform the relative power compared to P-CPICH power	· There is no difference.	High
8.3.10	PICH	· Inform the relative power compared to P-CPICH power	· Inform the relative power compared to P-CPICH power	· There is no difference.	High
8.3.11	CSICH	· Not defined	· Inform the relative power compared to P-CPICH power	· In S-UMTS G, PCH is not implemented.	Low
Abbreviations TPC: Transmit Power Control BSDT: Beam Selection Diversity Transmission CPCH-CCPCH: Common Packet Channel - Common Control Physical Channel					

Comment 8.3.2: 4 level adjustment by 2 bit TPC command in SAT-CDMA can reduce signal overhead and signalling delay between physical layer and higher layer because SAT-CDMA does not use high layer parameter for level adjustment unlike W-CDMA. Additionally, algorithm 2 for processing TPC commands is not needed in SAT-CDMA with power control period of 1 radio frame because, although algorithm 2 in 3GPP is for emulating smaller step size than the minimum power control step in good channel condition according to achieve one power control per 5 slots, one TPC command per 5 frame in SAT-CDMA does not have a meaning of inner loop power control due to very large loop delay.

Comment 8.3.2: In SAT-CDMA, UE does not need to consider Δ_{pliot} when it shall adjust the transmit power of the uplink DPCCH in compressed mode. Because, in 3GPP, at the start of the first slot after an uplink or downlink transmission gap the UE shall apply a change in the transmit power of the uplink DPCCH by an amount Δ_{DPCCH}, with respect to the uplink DPCCH in the most recently transmitted uplink slot, where $\Delta_{DPCCH\_cmp} = \Delta_{DPCCH} + \Delta_{pilot}$ but, in two RTTs, Δ_{pilot} over SIR_{target} shall be reflected in RAN and power adjustment shall be applied per one frame differently from one slot in 3GPP specifications.

Comment 8.3.2: TS 101 851-4-1 [i.8] table 1 in this clause represents 2 bit TPC bit pattern. This is not consistent with the description as 1 bit TPC command in W-CDMA. Additionally, other contents of this clause should also be consistent with the description as TPC command per 1 frame in S-UMTS.

Table 8-4: Commonality in the random access procedure

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
8.4.1	Step 1	· Select one access slot	· Select one access frame	· SRI-G does not define transmission timing in detail. · SAT-CDMA define the access frame time at UE. · SAT-CDMA define the same access slot time at UE as 3GPP specification.	Low
8.4.2	Step 2	· Select one signature	· Select one signature	· There is no difference.	High
8.4.3	Step 3	· Set the Retrans Counter	· Set the Retrans Counter	· There is no difference.	High
8.4.4	Step 4	· Set the preamble power	· Set the preamble power	· There is no difference.	High
8.4.5	Step 5	· Not mentioned	· Select one transmission time offset (access frame)	· In SAT-CDMA, RACH is transmitted with a time offset from the start of the access frame.	Low
8.4.6.	Step 6	· Transmit the RACH preamble.	· Transmit the RACH preamble and message (including the Doppler pre-compensation)	· In SAT-CDMA, RACH preamble and message is transmitted together. · SRI-G has the same step as 3GPP specification.	Low
8.4.7	Step 7	· If the acquisition indication on the AICH is not detected after a predefined interval - Select the next access slot - Select a new signature - Increase the transmission power - Decrease the Retrans Counter - Repeat from step 5 if Retrans Counter > 0	· If the acquisition indication on the AICH is not detected after a predefined interval - Select the next access frame - Select a new signature - Increase the transmission power - Decrease the Retrans Counter - Repeat from step 5 if Retrans Counter > 0	· SRI-G has the same step as 3GPP specification. · SAT-CDMA has the step similar to 3GPP specification.	Medium

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
8.4.8	Step 8	· If the Nack on the AICH is detected, report to higher layer and stop	· If the Nack on the AICH is detected, report to higher layer and stop	· There is no difference.	High
Abbreviations MAC: Medium Access Control			Nack: Negative acknowledgement		

Comment 8.4: In SAT-CDMA, transmission interval in AICH and PRACH is longer than 15 ms considering the maximum difference of round trip delays in a beam of satellite systems. Therefore, in satellite radio interfaces, timing reference is defined using access frame (20 ms) instead of access slot (20/15 ms).

Comment 8.4: In SAT-CDMA, this procedure could reduce the additional access delay to transmit both preamble part and massage part together.

Table 8-5 Commonality in the access procedure for CPCH

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
8.5.1	Step 1	· Not defined	· Check the CPCH status information on the CSICH	· In S-UMTS G, CPCH is not implemented.	High
8.5.2	Step 2	· Not defined	· Set the preamble power and retransmission counter	· In S-UMTS G, CPCH is not implemented.	High
8.5.3	Step 3	· Not defined	· Select an access frame, a AP signature, a time offset	· In S-UMTS G, CPCH is not implemented.	High
8.5.4	Step 4	· Not defined	· Select a time offset	· In S-UMTS G, CPCH is not implemented.	High
8.5.5	Step 5	· Not defined	· Select a CD signature	· In S-UMTS G, CPCH is not implemented.	High
8.5.6	Step 6	· Not defined	· Transmit the AP and CDP	· In S-UMTS G, CPCH is not implemented.	High
8.5.7	Step 7	· Not defined	· If no ack on APA/CD/CA-ICH - Select the next access frame - Select the new CD signature - Increase the transmit power - Decrease the retrans counter - Repeat from step 4 if Retrans Counter > 0	· In S-UMTS G, CPCH is not implemented.	High
8.5.8	Step 8	· Not defined	· If Nack on APA/CD/CA-ICH - Report to MAC and stop	· In S-UMTS G, CPCH is not implemented.	High
8.5.9	Step 9	· Not defined	· If Ack on APA/CD/CA-ICH - Transmit the CPCH initial preamble and the CPCH message	· In S-UMTS G, CPCH is not implemented.	High
8.5.10	Step 10	· Not defined	· If no Start of Message Indicator in the first NStart_Message frames of the CPCH-CCPCH - Halt the transmission and report to MAC	· In S-UMTS G, CPCH is not implemented.	High

Item ref.	Item	W-CDMA	SAT-CDMA	Difference	Commonality
8.5.11	Step 11	· Not defined	· Perform the inner loop power control during the CPCH message transmission	· In S-UMTS G, CPCH is not implemented.	High
8.5.12	Step 12	· Not defined	· If Emergency Stop command on the CPCH-CCCH - Halt the transmission and report to MAC	· In S-UMTS G, CPCH is not implemented.	High
Abbreviations AP: Access Preamble APA: Access Preamble Acquisition CD: Collision Detection CD P: Collision Detection Preamble CA: Channel Assignment CPCH-CCPCH: Common Packet Channel - Common Control Physical Channel					

Comment 8.5: See comment 1.2.2 and 1.2.4.

6 Synthesis

This clause highlights the functions which differs when comparing SW-CDMA and SAT-CDMA and WCDMA and SAT-CDMA and identify also the complementarities.

6.1 SW-CDMA and SAT-CDMA

A synthetic view of SW-CDMA and SAT-CDMA is presented in the table 9.

Table 9: Synthetic view of SW-CDMA and SAT-CDMA

Functions	SW-CDMA	SAT-CDMA	Complementarities
Uplink random access	- based on an ALOHA approach - define timing reference using Access Slot	- based on so-called slotted ALOHA approach - define timing reference using Access Frame	difficult (different access approaches and timing references)
Uplink common packet access	Not defined	- based on DSMA-CD approach - transmission=1AP/CDP part + 1 message part - define timing reference using Access frame - define a downlink CPCH-CCPCH	Easy (The function will be deleted in SAT-CDMA)
TFCI/TPC bits generation and transmission	- TFCI and TPC bits: encoded together	- TFCI and TPC bits: encoded separately - two bit TPC command per frame - TPC field of one bit per slot	Difficult (different encoding method, TPC filed of one bit per slot)
FSW for path diversity from different satellites	- Slot of P-CCPCH: TxOFF+Frame Sync+Data - Frame Sync filed: differentially encoded 4QPSK symbols.	- slot of P-CCPCH: TxOFF +Data	difficult (Not defined of FSW in SAT-CDMA)
Power control algorithm	- CLPC: a delay compensation power control scheme - SIR estimation from CPICH	- CLPC: a delay compensation power control scheme + prediction algorithm - SIR estimation from CPICH and S-CCPCH - OLPC algorithm using pilot diversity in option	Moderate (addition of prediction algorithm in SAT-CDMA and diversity gain from S-CCPCH)
Downlink short scrambling code and data scrambling for multiuser detection	- short Gold-like code with the length of 256 chips. - additional data scrambling for the MUD	· Not defined	easy (short scrambling code can be used in SAT-CDMA for commonality with terrestrial system)
Synchronization codes for downlink SCH in LEO constellation	- one so-called generalized hierarchical Golay sequence	- two co-called generalized hierarchical Golay sequence - beam search and initial synchronization with good performance under a high frequency offset	Difficult (different synchronization code) But easy in GEO

6.2 W-CDMA and SAT-CDMA

A synthetic view of W-CDMA and SAT-CDMA is presented in table 10.

Table 10: Synthetic view of W-CDMA and SAT-CDMA

Functions	W-CDMA	SAT-CDMA	Complementarities
Uplink random access	- transmission of preamble and message part, separately. - access slot: 2 slots	- transmission of preamble and message, together. - access frame: 2 radio frames	difficult (different transmission methods and timing references)
Uplink common packet access	· Not defined	- based on DSMA-CD approach - transmission=1AP/CDP part + 1 message part - define timing reference using Access frame - define a downlink CPCH-CCPCH	Easy (The function will be deleted in SAT-CDMA)
TFCI/TPC bits generation and transmission	- TPC field: 1 or 2 bits per slot depending on slot format	- TPC field: 1 bits per slot	Easy (TPC field of SAT-CDMA can be used in 1 bit TPC field of WCDMA)
Power control algorithm	- not recommend to activate inner loop power control for GEO - 1-bit TPC command	- CLPC: a delay compensation power control scheme + prediction algorithm - SIR estimation from CPICH and S-CCPCH - 2-bit TPC command - OLPC algorithm using pilot diversity in option	Moderate (addition of CLPC in GEO of SAT-CDMA and diversity gain from S-CCPCH)
Downlink short scrambling code and data scrambling for multiuser detection	- short gold-like code with the length of 256 chips. - additional data scrambling for the MUD	· Not defined	easy (short scrambling code can be used in SAT-CDMA for commonality with terrestrial system)
Synchronization codes for downlink SCH in LEO constellation	- one so-called generalized hierarchical Golay sequence	- two co-called generalized hierarchical Golay sequence - beam search and initial synchronization with good performance under a high frequency offset	Difficult (different synchronization code) But easy in GEO

6.3 SW-CDMA and W-CDMA

A synthetic view of SW-CDMA and W-CDMA is presented in table 11.

Table 11: Synthetic view of SW-CDMA and W-CDMA

Functions	SW-CDMA	W-CDMA
Uplink slot structure		
FBI bits	- No FBI bits	- 3GPP format. For satellite operation, FBI bits may be used for Spot Selection Diversity Transmission, not used or used for another purpose
Pilot bits pattern	- 1 single pattern allowed (n_{pilot}=8), no flexibility	- Several pilot bits patterns, (n_{pilot}=3 to 8). Configurable according to radio environment (e.g. n=3 could be sufficient for GEO while n=8 could be more suitable for LEO)
TPC coding	- 2 bits for coding 4 TPC commands, no protection against transmission errors	- Possibility to encode 1 TPC on 2 bits for protection against transmission errors (redundancy)
Compressed mode	- 1 single format	- Several formats allowing flexibility of compressed mode configuration
Initialization of dedicated physical channels	- Not indicated if transmission of DPDCH is allowed during power control preamble of DPCCH. - TFCI bits filled with "1"	- Initialization with transmission of DPCCH with power control preamble prior to start of DPDCH - TFCI bits filled with "0"
Downlink slot structure dedicated channels		
Slot format	- Proprietary format, reduced number of configurations	- 3GPP format, extended number of configurations (pilots, etc.)
Data field position	- 1 single block	- 2 blocks
TFCI/TPC position	- Beginning of the slot	- In the middle of the slot (protection)
Slot formats for the compressed mode	None	- Several, allowing UE energy saving mode
TPC coding	- 2 bits for coding 4 TPC commands, no protection against transmission errors	- Possibility to encode 1 TPC on 2 bits for protection against transmission errors
DTX	None	- Possibility of DTX bits if TFCI not used.
Other features		
P-CCPCH (for BCH)	- Proprietary format. - Data field: 10 bits - FSW: Frame Synchronization Word (4 QPSK symbols) → reduced BCH rate	- 3GPP format. - Data field: 18 bits
P-CCPCH channelization code	- Fixed ($C_{CH,256,1}$)	- Configurable
Physical layer bits scrambling	- As an option for downlink, with data randomization	None
Coding of TFCI	- Sequence shorter than 3GPP and proprietary coding	- 3GPP
Downlink channels phase reference	- By default for all the downlink channels primary CPICH. - As an option 2^{ndary} CPICH for DPCH and S-CCPCH	- Primary CPICH for all the downlink channels, optional for DPCH. - As an option for DPCH: 2^{ndary} CPICH, dedicated pilots or none.
Synchronization channel	- 1 single SCH	- Primary and 2^{ndary} SCH
Synchronization code	- Proprietary (thus proprietary cell search procedure)	- 3GPP. Ease integration in RAN of satellite cells.
Construction of the sequence for the synchronization code	-Proprietary	- 3GPP

Functions	SW-CDMA	W-CDMA
Downlink scrambling code (rules for use of secondary scrambling codes)	- P-CPICH, P-CCPCH: primary scrambling code. - Other channels:either primary or 2ndary scrambling code	- P-CPICH, P-CCPCH, PICH, MICH, AICH and S-CCPCH carrying PCH: primary scrambling code - PDCH and S-CCPCH carrying FACH: either primary or 2ndary scrambling code - Restriction: no more than one 2ndary scrambling code per CCTrCH
Uplink scrambling code	- Short or long	- Long
AICH	- Not supported	- Supported
MICH	- Not supported	- Supported
Downlink Shared Channel	- Supported	- Not supported for satellite operation
HPPICH	- Supported	- Not supported. High penetration of paging is obtained with power allocation
Indicators (physical signals)	- Paging Indicator (PI)	- Paging Indicator (PI) - Notification Indicator (NI) - Acquisition Indicator (AI)
Random access	- Based on ALOHA, efficiency: 18 %	- Based on slotted ALOHA, efficiency: 62 % (with capture effect)
	- Message part transmitted together with the preamble, collision risk over the whole (10/20 ms)	- Preamble prior to message part transmission, collision risk over 5 120 chips (preamble), no collision risk on message part
Closed loop power control	- Proprietary procedure	- For satellite operation, 3GPP physical layer procedure can be deactivated by higher layer, using 3GPP standardized protocol. - Possibility of slow closed loop power control managed at layer 3 level (RRC) without modification of 3GPP protocol
Open loop power control	- Proprietary (using proprietary information broadcast over BCH)	- 3GPP
Spot (cell) search procedure	- 2 steps procedure: 1) Initial satellite search together with scrambling code identification 2) Frame synchronization	- 3 steps procedure: 1) Slot synchronization 2) Frame synchronization and code-group identification 3) Scrambling-code identification
MBMS	- Not supported	- Supported
DSCH	- Supported	- Not supported for satellite operation
S-CCPCH soft combining	- Not supported	- Supported
Out of synchronization proc.	- Proprietary - Estimate quality over 200 ms	- 3GPP. Two steps procedure. - Estimate quality over 40 ms then 2nd phase over 200 ms
In-sync procedures	- Proprietary - Estimate quality over 200 ms	- 3GPP. Two steps procedure. - Estimate quality over 40 ms then 2nd phase over 200 ms
Synchronization procedure at dedicated channel setup	- Proprietary	- 3GPP
Radio link monitoring procedure	- Not supported	- 3GPP
Timing adjustment	- Not supported	- As an option, dedicated channels can be time adjusted
Spot Selection Diversity Transmit	- Not supported	- Supported

Finally, attention should be paid on the fact that radio equipment performance (demodulation performances, transmission an reception RF characteristics) are not standardized for SW-CDMA while they are for WCDMA.

7 SAT-CDMA new features with respect to WCDMA and expected added value for context and service requirements

7.1 SAT-CDMA new features with respect to W-CDMA

7.1.1 Uplink random access

One of the main IMT-2000 services is a packet service. The PRACH is used to transmit a short packet over one or two frames without the establishment of a prior radio link. Although the notation and purpose of the channel are the same in both SAT-CDMA and W-CDMA satellite radio interfaces, different operation and procedure are designed for the SAT-CDMA, considering a longer round trip delay.

In the random access of the W-CDMA, a user terminal transmits a preamble and receives a detection indication from a RAN before transmitting the data message. The access scheme using at transmission-after-detection indication causes a severe access delay. In SAT-CDMA, the user terminal successively transmits the message along with the preamble, and then it waits for a detection indication for successful reception. The physical layer of a Satellite-RAN immediately transmits the indication without latency for signalling and processing in higher layers. This detection-indication-after-transmission scheme can reduce the access delay more than the method in W-CDMA. It also has a shorter retransmission delay than the W-CDMA random access scheme because of fast acknowledgment. In the W-CDMA, the response message is not a detection acknowledgment but a high-layer acknowledgment of the RAN physical layer. The higher-layer acknowledgment cannot be transmitted by the Satellite-RAN within the signalling and processing delay in the higher layers, which depends on the contents of the random access message.

Concerned about the structure of the random access transmission in the SAT-CDMA, the transmission timing is based on the access frame. Each access frame has a length of two radio frames and consists of two sub-access frames: an even sub-access frame and an odd sub-access frame. The random access transmission at the even sub-access frame and the odd sub-access frame use different scrambling codes for discrimination. The random access transmission consists of a preamble with a length of several sub-preambles with 4 096 chips and a message with a length of 10 ms or 20 ms. In SAT-CDMA, the number of sub-preamble repetition is not fixed and signalled by higher layers. Generally, the repetition number depends on the detection scheme and the amount of the Doppler shift. For example, many sub-preambles may be required in LEO case with high Doppler shift. The structure of each sub-preamble is identical to that of the preamble in the random access of the W-CDMA and consists of 256 repetitions of a signature with a length of 16 chips. The same scrambling code sequence with a length of 4 096 chips is repeatedly used in the sub-preambles except for the last sub-preamble. The last sub-preamble is scrambled by a conjugate code sequence with a length of 4 096 chips. This indicates the end of the sub-preamble repetition. The message part is identical to that of the W-CDMA.

Regarding the structure of the AICH, the AICH access frame has the same length as the PRACH access frame and consists of 15 access slots. The transmission of an Access Indicator (AI) in the access slot is identical to that of the W-CDMA. However, in the SAT-CDMA, the AI for the PRACH is transmitted only on the 1st access slot and the 9th access slot at each AICH access frame, but not transmitted during the rest of the 13 access slots.

In result, compared with the W-CDMA scheme, the SAT-CDMA has a feature of one-step transmission that results in a shorter access delay for packet service.

7.1.2 Dedicated Physical Channels

In SAT-CDMA and W-CDMA satellite radio interface, it is noted that the fast power control for combating fast fading in the terrestrial counterpart is impossible to be implemented in satellite systems and that it is necessary to take a different approach to implement in satellite systems. Accordingly, they transfer once a frame and thus the command rate is 100 Hz. In SAT-CDMA, it is considered that usage of several bits per slot for TPC field is wasteful differently from W-CDMA terrestrial interface since one power control period corresponds to one radio frame. Therefore, instead of a half of TPC field, SAT-CDMA has an extension of pilot field to make channel estimation more correct in uplink (i.e. performance enhancement) and an extension of data field (i.e. throughput increase) to increase a data rate in downlink.

Next, in SAT-CDMA, the FBI field is used only in the uplink DPCCH in order to support beam selection diversity transmission (BSDT). In the terrestrial interface, the FBI bits are used when closed-loop transmission diversity and the Site Selection Diversity Transmission (SSDT) are applied in the downlink and the base station transmits signals using two antennas. However, because there is no diversity gain from the spatial separation of two satellite antennas in satellite system, in SAT-CDMA, a slot format for the transmit diversity is deleted.

7.1.3 Uplink packet access

The PCPCH is intended to carry bursty packets of user data with a length of several tens of frames, while the PRACH is used to transmit a short packet over one or two frames.

In SAT-CDMA interface, we designed a modified uplink packet access scheme so that the PCPCH can be efficiently used for a satellite link with a relatively longer round trip delay. The main elements that are different from the terrestrial W-CDMA can be summarized as follows: one-step access/channel assignment, the use of a downlink common control channel for PCPCH transmission and power control, and a power control speed of 100 Hz.

In SAT-CDMA, a user transmits a combined preamble to obtain an access grant. The combined preamble consists of an AP and a CDP, both of which have the same structures as those of the terrestrial counterparts. The Satellite-RAN responds to the preamble, transmitting two consecutive acknowledgments. The user terminal, thus, can obtain transmission permission and channel assignment by a one-step access mechanism. Additionally, in SAT-CDMA, the power control period was designed to be equal to a radio frame length. In order to control the transmission power on the uplink PCPCH, the SAT-CDMA defines a downlink CPCH common control physical channel (CPCH-CCPCH). The CPCHs up to 15 in a CPCH set are associated with the common control channel. Unlike in the W-CDMA, the transmission power of the downlink channel is not controlled by each PCPCH. Additionally, by using a common control channel instead of several dedicated control channels, the number of channelization codes available for the downlink can be reduced.

In SAT-CDMA, the PCPCH transmission is based on a reservation approach. The user can start transmission at the beginning of access frames or sub-access frames. The structure of PCPCH access transmission consists of one or several pairs of AP with a length of several 4 096 chips, a CDP with a length of 4 096 chips, initial transmission preamble with a length of several slots, and a message with a variable length. The structures of them are identical to W-CDMA radio interface while the transmission power of each frame in the message part is controlled by the power control command received on the downlink CPCH-CCPCH.

In result, although the PCPCH and its downlink indicator channels might be deleted in SAT-CDMA hereafter since PCPCH has not been used in a real implementation, modified uplink packet access in SAT-CDMA can reduce an access delay for packet service.

7.1.4 Downlink synchronization channel

The synchronization channel (SCH) is a downlink channel used for satellite beam search. During the beam search, the UE searches for a beam and determines the downlink scrambling code and frame synchronization for the beam. The hierarchical beam search is based on the same idea as in W-CDMA interface, but the synchronization codes transmitted through SCHs are different. Because of a satellite's fast movement in case of LEO, the Doppler shift reaches several tens of kHz. Although a pre-compensation scheme is applied for each beam, the frequency offset may reach to about 10 kHz because of frequency uncertainty in user terminals as well as the residual Doppler shift after pre-compensation. This prohibits coherent correlation on the synchronization code with a length of 256 chips, because the phase offset may not remain constant within the correlation length (or within 256 chips). Therefore, in SAT-CDMA, the coherent correlation length is decreased to 128 chips so that the detection performance may not deteriorate.

The Primary Synchronization Code (PSC) for the W-CDMA interface can be used in SAT-CDMA without modifications by using a 128 chips coherent correlation length. However, for the secondary synchronization code (SSC), it is difficult to use the same code as used in the W-CDMA. This is because the SSC includes a Hadamard sequence with a 256 chips length that requires the coherent correlation during the whole code length. Therefore, a new secondary code is needed and a revised primary code is also required in order to minimize cross-correlation between the two codes. In
SAT-CDMA, two synchronization codes are designed using hierarchical Golay complementary sequence. The best PSC and SSC were selected from the simulation on detection performance.

In conclusion, 128 chips coherent detection in SAT-CDMA could provide satisfactory performance even at high frequency offset due to a satellite's fast movement (e.g. in case of LEO constellation).

7.1.5 Power control algorithm

One of the main differences between terrestrial and satellite networks is in a significant difference of the round trip delay. This induces significant degradation of the close-loop power control if the power control used for the terrestrial interface is employed. In order to reduce the power control error due to such a long delay, two factors are considered in SAT-CDMA. One is to optimize the basic power control loop parameters, including the power control rate, power control step size, and the number of control levels, because they are highly dependent on the round trip delay. The other is to consider the round trip delay compensation algorithm.

For the case of the uplink closed-loop power control in SAT-CDMA, the UE calculates the actual amount of the transmission power control by using the two most recently received power control commands, which is aimed to change the loop dynamics and shorten the latency in updating transmission power. Multiplying the previous power control command by a gain factor and subtracting it from the latest power control command generates the actual amount of transmission power control.

In the uplink closed-loop power control adjust the UE transmit power in order to keep the received uplink power SIR at a given SIR target, SIR_{target}. The RAN estimates the SIR of the received uplink DPCCH, generates two-bit TPC commands and transmits the commands once per 10 ms (the length of a radio frame) according to the following rule. Define $\Delta = SIR_{est} - SIR_{target}$, where SIR_{est} denotes the estimated SIR of the received uplink DPCCH, then a four-level quantized power control step $\Delta_P(i)$ generated according to the region of Δ:

- if $|\Delta| < \varepsilon_T$ and $\Delta < 0$, $\Delta_P(i) = \Delta_s$,
- if $|\Delta| > \varepsilon_T$ and $\Delta > 0$, $\Delta_P(i) = -\Delta_s$,
- if $|\Delta| > \varepsilon_T$ and $\Delta < 0$, $\Delta_P(i) = \Delta_L$,
- if $|\Delta| < \varepsilon_T$ and $\Delta > 0$, $\Delta_P(i) = -\Delta_L$,

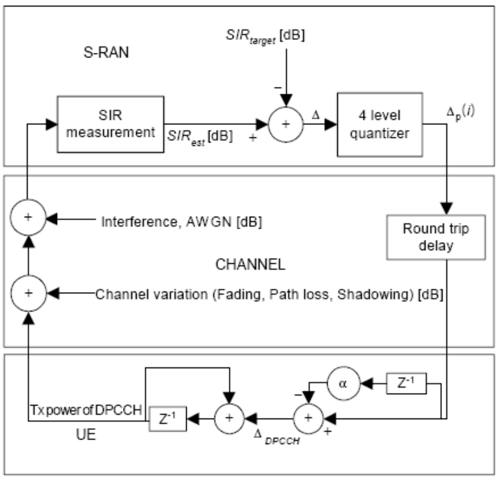


Figure 1: The block diagram for the uplink closed-power control loop

The relationship between $\Delta_P(i)$ and the transmitter power control command TPC_{cmd} is presented as follows.

Table 11: Relationship between $\Delta_P(i)$ and TPC_{cmd}

TPC_{cmd}	$\Delta_P(i)$
-2	$-\Delta_L$
-1	$-\Delta_S$
1	Δ_S
2	Δ_L

Because of the round trip delay, the UE can reflect $\Delta_P(i)$ at its transmission power after about 10 ms to 50 ms in case of LEO constellation during which there may be a considerable change in the SIR. In the SAT-CDMA, we employ a simple pre-processing $\Delta_P(i)$ for before it is reflected at the transmission power in order to compensate for the round trip delay. The UE adjust the transmit power of the uplink DPCCH with an amount of Δ_{DPCCH} using the two most recently received power control steps, $\Delta_P(i)$ and $\Delta_P(i-1)$, as follows:

$$\Delta_{DPCCH} = \Delta_P(i) - \alpha\Delta_P(i-1) .$$

We can rewrite the above equations as follows:

$$\Delta_{DPCCH} = (1-\alpha)\Delta_P(i) + \alpha(\Delta_P(i) - \Delta_P(i-1)) ,$$

which means that Δ_{DPCCH} is determined not only by $\Delta_P(i)$ but also by the difference between $\Delta_P(i)$ and $\Delta_P(i-1)$ with weighting factors (1- α) and α , respectively. As increase, becomes more dependent the term $\Delta_P(i) - \Delta_P(i-1)$, which corresponds to an estimate for the amount of the recent channel variance.

For the case of the downlink closed power loop control, the UE may employ a prediction algorithm that estimates the future signal-to-Interference Ratio (SIR) value after a round trip delay by observing the SIR of the downlink CPICH and S-CCPCH. The compensation algorithm in SAT-CDMA reduces power control errors regardless of the round trip delay or the UE velocity. Especially, the improvement is the most apparent for the case when the round trip delay is large. This is because, as the round trip delay increases, the amount of the SIR change increases and thus the compensation algorithm is more effective. Beside the improvement by round trip delay compensation, an additional improvement can be obtained by using the prediction algorithm using the CPICH and S-CCPCH to obtain an improved pilot diversity for downlink closed-loop power control in SAT-CDMA.

Additionally, differently from 2 level adjustment by 1 bit TPC command in W-CDMA, 4 level adjustment by 2 bit TPC command in SAT-CDMA can reduce signal overhead and signalling delay between physical layer and higher layer because SAT-CDMA do not use high layer parameter for level adjustment.

Power control algorithm in SAT-CDMA gives a remarkable reduction in power control error and is more efficient for GEO constellation and fast UE movement than as in W-CDMA.

7.1.6 TPC bits generation

The TPC command consists of two bits defined by the power control procedure described in clause 4 and is encoded into a codeword by repetition. The code word is then mapped to the TPC fields of 15 slots in a radio frame.

As mentioned before, TPC coding for 2-bit TPC command in SAT-CDMA per one frame supports power control algorithm adapted fast to channel attenuation.

8 Conclusion

The A, C and G family satellite radio interfaces share a common view since they represent an approach whereby a great degree of commonality with terrestrial W-CDMA radio interface of 3GPP is achieved. Therefore, for consideration on possible harmonization between those satellite radio interfaces, in the present document, all commonalities and differences have been identified and the characteristics of the new features implemented in A family and C family with respect to G family have been put forward.

G family is fully compliant with 3GPP User Equipment chip-set.

Major different features between A family and G family can be summarized as follows.

- slot structure;
- slot formats for the compressed mode;
- initialization of dedicated physical channels;
- downlink channels phase reference;
- synchronization channel;
- construction of the sequence for the synchronization code;
- BCH Transport channel rate (due to different physical channel structure) and channelization code;
- support of Downlink Shared Channel;
- physical layer processing (data scrambling);
- rules for use of secondary scrambling codes;
- random access;
- power control;
- support of MICH and MBMS services;
- support of soft combining for common channels;
- out of synchronization and In-sync procedures;
- radio link monitoring procedure;
- possibility for time adjustment;
- support of Spot Selection Diversity Transmit (SSDT);
- spot search procedure (for the scrambling code identification);
- optional use of short scrambling code;
- use of HPPICH.

C family introduce new features with respect to G family and can be summarized as follows.

- Uplink random access for shorter access delay for packet data service.
- TFCI/TPC bits generation and transmission for better channel estimation in uplink and increase of data rate in downlink.
- Power control process applying the compensation scheme and the prediction algorithm (only downlink) in order to reduce power control error and signal overhead/signalling delay between the physical layer and higher layer.
- Synchronization codes for downlink SCH with good performance for beam search and initial synchronization under a high frequency offset in LEO constellation.

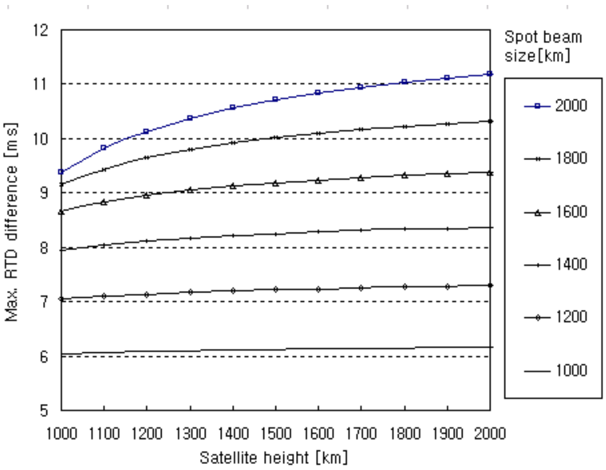
Based on the above results, possible harmonization can be achieved. New features (e.g. power control algorithm, synchronization code, uplink random access) introduced by C family can provide optimized performance with respect to G family at the expense of chip-set upgrade.

Annex A: SAT-CDMA features technical assessment

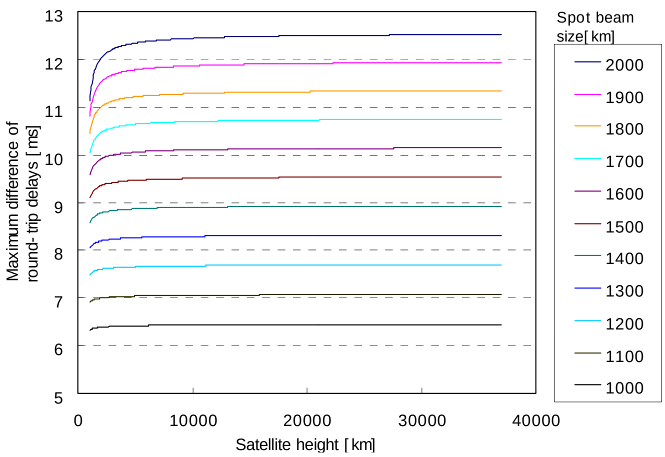
A.1 Uplink random access

The random access scheme of SAT-CDMA is based on a so-called slotted ALOHA. If users with a divergence of round trip delays transmit PRACH preambles in accordance with a timing reference derived from the received timing of downlink P-CCPCH frame, the preambles would be received within a slot at RAN (Gateway). SAT-CDMA defines timing reference using Access Frame instead of the slot. The time period of the Access Frame is 20 ms (equal to the time period of two radio frames) and larger than the maximum difference of round trip delays in a beam. At the user side, the timing of the Access Frame used for PRACH transmissions is derived from and time aligned with the downlink
P-CCPCH frame with SFN mod 2 = 0. At the RAN side, the downlink AICH frames are also time aligned with the downlink P-CCPCH frame with SFN mod 2 = 0. That is, the uplink PRACH Access Frame is time aligned with the reception of downlink AICH frame. Detailed timing relation can be found in SAT-CDMA TS 125 211 [i.9].

SAT-CDMA radio interface has originally been designed to be used for LEO or GEO constellation. Therefore, we can find that the delay difference for satellite height of even around 36 000 km is smaller than 20 ms. Figure A.1 shows the difference of maximum and minimum round trip delays in a spot beam with a range of beam sizes. This implies that transmission interval in AICH and PRACH should be longer than 12 ms. Therefore, in SAT-CDMA, the Access Frame in AICH and PRACH preamble transmissions has a length of 20 ms.



(a) For LEO satellite height



(b) For more than LEO satellite height

Figure A.1: Difference of maximum and minimum round trip delays in the satellite spot beam (minimum elevation angle of 15°)

The timing relation between PRACH and AICH can be described by the parameter of preamble-to-AI distance in specifications. The parameter value is determined by the round trip delay in each beam. In SAT-CDMA, the parameter was set such that:

$$(n-1) \times L_{AF} < RTD_{max} + 2\times\tau_{off,,max} + T_{ps} < n \times L_{AF,}\ \text{n is an integer}$$

where L_{AF}, RTD_{max}, $\tau_{off,,max}$ and T_{ps} are Access Frame length, maximum round trip delay in a beam, maximum transmission offset and processing time required for preamble detection, respectively. The RTD may be different for different beams of the same satellite and for position in which Node-B functionalities are implemented. The P-CCPCH of each beam broadcast AICH timing parameter so that users belonging to the beam is notified the PRACH/AICH timing relationship. In SAT-CDMA, the AICH parameter has two different values as shown in table A.1. These values were set by considering the RTD in SAT-CDMA LEO or GEO constellation.

Table A.1: PRACH/AICH timing relationship for LEO based SAT-CDMA

AICH timing parameter	$\tau_{p-p,min}$	τ_{p-a}
0	3 access frames (60 ms)	2 access frames (40 ms)
1	4 access frames (80 ms)	3 access frames (60 ms)

Table A.2: PRACH/AICH timing relationship for GEO based SAT-CDMA

AICH timing parameter	$\tau_{p-p,min}$	τ_{p-a}
0	15 access frames (300 ms)	14 access frames (280 ms)
1	28 access frames (560 ms)	27 access frames (540 ms)

Simulations has been performed for performance evaluation of the random access scheme of SAT-CDMA. The simulation environment and parameters are shown in tables A.4, A.5 and A.6. In the simulations, the RACH messages at the UE are generated by a poison process with a mean arrival rate. Each UE in a spot experiences independences independent Rician fading and log-normal shadowing. The round trip delay is assumed to be within 39 ms to 49 ms considering a LEO satellite altitude of 1 600 km and an elevation angle of 40 º. The initial transmit power of the preamble is estimated by the UE using open-loop power control. It is assumed that a power control error is generated by a Gaussian distribution with a standard deviation in dB scale. The preamble structure of the WCDMA and SW-CDMA is identical to that of SAT-CDMA scheme. We assume that the preamble and the massage can be successfully received if the average received SIR exceeds the required SIR in tables.

Figure A.5 of annex A.7 shows the simulation results. Throughput was normalized by the target SIR of PRACH message part. Transmission delay was scaled by the radio frame length (10 ms). T-UMTS, S-UMTS and SAT-CDMA mean the random access schemes of WCDMA, SW-CDMA and SAT-CDMA specifications. Figure A.5 (b) shows that the SW-CDMA has the maximum throughput at about 0,25, where the arrival rate has the same amount. It becomes unstable if the arrival rate is larger than 0,25, so that the throughput falls rapidly and the delay increases abruptly. For the SAT-CDMA scheme, the throughput reaches about 0,31, and we can see this is the highest value of the three schemes. We note that maximum throughput for the SW-CDMA and WCDMA schemes are 0,25 and 0,18, respectively. The SAT-CDMA has a smaller delay than the WCDMA by about 10 frames or 30 frames. With WCDMA scheme, the user terminal has to wait for the success of the preamble transmission before the message part is transmitted. Additionally, although the preamble is successfully received at the S-RAN, a successful transmission of the message cannot be guaranteed because the channel and interference situation will change after the time duration of the preamble-to-message distance.

A.2 TFCI/TPC bits generation and transmission

After simulations for coding of two-bit TPC command, SAT-CDMA has concluded to employ command repetition instead of the (16,2) bi-orthogonal coding. This is because code rate of 0,125 is too low to produce an appreciable coding gain. The BER performance of the (16,2) bi-orthogonal code on an AWGN channel, which was measured by bit energy to nose ratio, were no better than that of the (8,1) repetition code. Simulation results using low earth orbit satellite channel model showed that the repetition code using power combining technique could produce diversity gain. This results in coding gains at most of the elevation angles and mobile speeds we have investigated.

In SAT-CDMA specification, the uplink DPCCH has TPC field of one bit per slot and the number of TPC bits transmitted in a radio frame becomes 15 bits. A user terminal generates a two-bit TPC command per frame, and repeating the MSB and the LSB 8 times and 7 times respectively. These total 15 bits are mapped into TPC fields. Detailed description for repetition and mapping to a radio frame can be found in SAT-CDMA TS 125 212 v130 [i.10].

The intention of splitting TFCI and TPC fields is to independently encode and decode each word. As it is mentioned in the previous document, to encode using the (32,10) RM code after combining two words would restrict the number of bits allocated for TFCI transmission in a radio frame.

If we employ the combined coding method, we should define a bit mapping of TPC command and TFCI bits to the combined TFCI/TPC bits not only in the normal mode ((32,10) RM coding) but also the split mode (two (16, 5) bi-orthogonal codings).

The combined encoding method would be acceptable for SAT-CDMA if the restriction of the TFCI bits is shown to be trivial and the bit allocation of TPC and TFCI is described clearly.

A.3 FSW for path diversity from different satellites

It is noted that, for every beam, BCH carried by P-CCPCH broadcasts System Frame Number (SFN) inserted by higher layers of RAN. The SFN has a period that can be considered as a multi frame. Using these SFNs from different beams and frame reception timing, when a user terminal enters into the soft handoff mode (i.e. path diversity from different satellites), it can estimate the delay difference among two or several beams and report it to RAN (see SAT-CDMA TS 125 215 [i.21]and 3GPP Technical Specifications related in higher layers). RAN then adjusts the transmission time of downlink dedicated channels to the user using such information on delay difference. Of course, detecting the SCH of each beam, the user terminal should acquire the frame synchronization for each beam in order to decode each P-CCPCH.

For these reasons, in SAT-CDMA, the FSW for path diversity from different satellites does not have to be inserted in P-CCPCH.

A.4 Power control algorithm

In SAT-CDMA, the compensation algorithms is developed for the round trip delay in the closed loop power control and reflected it in the specification for the power control algorithm. The Round Trip Delay (RTD) of a GEO system results in significant performance degradation of the CLPC if the third generation partnership project (3GPP) standard is employed as it is. There are two main problems that degrade the CLPC under such a long RTD. The first one is the instability in the internal loop dynamics due to the fact that the power control step size specified in 3GPP is too large to keep the loop stable under such a long propagation delay. In other words, the measurements at UE do not reflect the results of the most recent power updates at the satellite radio access network (S-RAN). The second one is the possibility of the large amount of SIR change during the loop delay thus resulting in large power control errors. As one of the effective solutions to the first problem, Gunnarsson proposed a delay compensation power control scheme, and this was reflected in the satellite-universal mobile telecommunications system (S-UMTS) standard. Although this effectively cancels the internal RTD in the power control loop, we still have the second problem.

In SAT-CDMA, we employed prediction algorithms for the closed loop power control in order to solve the second problem in combination with SW-CDMA scheme. For the case of uplink closed loop power control, UE calculates the actual amount of the transmission power control by using 2 most lately received power control commands. Multiplying the previous power control command by a gain factor and subtracting it from the latest power control command generates the actual amount of transmission power control. The power control command step size and the gain factor are UE-specific and are defined by high layer.

For the case of downlink closed power control of SAT-CDMA, UE may employ prediction algorithm that estimates the future SIR value after the round trip delay. Power control command is generated based on the predicted SIR value. The prediction for the SIR variation can be implemented by observing the SIR of the CPICH and S-CCPCH. When the UE is in soft handover and BSDT is not activated, the UE should observe the SIR of all cells' CPICHs and S-CCPCHs in the active set. In order to support UEs that employ the prediction algorithm, round trip delay between the Satellite-RAN and the center position of the beam, which the UE belongs to, is signalled by higher layers in the unit of number of frames.

Simulation parameters are given in table A.3. In figure A.2, we present the simulation results of the proposed CLPC scheme over GEO-based environments, and compared the performance of the various conventional CLPC algorithms. As the conventional schemes, we used the terrestrial CLPC scheme in the WCDMA system and Gunnarsson's scheme in SW-CDMA and they are denoted as T-UMTS, S-UMTS in the figures. In our simulations, we consider a satellite system with a single beam and ignore the inter-spot interference. We assume that the path loss exponent is taken to be 2. For the simulation we chose a common SIR of 5 dB. We select the Processing Gain (PG) of 256. We assumed power control begin to work since about 250 ms due to propagation delay. Figure A.2 shows average transmits power consumed at the transmitters of specific users according to mobile speed. We can see that users with the efficient CLPC scheme consume less power.

Figure A.3 illustrates power control error according to normalized maximum Doppler frequency. When employing our efficient channel estimator, power control shows greater stability, which is important in sense of network. Performance of S-UMTS and proposed algorithms with increased power control command error probability is illustrated in figure A.4, but the proposed algorithm is still powerful compared to S-UMTS. As seen in simulation results, the conventional power control methods incur many errors in case of deep fading. On the other hand, since the proposed power control using the S-CCPCH and CPICH to the conventional channel estimation methods can obtain an improved pilot diversity gain by performing the channel estimation using other channel in case that once channel is not come up to a required level of a received signal, it is possible to implement an ideal maximum ratio combining method in a RAKE receiver.

The lower power consumption will also directly lead to the capacity increase. The superior power control performance is due to more efficient estimation of SIR.

Additionally, in SAT-CDMA, the open loop power control (OLPC) algorithms using pilot diversity is developed in option. UE can measure the SIR value with gain from pilot diversity more correctly than conventional OLPC.

Table A.3: Simulation environment

Carrier frequency (fc)	2 170 MHz
Power control sample interval (Td)	10 ms
Frame length	10 ms
Round trip delay	250 ms
Path loss	150 dB
Processing gain	256 (about 24 dB)
Transmit frame	150 000 frames
Small step size	1 dB
Large step size	2 dB
Fading model	Clarke's model (Classical Doppler spectrum)
Target SIR	5 dB
Power command error probability	0 ~ 0.1
Rician K-factor	-inf, 5 dB
Interference plus noise power	-123 dBm
Maximum transmit power	28 dB
Power control dynamic range	89 dB
Mobile speed	1 m/s ~ 10 m/s

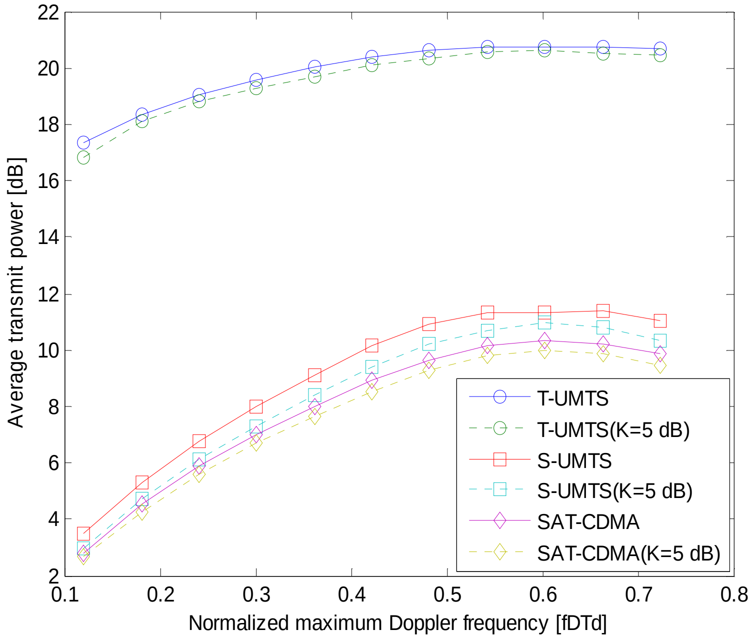


Figure A.2: Average transmit power according to mobile velocity

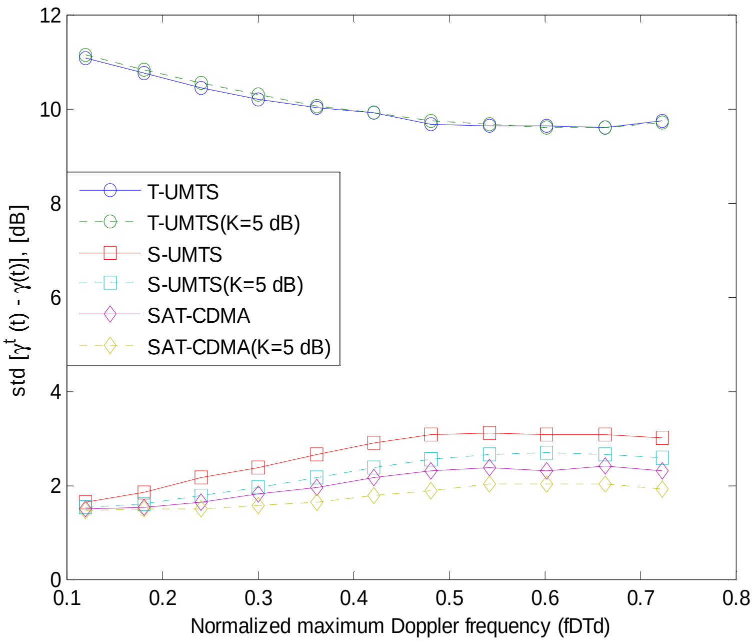


Figure A.3: Control error: Standard deviation of target SIR minus received SIR

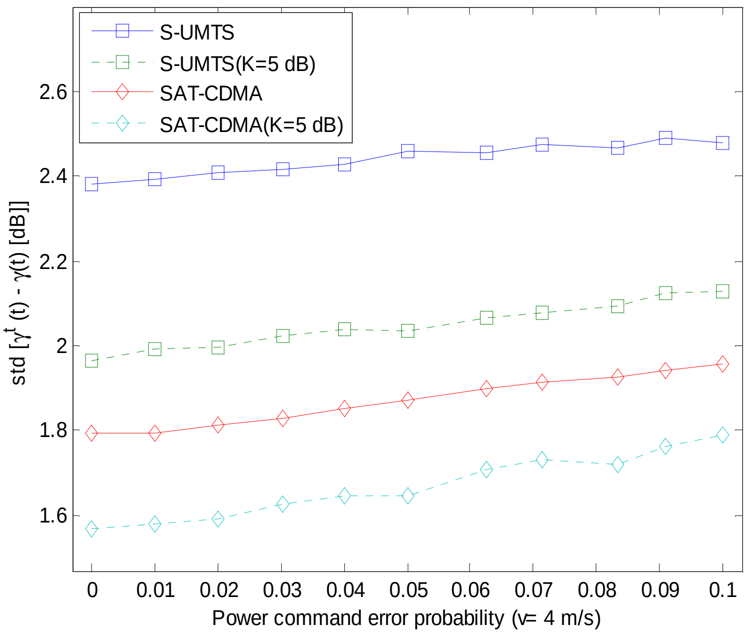


Figure A.4: Performance of S-UMTS and SAT-CDMA with increased power control command error probability

A.5 Downlink short scrambling code and data scrambling for multi-user detection

Interference cancellation scheme is useful at user terminals since the downlink interference from multiple satellites would be severe. However, although the multi-user detection does not increase so much complexity, we need to consider the performance degradation at user terminals without the MUD scheme. If the performance degradation at the conventional terminal is severe, we may have to recommend avoiding heterogeneous deployment of terminals with/without the MUD scheme. The prerequisite condition, that the aforementioned performance degradation can be neglected, would be necessary in order to use downlink short scrambling code.

Regarding to the additional data scrambling for the MUD, SAT-CDMA does not have any quantitative analysis at this stage. However, we would like to note that, according to S-UMTS-A TS 125 212 [i.10], the scrambling only affect data stream from higher layers, that is, DPDCH part only. Such data stream has already been scrambled in higher layers. Therefore, there would be no need for the additional scrambling in physical layer. SW-CDMA specifies the scrambling rate as a fixed rate of 30 kbit/s. However, the channel bit rate for the DPCH could be larger than 30 kbit/s.

EXAMPLE: In case of SF < 256).

In this case, even though it is assumed TFCI/TPC field would also be scrambled, there will be groups of non-scrambled bits. If the data scrambling is important even for small portion, the non-scrambled portions may cause a negative effect on the interference mitigation technique. It would be necessary to clear this negative effect in order to use downlink data scrambling.

A.6 Synchronization codes for downlink SCH in LEO constellation

In SAT-CDMA, the downlink synchronization codes has been evaluated for beam search and initial synchronization, and designed new codes for better performance. A study result showed that a coherent detection of length 256 chips on the synchronization code had poor performance under a frequency offset of more than around 6 kHz. The frequency offset can be reached to more than 6 kHz due to the residual Doppler shift after pre-compensation and frequency uncertainty in terminals. It would be, thus, desirable to use a shorter coherent detection length than 256 chips.

It is found that 128-chip coherent detection could provide a satisfying performance even as high frequency offset as 15 kHz. In this case, a new designed 128-chip length code was necessary because it is not possible to detect the original Secondary Synchronization Code (SSC) (defined by 3GPP) due to multiplication of a Hadamard sequence. In other words, the Hadamard sequence of length 256 chips requires the 256-chip coherent detection. Therefore, we designed a new synchronization code which make it possible to do coherent detection of length 128 chips. The new codes are derived from hierarchical Golay complementary sequences, and position-wise multiplied by Hadamard sequences with of length 128 chips. The new SSC of length 256 chips is obtained by concatenating two different codes of length 128 chips. In addition to designing the SSC, Primary Synchronization Code (PSC) was also designed in order to minimize cross correlation between PSC and SSC. The best PSC and SSC are selected from extensive simulations. Detailed code generation is described in SAT-CDMA TS 125 213 [i.11].

If the SSC is not used for downlink synchronization, it is possible to receive the PSC by the 128-chip coherent detection. However, the hierarchical beam search procedure using the SSC sequences as well as the PSC is necessary to reduce the beam search time and to identify the group of downlink scrambling codes used for the target beam.

A.7 Another comment

It would not be important to mention the comment 1.6.5 in the part on commonalities and difference. The comment is:

Comment 1.6.5: In SW-CDMA, this is an important possibility to improve S-UMTS efficiency as there is no need for user dedicated pilot channel (user steerable antenna is not likely to happen) but exploiting the beam common pilot for channel estimation.

However, in SAT-CDMA, the use of the smart antenna was not envisaged at satellites, but it would like to be noted that one of main purposes of dedicated pilot bits in the downlink DPCH is to make it convenient for a user terminal to estimate SIR values for the dedicated channel. The user terminal can generate a TPC command from the estimated SIR value and send it through an uplink dedicated channel to maintain an appropriate received SIR for the downlink channel. It is also worth noticing that the beam common pilot is not power-controlled and accordingly the user cannot estimate the SIR of user's own downlink dedicated channel.

A.8 RACH Simulation

Table A.4: Simulation environment

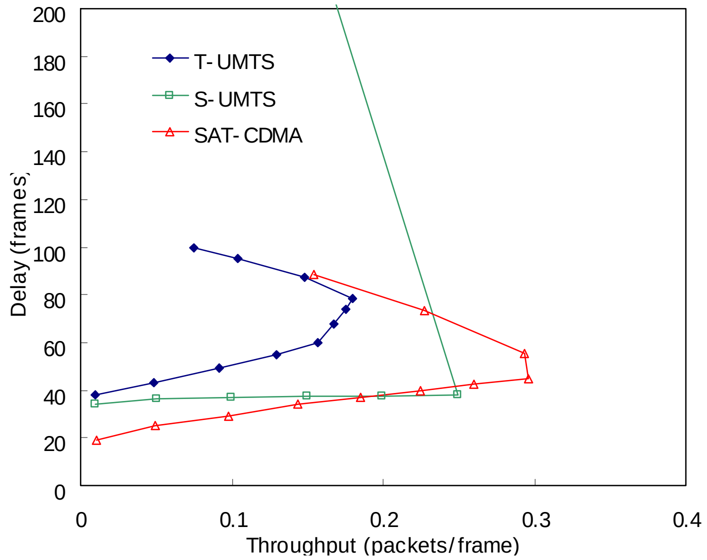
Simulation environment	
RACH message arrival	Poison process with mean of λ messages/frame
RACH message length	1 frame (10 ms, fixed)
Round trip delay	Uniform over 3,9 to 4,9 frames
Simulation time resolution	15 k samples/second
Total simulation time	10 000 frames
Open loop power control error	Gaussian random variable with standard deviation σ_{PCE} = 3 dB
Background noise and interference	-100 dBm
Target SIR for preamble detection	-18 dB
Target SIR for message reception	-15 dB
RACH/FACH signalling delay	10 frames
Maximum number of RACH trials	$M_{max,rach\_trials}$ = 3
Waiting time for FACH acknowledgement	18 frames
Message backoff time	Uniform over 1 to 10 frames

Table A.5: RACH parameters.

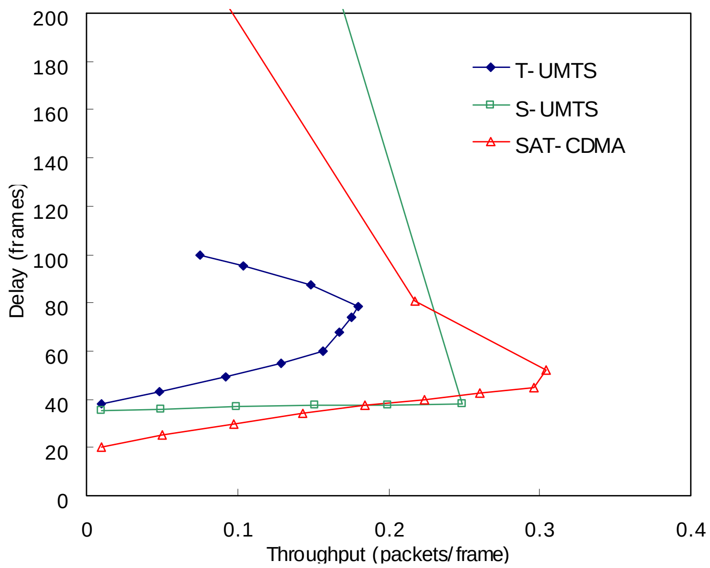
RACH parameters	
Persistence value	P_r = 0.5
Backoff time for the negative AI	Uniform over 1 to 10 frames
PRACH parameters	
Maximum number of transmission cycles	M_{cycle} = 3
Maximum number of power-ramping transmissions	$M_{ramping}$ = 3
Preamble length	$N_p \times$4 096 chips (N_p =1 and 3)
Number of signatures	16
Transmission offset	0
Preamble-to-preamble distance	8 frames
Preamble-to-AI distance	6 frames
Preamble-to-message distance	8 frames
Power-ramping step	ΔP = 3 dB
Power offset between preamble and message	3 dB

Table A.6: Fading channel.

Channel environment	
Fading model	Corrazza Model
Carrier frequency	2 GHz
Environment	Urban and Rural
Elevation angle	40 degree
Long-term fading (Shadowing)	Log-normal distribution
Short-term fading	Rician distribution
Mobile speed	3 km/h and 70 km/h



(a) Preamble length = 4 096 chips



(b) Preamble length = 3 * 4 096 chips

Figure A.5: Throughput-delay performance (mobile velocity: 3 km/h)

Annex B: W-CDMA radio interface parameters that need specific configuration for satellite operation

B.1 Introduction

S-UMTS made a feasibility study for operating 3GPP WCDMA radio interface in a satellite environment which means a remote access infrastructure antenna to be compared to terrestrial networks where the infrastructure antenna is located on the earth.

The objective was to show that it is possible to operate terminals equipped with 3GPP WCDMA chipsets without modification, but with appropriate configuration of the physical layer parameters among the multiple possibilities offered by 3GPP WCDMA.

The evaluation was oriented to geo-stationary constellation, it concluded as positive feasibility. The results are reported in TR 102 058 [i.14].

Hereafter are re-called the optimization of the parameters for satellite operation.

B.2 Random access

Clause 5.5.2 of TR 102 058 [i.14] details the random access satellite operation.

B.2.1 Preamble access

Time reference is broadcast by satellite and is received at UEs with a delay which is depending on their position in the spot coverage. Thus there is time dispersion which increases preamble collision risk. Time dispersion is evaluated to ~13 ms i.e. 10 preamble access slots under European coverage, to ~4 ms i.e. ~3 access slots under national coverage.

The guard time specified in 3GPP standards (1 024 chips) is not sufficient to absorb delay jitter under satellite coverage.

As an option UE transmission timing could be corrected with GNSS reference so that it is guaranteed preamble reception fits within one access slot at gateway receiver arrival.

As an alternative UE could repeat preambles with a time shift chosen according to an algorithm configured depending on the spot size. Several transmissions would be tried until to cope with gateway preamble acquisition window. A major drawback of this solution would be increase of time for preamble acquisition due to multiple preamble re-transmissions.

With 3GPP UE standard chipset, i.e. without any GNSS transmission or time shifted preamble repetition, the process is as follows.

- 3GPP access slot map structure is kept unmodified.
- Adaptation to satellite is done by inhibiting some of the access slots of the map broadcast over BCH.
- The number of inhibited access slots is satellite constellation configuration dependant.

In figure C.1, access slot map broadcast over BCH indicates only 1 access slot is available for a total of 3 access slots (slots number slots 0, 3, 6, 9 and 12).

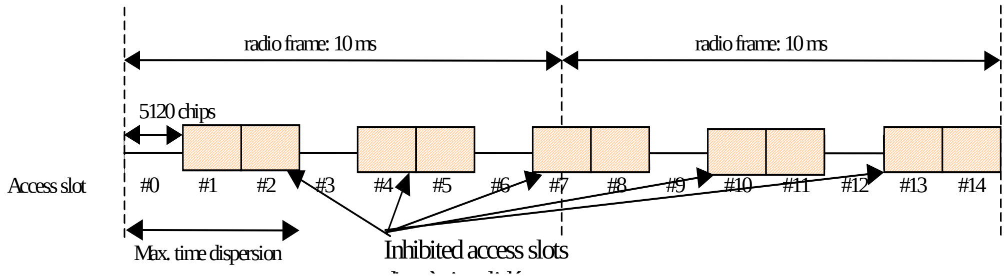


Figure C.1: Access slot map example

But due to UE dispersion delay the gateway is subject to receive preambles in all the access slots including the ones which are "officially" (according to BCH info) inhibited.

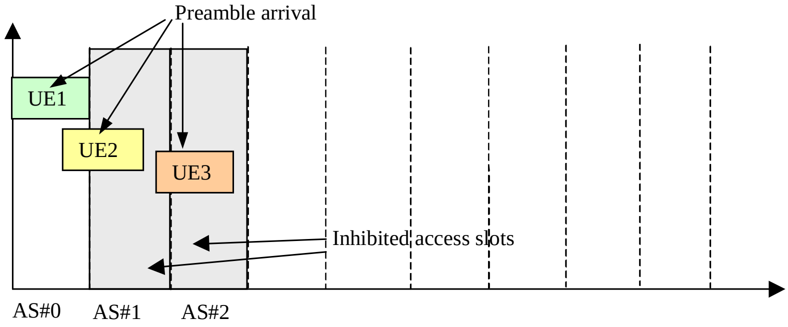


Figure C.2: Preamble arrival

At the gateway preamble search window is adjusted to the maximum UEs time dispersion. Enlarged preamble acquisition window means that several preambles received in the same reception window are not distinguished, while there is no preambles overlapping (collision). This reduces artificially RACH capacity.

In order to improve system efficiency, it is possible as an option to implement several preamble reception windows per group of access slots, i.e. running also for inhibited access slots as in figure C.3.

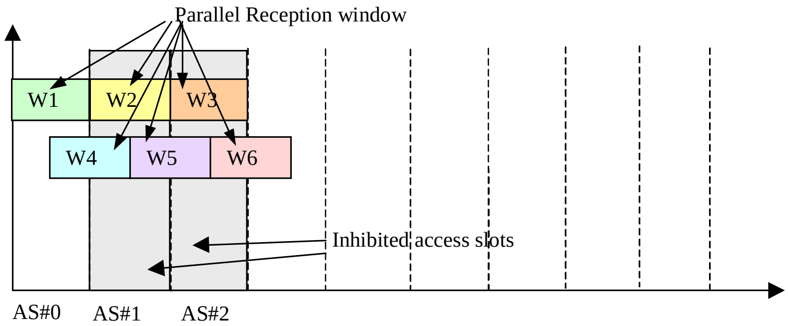


Figure C.3: Hub parallel reception windows

B.2.2 Preamble Acquisition Indicator reception

3GPP standards set preamble-to-Acquisition Indicator distance, $\tau_{p\text{-}a}$, in relation with terrestrial propagation delays, which does not fit with satellite channel latency.

Thus UE Acquisition Indication reception window is adapted in order to cope with satellite propagation delay in that way: UE implements with a multiplication factor and AICH reception window is time shifted to be compared to 3GPP terrestrial procedure. The multiplication factor is satellite constellation dependant.

B.2.3 Message part reception

When gateway has sent positive acknowledgement over AICH, it must prepare RACH message part reception after a delay compatible with satellite channel latency. The reception delay is satellite constellation dependant.

B.2.4 Performances

Performances for unsynchronized UEs have been reported in TR 102 058 [i.14], clause 6.2.1, and detailed for several search window sizes, it was concluded that it will fit with satellite link budget constraints.

Moreover, a method for improving performance are possible where RACH synchronization is done through repetition of the preamble. It consists in the *adjacent slotted repetition* of $N\ C_{pre}$ of length 4 096 chips. The 3GPP slotted frame structure is kept unmodified, and composed by 5 120 chip slots; thus, successive C_{pre}'s are spaced by a guard period of 1 024 chips. See figure C.4:

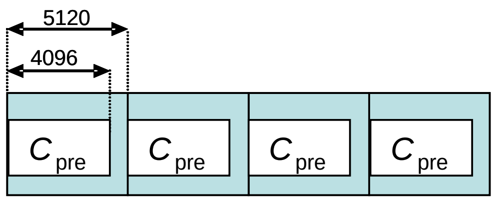


Figure C.4: Repetition structure of the preamble

Performance of such a method is detailed in TR 102 058 [i.14].

B.3 Power control

Configuration of power control is explained in TR 102 058 [i.14], clause 5.5.5. A Synthesis is given hereafter.

B.3.1 Open loop power control

Open loop power control is operated in the same manner as 3GPP terrestrial cellular networks.

B.3.2 Physical layer Closed loop power control

Generating one Transmit Power Control (TPC) command per slot, as done for terrestrial networks, is not efficient via satellite, due to slow channel reactivity (round trip delay) TPC commands don't match fast fading correction and are destructive.

In order to avoid oscillation loops, several methods were presented, among them:

- The processing of TPC commands is adapted to satellite environment: the receiver averages TPC commands over several slots (several frames) before applying the update of the transmit power. This is similar to 3GPP Algorithm 2, with a filtering period extended from 5 slot to several frames. The averaging period is to be adapted according to satellite constellation type (LEO, MEO, HEO, GEO). It is configured via the parameter DPC_MODE in the RRC protocol message sent to the UE at link establishment. One TPC command is repeated over several slots, filtered at the receiver, so that the TPC rate is reduced.

- Or layer 1 closed loop power control can also be inhibited by radio link configuration. For the uplink 3GPP algorithm 2 is used, UE processes received TPC commands on a 5 slots cycle. The gateway generates an alternating series of TPC commands so that UE always interprets the overall TPC command as null. For the downlink, layer 1 power control is inhibited via Iub RADIO LINK SETUP REQUEST protocol message with the Inner Loop DL PC Status information element set to "*Inactive*".

- Explicitly at channel setup, with the associated RRC protocol message element which configures the radio link, the TPC bits are transmitted but have no meaningful value. In order not to waste energy, power allocated to TPC bits can be configured to the lowest value.

Additionally, this is not mentioned in TR 102 058 [i.14], but there is also another possibility to implicitly inhibit power control for the uplink, by configuring the UE maximum transmit power in the RRC connection message, and for the downlink by just not executing the TPC commands received at the gateway.

B.3.3 Slow closed loop power control (layer 3 power control)

Moreover, a slow closed loop power control, which is managed at the RRC level, has been proposed in TR 102 058 [i.14]:

- For the uplink: the gateway processes and transmits RRC physical channel reconfiguration messages. All of the radio link parameters are kept unchanged apart from the transmit power that is ordered to the UE. The gateway takes decision based on uplink reception quality measurements and UE measurement reports (that contain information such as UE effective transmitted power and CPICH Received Signal Code Power.
- For the downlink: the gateway adjusts its transmitted power based on UE measurement reports and uplink quality measurements. The UE measurement reports contain UE quality measurement and carrier RSSI i.e. the received wide band power, including thermal noise and noise generated in the receiver, within the bandwidth defined by the receiver pulse shaping filter.

Slow power control performance in presence of slow fading or brutal signal obstruction is reported in clause 6.2.5.4 of TR 102 058 [i.14].

B.4 Timers adaptation

The RRC, RLC and MAC timers are configurable to several values.

3GPP standards allow values up to several seconds: this is compliant with satellite round trip delay constraint.

The only exception could be the RLC timer_discard in case RRC would configure the Transmission RLC Discard operation mode as "*Timer based no explicit*". In that case timer_discard value would be limited to 100 ms and thus wouldn't fit operation requirement. For that reason, this option is not used. Transmission RLC Discard operation mode is set by RRC at the gateway to "*Timer based explicit*" so that timer_discard value is extended up to 900 ms according to 3GPP standards.

History

Document history		
V1.1.1	August 2008	Publication