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3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Study on scalable UMTS Frequency Division Duplex (FDD) bandwidth (Release 12)

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Contents

Foreword 7
1 Scope 9
2 References 9
3 Definitions and abbreviations 10
3.1 Definitions 10
3.2 Abbreviations 10
4 Scenarios of scalable UMTS 11
4.1 Description 11
4.2 Deployment scenarios 11
4.3 Feature support in UMTS and scalable UMTS 11
5 Evaluation methodology 13
5.1 Channel model 13
5.2 Link-level simulation 15
5.2.1 Simulation assumptions 15
5.2.1.1 Downlink simulation assumptions 15
5.2.1.2 Uplink simulation assumptions 17
5.2.2 Performance evaluation metrics 18
5.3 System-level simulation 19
5.3.1 Simulation assumptions 19
5.3.2 Performance evaluation metrics 21
6 Solutions of scalable UMTS 22
6.1 Time dilation solution for scalable UMTS 22
6.1.1 Description 22
6.1.1.1 Power Spectral Density (PSD) of scalable UMTS Systems 23
6.1.1.1.1 Standalone time-dilated UMTS in downlink 23
6.1.1.1.2 Multi-carrier time-dilated UMTS in DL 24
6.1.1.2 Design options for PCCPCH channel 26
6.1.1.2.1 Single PCCPCH channel with reduced spreading factor 26
6.1.1.2.2 Multiple PCCPCH channels 26
6.1.1.3 CS voice in time-dilated UMTS 27
6.1.1.4 PRACH and AICH 28
6.1.1.4.1 PRACH/AICH timing relation 28
6.1.1.4.2 Random access procedure 29
6.1.1.4.3 Random access procedure 30
6.1.2 Evaluation results 31
6.1.2.1 HSPA link level simulation results 31
6.1.2.1.1 HSDPA simulations results 31
6.1.2.1.2 HSUPA simulations results 35
6.1.2.2 DCH link level simulation results 37
6.1.2.3 System level simulation results 38
6.1.2.3.1 Downlink bursty UEs simulation results in Band VIII 38
6.1.2.3.2 Downlink bursty UEs simulation results in Band I 43
6.1.3 Coverage of time-dilated UMTS 45
6.1.3.1 Simulation results 46
6.1.3.2 Link budget analysis 48
6.1.4 Impacts on the network and UE 52
6.1.4.1 UE receiver 52
6.1.4.1.1 RF and digital front-end 52
6.1.4.1.2 Base-band detector 54
6.1.4.1.3 Base-band decoder 54
6.1.4.2 UE transmitter 55
6.1.4.3 BS receiver 55
6.1.4.3.1 RF and digital front-end 55

6.1.4.3.2 Base-band detector 56
6.1.4.4 BS transmitter 56
6.1.4.4.1 Base-band process 56
6.1.4.4.2 RF and digital front-end 56
6.1.4.5 Impact to UE performance 56
6.1.4.5.1 Link performance of time-dilated UMTS with CPC 56
6.1.4.5.2 Impact to on-percentage due to time-dilation 64
6.1.4.6 Impact on network performance 65
6.1.4.6.1 Impact on physical layer procedures 65
6.1.4.6.2 Impact on higher layer timers 66
6.1.4.6.3 Impact on radio resource management 66
6.1.4.6.3a Other issues relating to introduction of less time-dilated carriers 67
6.1.4.6.4 KPI impact 67
6.1.4.6.5 Hardware complexity impact - summary 67
6.1.4.6.6 Site migration 67
6.1.4.6.7 UE battery consumption 68
6.1.4.6.8 O&M, parameter management 68
6.1.4.6.9 Timing relations 68
6.1.4.6.10 Scheduler impact 69
6.1.4.6.11 Positioning 69
6.1.4.6.12 Impact on system information 69
6.1.4.6.13 Impact on other RATs 69
6.1.5 Impacts on specifications 70
6.1.5.1 Impact to RAN1 specifications 70
6.1.5.2 Impact to RAN4 specifications 78
6.1.5.2.1 General 78
6.1.5.2.2 BS RF core and performance requirements 79
6.1.5.2.3 UE RF core and performance requirements 86
6.1.5.2.4 RRM requirements 95
6.1.5.3 Impact to GERAN1 specifications and coexistence 97
6.1.5.4 Impact to RAN3 specifications 97
6.1.5.5 Impact to RAN5 specifications 97
6.1.6 Impacts on coexistence 99
6.1.6.1 BS transmitter characteristics 100
6.1.6.2 BS receiver characteristics 102
6.1.6.3 UE transmitter characteristics 102
6.1.6.4 UE receiver characteristics 103
6.1.7 User plane latency analysis 103
6.1.7.1 Downlink user plane latency analysis 103
6.1.7.1.1 Example: web page download user plane latency over Uu interface 104
6.1.7.1.2 Lab test results 104
6.1.7.2 Uplink user plane latency analysis 107
6.1.7.2.1 Uplink user plane latency mitigation techniques 109
6.1.7.3 User plane latency analysis in CELL_FACH state 111
6.1.7.3.1 Uplink 111
6.1.7.3.2 Downlink 114
6.1.8 Impact on mobility (idle mode and connected mode) 115
6.1.8.1 Carrier identification and UE capability 115
6.1.8.2 Inter-frequency mobility 115
6.1.8.3 Impact on Cell Selection and Cell Reselection 116
6.1.8.4 Positioning 116
6.1.8.5 Other mobility aspects 116
6.1.8.5.1 RL failure or RLC unrecoverable error 116
6.1.9 Impact on SIBs acquisition 116
6.1.10 Impact on signalling and user plane data 116
6.1.10.1 SRB performance 116
6.1.10.1.1 Call setup delay for speech AMR NB MM multi-rate 12.2/7.4/5.9/4.95 from idle 117
6.1.10.2 User plane performance 117
6.1.10.3 New radio configurations 118
6.1.11 Impact on MAC, RLC and RRC performance, including impact on timers and procedures 118
6.2 Time-dilated solution for Carrier Aggregation scenarios 119
6.2.1 Solutions for Carrier Aggregation scenarios 119

6.2.1.1 Timing relation of HS-PDSCHs and HS-DPCCHs 119
6.2.1.2 HS-DPCCH solutions 119
6.2.2 Evaluation results 121
6.2.2.1 Link level results for carrier aggregation of time-dilated UMTS with UMTS 121
6.2.2.2 System simulation results for Carrier Aggregation of time-dilated UMTS with UMTS 124
6.2.2.2.1 Inter-carrier leakage 128
6.2.2.2.2 Results for UMTS + 1.25 MHz time-dilated UMTS in 6 MHz block assuming equal PSD 132
6.3 Void 133
6.4 Void 133
6.5 Void 133
6.6 Void 133
6.7 Void 133
6.8 Scalable Bandwidth UMTS by Filtering 133
6.8.1 Description 133
6.8.2 Preliminary evaluation results on filtered UMTS motivating further study 133
6.8.2.1 Downlink link level results 133
6.8.2.1.1 HSDPA link analysis 134
6.8.2.1.2 DCH simulation results 136
6.8.2.2 Uplink link level results 137
6.8.2.2.1 Uplink E-DCH performance of Scalable Bandwidth UMTS by filtering in 2.5 MHz channel BW 137
6.8.2.2.2 Uplink E-DCH performance of Scalable Bandwidth UMTS by filtering and zeroing every second chip in 2.5 MHz channel BW 137
6.8.2.2.3 EUL link analysis 138
6.8.3 Impacts on the network and UE 139
6.8.3.1 UE receiver RF and digital front-end 139
6.8.3.2 UE transmitter 140
6.8.3.3 BS receiver RF and digital front-end 140
6.8.3.4 BS transmitter RF and digital front-end 140
6.8A Scalable bandwidth UMTS by chip zeroing 140
6.8A.1 Description 140
6.8A.2 Power Spectrum Density and SINR analysis 142
6.8A.3 Control channel in CZ-UMTS 143
6.8A.3.1 Control channel overhead 143
6.8A.3.2 PRACH preamble design options for CZ-UMTS 143
6.8A.3.3 AICH design options for CZ-UMTS 144
6.8A.3.4 PICH design options for CZ-UMTS 145
6.8A.4 Impacts on network and UE 146
6.8A.4.1 Impacts on network implementation 146
6.8A.4.2 UE implementation 148
6.8A.4.2.1 PAPR 150
6.8A.5 Cross carrier scheduling for multi-carrier filtered CZ-UMTS 150
6.8A.5A Design for cross carrier scheduling for multi-carrier filtered CZ-UMTS 151
6.8A.6 Impact on 3GPP RAN1 specification 153
6.8A.6.1 TS 25.201 153
6.8A.6.2 TS 25.211 153
6.8A.6.3 TS 25.212 153
6.8A.6.4 TS 25.213 153
6.8A.6.5 TS 25.214 153
6.8A.6.6 TS 25.215 153
6.8B Link level simulation for filtered scalable UMTS 154
6.8B.1 Simulation assumptions for filtered scalable UMTS 154
6.8B.1.1 Downlink simulation assumptions for filtered scalable UMTS 154
6.8B.2 Performance evaluation metrics for filtered scalable UMTS 157
6.8C Link simulation results of scalable bandwidth UMTS with chip zeroing 157
6.8C.1 HSDPA link analysis 157
6.8C.1.1 Standalone CZ-UMTS carrier 157
6.8C.1.1A HSDPA link analysis with chip zeroing assuming N times overhead power ratio 159
6.8C.1.2 Multi-carrier UMTS+ CZ-UMTS configurations 160
6.8C.1.3 DCH analysis 167
6.8C.2 Uplink link level results 170
6.8C.2A PRACH preamble simulation results 170

6.8C.3 System Simulations – Bursty Traffic (Chip zeroed Filtered UMTS) 171
6.8C.4 Impacts on cell search 174
6.8C.4.1 Impacts on synchronization codes and primary scrambling codes 174
6.8C.4.2 Synchronization codes 174
6.8C.4.3 Primary scrambling codes 177
6.8C.4.4 Searcher performance 179
6.8C.4.5 Impacts on searcher implementation and performance 183
6.8D Uplink signal characteristics 183
6.8D.1 Background 183
6.8D.2 Simulation assumptions 183
6.8D.3 Power distribution 184
6.8D.4 PAPR and CM 185
6.8D.4.1 Comparing 5 MHz UMTS with 2.5 MHz F-UMTS/CZ-UMTS 185
6.8D.4.2 Comparing F-UMTS with CZ-UMTS in different bandwidths 188
6.8D.5 Discussion 189
6.9 Less relevant simulation results 189
6.9.1 Time dilated UMTS configurations 189
6.9.2 System performance for full buffer traffic 190
6.9.2.1 Evaluations based on user geometry distribution 190
6.9.2.1.1 UE throughput 194
6.9.2.2 Evaluation with a practical scheduler 195
6.9.3 HSDPA bursty traffic simulations results 196
6.9.4 HSUPA bursty traffic simulations results 196
6.10 Less relevant simulation results 197
6.10.1 Results for UMTS + 2.5 MHz time-dilated UMTS in 6 MHz block assuming equal PSD 197
6.10.2 Results for 3xUMTS + 2.5 MHz time-dilated UMTS in 15 MHz block assuming equal PSD 198
6.10.3 Results for 3xUMTS + 1.25 MHz time-dilated UMTS in 15 MHz block assuming equal PSD 199

7 Conclusions 201
7.1 Conclusions for Time-Dilated UMTS 201
7.2 Conclusions for Scalable UMTS by filtering 203

Annex A: Change history 206

Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

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1 Scope

The present document is the result of the study item "Scalable UMTS FDD Bandwidth".
This study identifies target scenarios and investigates candidate solutions by considering benefits and technical complexity. The detailed objectives are described in RP-130221 [3].

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document.*

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] RP-122017: "Proposed SID: Study on Scalable UMTS"

[3] RP-130221: "Revised SID for Scalable UMTS FDD Bandwidth".

[4] R4-133349: "BS Tx coexistence aspects for S-UMTS", Huawei.

[5] R4-133351: "SEM analysis for Scalable UMTS carrier", Huawei.

[6] R4-133852: "time-Dilated UMTS: BS emissions", Ericsson, ST-Ericsson.

[7] R4-133350: "BS Rx coexistence aspects for S-UMTS", Huawei.

[8] R4-132338: "Co-existence issue for S-UMTS", Huawei.

[9] R1-131588: "Modelling of Adjacent Carrier Interference ", Qualcomm.

[10] R4-134138: "Scalable UMTS UE searcher performance ", Qualcomm.

[11] R4-134139: "UE RRM specification impact due to introduction of Scalable UMTS ", Qualcomm.

[12] R4-132165: "Impact of S-UMTS on RRM Requirements and Specifications ", Ericsson, ST-Ericsson.

[13] R4-132166: "Impact of S-UMTS on RRM related Procedures ", Ericsson, ST-Ericsson.

[14] R4-133846: "Further study on co-existence of Scalable UMTS", NSN.

[15] R4-132856: "UE Tx coexistence aspects with Scalable UMTS ", Qualcomm.

[16] R4-134130: "UE Tx coexistence aspects with Scalable UMTS ", Qualcomm.

[17] R4-134135: "UE Rx coexistence aspects with Scalable UMTS", Qualcomm.

[18] R1-140145: "Structure of TR25.701", Alcatel-Lucent, Alcatel-Lucent Shanghai Bell

[19] R1-140794: "Uplink performance of 1.25 MHz S-UMTS by Filtering", NSN

[20] R1-140946: " Enhanced Filtering for Scalable UMTS", Qualcomm.

[21] R1-140984: "TP on Simulation Results for Scalable UMTS with Filtering", Qualcomm.

[22] R1-140986: " Link level simulation assumptions for Scalable UMTS", Ericsson.

[23] R1-140988: " TP on conclusions ", Qualcomm.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply.
A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply.
An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

4 Scenarios of scalable UMTS

4.1 Description

In standalone scenario, scalable UMTS carrier can be supported as standalone utilization.

The multi-carrier scenario refers to the mode of operation where the 5 MHz carrier acts as the primary carrier, and the scalable UMTS carrier is usable as the secondary HS-DSCH carrier in downlink.

4.2 Deployment scenarios

Tables 4.2-1 and 4.2-2 below are listing the scenarios of scalable UMTS.

Table 4.2-1: The first deployment scenarios for Scalable UMTS

Mode of Operation	Bandwidth	Comments	Bands
Standalone	2.5 MHz (corresponds to N=2)	Support for DCH shall be considered.	Band VIII as the first band to consider
Standalone	1.25 MHz (corresponds to N=4)	HSPA data only	Band VIII as the first band to consider
Multi-carrier	5 MHz + 1.25 MHz (corresponds to N=4) 5 MHz+ 2.5 MHz (corresponds to N=2)	6 MHz of contiguous band to consider first	Band VIII as the first band to consider
Standalone	2.5 MHz (corresponds to N=2)	To understand the impact of band	Band I as the first band to consider

Table 4.2-2: Additional scenario may be considered for Scalable UMTS

Mode of Operation	Bandwidth	Comments	Bands
Multi-carrier	5 MHz + 2.5 MHz (corresponds to N=2)	For example 3x5MHz + 1x2.5MHz in 15 MHz of band	Band I as the first band to consider
NOTE: 5 MHz + 2.5 MHz multicarrier is not applicable in 6 MHz scenario.			

4.3 Feature support in UMTS and scalable UMTS

Potentially, the feature set supported by UMTS and scalable UMTS may differ. Some initial observations have been made, but the following aspects have not been considered in any detail by RAN1:

- The degree to which scalable UMTS and UMTS features should be tied

Future standardization of new features for UMTS may potentially become more complicated if scalable UMTS is introduced. For example, for each new UMTS feature, an evaluation of the benefit of including the feature into scalable UMTS would need to be evaluated. It should be clear from the initiation of a scalable UMTS RAT whether new features should be always applicable to both.

An alternative would be to decouple scalable UMTS from UMTS and see it as a separate RAT with more limited capabilities and its own evolution roadmap. Specifying different capability levels for UMTS and scalable UMTS should be seen in the light of the overall evolution roadmap.

- How capability signaling should be managed, considering signaling and test overhead

Another consideration should be whether UE capability for optional features should be tied between UMTS and scalable UMTS, or whether capability should be signaled separately. Introducing a new separate set of capabilities for the scalable UMTS carrier could lead to increased signaling, and an explosion of capability combinations that need to

be tested, and will cause complications in the RNC's radio resource management algorithms. On the other hand, tying capabilities would require consideration of the benefits of features for both scalable UMTS and UMTS.

- Impacts on the overall benefit of scalable UMTS and carrier management of not supporting all UMTS features

The performance of time dilated UMTS and scalable UMTS by filtering has been evaluated against UMTS considering a release 6 configuration (i.e. no MIMO, no advanced receivers, no multiflow etc.). The evolution of UMTS has aimed to provide increased performance. Thus, against a benchmark of release 12 UMTS, the performance of scalable UMTS will be further reduced. This highlights the questions further as to whether scalable UMTS should support release 12 features, what the relative benefits of the features look like, and whether if release 12 features are not supported the intention should be to evolve scalable UMTS or that it always remains a low capability feature.

- Specification complexity and management

Differing support between UMTS and scalable UMTS for different features would potentially impact the complexity and diversity of the specifications. If the reduced bandwidth UMTS would be specified within the existing specification series, then the modes of operation and applicability of different features would need to be differentiated. An alternative would be specifying reduced bandwidth UMTS in separate specifications, however this would increase overhead for specification maintenance.

5 Evaluation methodology

5.1 Channel model

The chip rate of time-dilated UMTS could be reduced to ½ or ¼ from the existing 3.84 Mcps operation.
Typically, in a UMTS link simulator, the wireless multipath resolution is in units of the over sampling frequency K/Tc at the output of the transmitter filter where Tc = 1 UMTS chip and K is the oversampling factor.
This is shown in Figure 5.1-1.

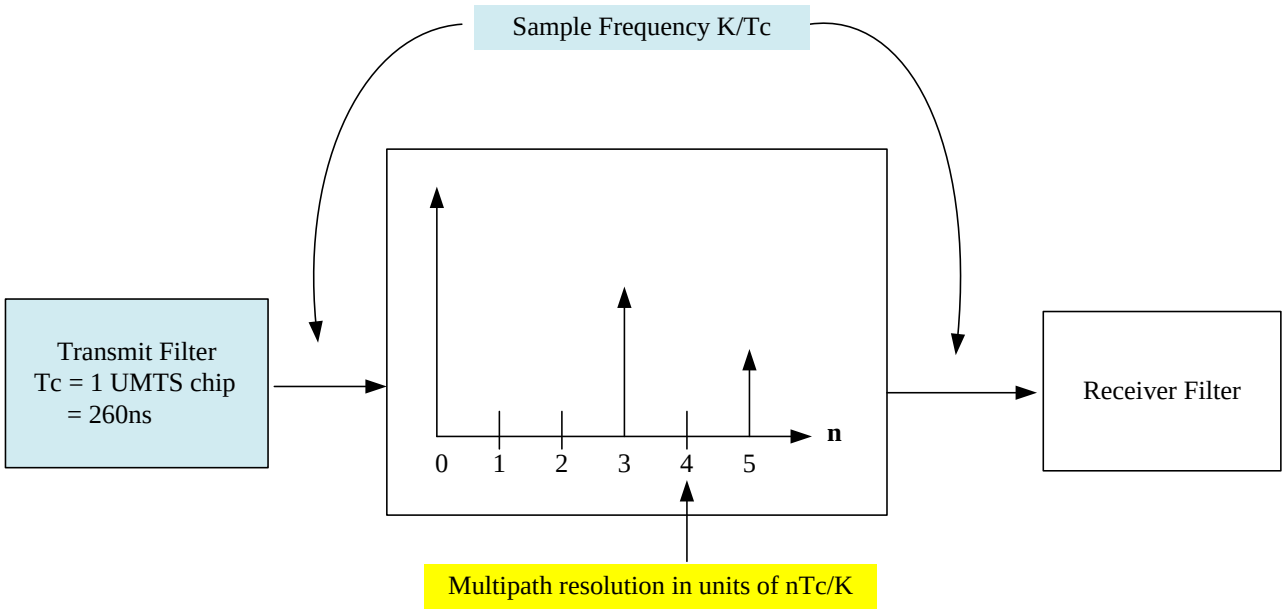


Figure 5.1-1: Sampling frequency at Tx filter output in UMTS

Channel multipath resolution should be invariant in different time-dilated UMTS bandwidths, which could be realized by using the same channel sampling rate as in the legacy UMTS system. Via this way, the existing PA, PB and VA channel designed for legacy UMTS evaluation can be reused for time-dilated UMTS.

For example, when K=4, the oversampling frequency is 15.36MHz in legacy UMTS system. If it maintains the same multipath resolution, the time-dilated UMTS oversampling frequency will be (K*N)/ Tc` = (K*N) / N*Tc = K / Tc. Therefore, the oversampling in time-dilated UMTS is also 15.36MHz. This is illustrated in Figure 5.1-2.

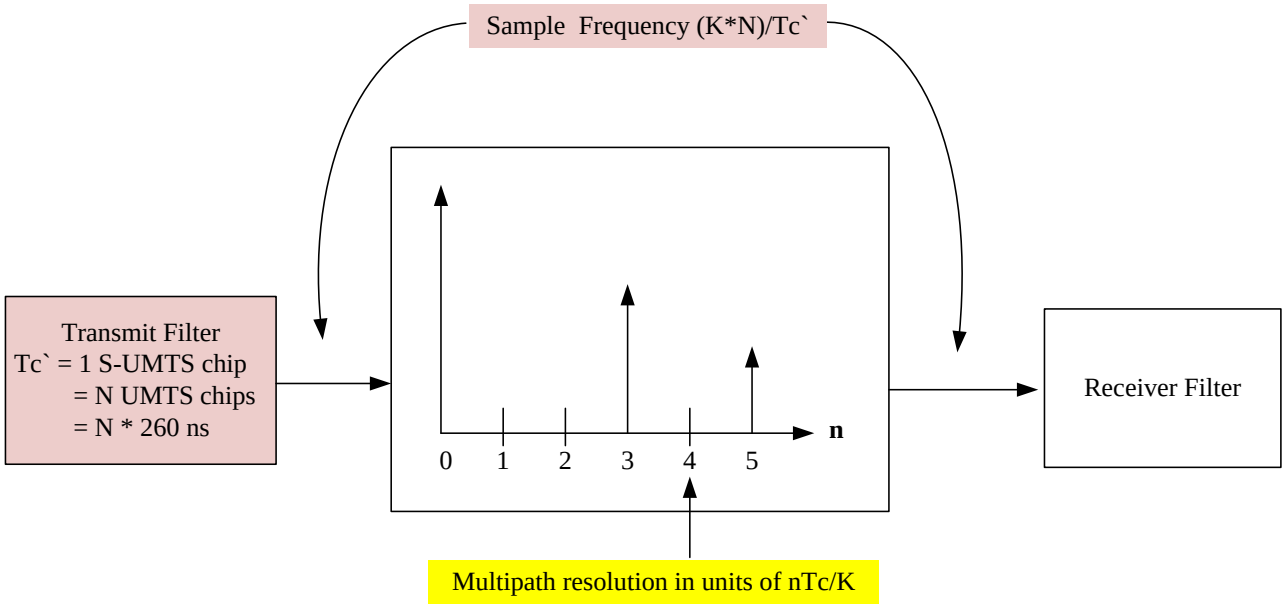


Figure 5.1-2: Sampling frequency at Tx filter output in time-dilated UMTS to maintain the same multipath resolution as in UMTS

5.2 Link-level simulation

Link-level simulation assumptions and performance metrics for time-dilated UMTS are defined in this subclause, for both the DownLink (DL) and UpLink (UL). Specifically, the standalone DL, standalone UL and Carrier Aggregation (CA) DL cases are covered. It should be noted that time-dilating control channels is a method for trading off overhead to latency.

5.2.1 Simulation assumptions

5.2.1.1 Downlink simulation assumptions

The baseline parameters to be used for link-level simulations of standalone time-dilated UMTS DL are listed in Table 5.2.1.1-1. For all DL link-level assumptions, residual frequency error shall be 0 ppm.

Table 5.2.1.1-1: General simulation assumptions for standalone time-dilated UMTS DL

Parameter	Value
Carrier Frequency	900 MHz, 2GHz
Scaling factor	1; UMTS carrier 2; time-dilated UMTS carrier 4; time-dilated UMTS carrier (HSPA data only)
P-CPICH_Ec/Ior	-10dB
P-CCPCH_Ec/Ior	-12dB per P-CCPCH code
SCH_Ec/Ior	-12dB
PICH_Ec/Ior	-15dB
HS-SCCH_Ec/Ior	-12dB
HS-PDSCH_Ec/Ior	Remaining power so that total transmit power spectral density of Node B (Ior) adds to one
Spreading factor for HS-PDSCH	16
Modulation	QPSK, 16QAM, 64QAM
TTI [ms]	DCH: 20ms
TBS	Variable for HS-PDSCH AMR12.2K for DCH
HSDPA Scheduling Algorithm	CQI based
Geometry	[-5 0 5 10 15 20]dB
CQI Feedback Cycle	1TTI, 2TTIs
CQI feedback error	1% CQI error means CQI erasure, in which case the Node B uses the previous CQI
HS-DPCCH ACK/NACK feedback error	1%
Maximum number of HS-DSCH codes	Up to 15*SF16 for TTI=2ms*Scaling factor per carrier for HS-PDSCH
Number of HARQ Processes	6
Maximum HARQ Transmissions Time	50ms * Scaling factor
HARQ Combining	Incremental Redundancy
First transmission BLER	10% after 1 transmission
Number of Rx Antennas	2
Channel Encoder	3GPP Turbo Encoder for HSDPA Convolutional for DCH
Turbo Decoder	Log MAP
Number of iterations for turbo decoder	8
CQI Feedback delay	8ms*Scaling factor (the case TTI length is increased); 8ms (the baseline)
Propagation Channel Type	PA3,VA3, VA30,VA120 in specific cases AWGN simulations could be used
Channel Estimation	Realistic
Noise Estimation	Realistic
UE Receiver Type	1-Rx Rake and 2-Rx LMMSE (Type 3)
Antenna imbalance [dB]	0
Tx Antenna Correlation	0
Rx Antenna Correlation	0
Number of transmit antennas	1

Table 5.2.1.1-2 lists the general parameters to be used for time-dilated carrier aggregation DL link simulations.

Table 5.2.1.1-2: General simulation assumptions for time-dilated carrier aggregation DL

Parameter	Value
Scaling factor	Primary Cell: 1; Secondary Cell: 2; 4
P-CPICH_Ec/Ior	-10dB
P-CCPCH_Ec/Ior	Primary Cell: -12dB Secondary Cell: OFF
SCH_Ec/Ior	Primary Cell: -12dB Secondary Cell: OFF
PICH_Ec/Ior	Primary Cell: -15dB Secondary Cell: OFF
HS-SCCH_Ec/Ior	-12dB
HS-PDSCH_Ec/Ior	Remaining power so that total transmit power spectral density of Node B (Ior) adds to one on each cell
Spreading factor for HS-PDSCH	16
Modulation	QPSK, 16QAM, 64QAM
TBS	Variable for HS-PDSCH
HSDPA Scheduling Algorithm	CQI based
Geometry	[-5 0 5 10 15 20]dB
CQI Feedback Cycle	1TTI, 2TTIs
CQI feedback error	1% CQI error should be explained to mean CQI erasure, in which case the Node B uses the previous CQI
HS-DPCCH ACK/NACK feedback error	1%
Maximum number of HS-DSCH codes	Up to 15*SF16 for TTI=2ms*Scaling factor per carrier for HS-PDSCH
Number of HARQ Processes	6
Maximum HARQ Transmissions Time	50ms * Scaling factor
HARQ Combining	Incremental Redundancy
First transmission BLER	10% after 1 transmission
Number of Rx Antennas	2
Channel Encoder	3GPP Turbo Encoder
Turbo Decoder	Log MAP
Number of iterations for turbo decoder	8
CQI Feedback delay	8ms*Scaling factor (the case TTI length is increased); 8ms (the baseline)
Propagation Channel Type	PA3,VA3, VA30,VA120 in specific cases AWGN simulations could be used
Channel Estimation	Realistic
Noise Estimation	Realistic
UE Receiver Type	1-Rx Rake and 2-Rx LMMSE (Type 3)
Antenna imbalance [dB]	0
Tx Antenna Correlation	0
Rx Antenna Correlation	0

5.2.1.2 Uplink simulation assumptions

Table 5.2.1.2-1 lists the general parameters to be used for UL link simulations, including DCH for voice traffic evaluation and E-DCH for data traffic evaluation. For all UL link-level assumptions, residual frequency error shall be 0 ppm.

Table 5.2.1.2-1: General simulation assumptions for standalone time-dilated UMTS UL

Parameter	Value
Physical Channels	E-DCH: E-DPDCH, DPCCH, EDPCCH DCH: DPCCH, DPDCH
Scaling factor	1; UMTS carrier 2; time-dilated UMTS carrier 4; time-dilated UMTS carrier (HSPA data only)
TTI [ms]	E-DCH: (2ms/10ms)*Scaling factor DCH: 20ms
TBS[bit]	DCH: AMR12.2K for DCH
Maximum HARQ Transmissions Time	50ms * Scaling factor
Operating Point	E-DCH: HARQ 1 % Residual BLER within maximum HARQ transmission time. DCH: 1 % BLER
E-DCH Scheduling Algorithm	RoT based
RoT	6dB
Number of Rx Antennas	2
Channel Encoder	3GPP Release 6 Turbo Encoder for E-DCH Convolutional for DCH
Turbo Decoder	Log MAP
Number of iterations for turbo decoder	8
DPCCH Slot Format	1 (8 Pilot, 2 TPC) for E-DCH 0 (6 pilot, 2 TFCI, 2 TPC) for DCH
Inner Loop Power Control	ON
Outer Loop Power Control	ON
Inner Loop PC Step Size	±1 dB
UL TPC Delay (sent on F-DPCH)	E-DCH: 1.33ms*Scaling factor
UL TPC Error Rate (sent on F-DPCH)	4%
Propagation Channel	PA3, VA3, VA30, VA120 in specific cases AWGN simulations could be used
NodeB Receiver Type	LMMSE, Rake
NodeB Rx Correlation	0
UE DTX	OFF
Number of transmit antennas	1

5.2.2 Performance evaluation metrics

For DCH voice traffic, the following metric should be considered:

- DL
  - BLER v/s Ec/Ior
- UL
  - Residual BLER v/s Transmitted Ec/No.
  - Residual BLER v/s Received Ec/N0.

For HSPA traffic, the following metrics should be considered:

- Throughput.
- For latency:
  - Compute transmission delay CDF for L1 delay.
  - CELL_DCH latency
    - Compare the CDFs of the average number of the transmissions and then take into account the increase in the TTI lengths to evaluate the latency.
  - Access latency
    - Consider with and without additional power/overhead.
- For coverage:
  - CELL_DCH coverage
    - Examine performance at different geometries.
  - Access coverage
    - Consider with and without additional power/overhead.

Inter-Carrier Interference (ICI) should be taken into account. The ICI model is described in R1-131588 [9].
The interference rise metric should be considered.

In time-dilated UMTS link-level simulation, the performance metrics shall be carrier specific.

5.3 System-level simulation

5.3.1 Simulation assumptions

The general system simulation parameters given in Table 5.3.1-1 are proposed to be used in system-level simulations, containing both uplink and downlink.

Table 5.3.1-1: General system simulation parameters for scalable UMTS performance evaluation

Parameters	Values and comments	
Cell Layout	57 cell hexagonal (19 NodeB, 3 sectors per Node B with wrap-around) Optional: 21 cell hexagonal	
Inter-site distance	1000 m Optional: 500 m	
Scaling factor	1 2 4	
Number of UEs per 5MHz sector	For full buffer (DL) 1,2, 4, 8 For full buffer (UL) 1, 2, 4, 8 For bursty traffic model variable up to system stability level	
Path Loss	2000MHz: L=128.1 + 37.6log10(R), R in kilometres 900MHz: L=120.9 + 37.6log10(R), R in kilometres	
Log Normal Fading	Standard Deviation: 8dB Inter-Node B Correlation: 0.5 Intra-Node B Correlation :1.0 Correlation Distance: 50m	
Antenna pattern	3GPP ant (2D ant): $A(\theta) = -\min\left[12\left(\frac{\theta}{\theta_{3dB}}\right)^2, A_m\right]$ $\theta_{3dB} = 70$ degrees, $A_m = 20dB$	
Channel Model	PA3, VA3, VA30, VA120	
Penetration loss	10dB Optional: 20dB	
Maximum UE EIRP	24dBm	
Maximum Tx Power of NodeB	43dBm per 5MHz 43dBm per carrier	
Max BS Antenna Gain	14dBi	
Max UE Antenna Gain	0dBi	
NodeB Noise Figure	5 dB	
UE Noise Figure	9 dB	
Thermal noise density	-174dBm/Hz	
E-DPCCH	$\beta_{ec}/\beta c$ = 15/15	
HS-DPCCH	CQI Feedback Cycle	1 TTI
	Δ_{ACK} [dB]	0
	Δ_{NACK} [dB]	0
	Δ_{CQI} [dB]	0
	CQI Feedback delay	8ms*Scaling factor (the case TTI length is increased); 8ms (the baseline)
HS-DSCH	Up to 15*SF16 for TTI=2ms*Scaling factor per carrier for HS-PDSCH HS-PDSCH uses all remaining power available after the HS-SCCH and other downlink channels power allocation, with HS-SCCH transmit power being driven by 1% HS-SCCH BLER. HS-PDSCH HARQ: Both chase combining and IR based can be used. 10% target BLER after the first transmission. Retransmissions are of highest priority.	
P-CPICH_Ec/Ior	-10dB	

S-CPICH Ec/Ior	-13dB
P-CCPCH_Ec/Ior	-12dB -12 dB + 10log(N) Optional: OFF Proponent should provide if other values are considered
SCH_Ec/Ior	-12dB Optional: OFF
PICH_Ec/Ior	-15dB Optional: OFF
Number of HARQ Processes	DL: 6 UL: 8
Maximum H-ARQ Transmissions Time	50ms * Scaling factor
HS-SCCH code number	4
UE Receiver	Type 3, Type 3i
Max active set size	3
Power control	UL: 1 % Residual BLER within maximum H-ARQ transmissions time DL: Based on CQI.
RoT Target	6dB
Network Configuration	SIMO Optional: MIMO
Scalable UMTS capable UE penetration	100% 30%

Parameters for downlink and uplink bursty traffic model are given in Table 5.3.1-2 and Table 5.3.1-3, respectively.

Table 5.3.1-2: Downlink bursty traffic model

Component	Distribution	Parameters	PDF
File size (S)	Truncated Lognormal	Mean = 0.25 Mbytes Std. Dev. = 0.0902 Mbytes Maximum = 1.25 Mbytes	$f_X = \frac{1}{\sqrt{2\pi}\sigma x}\exp\left[\frac{-(\ln x-\mu)^2}{2\sigma^2}\right], x \geq 0$ $\sigma = 0.35, \mu = 12.368$
Inter-burst time	Exponential	Mean = 5 sec	$f_X = \lambda e^{-\lambda x}, x \geq 0$ $\lambda = 0.2$

Table 5.3.1-3: Uplink bursty traffic model

Component	Distribution	Parameters	PDF
File size (S)	Truncated Lognormal	Mean = 0.0625 Mbytes Std. Dev. = 0.0225 Mbytes Maximum = 0.3125 Mbytes	$f_X = \frac{1}{\sqrt{2\pi}\sigma x}\exp\left[\frac{-(\ln x-\mu)^2}{2\sigma^2}\right], x \geq 0$ $\sigma = 0.35, \mu = 10.982$
Inter-burst time	Exponential	Mean = 5 sec	$f_X = \lambda e^{-\lambda x}, x \geq 0$ $\lambda = 0.2$

5.3.2 Performance evaluation metrics

The following performance metrics should be compared between UMTS and scalable UMTS.

For bursty traffic, the following performance measures are used for evaluation:

- Average burst rate:
  - The burst rate is defined as the ratio between the data burst size in bits and the total time the burst spent in the system.
  - The total time the burst spent in the system is the time difference measured between the instant the data burst arrives at the Node B and the instant when the transfer of the burst over the air interface is completed.
  - The total time the burst spent in the system is equal to the sum of the transmission time over the air and the queuing delay.
- Total system throughput
- UE throughput: average, 50%, and 5%
- PDF of RLC packet delay: the delay is calculated as the time between when the RLC packet is constructed at the RNC until it is delivered by UE RLC receiver to upper layers; RLC packets discarded after maximum number of retransmissions should be counted separately.
- Average and CDF of RoT for UL

For full buffer traffic, the following performance measures are used for evaluation:

- Sector throughput
- UE throughput: average, 50%, and 5%
- Average and CDF of RoT for UL

The neighbour cell activity level should be modelled realistically considering the offered load level and link throughput.

The full buffer results are indicative of the relative spectral efficiencies that can be achieved with time-dilated UMTS, and are a complement to link level simulations. However, they do not capture key system level aspects load variation, activity factor, scheduling impact, queuing delay etc.

The bursty traffic results are a better indicator of the overall performance of time-dilated UMTS since they take into account the differences in activity factors, neighbour cell loading and inter-cell interference in a more realistic manner. Therefore, conclusions on the relative performance of time-dilated UMTS are primarily based on the bursty traffic analysis.

6 Solutions of scalable UMTS

6.1 Time dilation solution for scalable UMTS

6.1.1 Description

The scalable UMTS time dilation solution comprises increasing the UMTS chip period by a time dilation factor N, where N is equal to 2 or 4. Consequently, the scalable UMTS chip period is increased to $N*T_c$, where T_c is the UMTS chip period (i.e., 0.26 µs). This results in the scalable UMTS chip rate being reduced by a factor of 1/N relative to the UMTS chip rate of 3.84 Mcps and the scalable UMTS spectrum bandwidth being reduced by a factor of 1/N relative to the UMTS spectrum bandwidth of 5 MHz. For example, in a 2.5 MHz bandwidth (referred to as time-dilated UMTS N=2), the chip rate is reduced by a factor of 2 relative to UMTS to 1.92 Mcps. In this sense, time dilation is used as a means of achieving a smaller spectrum bandwidth. In the present document, this solution is referred to as time-dilated UMTS. Figure 6.1.1-1 illustrates the time dilation concept.

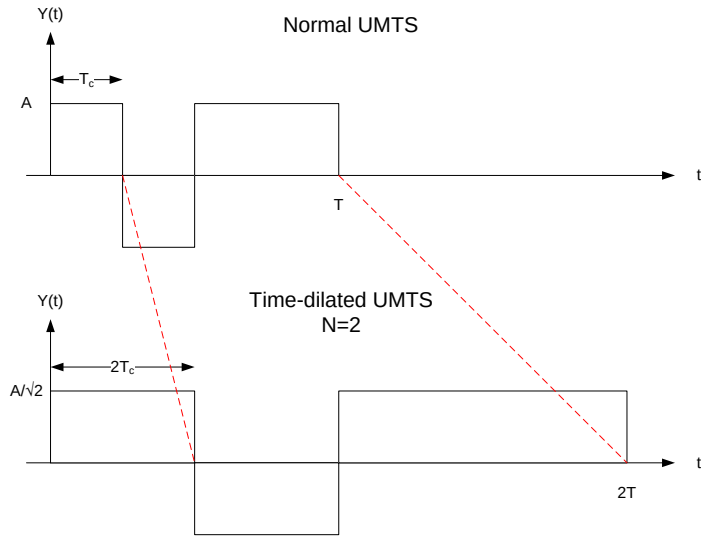
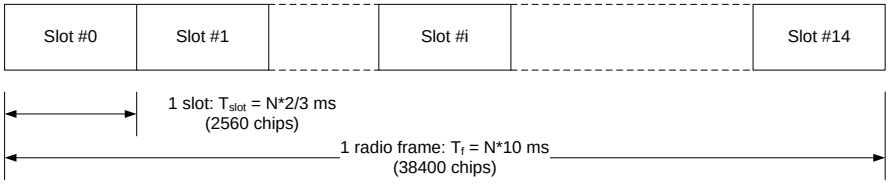


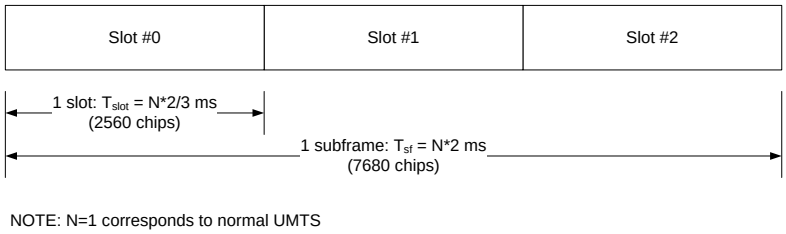
Figure 6.1.1-1: time-dilated UMTS FDD waveform

Time-dilated UMTS reuses the UMTS FDD physical layer specifications to as large extent as possible. However, due to time dilation, all time-related physical layer parameters in time-dilated UMTS are scaled accordingly (i.e., dilated N times relative to UMTS). For example, in the case of time-dilated UMTS N=2, the radio frame duration increases from 10 ms to 20 ms which is illustrated in Figure 6.1.1-2. Also, the HS-PDSCH subframe duration increases from 2 ms to 4 ms as shown in Figure 6.1.1-3.



NOTE: N=1 corresponds to normal UMTS

Figure 6.1.1-2: Radio frame structure for scalable UMTS time dilation solution



NOTE: N=1 corresponds to normal UMTS

Figure 6.1.1-3: HS-PDSCH subframe structure for scalable UMTS time dilation solution

6.1.1.1 Power Spectral Density (PSD) of scalable UMTS Systems

In this subclause, different options for power spectral density are discussed for standalone and dual carrier time-dilated UMTS systems. Since the bandwidth of the time-dilated UMTS waveform is reduced, the PSD of time-dilated UMTS system can be increased so that the total power of the time-dilated UMTS system is the same as the total power of the equivalent UMTS system. On the other hand, the PSD of the time-dilated UMTS system may also be increased to be comparable with the UMTS system. These options are reviewed in this subclause.

6.1.1.1.1 Standalone time-dilated UMTS in downlink

Figure 6.1.1.1.1-1 shows the scalable UMTS system based on the time dilation solution, with the same PSD as normal UMTS system. In this scenario, time-dilated UMTS system NodeB power is smaller than the UMTS system.
In this case, the power of time-dilated UMTS system with N = 2 is half, and in N = 4, the power is one-fourth of the total power of the equivalent normal UMTS system. This is illustrated in Figure 6.1.1.1.1-1. For example, for the uplink, if the normal UMTS UE transmit power is 23 dBm, then the time-dilated UMTS UE transmit power is 23 dBm – $10\log_{10}(N)$ (i.e., 20 dBm for time-dilated UMTS N=2 and 17 dBm for time-dilated UMTS N=4). In the downlink, if the normal UMTS Node B/cell transmit power is 43 dBm, then the time-dilated UMTS Node B/cell transmit power is 43 dBm - $10\log_{10}(N)$ (i.e., 40 dBm for time-dilated UMTS N=2 and 37 dBm for time-dilated UMTS N=4).

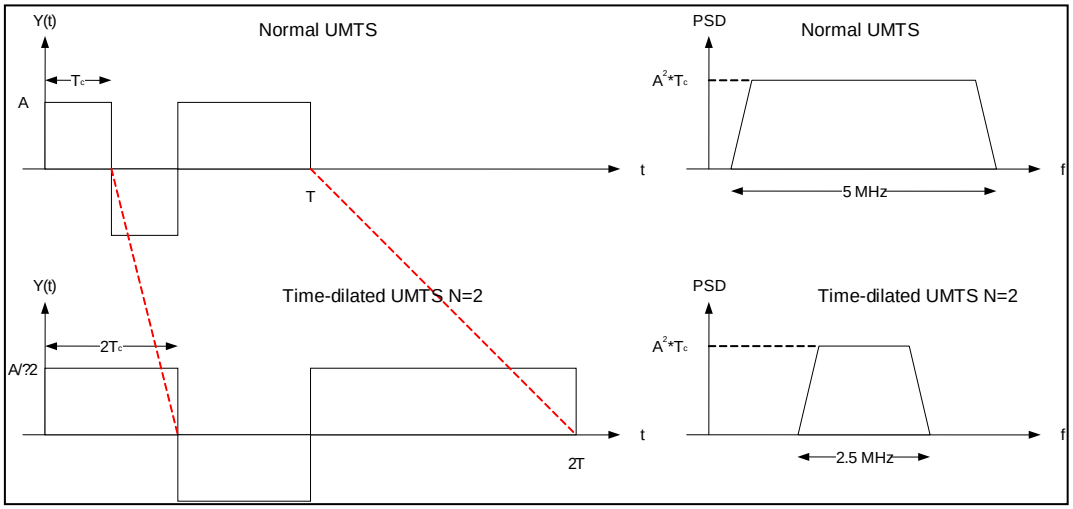


Figure 6.1.1.1.1-1: Scalable UMTS N=2 time-dilation solution, with the same PSD. The same principle applies to N = 4

Figure 6.1.1.1.1-2 shows the scalable UMTS system based on the time-dilation solution, with higher PSD.
In this scenario, time-dilated UMTS system has the same power as compared with the UMTS system.
The PSD of time-dilated UMTS system with N = 2 is twice, and in case of N = 4, is four times the PSD of equivalent UMTS system, giving the time-dilated UMTS the same power as the equivalent UMTS system.
For example, in DL, if the normal UMTS Node B/cell transmit power is 43 dBm, then the time-dilated UMTS Node

B/cell transmit power is also 43 dBm (for both time-dilated UMTS N=2 and N=4). In UL, if the normal UMTS UE transmit power is 23dBm, then the time-dilated UMTS UE transmit power is also 23dBm (for both N =2 and N = 4).

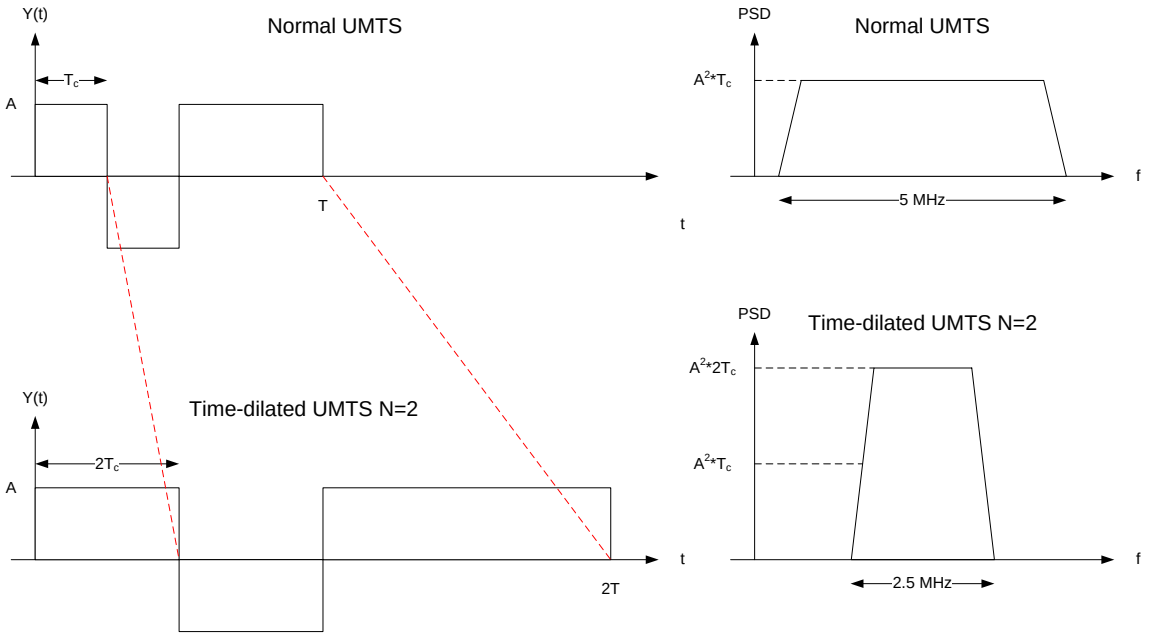


Figure 6.1.1.1.1-2: time-dilated UMTS PSD scaled by N relative to normal UMTS (i.e. time-dilated UMTS transmit power same as normal UMTS)

6.1.1.1.2 Multi-carrier time-dilated UMTS in DL

The PSD level of dual carried Scalable UMTS depends on whether additional power is available for the time-dilated UMTS carrier, or the total power is shared between legacy UMTS and time-dilated UMTS systems.

In Table 6.1.1.1.2-1, a summary of possible scenarios for multi-carrier UMTS system is considered.
Extra NodeB power may be dedicated to the time-dilated UMTS carrier, with higher PSD or the same PSD level. Alternatively, time-dilated UMTS and legacy UMTS may share the total NodeB power. These options are summarized in Table 6.1.1.1.2-1, and further explained in this subclause.

Table 6.1.1.1.2-1: Scenarios for multi-carrier time-dilated UMTS system

Total NodeB Power	time-dilated UMTS vs. UMTS Carrier PSD	Note
Extra Power for time-dilated UMTS Carrier	Same PSD between time-dilated UMTS and Legacy UMTS	e.g., separate PA, without increasing time-dilated UMTS PSD
Shared Power between time-dilated and Legacy UMTS Carrier	Same PSD between time-dilated UMTS and Legacy UMTS	e.g., single PA, reducing PSD of both UMTS and time-dilated UMTS
Extra Power for time-dilated UMTS Carrier	Higher PSD for time-dilated UMTS as compared to Legacy UMTS Carrier	e.g., separate PA, with increasing time-dilated UMTS PSD

Figure 6.1.1.1.2-1 represents the PSD of a dual carrier time-dilated UMTS system with increased total power, and same PSD for time-dilated UMTS carrier. In this case, the PSD of the time-dilated UMTS system is at the same level of the PSD of the UMTS system. The overall power of the combined system is increased, with extra power dedicated for the time-dilated UMTS carrier.

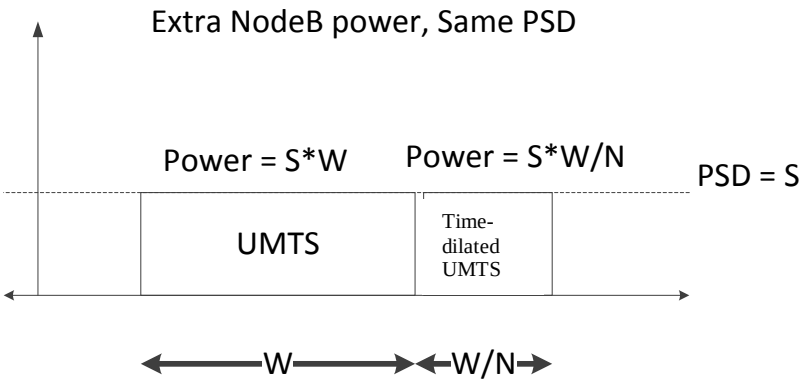


Figure 6.1.1.1.2-1: Multi-carrier UMTS system with the same PSD, with additional power dedicated to time-dilated UMTS carrier (N = 2 or 4).

Figure 6.1.1.1.2-2 represents the PSD of a multi- carrier time-dilated UMTS system in case of shared power between normal UMTS and time-dilated UMTS carriers. The total NodeB power remains unchanged in this scenario, while PSD of both normal UMTS and time-dilated UMTS is reduced. This scenario can be attractive for example, if there is not additional NodeB power available for time-dilated UMTS carrier.

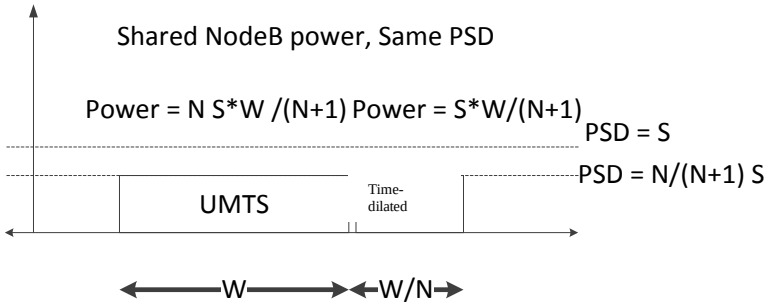


Figure 6.1.1.1.2-2: Multi-carrier UMTS system with reduced PSD, and shared PA (N = 2 or 4).

Figure 6.1.1.1.2-3 represents the PSD of a multi-carrier time-dilated UMTS system with increased total NodeB power, and increased PSD for the time-dilated UMTS system. In this case, the time-dilated UMTS carrier has the same total power as the UMTS carrier. The overall NodeB across carriers is increased.

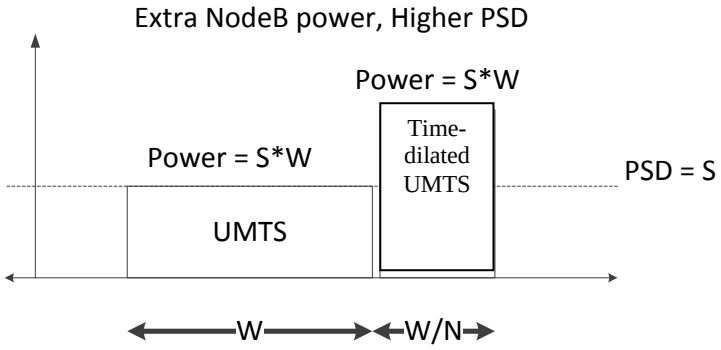


Figure 6.1.1.1.2-3: Multi-carrier UMTS system with increased PSD, and shared PA (N = 2 or 4).

6.1.1.2 Design options for PCCPCH channel

In this subclause, several design options are reviewed for the PCCPCH channel with the time dilation solution. Two approaches are discussed, based on reduction of the spreading factor, or addition of secondary PCCPCH channels.

6.1.1.2.1 Single PCCPCH channel with reduced spreading factor

In this approach, the spreading factor of the PCCPCH is channel is scaled down by a factor of N, N = 2 or 4. In conjunction of reduction of spreading factor, the power allocated to the PCCPCH channel is scaled up by a factor of N.

6.1.1.2.2 Multiple PCCPCH channels

In this approach, multiple PCCPCH channels are provision in N = 2 or N = 4 scenarios. These secondary PCCPCH channels use the same spreading factor and power as standard PCCPCH channel in normal UMTS system. Two cases of N = 2 and N = 4 are discussed in this subclause.

6.1.1.2.2.1 Time-dilated UMTS N=2

For time-dilated UMTS N=2, the multiple PCCPCH mechanism consists of using a total of two SF=256 PCCPCHs in order to support the same BCH user data rate as normal UMTS (i.e., 12.3 kbps). Since two SF=256 PCCPCHs are required, 3 dB more power must be allocated to the time-dilated UMTS N=2 broadcast channel. As an alternative to two SF=256 PCCPCHs, a single SF=128 PCCPCH could be used.

Table 6.1.1.2.2.1-1 lists the time-dilated UMTS N=2 time dilation solution BCH parameters if two SF=256 PCCPCHs are used.

Table 6.1.1.2.2.1-1: Time-dilated UMTS N=2 time dilation solution BCH parameters using two SF=256 PCCPCHs

Transport block size	246 bits
CRC and tail bits	16 bits + 8 bits
Coding	CC, coding rate = 1/2
TTI	20 ms (i.e., 1 time-dilated radio frame)
Number of channelization codes	2
SF	256
Channelization code for P-CCPCH1	$C_{ch,256,TBD}$
Channelization code for P-CCPCH2	$C_{ch,256,TBD}$
Channel symbol rate	13.5 ksps
Channel bit rate	27 kbps
User data rate (not including CRC and tail bits)	12.3 kbps

6.1.1.2.2.2 Time-dilated UMTS N=4

For time-dilated UMTS N=4, the multiple PCCPCH mechanism consists of using a total of four SF=256 PCCPCHs in order to support the same BCH user data rate as normal UMTS (i.e., 12.3 kbps). Since four SF=256 PCCPCHs are required, 6 dB more power must be allocated to the time-dilated UMTS N=4 broadcast channel. As an alternative to four SF=256 PCCPCHs, a single SF=64 PCCPCH could be used.

Table 6.1.1.2.2.2-1 lists the time-dilated UMTS N=4 time dilation solution BCH parameters if four SF=256 PCCPCHs are used.

Table 6.1.1.2.2.2-1: Time-dilated UMTS N=4 time dilation solution BCH parameters using four SF=256 PCCPCHs

Transport block size	246 bits
CRC and tail bits	16 bits + 8 bits
Coding	CC, coding rate = 1/2
TTI (two transport blocks per TTI)	40 ms (i.e., 1 time-dilated radio frame)
Number of channelization codes	4
SF	256
Channelization code for P-CCPCH1	$C_{ch,256,TBD}$
Channelization code for P-CCPCH2	$C_{ch,256,TBD}$
Channelization code for P-CCPCH3	$C_{ch,256,TBD}$
Channelization code for P-CCPCH4	$C_{ch,256,TBD}$
Channel symbol rate	13.5 ksps
Channel bit rate	27 kbps
User data rate (not including CRC and tail bits)	12.3 kbps

6.1.1.3 CS voice in time-dilated UMTS

Since the spreading factor is maintained on all of the channelization codes, the data rates are also reduced by a factor of 1/N for time-dilated UMTS. However, for time-dilated UMTS N=2, for delay sensitive radio bearers such as the standalone 3.4 kbps signalling radio bearers on DCH, the same bit-rate as UMTS should be maintained.

In UMTS, a voice packet is produced every 20 ms from the vocoder and is transmitted with a 20 ms TTI over the air interface. Together with the voice packet, the SRB packet could also be transmitted over the air interface but with a different TTI e.g. 40 ms TTI, as illustrated in Figure 6.1.1.3-1.

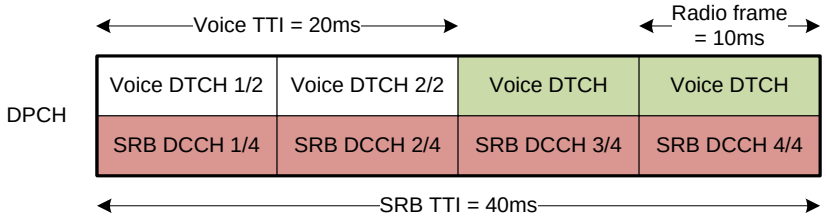


Figure 6.1.1.3-1: CS voice in UMTS

With the introduction of time-dilated UMTS, it is expected that the vocoder function is to be kept unchanged.
The voice packet should be transmitted over the air interface with the same TTI as in UMTS i.e. 20 ms. Since with time-dilated UMTS *N*=2, the radio frame is 20 ms, the voice packet transmission in stand-alone time-dilated UMTS can be re-designed as follows.

Option 1: **DPCH SF unchanged**.
The same DPCH spreading factor as in the legacy system is used. To maintain the same voice quality, multiple codes for DPCH are to be used for one user. It is shown in Figure 6.1.1.3-2. Two DPCHs per user are allocated for voice packet transmission. The SRB is transmitted in both the DPCHs with TTI being kept unchanged i.e. 40 ms as in the legacy system.

Option 2: **DPCH SF reduced**.
The DPCH spreading factor is half of that used in the legacy system, as illustrated in Figure 6.1.1.3-3. One DPCH per user is allocated for voice packet transmission, with reduced SF compared with UMTS, e.g. SF=64 in downlink in time-dilated UMTS N=2.

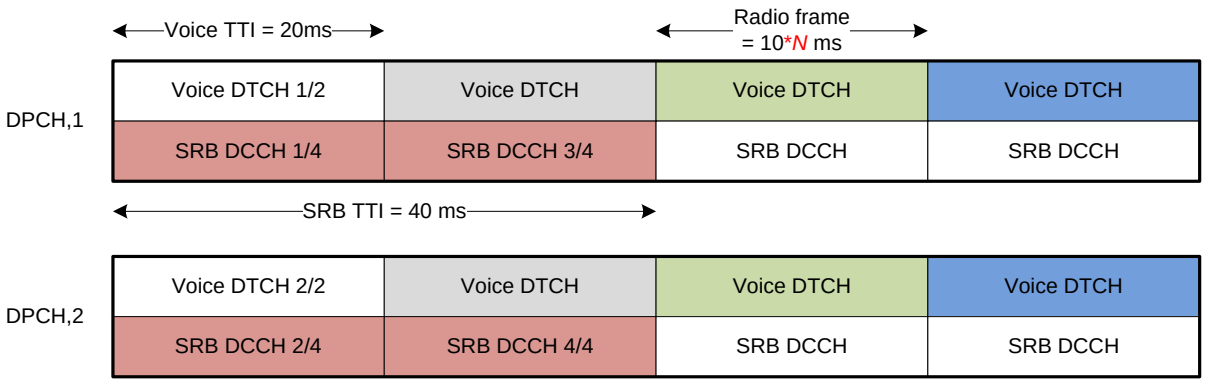


Figure 6.1.1.3-2: CS voice in stand-alone time-dilated UMTS option 1: DPCH SF unchanged, SRB TTI = 40 ms

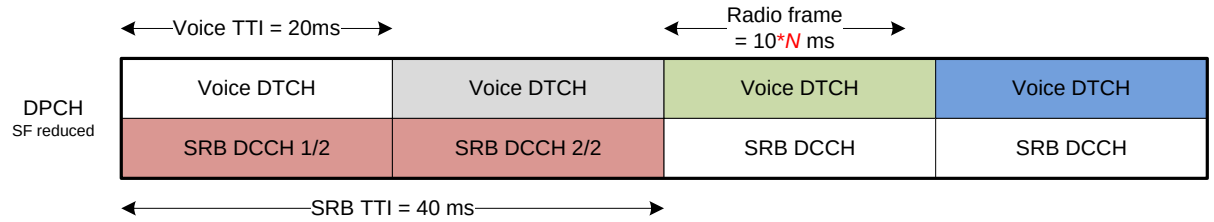


Figure 6.1.1.3-3: CS voice in stand-alone time-dilated UMTS option 2: DPCH SF reduced, SRB TTI = 40 ms

Standalone time-dilated UMTS with N=2 supports CS voice over DCH using either of the two options above. However, the voice capacity of time-dilated UMTS is expected to be reduced when compared with UMTS.

6.1.1.4 PRACH and AICH

The PRACH is used to carry the RACH. The AICH is used to carry the Acquisition Indicator (AI).

6.1.1.4.1 PRACH/AICH timing relation

Figure 6.1.1.4.1-1 illustrates the timing relationship between the AICH and PRACH access slots for UMTS (i.e., N=1) and time-dilated UMTS N=2 and N=4. The preamble-to-AI distance $\tau_{p\text{-}a}$ is defined in Table 6.1.1.4.2-1 of this contribution. As depicted in figure 6.1.1.4.1-1, the PRACH and AICH access slot lengths for time-dilated UMTS N=2 are increased from 1.33 ms to 2.67 ms relative to UMTS. For time-dilated UMTS N=4, they are increased from 1.33 ms to 5.33 ms relative to UMTS. Also, the radio frame length for time-dilated UMTS N=2 is increased from 10 ms to 20 ms relative to UMTS while for time-dilated UMTS N=4 it is increased from 10 ms to 40 ms relative to UMTS.

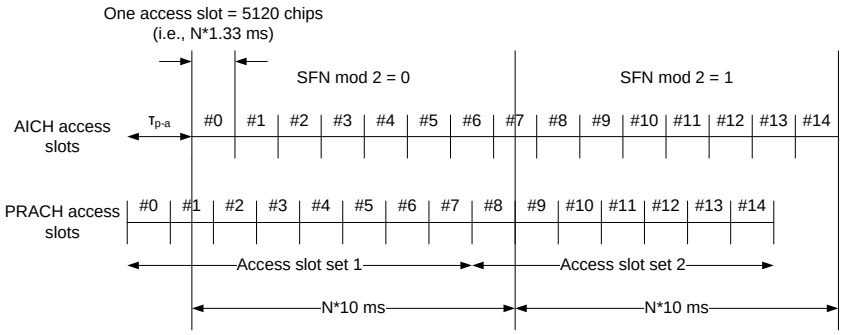


Figure 6.1.1.4.1-1: Timing relation between AICH and PRACH access slots for UMTS and time-dilated UMTS N=2 and N=4

6.1.1.4.2 Random access procedure

Figure 6.1.1.4.2-1 illustrates the UMTS (i.e. N=1) and time-dilated UMTS N=2 and N=4 random-access procedure. The preamble-to-preamble distance $\tau_{p\text{-}p}$, preamble-to-AI distance $\tau_{p\text{-}a}$ and preamble-to-message distance $\tau_{p\text{-}m}$ are defined in Table 6.1.1.4.2-1. As shown in Table 6.1.1.4.2-1, $\tau_{p\text{-}p}$, $\tau_{p\text{-}a}$ and $\tau_{p\text{-}m}$ for time-dilated UMTS N=2 and N=4 are increased by a factor of N (i.e., 2 and 4) relative to UMTS. Also, the PRACH message part radio frame for time-dilated UMTS N=2 is increased from 10 ms to 20 ms relative to UMTS while for time-dilated UMTS N=4 it is increased from 10 ms to 40 ms relative to UMTS.

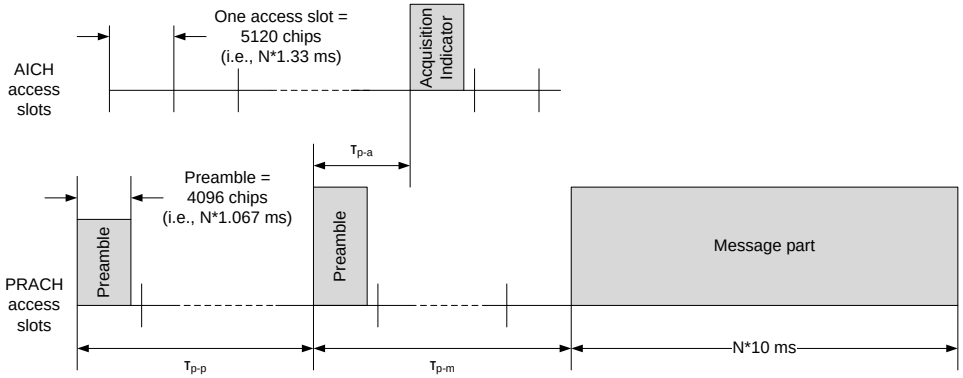


Figure 6.1.1.4.2-1: UMTS and time-dilated UMTS N=2 and N=4 random-access procedure

Table 6.1.1.4.2-1: UMTS and time-dilated UMTS N=2 and N=4 $\tau_{p\text{-}p}$, $\tau_{p\text{-}a}$ and $\tau_{p\text{-}m}$

	AICH_Transmission_Timing					
	0			1		
$\tau_{p\text{-}p}$	> 15360 chips			> 20480 chips		
	N=1	N=2	N=4	N=1	N=2	N=4
	> 4 ms	> 8 ms	> 16 ms	> 5.33 ms	> 10.67 ms	> 21.33 ms
$\tau_{p\text{-}a}$	7680 chips			12800 chips		
	N=1	N=2	N=4	N=1	N=2	N=4
	2 ms	4 ms	8 ms	3.33 ms	6.67 ms	13.33 ms
$\tau_{p\text{-}m}$	15360 chips			20480 chips		
	N=1	N=2	N=4	N=2	N=2	N=4
	4 ms	8 ms	16 ms	5.33 ms	10.67 ms	21.33 ms

6.1.1.4.3 Random access procedure

Figure 6.1.1.4.3-1 illustrates the structure of the PRACH message part radio frame for UMTS (i.e. N=1) and time-dilated UMTS N=2 and N=4. The N*10 ms message part radio frame is split into 15 slots, each of length T_{slot} = 2560 chips. Each slot consists of two parts, a data part to which the RACH transport channel is mapped and a control part that carries Layer 1 control information. The data and control parts are transmitted in parallel. An N*10 ms message part consists of one message part radio frame, while an N*20 ms message part consists of two consecutive N*10 ms message part radio frames. The message part length is equal to the TTI of the RACH transport channel in use. This TTI length is configured by higher layers (e.g., in SIB5).

NOTE: During the RRC connection establishment procedure, the PRACH message part carries the RRC CONNECTION REQUEST message.

As depicted in Figure 6.1.1.4.3-1, the PRACH message part radio frame for time-dilated UMTS N=2 is increased from 10 ms to 20 ms relative to UMTS while for time-dilated UMTS N=4 it is increased from 10 ms to 40 ms relative to UMTS.

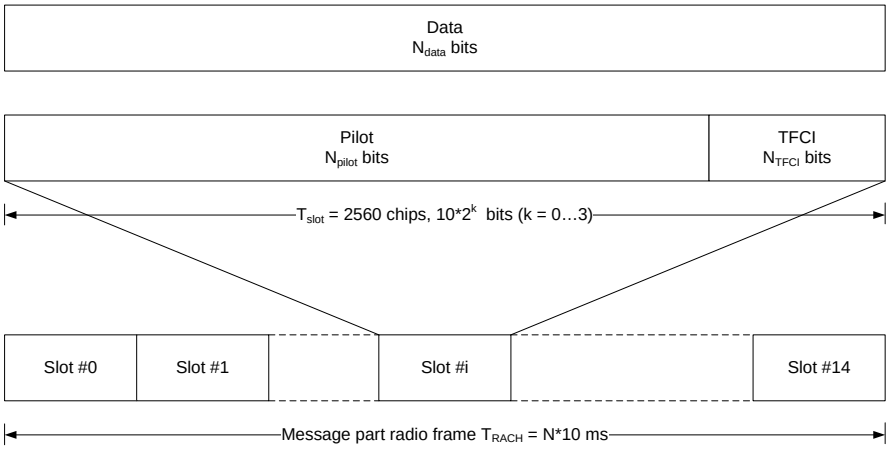


Figure 6.1.1.4.3-1: UMTS and time-dilated UMTS N=2 and N=4 PRACH message part radio frame structure

Table 6.1.1.4.3-1 lists the random-access message data fields and Table 6.1.1.4.3-2 lists the random-access control fields for UMTS (i.e., N=1) and time-dilated UMTS N=2 and N=4. Note that the channel bit rate and symbol rate are reduced by a factor of 1/2 for time-dilated UMTS N=2 relative to UMTS. For time-dilated UMTS N=4, they are reduced by a factor of 1/4 relative to UMTS. Consequently, the SF for all slot formats stays the same.

Table 6.1.1.4.3-1: UMTS and time-dilated UMTS N=2 and N=4 random-access message data fields

Slot Format #i	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/ Frame	Bits/ Slot	N_{data}
0	15/N	15/N	256	150	10	10
1	30/N	30/N	128	300	20	20
2	60/N	60/N	64	600	40	40
3	120/N	120/N	32	1200	80	80

Table 6.1.1.4.3-2: UMTS and time-dilated UMTS N=2 and N=4 random-access message control fields

Slot Format #i	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/ Frame	Bits/ Slot	N_{pilot}	N_{TFCI}
0	15/N	15/N	256	150	10	8	2

6.1.2 Evaluation results

6.1.2.1 HSPA link level simulation results

6.1.2.1.1 HSDPA simulations results

Tables 6.1.2.1.1-1 and 6.1.2.1.1-2 show the DL link level simulation results for HSPA, comparing UMTS and time-dilated UMTS with scaling factor N =2, for PA3, VA3, VA30 and VA120 channels, assuming one P-CCPCH channel. For outer-loop ON, HARQ BLER control steers the BLER to a 10% target for the first HARQ transmission. Table 6.1.2.1.1-1 and Table 6.1.2.1.1-2 correspond to the results assuming outer loop ON and outer loop OFF, respectively. Due to the variable implementation of outer loop by different network vendors, for completeness, the outer loop OFF results are also included along with outer loop ON results.

The performance metrics that are shown are computed as follows:

*Throughput gain = ((Throughput with time-dilated UMTS)*N – (Throughput with UMTS))/ (Throughput with UMTS)*

Table 6.1.2.1.1-1a: Standalone time-dilated UMTS downlink simulation results for HSDPA with outer loop ON, One P-CCPCH; Band VIII

Specific Condition	Source	Ior/Ioc	Throughput Gain			
			PA3	VA3	VA30	VA120
Outer loop ON, One P-CCPCH	Huawei, HiSilicon	-5	-4.74%	3.52%	-15.66%	-0.17%
		0	-3.72%	2.16%	-13.99%	-0.23%
		5	-2.33%	3.95%	-8.09%	-2.81%
		10	-1.85%	3.84%	-4.13%	-0.78%
		15	-1.13%	3.26%	-0.76%	-2.75%
		20	1.10%	2.60%	5.44%	-6.41%
	Qualcomm	-5	-2.98%	-0.42%	-20.07%	3.28%
		0	-3.37%	-0.25%	-14.54%	3.32%
		5	-2.67%	0.08%	-10.55%	2.63%
		10	-2.15%	0.60%	-6.51%	1.81%
		15	-1.21%	1.12%	-3.00%	0.79%
		20	-0.43%	2.21%	0.13%	-0.83%

Table 6.1.2.1.1-1b: Standalone time-dilated UMTS downlink simulation results for HSDPA with outer loop ON, One P-CCPCH; Band I

	Source	Ior/Ioc	Throughput Gain			
			PA3	VA3	VA30	VA120
Outer loop ON, One P-CCPCH	**Qualcomm**	-5	-30.17%	-17.87%	-15.17%	5.02%
		0	-23.77%	-14.51%	-9.01%	3.07%
		5	-19.24%	-12.76%	-6.26%	-2.17%
		10	-15.19%	-11.14%	-3.25%	-6.02%
		15	-11.60%	-10.01%	-1.47%	-11.43%
		20	-9.92%	-9.74%	-0.11%	-14.22%

Table 6.1.2.1.1-2a: Standalone time-dilated UMTS downlink simulation results for HSDPA with outer loop OFF, One P-CCPCH; Band VIII

Specific Condition	Source	Ior/Ioc	Throughput Gain			
			PA3	VA3	VA30	VA120
Outer loop OFF, One P-CCPCH	Huawei, HiSilicon	-5	1.20%	9.28%	0.41%	-7.91%
		0	-1.43%	3.11%	-0.36%	-5.68%
		5	-2.30%	-0.52%	1.69%	-2.53%
		10	0.31%	-2.58%	2.29%	-3.36%
		15	5.35%	5.90%	2.83%	-4.68%
		20	1.56%	4.46%	-2.42%	-8.78%
	Qualcomm	-5	2.71%	1.02%	-8.91%	-1.85%
		0	0.17%	0.17%	-4.82%	-0.79%
		5	-0.12%	-0.12%	-2.33%	-0.55%
		10	-0.63%	-0.63%	0.12%	-0.20%
		15	-0.32%	-0.32%	2.04%	-0.17%
		20	0.16%	0.16%	3.33%	-0.14%

Table 6.1.2.1.1-2b: Standalone time-dilated UMTS downlink simulation results for HSDPA with outer loop OFF, One P-CCPCH; Band I

Source	Ior/Ioc	Throughput Gain			
		PA3	VA3	VA30	VA120
Qualcomm	-5	-5.52%	-3.23%	-10.37%	-8.86%
	0	-6.35%	-4.13%	-6.27%	-8.48%
	5	-6.54%	-4.64%	-4.63%	-10.25%
	10	-7.05%	-5.23%	-2.88%	-11.58%
	15	-7.24%	-5.65%	-1.99%	-13.78%
	20	-8.06%	-6.18%	-1.62%	-15.52%

Tables 6.1.2.1.1-3(a-d) show the DL link level simulation results for HSPA, comparing UMTS and time-dilated UMTS with scaling factor N =2, for PA3, VA3, VA30 and VA120 channels, assuming two P-CCPCH channels for outer loop ON and OFF respectively.

Table 6.1.2.1.1-3a: Standalone time-dilated UMTS downlink simulation results for HSDPA with outer loop ON, Two P-CCPCHs; Band VIII

Specific Condition	Source	Ior/Ioc	Throughput Gain			
			PA3	VA3	VA30	VA120
Outer loop ON, Two P-CCPCHs	Huawei, HiSilicon	-5	-11.56%	-4.02%	-23.39%	-8.26%
		0	-8.64%	-4.20%	-21.02%	-8.97%
		5	-6.96%	-1.02%	-13.54%	-7.65%
		10	-5.01%	-0.30%	-8.17%	-5.83%
		15	-4.50%	-0.18%	-4.11%	-5.50%
		20	-1.61%	0.23%	0.86%	-9.04%
	Qualcomm	-5	-8.50%	-12.27%	-25.43%	-4.30%
		0	-12.01%	-7.58%	-20.08%	-2.72%
		5	-8.85%	-6.95%	-15.17%	-2.27%
		10	-7.58%	-4.57%	-12.35%	-2.10%
		15	-3.45%	-4.12%	-8.98%	-2.21%
		20	-2.15%	-0.37%	-11.34%	-3.45%

Table 6.1.2.1.1-3b: Standalone time-dilated UMTS downlink simulation results for HSDPA with outer loop ON, Two P-CCPCHs; Band I

Specific Condition	Source	Ior/Ioc	Throughput Gain			
			PA3	VA3	VA30	VA120
Outer loop OFF, Two P-CCPCHs	Qualcomm	-5	-36.61%	-25.66%	-21.95%	-3.58%
		0	-28.74%	-20.12%	-14.86%	-3.76%
		5	-23.33%	-17.45%	-11.34%	-7.69%
		10	-18.49%	-14.76%	-7.58%	-10.45%
		15	-14.27%	-13.03%	-5.09%	-14.85%
		20	-12.37%	-12.20%	-3.13%	-17.39%

Table 6.1.2.1.1-3c: Standalone time-dilated UMTS downlink simulation results for HSDPA with outer loop OFF, Two P-CCPCHs; Band VIII

Specific Condition	Source	Ior/Ioc	Throughput Gain			
			PA3	VA3	VA30	VA120
Outer loop OFF, Two P-CCPCHs	Qualcomm	-5	-7.66%	-8.35%	-15.38%	-8.53%
		0	-6.49%	-5.12%	-10.46%	-6.40%
		5	-4.89%	-5.13%	-7.00%	-5.30%
		10	-3.72%	-5.05%	-3.70%	-6.76%
		15	-2.26%	-6.09%	-0.83%	-7.72%
		20	-1.81%	-7.94%	1.12%	-15.83%

Table 6.1.2.1.1-3d: Standalone time-dilated UMTS downlink simulation results for HSDPA with outer loop OFF, Two P-CCPCHs; Band I

Specific Condition	Source	Ior/Ioc	Throughput Gain			
			PA3	VA3	VA30	VA120
Outer loop OFF, Two P-CCPCHs	Qualcomm	-5	-12.66%	-11.68%	-16.86%	-16.32%
		0	-12.28%	-9.65%	-11.55%	-13.93%
		5	-11.46%	-9.17%	-9.07%	-15.04%
		10	-10.88%	-8.53%	-6.53%	-15.58%
		15	-10.85%	-8.46%	-4.95%	-17.47%
		20	-10.82%	-8.52%	-4.18%	-19.03%

Table 6.1.2.1.1-4 shows the DL link level simulation results for HSPA, comparing UMTS and time-dilated UMTS with scaling factor N =2, for PA3, VA3, VA30 and VA120 channels, assuming one P-CCPCH channel and CQI cycle =2 TTI , i.e. for UMTS the CQI cycle is 4 ms, and for time-dilated UMTS with scaling factor N=2, the cycle is 8 ms.

Table 6.1.2.1.1-4: Standalone time-dilated UMTS downlink simulation results for HSDPA with outer loop ON, One P-CCPCH, CQI cycle =2TTI

Source	Ior/Ioc	Throughput Gain			
		PA3	VA3	VA30	VA120
Huawei, HiSilicon	-5	-5.37%	2.60%	-13.17%	-2.74%
	0	-3.91%	1.50%	-10.70%	-4.37%
	5	-2.71%	3.75%	-5.74%	-5.03%
	10	-2.65%	3.68%	-1.82%	-2.37%
	15	-1.09%	3.73%	0.76%	-4.01%
	20	0.99%	2.64%	6.53%	-7.15%

HSDPA latency as an additional metric for time-dilated UMTS (N=2, 4) for outer loop ON setting is presented.
The latency presented is the OTA transmission delay taken to transmit a data packet. The following two figures depict the CDF and average transmission delay metrics for UMTS and the time-dilated UMTS for the same PSD and single PCCPCH code assumption.

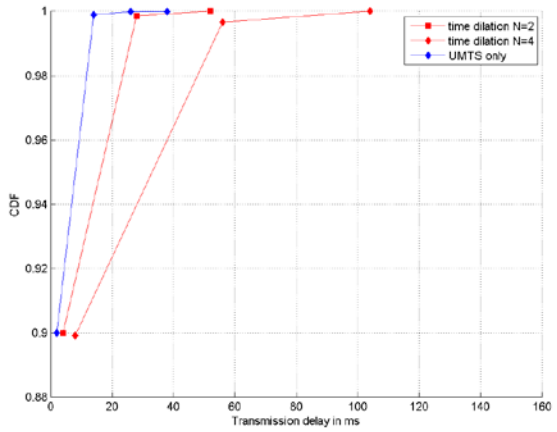
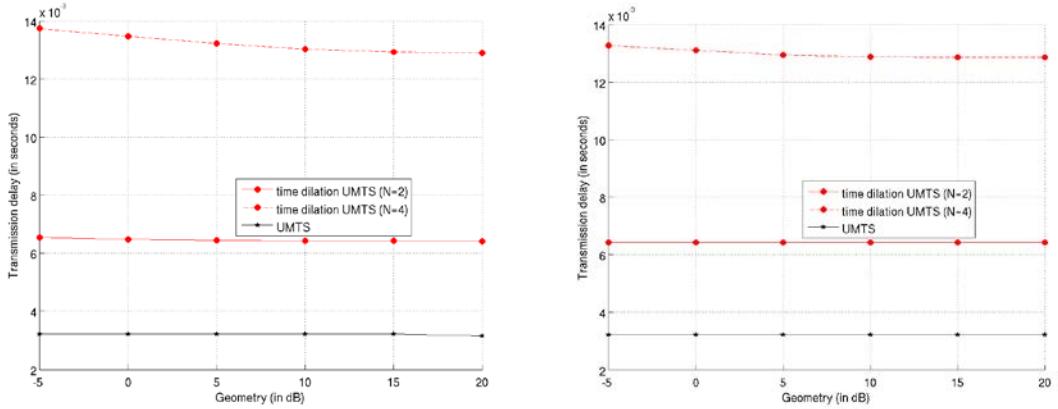


Figure 6.1.2.1.1-1: CDF of the latency in terms of transmission delay for time-dilated UMTS compared to UMTS; PA3 channel, 10 dB geometry

(a) PA3 **(b) VA3**



(c) VA 30 **(d) VA120**

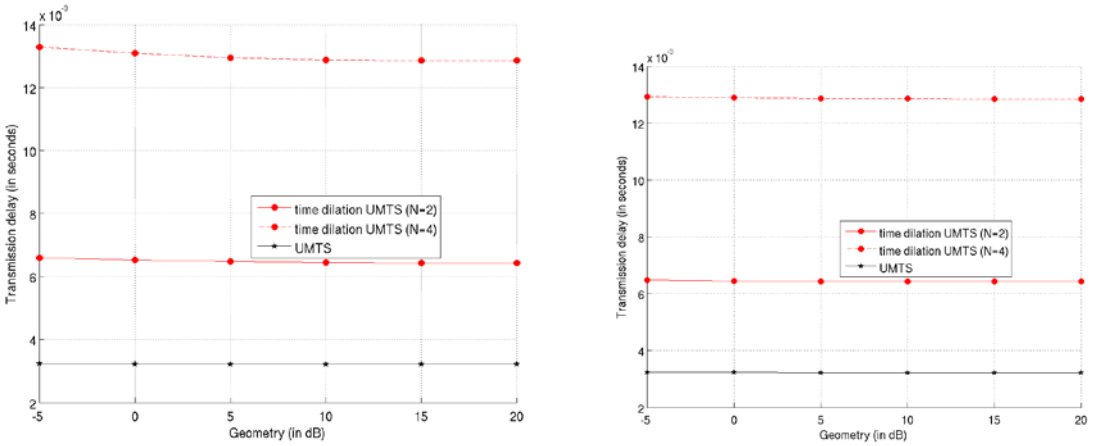


Figure 6.1.2.1.1-2: Average transmission delay for time-dilated UMTS compared to UMTS

The latency of DL control channels has increased due to time dilation – by a factor of 2 for N=2 time-dilated UMTS and by a factor of 4 for N=4 time-dilated UMTS. The increase in latency allows the DL control channels to be transmitted at the same transmit Ec/Ior as UMTS.

If the latency for the DL control channels in time dilation UMTS were to be the same as UMTS, then the transmit Ec/Ior would have to increase by a factor of 10logN.

6.1.2.1.2 HSUPA simulations results

Table 6.1.2.1.2-1 shows the UL link level simulation results for HSUPA, compared with UMTS and standalone time-dilated UMTS with scaling factor N =2, for PA3, VA3, VA30 and VA120 channels.

The performance metrics that are shown are computed as follows:

*Throughput gain = ((Throughput with time-dilated UMTS)*N – (Throughput with UMTS))/ (Throughput with UMTS)*

Table 6.1.2.1.2-1: Standalone time-dilated UMTS uplink simulation results for HSUPA

Source	PA3	VA3	VA30	VA120
Huawei, HiSilicon	-0.08%	-0.04%	-0.77%	-0.43%

Channel	1% after 4Tx	10% after 1 Tx
PA 3	14.35	4.36
VA 3	7.51	4.23
VA 30	3.73	-6.07
VA 120	-1.53	3.23

Figure 6.1.2.1.2-1 shows the transmission delay for time-dilated UMTS and UMTS for the PA3, VA3, VA30 and VA120 channels for the case where the operating point is 1% after 4 transmissions.

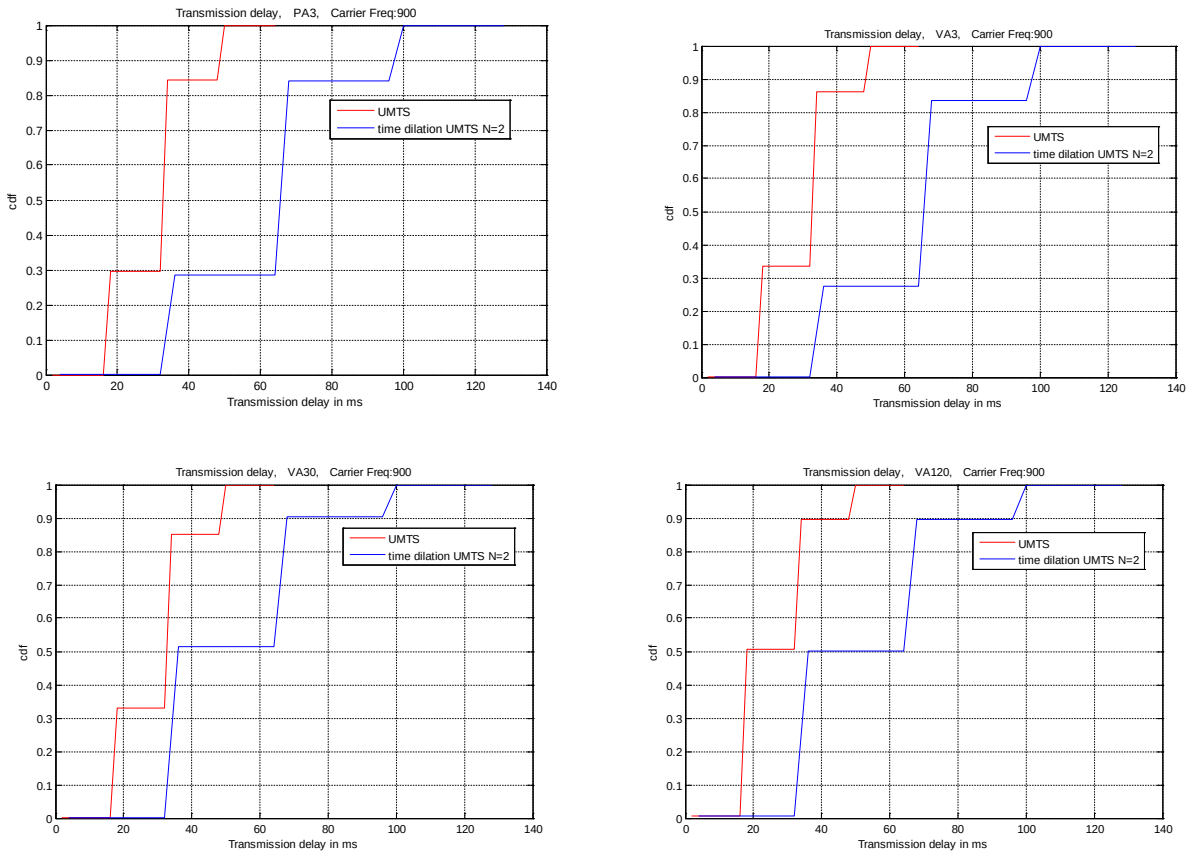


Figure 6.1.2.1.2-1: CDF of transmission delay for UL time-dilated UMTS N=2 with 1% after 4 transmissions

Figure 6.1.2.1.2-2 shows the transmission delay for time-dilated UMTS and UMTS for the PA3, VA3, VA30 and VA120 channels for the case where the operating point is 10% after 1 transmission.

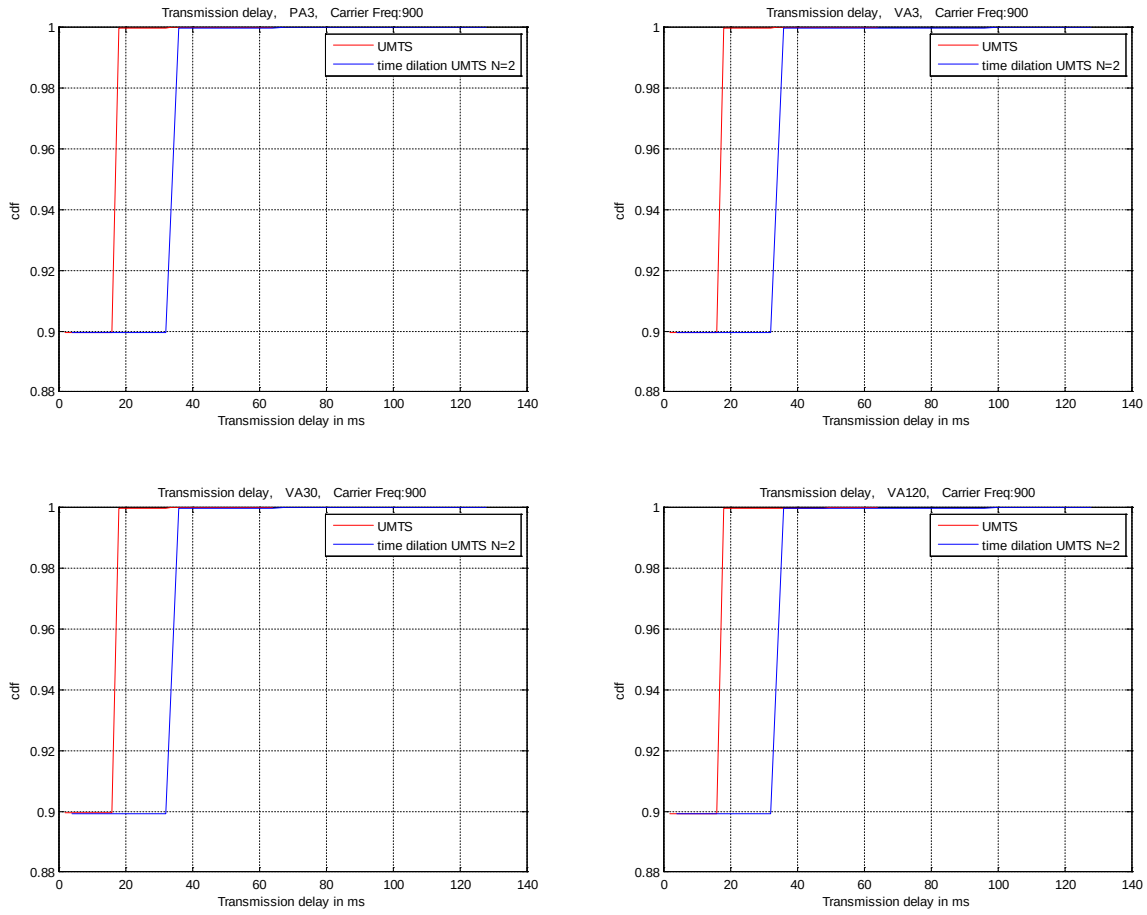


Figure 6.1.2.1.2-2: CDF of transmission delay for UL time-dilated UMTS N=2 with 10% after 1 transmission

6.1.2.2 DCH link level simulation results

Time-dilated UMTS with scaling factor N = 2 is considered to be able to carry AMR 12.2kbps DCH voice. In order to compare the performance of time-dilated UMTS with UMTS, the following performance metrics are computed as:

- *time-dilated UMTS gain (UL) = (Rx Ec/No with UMTS) – (Rx Ec/No with time-dilated UMTS -3dB)*
- *time-dilated UMTS gain (DL) = (Tx Ec/Ior with UMTS) – (Tx Ec/Ior with time-dilated UMTS -3dB)*

Table 6.1.2.2-1 shows the downlink and uplink link level simulation results for AMR 12.2 kbps on DCH, in PA3, VA3 and VA120 channels.

Table 6.1.2.2-1: Standalone time-dilated UMTS gain (in dB) for AMR12.2 kbps on DCH

Source		PA3	VA3	VA30	VA120
Huawei, HiSilicon	UL	0.53	0.64	-0.20	-0.31
	DL	0.06	1.11	-0.70	-0.45
ZTE	UL	-0.0277	0.0091	-0.2600	-0.0027
	DL				

Table 6.1.2.2-2: N=2 time-dilated UMTS DL performance of AMR 12.2 kbps voice

Carrier Frequency (MHz)	Channel	Geometry (dB)	DPCH EcIor (dB)	DPCH EcIor Loss (dB)	TrCh1 BLER	TrCh2 BLER	TrCh3 BLER
900	PA3	0 (SHO)	-14.4	0.3	1.0%	1.5%	2.3%
900	PA3	5	-14.0	0.1	1.0%	1.0%	2.2%
900	PA3	10	-17.4	0.1	1.0%	1.0%	1.4%
900	VA3	0	-11.4	0.5	1.1%	1.5%	3.5%
900	VA3	5	-14.5	0.6	1.0%	1.3%	2.6%
900	VA3	10	-16.4	0.4	1.0%	1.2%	2.6%
900	VA30	0	-12.4	0.1	1.2%	1.3%	2.2%
900	VA30	5	-15.3	0.2	1.0%	1.1%	2.2%
900	VA30	10	-17.3	0.2	1.0%	1.3%	2.4%
900	VA120	0	-12.3	-0.6	1.0%	1.4%	2.9%
900	VA120	5	-15.5	-0.5	1.0%	1.4%	3.0%
900	VA120	10	-17.6	-0.9	1.0%	1.5%	3.4%
2000	PA3	0 (SHO)	-14.2	0.5	1.1%	1.2%	2.0%
2000	PA3	5	-13.1	0.9	1.0%	1.5%	1.8%
2000	PA3	10	-17.6	-0.2	1.1%	1.1%	1.6%
2000	VA3	0	-12.0	0.7	1.1%	1.5%	2.5%
2000	VA3	5	-15.1	0.8	1.0%	1.3%	2.6%
2000	VA3	10	-17.0	0.5	1.0%	1.3%	2.9%
2000	VA30	0	-12.7	0.1	1.1%	1.1%	2.2%
2000	VA30	5	-15.5	0.2	1.0%	1.3%	2.5%
2000	VA30	10	-17.3	0.1	1.0%	1.3%	2.4%
2000	VA120	0	-12.0	-0.5	1.0%	1.4%	3.0%
2000	VA120	5	-15.4	-0.6	1.0%	2.0%	3.0%
2000	VA120	10	-17.5	-0.8	1.1%	1.4%	3.3%

Table 6.1.2.2-3: N=2 time-dilated UMTS UL performance of AMR 12.2 kbps voice

Carrier Frequency (MHz)	Channel	Rx EcNo (dB)	Tx EcNo (dB)	Rx EcNo Loss (dB)	Tx EcNo Loss (dB)	TrCh1 BLER	TrCh2 BLER	TrCh3 BLER
900	PA3	-15.2	-16.2	-0.1	-0.2	1%	2%	3%
900	VA3	-13.1	-15.0	1.3	1.6	1%	2%	3%
900	VA30	-12.8	-15.2	1.1	1.4	1%	1%	2%
900	VA120	-12.5	-15.1	0.8	1.0	1%	2%	3%
2000	PA3	-15.2	-16.1	-0.2	-0.4	1%	1%	2%
2000	VA3	-13.1	-14.9	1.3	1.4	1%	1%	2%
2000	VA30	-12.7	-15.2	0.7	1.1	1%	2%	2%
2000	VA120	-12.2	-14.9	1.2	1.4	1%	2%	3%

6.1.2.3 System level simulation results

In the standalone case, if an operator has a 5MHz UMTS carrier available that is not fully loaded, it is always better to map users to the 5 MHz carrier, since the users will experience significantly better throughput on 5 MHz than 2.5 MHz. Thus the metric of interest is the capacity available from a standalone time-dilated UMTS carrier when other UMTS carriers are loaded or no other carriers are available.

6.1.2.3.1 Downlink bursty UEs simulation results in Band VIII

Average, 90^{th} and 5^{th} percentile burst rate of bursty traffic UEs is used as the performance measure for the scenarios simulated. Burst rate is defined as the ratio between the data burst size in bits and the total time the burst spent in the system. Two evaluations of user burst rate and capacity in band VIII have been performed and are presented in this subclause.

Figures 6.1.2.3.1-1~3 show the bursty traffic performance of UMTS and time-dilated UMTS for different user percentiles from evaluation 1.

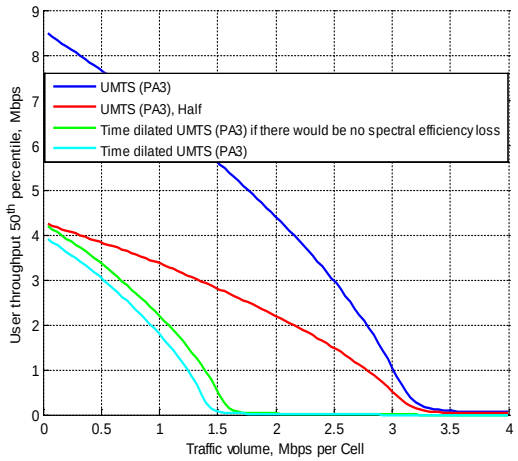


Figure 6.1.2.3.1-1: Average UE burst rates for 50th percentile

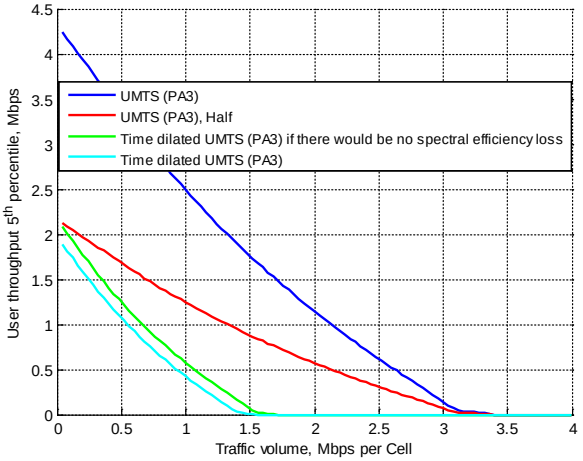


Figure 6.1.2.3.1-2: Average UE burst rates for 5th percentile

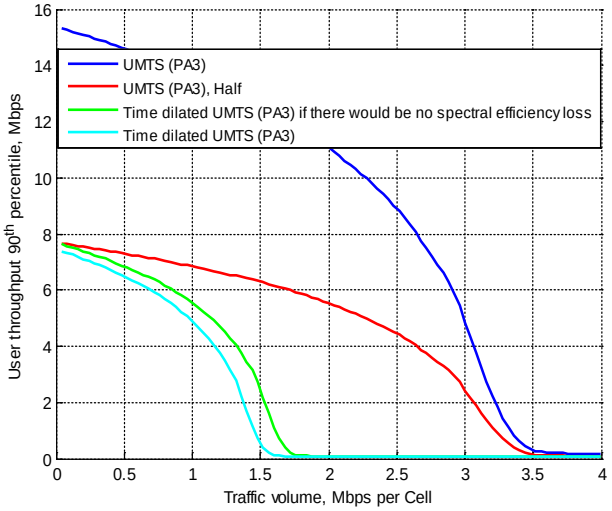


Figure 6.1.2.3.1-3: Average UE burst rates for 90th percentile

The x-axis for Figures 6.1.2.3.1-1~3 indicates the offered load per cell. The number of users for any point can be obtained by dividing the offered load by the average file size introduced in accordance with the bursty traffic model.

The performance of UMTS and time-dilated UMTS can be compared by examining the performance of the two systems at the same relative load. Since time-dilated UMTS N=2 (shown in the plots above) has half the bandwidth of UMTS, the load for the two systems is equal when the number of users for time-dilated UMTS is half that for UMTS. In other words, the average burst rate is compared when the offered load for time-dilated UMTS is half that of UMTS,

When handling packet data in general, system level investigations in the downlink indicate that user packet throughput will reduce to be lower than 1/N. This implies that packet transfer times increase by at least N, and in most cases greater than N when comparing time-dilated UMTS and UMTS. This will increase in general the activity level of the cell. (For small packets that can be transferred in less than 1 TTI and voice packets, transfer time will increase by N.)

In another evaluation (evaluation 2), the average UE burst rate for UMTS and time-dilated UMTS is shown in Figure 6.1.2.3.1-4. In addition the performance for multiple P-CCPCHs is also shown for N=2 and N=4 time-dilated UMTS.

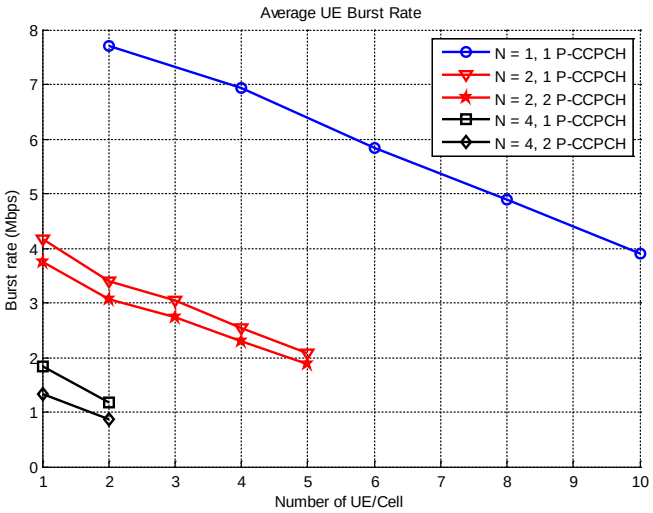


Figure 6.1.2.3.1-4: Average UE burst rate for Time dilated UMTS

Figures 6.1.2.3.1-5~7 show the performance of time-dilated UMTS with normalized offered load for evaluation 1. A comparison of the performance at the same relative load per carrier can be made from these figures.

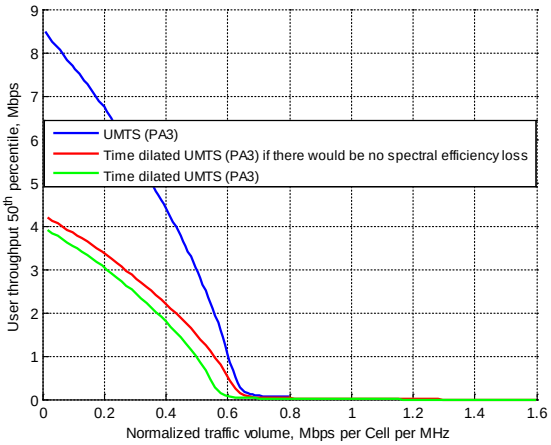


Figure 6.1.2.3.1-5: 50th percentile vs. normalized offered load

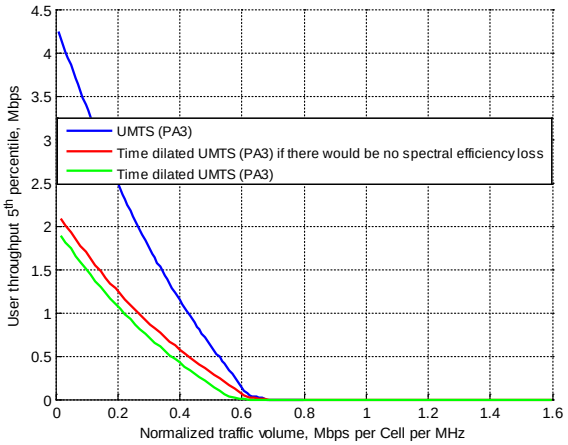


Figure 6.1.2.3.1-6: 5th percentile user throughput vs. offered load

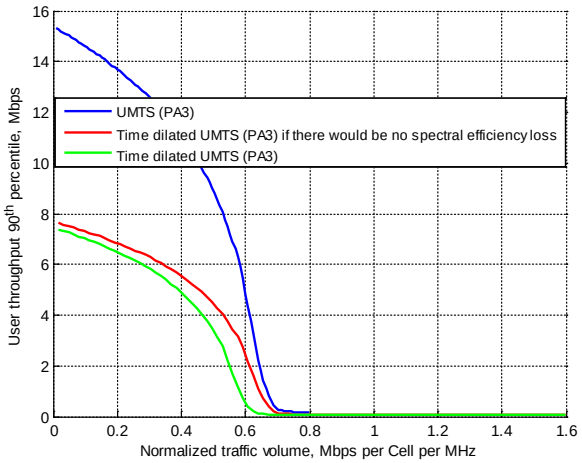


Figure 6.1.2.3.1-7: 90th percentile user throughput vs. offered load

It is observed that if there would be no spectral efficiency loss at link level, the average burst rate of UMTS system would be approximately twice that of Time dilated UMTS system with N =2 when the load per MHz is the same (i.e. the there is half as much traffic on 2.5 MHz compared with 5 MHz). Also, the average burst rate of UMTS would be approximately 4 times the average burst rate of Time dilated UMTS with N = 4 when the load per MHz is the same (i.e. one quarter of the traffic volume of 5 MHz). This is expected as the loading is the same in a UMTS system with m UEs and m/N UEs for Time dilated UMTS system with dilation factor N. The reduction in the bandwidth accounts for the reduced burst rate.

It can also be observed that while the burst rate for time-dilated UMTS N=2 is expected to be half of UMTS, when practical link losses are accounted for, it is somewhat less than half of UMTS due to link level losses, the lower trunking efficiency in time-dilated UMTS and the increased inter-cell interference.

Table 6.1.2.3.1-1 shows the 50th and 5th percentile user burst rates that can be achieved with a 5 MHz UMTS carrier and with a 2.5 MHz UMTS carrier at several normalized offered load levels, derived from figures 6.1.2.3.1-5 to 6.1.2.3.1-7.

Table 6.1.2.3.1-1: 50th percentile and 5th percentile user burst rates

Normalized traffic volume (Mbps/MHz)	50th percentile user burst rate		5th percentile user burst rate	
	5 MHz UMTS	2.5 MHz Time-Dilated UMTS	5 MHz UMTS	2.5 MHz Time-dilated UMTS
0.1	7.5	3.4	3.1	1.4
0.2	6.9	3.0	2.5	1.1
0.3	5.0	2.2	1.7	0.7
0.4	4.2	1.8	1.2	0.5
0.5	3.0	1.0	0.6	0.2
0.6	1.0	0.07	0.2	0.01

The CDF of burst rate for different number of UEs for time-dilated UMTS and UMTS for evaluation 2 is plotted in Figure 6.1.2.3.1-8. This corresponds to 8 UEs for UMTS and 4 and 2 for time-dilated UMTS N=2 and N=4.

From Figure 6.1.2.3.1-8, it is observed that the effect of the additional P-CCPCH and consequently the increased Ec/Ior is approximately a constant change in the burst rate over different number of UEs. For N =2 Time dilated UMTS system, the burst rate is about 300 kbps more when a single P-CCPCH is configured compared to when two P-PCCPCHs are configured. For time-dilated UMTS N =4, the burst rate is about 500 kbps more when a single P-CCPCH is configured.

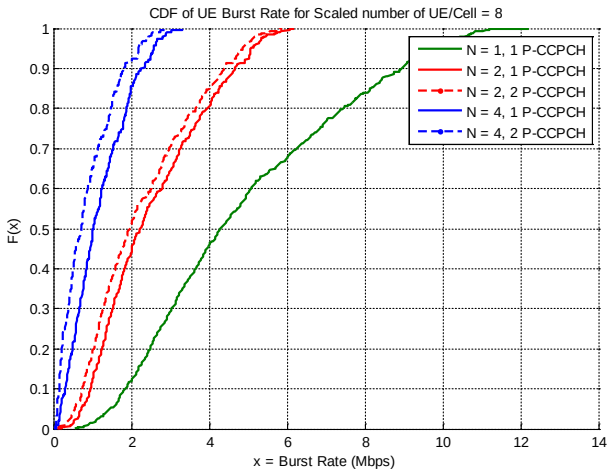


Figure 6.1.2.3.1-8: CDF of UE burst rate for N* Num UE/ Cell = 8

The 10% and 50% tails are also presented in Tables 6.1.2.3.1-2, 6.1.2.3.1-3 and 6.1.2.3.1-4. Similar results as seen for the average burst rate are also observed.

Table 6.1.2.3.1-2: Average UE burst rate (Mbps)

	N = 1	N = 2		N = 4	
N* Num UE/Cell	1 P-CCPCH	1 P-CCPCH	2 P-CCPCH	1 P-CCPCH	2 P-CCPCH
2	7.70	4.16	3.75	-	-
4	6.94	3.40	3.05	1.82	1.32
6	5.83	3.04	2.73	-	-
8	4.88	2.54	2.29	1.18	0.86
10	3.89	2.08	1.86	-	-

Table 6.1.2.3.1-3: 5% tail of UE burst rate (Mbps)

	N = 1	N = 2		N = 4	
N* Num UE/Cell	1 P-CCPCH	1 P-CCPCH	2 P-CCPCH	1 P-CCPCH	2 P-CCPCH
2	3.69	2.01	1.71	-	-
4	3.16	1.34	1.07	0.78	0.35
6	2.20	0.93	0.67	-	-
8	1.47	0.72	0.54	0.19	0.09
10	0.84	0.40	0.26	-	-

Table 6.1.2.3.1-4: 50% tail of UE burst rate (Mbps)

	N = 1	N = 2		N = 4	
N* Num UE/Cell	1 P-CCPCH	1 P-CCPCH	2 P-CCPCH	1 P-CCPCH	2 P-CCPCH
2	7.33	4.29	3.95	-	-
4	6.42	3.18	2.82	1.88	1.25
6	5.42	2.81	2.43	-	-
8	4.28	2.23	1.96	1.01	0.72
10	3.3	1.78	1.54	-	-

In general, it may be desirable to deploy systems in such a manner that a target minimum user throughput can be met. Table 6.1.2.3.1-5 shows the capacity, in terms of Mbps of offered load for 5 MHz UMTS and 2.5 MHz time-dilated UMTS carriers considering several target 50^{th} and 5^{th} percentile user throughput levels.

Table 6.1.2.3.1-5: Capacity (in Mbps of offered load) for different 50th and 5th percentile user throughput levels for 5 MHz UMTS and 2.5 MHz UMTS

50th percentile user throughput (Mbps)	Capacity (Mbps of offered load)	
	5 MHz UMTS	2.5 MHz Time-Dilated UMTS
1	3.0	1.25
2	2.75	0.90
3	2.50	0.50
4	2.20	0.01

5th percentile user throughput (Mbps)	Capacity (Mbps of offered load)	
	5 MHz UMTS	2.5 MHz Time-Dilated UMTS
0.25	2.80	1.25
0.5	2.65	0.95
1.0	2.15	0.50
1.5	1.75	0.25
2.0	1.30	-

6.1.2.3.2 Downlink bursty UEs simulation results in Band I

A single evaluation of user burst rate and capacity in band I has been performed and is presented in this subclause.

Figures 6.1.2.3.2-1~3 show the bursty traffic performance of UMTS and time-dilated UMTS for different user percentiles.

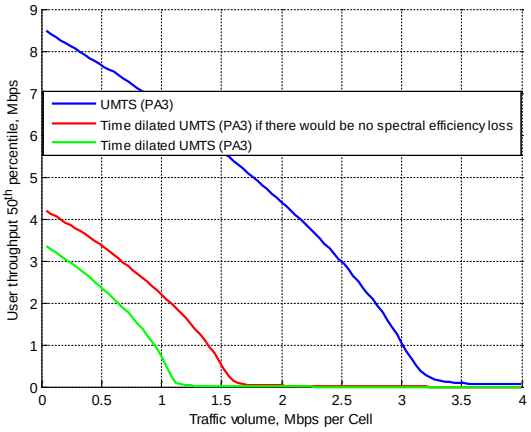


Figure 6.1.2.3.2-1: 50th percentile vs. normalized offered load

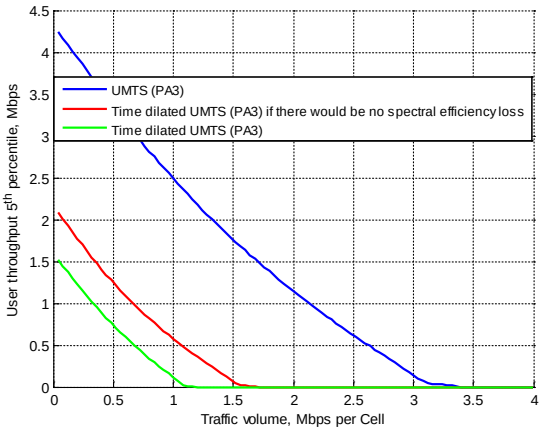


Figure 6.1.2.3.2-2: 5th percentile user throughput vs. offered load

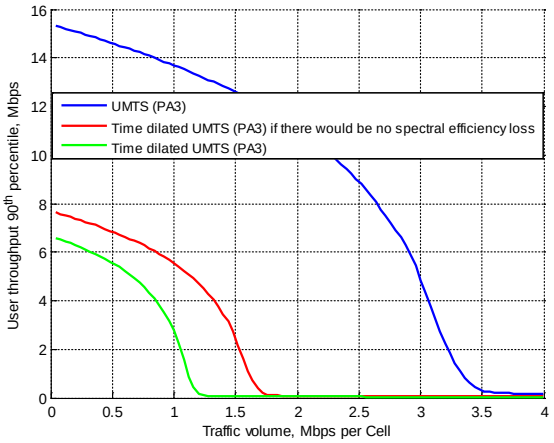


Figure 6.1.2.3.2-3: 90th percentile user throughput vs. offered load

Figures 6.1.2.3.2-4~6 show the performance of time-dilated UMTS with normalized offered load.
A comparison of the performance at the same relative load per carrier can be made from these figures.

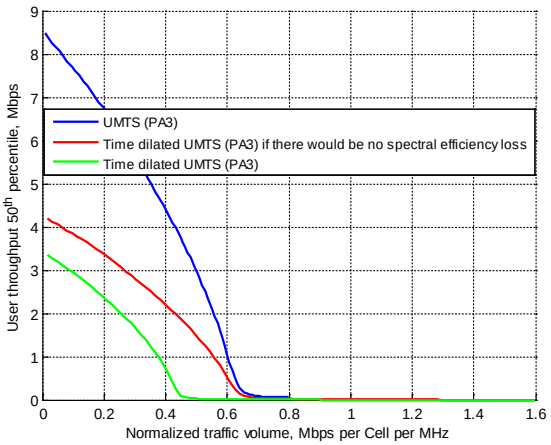


Figure 6.1.2.3.2-4: 50th percentile vs. normalized offered load

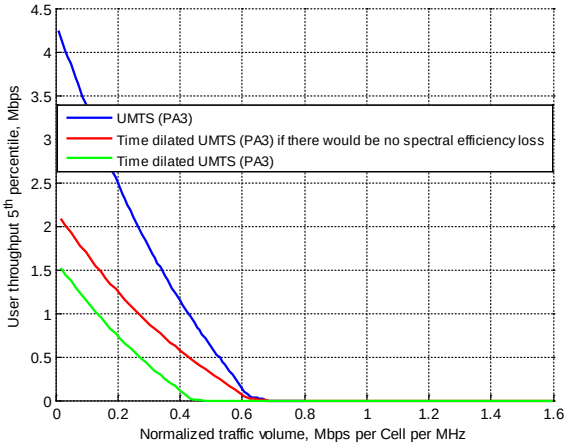


Figure 6.1.2.3.2-5: 5th percentile user throughput vs. offered load

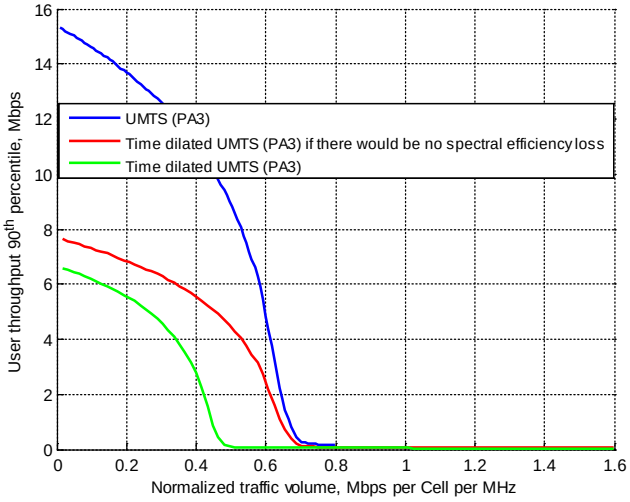


Figure 6.1.2.3.2-6: 90th percentile user throughput vs. offered load

Table 6.1.2.3.2-1 shows the 50th and 5th percentile user burst rates that can be achieved with a 5 MHz UMTS carrier and with a 2.5 MHz UMTS carrier at several normalized offered load levels, derived from figures 6.1.2.3.2-4 to 6.1.2.3.2-6.

Table 6.1.2.3.2-1: 50th percentile and 5th percentile user burst rates

Normalized traffic volume (Mbps/MHz)	50th percentile user burst rate		5th percentile user burst rate	
	5 MHz UMTS	2.5 MHz Time-Dilated UMTS	5 MHz UMTS	2.5 MHz Time-dilated UMTS
0.1	7.5	3.0	3.2	1.1
0.2	6.9	2.2	2.5	0.75
0.3	5.5	1.5	1.75	0.40
0.4	4.4	0.8	1.1	0.10

In general, it may be desirable to deploy systems in such a manner that a target minimum user throughput can be met. Table 6.1.2.3.2-2 shows the capacity, in terms of Mbps of offered load for 5 MHz UMTS and 2.5 MHz time-dilated UMTS carriers considering several target 50th and 5th percentile user throughput levels.

Table 6.1.2.3.2-2: Capacity (in Mbps of offered load) for different 50th and 5th percentile user throughput levels for 5MHz UMTS and 2.5MHz UMTS

50th percentile user throughput (Mbps)	Capacity (Mbps of offered load)	
	5 MHz UMTS	2.5 MHz Time-Dilated UMTS
1	3.0	0.90
2	2.75	0.65
3	2.50	0.20
4	2.20	-

5th percentile user throughput (Mbps)	Capacity (Mbps of offered load)	
	5 MHz UMTS	2.5 MHz Time-Dilated UMTS
0.25	2.80	0.80
0.5	2.65	0.70
1.0	2.15	0.30
1.5	1.70	0.10
2.0	1.30	-

6.1.3 Coverage of time-dilated UMTS

The coverage of time-dilated UMTS is analyzed by computing the link budget of time-dilated UMTS N=2 and with that of UMTS (N=1). The evaluation is done for both 2 ms and 10 ms TTI lengths and for the cases where the power spectral densities are set to be the same for both UMTS and time-dilated UMTS and where the power levels are set to be the same.

The comparison is made for R99 voice as well as E-DCH traffic. In the case of E-DCH traffic, the TBS size for time-dilated UMTS is set to be twice that of UMTS. The T/P is chosen such that the data rates of UMTS and time-dilated UMTS are the same for fair comparison of coverage.

Simulations were performed to evaluate the required Eb/No per antenna to complete the link. Since the link budget evaluates the MAPL (Maximum Allowed Path Loss), the UE is assumed to have reached it max power limit and so power control is disabled. The most challenging channel from a coverage perspective is the PA3 channel and so, the simulations assumed this channel. The assumptions made for computing the link budget are shown in Table 6.1.3-1.

Table 6.1.3-1: Simulation Assumptions for Link Budget Analysis

Parameter	UMTS	time-dilated UMTS N=2
Carrier Freq	900Mhz	900Mhz
RF BW	3.84Mhz	1.92Mhz
Max UE Transmit Power	24dBm	21dBm for same PSD 24dBm for same Power
TTI	[2ms 10ms]	[4ms 20ms]
Number of H-ARQ Processes	8 for 2ms TTI 4 for 10ms TTI	8 for 2ms TTI 4 for 10ms TTI
Target Number of H-ARQ Transmissions	4 for 2ms TTI 2 for 10ms TTI	4 for 2ms TTI 2 for 10ms TTI
E-TFC Block Size [bits]	330 for 2ms TTI 331 for 10ms TTI	660 for 2ms TTI 662 for 10ms TTI
Number of Rx Antennas	2	2
E-DPDCH T/P [dB]	8dB for 2ms TTI 4dB for 10ms TTI	Chosen to meet data rate for UMTS
E-DPCCH C/P [dB]	2dB for 2ms TTI -2dB for 10ms TTI	2dB for 2ms TTI -2dB for 10ms TTI
HS-DPCCH C/P [dB]	2dB	2dB
Channel Estimation	Realistic	Realistic
Channel Model	PA3	PA3
PC	OFF	OFF

6.1.3.1 Simulation results

Figures 6.1.3.1-1~6.1.3.1-3 show the performance of UMTS and time-dilated UMTS N=2 in the PA3 channel for 2 ms and 10 ms TTIs. The power control is turned off and hence the performance corresponds to the worst case scenario for purposes of coverage or link budget analysis.

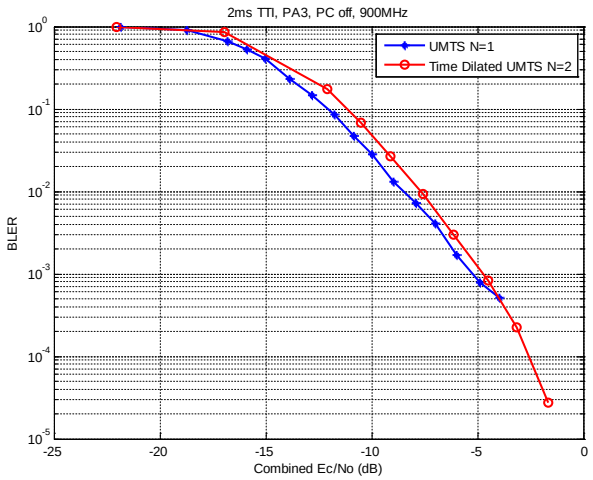


Figure 6.1.3.1-1: BLER vs. combined Ec/No for UMTS and time-dilated UMTS with N=2; 2 ms TTI; 900 MHz

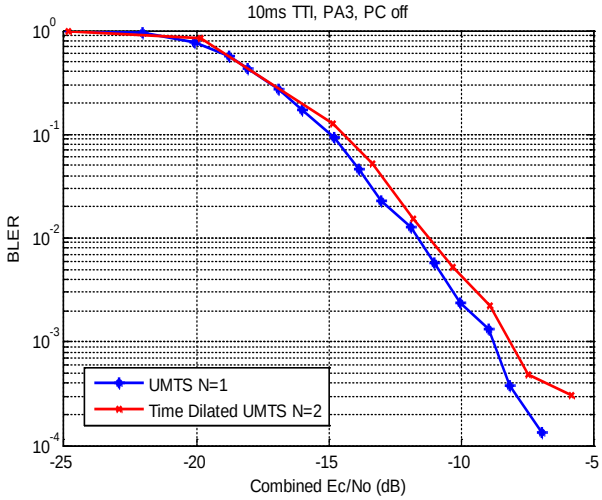


Figure 6.1.3.1-2: BLER vs. combined Ec/No for UMTS and time-dilated UMTS with N=2; 10 ms TTI; 900 MHz

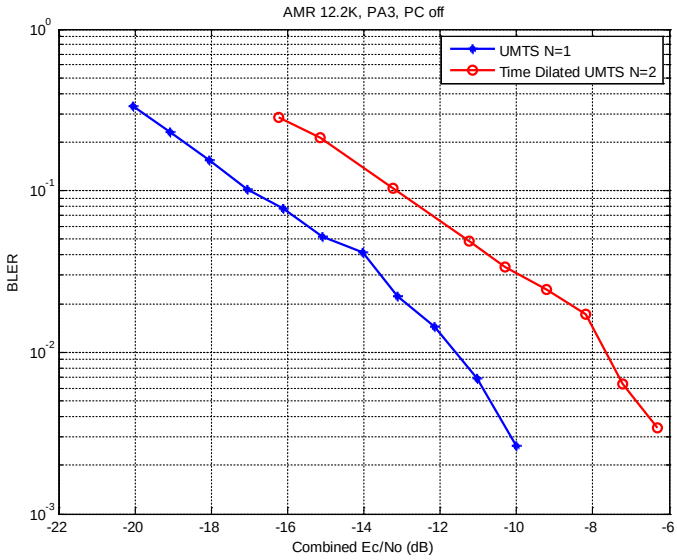


Figure 6.1.3.1-3: BLER vs. combined Ec/No for UMTS and time-dilated UMTS with N=2; AMR 12.2K; 900 MHz

From Figures 6.1.3.1-1 and 6.1.3.1-2, it can be seen that since the bandwidth of time-dilated UMTS N=2 is half that of UMTS, the noise power is reduced by half as well. Therefore, we would expect that the difference between the two curves would be 3dB. However, note that the TBS size is doubled and the resolution of the channel paths is lower in time-dilated UMTS resulting in the allocation of a smaller number of fingers. Therefore, there is a reduction in gains and we have a small loss in performance for time-dilated UMTS.

From Figure 6.1.3.1-3, it is seen that time-dilated UMTS requires around 3-4dB additional SNR to achieve the same rate and latency for AMR12.2K. This is expected since the spreading factor is reduced by half.

The target Ec/No is obtained from these curves in order to achieve a performance of 1% BLER. This value is used to compute the corresponding link budget and the results are presented in the next subclause.

6.1.3.2 Link budget analysis

Link budget is analysed for UMTS and time-dilated UMTS for the following cases:

- R99 Full Rate AMR 12.2k
- E-DCH with 2 ms and 10 ms TTI for UMTS
  - Corresponds to 4 ms and 20 ms TTIs for time-dilated UMTS N=2
- Same PSD for both UMTS and time-dilated UMTS N=2
- Same power levels for both UMTS and time-dilated UMTS N=2
  - Corresponds to different PSDs for UMTS and time-dilated UMTS N=2
- The effective data rate is the same for both UMTS and time-dilated UMTS

Table 6.1.3.2-1 shows the link budget comparison between UMTS and time-dilated UMTS N=2 for E-DCH data at the same data rates for 2 ms TTI.

Table 6.1.3.2-2 shows the link budget comparison between UMTS and time-dilated UMTS N=2 for E-DCH data at the same data rates for 10 ms TTI.

Table 6.1.3.2-3 shows the link budget comparison between UMTS and time-dilated UMTS N=2 for AMR 12.2K at the same latency.

Table 6.1.3.2-4 summarizes the MAPL values for all the link budget comparisons between UMTS and time-dilated UMTS N=2.

Table 6.1.3.2-1: Link budget comparison between UMTS and time-dilated UMTS N=2; 2 ms TTI

Target BLER = 1%			
UpLink Budget	**UMTS**	**time-dilated UMTS - Same PSD**	**time-dilated UMTS - Same power**
Carrier Frequency [MHz]	900	900	900
TTI [ms]	2	4	4
Transport Block Size [bits]	330	660	660
RX Ant	2	2	2
Target Number of H-ARQ Transmissions	4	4	4
E-DPCCH/DPCCH Power Ratio [dB]	2	2	2
HS-DPCCH/DPCCH Power Ratio [dB]	2	2	2
Effective Data Rate [kbps]	116.0	114.9	114.9
RF Symbol Rate [Msps]	3.84	1.92	1.92
Max MS Tx [Watt]	0.251	0.126	0.251
Max MS Tx [dBm]	24.0	21.0	24.0
MS Antenna Gain [dBi]	0.0	0.0	0.0
Body Loss [dB]	3.0	3.0	3.0
EIRP [Watts]	0.13	0.06	0.13
EIRP [dBm]	21.0	18.0	21.0
BTS Antenna Gain [dBi]	18.0	18.0	18.0
BTS Rx Cable Loss [dB]	3.0	3.0	3.0
BTS Noise Figure [dB]	5.0	5.0	5.0
BTS Rx Noise Power [dBm/Hz]	-169.0	-169.0	-169.0
Interference Margin [dB]	5.2	5.2	5.2
BTS Rx Interference Power [dBm/Hz]	-165.3	-165.3	-165.3
Rx Noise+Interference Power [dBm/Hz]	-163.8	-163.8	-163.8
Eb/No per antenna [dB]	2.66	0.58	0.58
Ec/No per antenna [dB]	-12.53	-11.68	-11.68
BTS Rx Sensitivity [dBm]	-110.5	-112.6	-112.6
Cell Edge Confidence [%]	90%	90%	90%
Log Normal Fading Margin [dB]	8.9	8.9	8.9
Shadowing Margin with Hard Handoff [dB]	11.4	11.4	11.4
Handoff/Diversity Gains [dB]	5.6	5.7	5.7
Effective Shadowing Margin [dB]	5.8	5.7	5.7
General MAPL [dB]	**140.67**	**139.92**	**142.92**

Table 6.1.3.2-2: Link budget comparison between UMTS and time-dilated UMTS N=2; 10ms TTI

Target BLER = 1%			
UpLink Budget	**UMTS**	**time-dilated UMTS - Same PSD**	**time-dilated UMTS - Same power**
Carrier Frequency [MHz]	900	900	900
TTI [ms]	10	20	20
Transport Block Size [bits]	331	662	662
RX Ant	2	2	2
Target Number of H-ARQ Transmissions	2	2	2
E-DPCCH/DPCCH Power Ratio [dB]	-2	-2	-2
HS-DPCCH/DPCCH Power Ratio [dB]	0	0	0
Effective Data Rate [kbps]	27.6	27.5	27.5
RF Symbol Rate [Msps]	3.84	1.92	1.92
Max MS Tx [Watt]	0.251	0.126	0.251
Max MS Tx [dBm]	24.0	21.0	24.0
MS Antenna Gain [dBi]	0.0	0.0	0.0
Body Loss [dB]	3.0	3.0	3.0
EIRP [Watts]	0.13	0.06	0.13
EIRP [dBm]	21.0	18.0	21.0
BTS Antenna Gain [dBi]	18.0	18.0	18.0
BTS Rx Cable Loss [dB]	3.0	3.0	3.0
BTS Noise Figure [dB]	5.0	5.0	5.0
BTS Rx Noise Power [dBm/Hz]	-169.0	-169.0	-169.0
Interference Margin [dB]	5.2	5.2	5.2
BTS Rx Interference Power [dBm/Hz]	-165.3	-165.3	-165.3
Rx Noise+Interference Power [dBm/Hz]	-163.8	-163.8	-163.8
Eb/No per antenna [dB]	6.11	3.46	3.46
Ec/No per antenna [dB]	-15.32	-14.97	-14.97
BTS Rx Sensitivity [dBm]	-113.3	-115.9	-115.9
Cell Edge Confidence [%]	90%	90%	90%
Log Normal Fading Margin [dB]	8.9	8.9	8.9
Shadowing Margin with Hard Handoff [dB]	11.4	11.4	11.4
Handoff/Diversity Gains [dB]	5.7	5.8	5.8
Effective Shadowing Margin [dB]	5.7	5.6	5.6
General MAPL [dB]	**143.56**	**143.31**	**146.31**

Table 6.1.3.2-3: Link budget comparison between UMTS and time-dilated UMTS N=2; AMR 12.2k

Target BLER = 1%			
UpLink Budget	**UMTS**	**time-dilated UMTS - Same PSD**	**time-dilated UMTS - Same power**
Carrier Frequency [MHz]	900	900	900
TTI [ms]	20	20	20
AMR Full Rate TBS [bits]	244	244	244
RX Ant	2	2	2
Effective Data Rate [kbps]	12.2	12.2	12.2
RF Symbol Rate [Msps]	3.84	1.92	1.92
Max MS Tx [Watt]	0.251	0.126	0.251
Max MS Tx [dBm]	24.0	21.0	24.0
MS Antenna Gain [dBi]	0.0	0.0	0.0
Body Loss [dB]	3.0	3.0	3.0
EIRP [Watts]	0.13	0.06	0.13
EIRP [dBm]	21.0	18.0	21.0
BTS Antenna Gain [dBi]	18.0	18.0	18.0
BTS Rx Cable Loss [dB]	3.0	3.0	3.0
BTS Noise Figure [dB]	5.0	5.0	5.0
BTS Rx Noise Power [dBm/Hz]	-169.0	-169.0	-169.0
Interference Margin [dB]	5.2	5.2	5.2
BTS Rx Interference Power [dBm/Hz]	-165.3	-165.3	-165.3
Rx Noise+Interference Power [dBm/Hz]	-163.8	-163.8	-163.8
Eb/No per antenna [dB]	9.23	10.41	10.41
Ec/No per antenna [dB]	-15.74	-11.55	-11.55
BTS Rx Sensitivity [dBm]	-113.7	-112.5	-112.5
Cell Edge Confidence [%]	90%	90%	90%
Log Normal Fading Margin [dB]	8.9	8.9	8.9
Shadowing Margin with Hard Handoff [dB]	11.4	11.4	11.4
Handoff/Diversity Gains [dB]	5.4	5.5	5.6
Effective Shadowing Margin [dB]	6.0	5.9	5.8
General MAPL [dB]	**143.68**	**139.60**	**142.69**

Table 6.1.3.2-4: Link budget comparison; Summary of results

MAPL	**UMTS**	**time-dilated UMTS N=2**	
		Same PSD	**Same power**
E-DCH with 2ms TTI	140.67	139.92	142.92
E-DCH with 10 ms TTI	143.56	143.31	146.31
AMR 12.2K	143.68	139.60	142.69

From Tables 6.1.3.2-1~6.1.3.2-4, the following observations can be made:

- For E-DCH traffic,
  - When the same PSD is assumed, then the coverage in terms of MAPL between UMTS and time-dilated UMTS is comparable. Even though the UE transmit power is reduced by 3 dB, the corresponding reduction in noise power compensates thereby resulting in similar coverage for both cases.
  - When the same power is assumed, there is a gain in coverage for time-dilated UMTS by about 3dB. This is because the noise power level is reduced by 3 dB due to the reduction in the bandwidth but there is no corresponding reduction in the transmit power. Note that the PSD in this case is not equal.
- For AMR 12.2K
  - When same PSD is assumed, the coverage of time-dilated UMTS is lesser than that of UMTS by around 4 dB. When the same power is assumed, the coverage is lesser by 1 dB. These results imply that the time-dilated UMTS system should be operated with the same power on the uplink.

6.1.4 Impacts on the network and UE

6.1.4.1 UE receiver

Scenarios for time-dilated UMTS are divided to two cases, standalone and multicarrier operation. It is justifiable to assume that time-dilated UMTS UE would need to support also legacy UMTS. The complexity aspects discussed in the following subclauses apply when UE is operating in the time-dilated UMTS mode. The UE still needs to be dimensioned to support also legacy UMTS operation.

The simulated time-dilated UMTS system in the present document assumed the same sampling rate as the UMTS system. This complexity analysis is based on scaled-down sampling rate, which is considered to be feasible.

6.1.4.1.1 RF and digital front-end

Figure 6.1.4.1.1-1 illustrates examples of RF and digital front-end receiver portions for the UMTS receiver that is also capable of receive diversity. An example of front-end implementation of standalone time-dilated UMTS is shown in Figure 6.1.4.1.1-2.

- In both cases, a single local oscillator implementation is assumed for the purpose of RF down-conversion.
- The analog Low Pass Filter (LPF) is now a narrower bandwidth (5/N MHz) when compared to the baseline case (5 MHz bandwidth).
- The ADC sampling rate decreases linearly in accordance with the analog LPF bandwidth.
- The complexity of the digital filter is 1/N to an FIR implementation of the UMTS FDD Square Root Raised Filter (roll-off factor = 0.22)

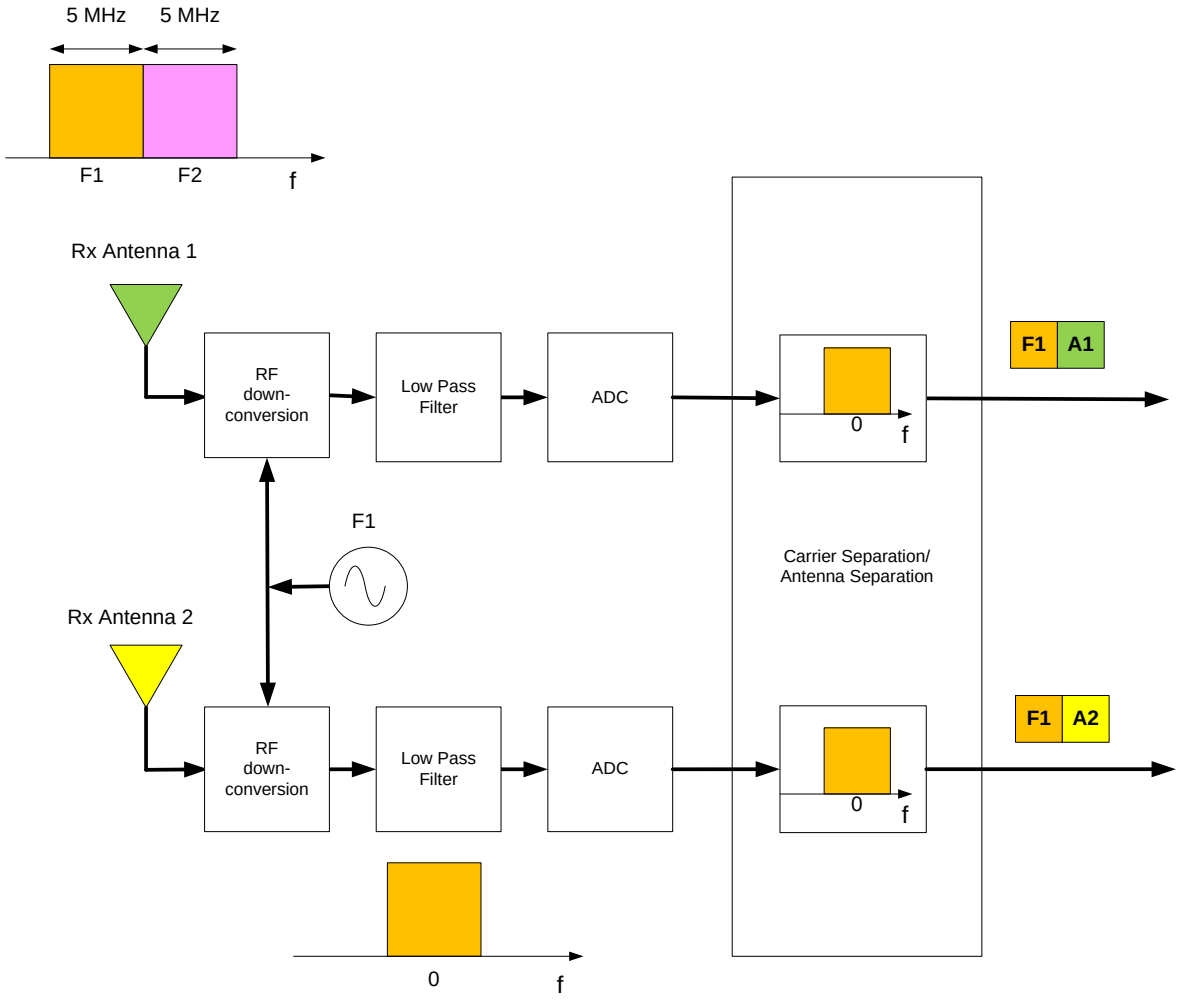


Figure 6.1.4.1.1-1: RF/Front-end block diagram for a UMTS receiver

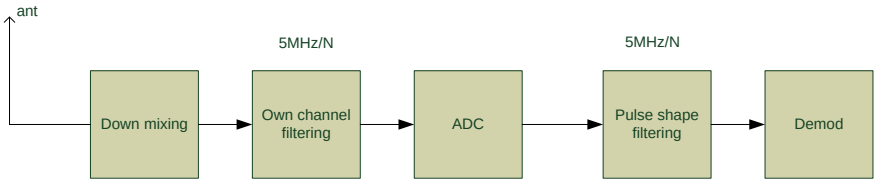


Figure 6.1.4.1.1-2: Front-end implementation for standalone time-dilated UMTS

An example of the front-end implementation for multicarrier time-dilated UMTS is shown in Figure 6.1.4.1.1-3. This example assumes similar frond end implementation as has been used in dual cell HSDPA. This implementation can be used only in case two carrier signals are within the front-end sampling bandwidth. Therefore carriers should be adjacent or nearly adjacent. Carrier C1 has here been assumed to be the legacy carrier and C2 is the time-dilated UMTS carrier. Hence carrier separation for C1 is similar to legacy DC-HSDPA and only rotates signal to base band. Carrier separation for C2 needs to be slightly changed from legacy since the centre frequency of the time-dilated UMTS carrier can be different. Similar to the standalone case, the sampling rate can be reduced and is beneficial for the rest of the receiver chain.

So far it has been assumed that in time-dilated UMTS bandwidth reduction is handled by changing carrier distances within operators own band. Hence additional filtering may not be needed. However, additional filtering, if needed, would result in additional complexity. In any case filters are required to support half and/or quarter bandwidths.

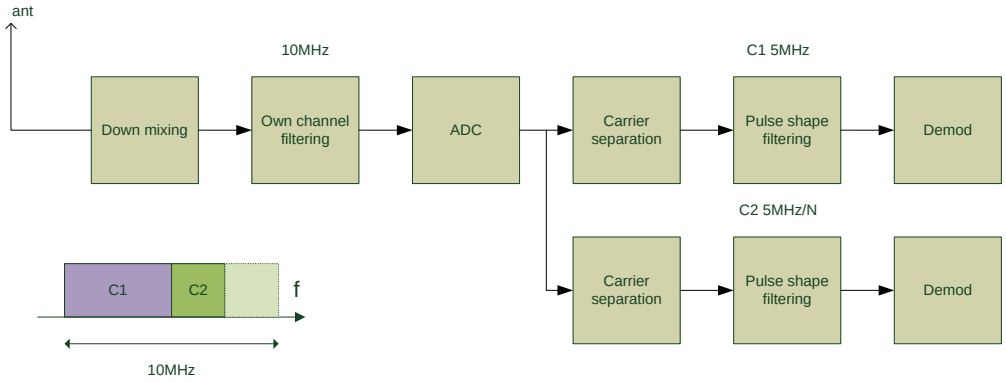


Figure 6.1.4.1.1-3: Front-end implementation for multicarrier time-dilated UMTS

6.1.4.1.2 Base-band detector

The differences in base-band processing of the HS-PDSCH detector between the baseline and time-dilated UMTS receiver structures are examined in this subclause.

The legacy UMTS UE receiver can be assumed to employ a linear MMSE receiver operating in diversity mode as shown in Figure 6.1.4.1.2-1. Both the UMTS and time-dilated UMTS UE receivers are required to estimate the channel impulse response on the two receiving branches.

However, since the time duration of time-dilated UMTS is dilated by N times, the length of the Channel Impulse Response (CIR) in unit of chips is reduced to 1/N of the CIR length for the UMTS receiver. Furthermore, because the sampling rate of time-dilated UMTS receiver is 1/N of the UMTS receiver, the complexity of searcher while searching for the CIR timing and channel estimator is $1/N^2$ of the UMTS receiver.

The complexity of LMMSE processing is scaled with the CIR length and sampling rate. Similar to the searcher and channel estimation complexity, the length and sampling rate of the linear equalizer in the time-dilated UMTS receiver are both 1/N of the linear equalizer in the UMTS receiver. So the complexity of LMMSE processing is also reduced to $1/N^2$ of the UMTS receiver. The allocation of the fingers in the rake receiver or the decision how to measure the impulse response in the type 3/3i receivers may need some fine tuning for different sampling rates and bandwidths.

When doing initial synchronization the UE may need to search time-dilated UMTS and legacy UMTS bandwidths, which could increase searcher complexity. However, the complexity may be limited by signalling information on possible bandwidths in each band. The same applies for neighbour cell measurements.

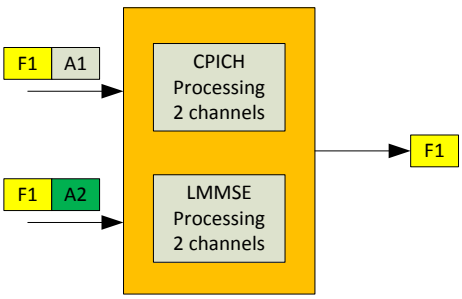


Figure 6.1.4.1.2-1: UMTS receiver: Base-band detector block diagram

6.1.4.1.3 Base-band decoder

Since the data throughput and peak rate are expected to be 1/N of the UMTS FDD system, the decoder complexity is also expected to be reduced to 1/N of the UMTS decoder. Figure 6.1.4.1.3-1 illustrates a high level block diagram of the base-band decoding process for both the UMTS and the time-dilated UMTS receivers. For time-dilated UMTS, the IR buffer requirement is the same as UMTS but the Turbo decoder speed requirement is reduced to 1/N.

Complexity of DCH decoding remains the same as legacy assuming that DCH content remains the same, e.g. data rate of speech call is not affected by time-dilated UMTS.

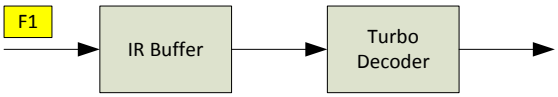


Figure 6.1.4.1.3-1: UMTS receiver: Base-band decoding

6.1.4.2 UE transmitter

Uplink of time-dilated UMTS is assumed to be using reduced bandwidth only in standalone case whereas legacy bandwidth is used in multicarrier. Changing the system bandwidth has impact to transmission filters and possibly PA implementations depending on the maximum transmission power.

In multicarrier scenarios, the HS-DPCCH feedback for the time-dilated UMTS carrier needs to be accounted for. Assuming time dilation, there is feedback for the secondary carrier in every Nth TTI. Feedback timing for the time-dilated UMTS carrier needs to be defined.

In case UE supports only time-dilated UMTS and not legacy UMTS, the following physical layer changes may be expected on the UL transmitter implementation:

- Reduction of the physical layer processing speed by 1/N;
- Reduction of the digital pulse shaping filter sampling rate by 1/N;
- Reduction of the analog filter bandwidth to 1/N of UMTS FDD sampling rate.

6.1.4.3 BS receiver

6.1.4.3.1 RF and digital front-end

One example of front-end implementation for UMTS and time-dilated UMTS receiver is shown in Figure 6.1.4.3.1-1. Received signal is filtered to the LPF after RF down-conversion and then is sampled to generate digital signals (ADC) for the rest of the receiver chain, i.e. carrier separation, pulse shaping filter and demodulation.

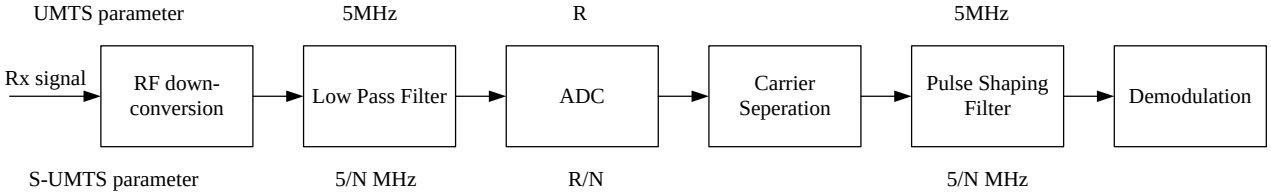


Figure 6.1.4.3.1-1: Example block diagram of RF and digital front-end

Comparison:

- The LPF handles a narrower bandwidth (5/N MHz) for time-dilated UMTS and 5 MHz bandwidth for baseline UMTS.
- The ADC sampling rate decreases to 1/N of the baseline.
- The pulse shaping filter handles a narrower bandwidth (5/N MHz) for time-dilated UMTS and 5 MHz bandwidth for baseline UMTS.

6.1.4.3.2 Base-band detector

The processing of decoder of time-dilated UMTS is the same as UMTS for a transport block with a specific size per TTI, which means the peak rate or throughput is 1/N since the TTI length of time-dilated UMTS is dilated by N times, hence the complexity is 1/N of the UMTS FDD system.

6.1.4.4 BS transmitter

6.1.4.4.1 Base-band process

The transmitter need perform encoding, modulation, spreading, scrambling and so on. All the same operation, assuming for the same TBS, is processed in N time longer TTI for time-dilated UMTS, comparing to UMTS FDD system, therefore the total complexity of time-dilated UMTS is 1/N of UMTS system.

6.1.4.4.2 RF and digital front-end

Similar to the same part of receiver, the time-dilated UMTS system requires a narrower bandwidth (5/N MHz) low pass filter, lower sampling rate(1/N) ADC and narrower bandwidth (5/N MHz) pulse shaped filter.

6.1.4.5 Impact to UE performance

6.1.4.5.1 Link performance of time-dilated UMTS with CPC

In this part performance comparisons are presented, when DPCCH gating impact is applied to both UMTS and time-dilated UMTS using 2.5 MHz of spectrum.

6.1.4.5.1.1 Simulation assumptions

Table 6.1.4.5.1.1-1 lists the simulation parameters.

Table 6.1.4.5.1.1-1: Simulation parameters

Parameter	Value
Carrier frequency[MHz]	2000, 900
Scaling factor[N]	1, 2
TTI [ms]	(2ms)*Scaling factor
TBS[bit]	128, 510, 3119
First transmission BLER	10% after 1 transmission
Number of Rx Antennas	2
DPCCH Slot Format	1 (8 Pilot, 2 TPC)
Inner Loop Power Control	ON
Outer Loop Power Control	ON
Inner Loop PC Step Size	±1 dB
UL TPC Delay	1.33ms*Scaling factor
UL TPC Error Rate	4%
HARQ process enable	1 active HARQ processes out of 8
Propagation Channel	PA3, VA3, VA30, VA120

6.1.4.5.1.2 Simulation results

This subclause presents simulation results for time-dilated UMTS (N=2) system and provides comparison with the standard UMTS system (N=1), when 0%, 50%, 75% gating patterns are used. They are shown in Figures 6.1.4.5.1.2-1~6.1.4.5.1.2-3.

- 0% gating illustrated in Figure 6.1.4.5.1.2-1 (baseline reference),
- 50% gating illustrated in Figure 6.1.4.5.1.2-2
- 75% gating illustrated in Figure 6.1.4.5.1.2-3

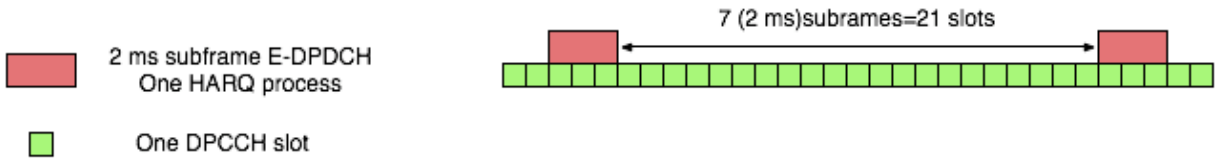


Figure 6.1.4.5.1.2-1: Baseline reference with continuous DPCCH transmission

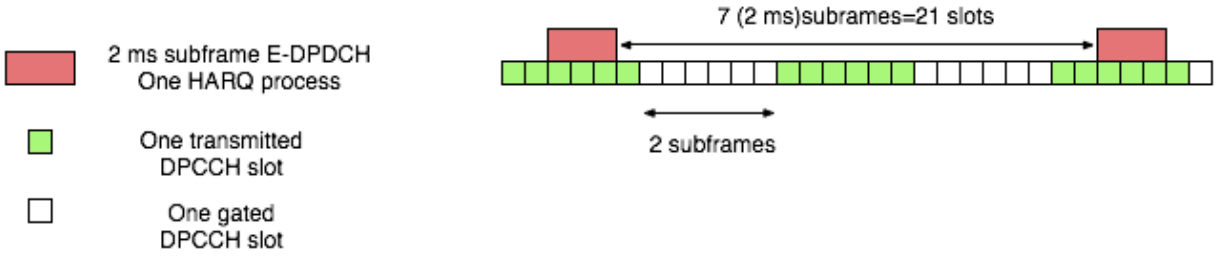


Figure 6.1.4.5.1.2-2: 50% gating DPCCH

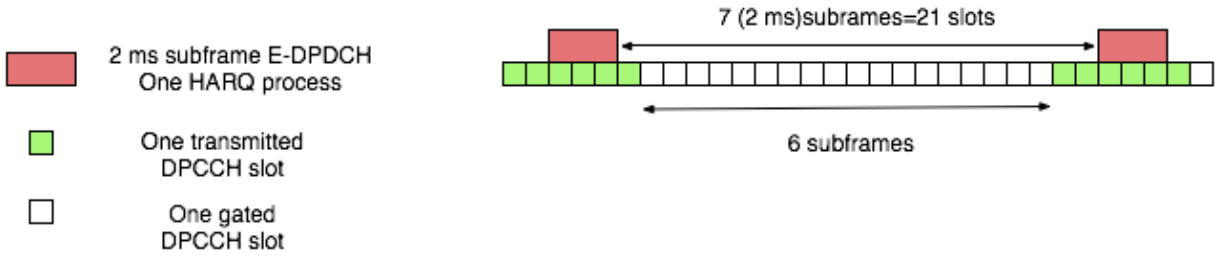


Figure 6.1.4.5.1.2-3: 75% gating DPCCH

6.1.4.5.1.3 Carrier frequency 2000MHz case

Figures 6.1.4.5.1.3-1~6.1.4.5.1.3-3 show the effective Rx Ec/No vs. T2P for carrier frequency 2000 MHz in case of TBS 128, 510 and 3110, respectively. The received total power is the sum of all the channel power in DTX and non DTX period. In these Figures the effective Ec/No is the average of the received power.

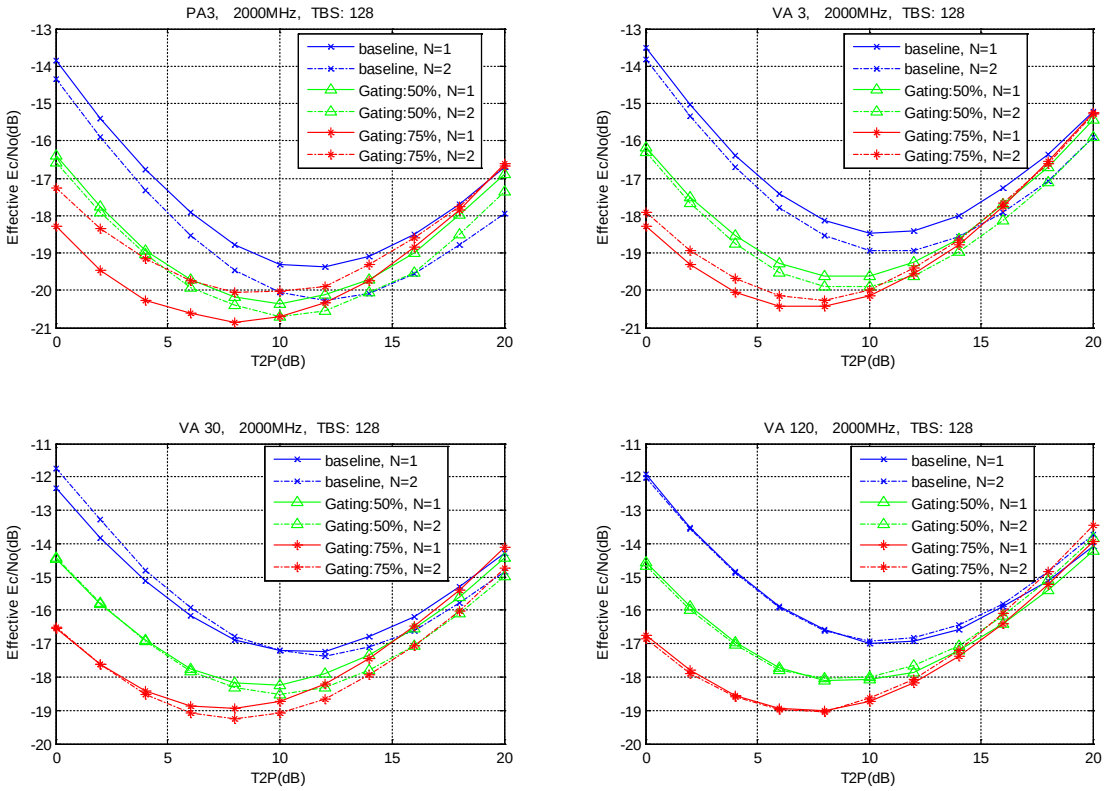


Figure 6.1.4.5.1.3 -1: Effective Ec/No for TBS=128

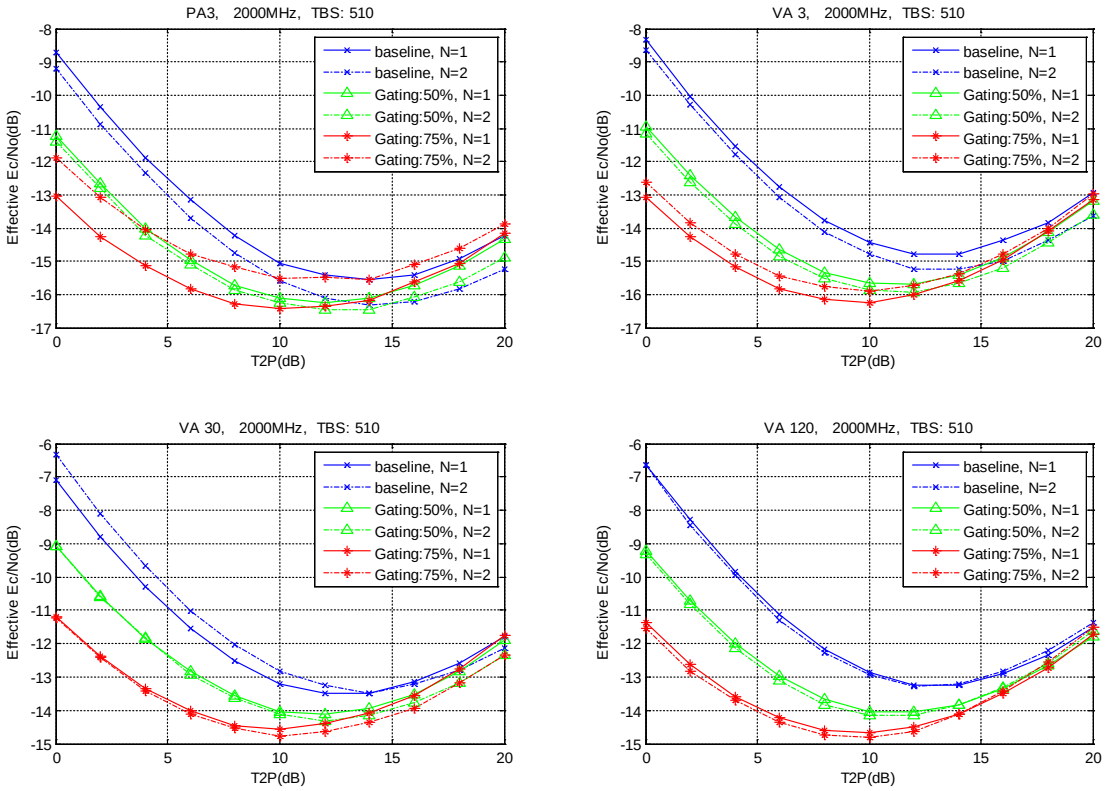


Figure 6.1.4.5.1.3-2: Effective Ec/No for TBS=510

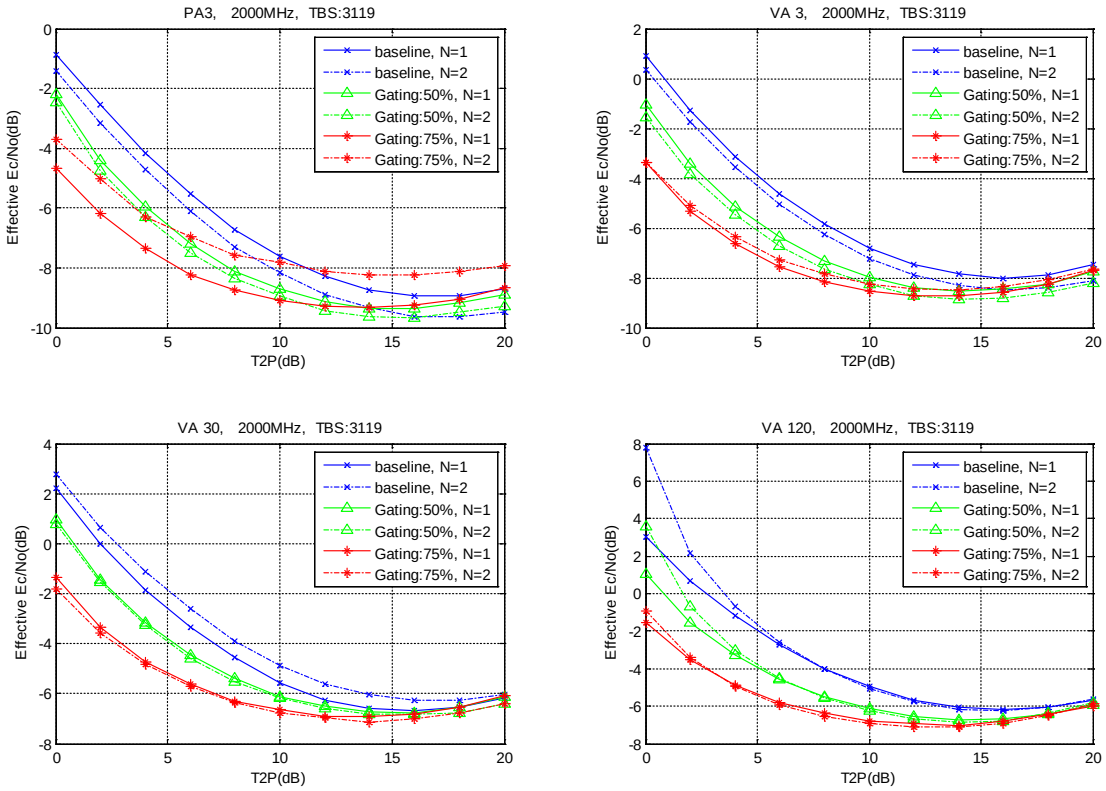


Figure 6.1.4.5.1.3-3: Effective Ec/No for TBS=3119

Tables 6.1.4.5.1.3-1~6.1.4.5.1.3-3 provide the performance comparison between UMTS (N=1) and time-dilated UMTS (N=2) for carrier frequency 2000MHz.
The effective Rx Ec/No values are provided and these values correspond to optimal T2P from the Figures 6.1.4.5.1.3-1~6.1.4.5.1.3-3. In these Tables, negative means gain in column 'Gain of N=2 over N=1'.
For PA3 and VA3, time-dilated UMTS had gain in case of 0% and 50% gating pattern and loss in case of 75% gating pattern because of longer gating slot. During gating slot, IPC gains are hold. For VA30 and VA120, time-dilated UMTS had gain for all gating pattern against UMTS except TBS 3119, 0% gating pattern in VA30.

Table 6.1.4.5.1.3-1: Effective Rx Ec/No with TBS=128, carrier frequency=2000 MHz

Channel	Effective Rx Ec/No(dB)								
	N=2			N=1			Gain of N=2 over N=1		
	Gating Ratio (%)			Gating Ratio (%)			Gating Ratio (%)		
	75	50	0	75	50	0	75	50	0
PA 3	-20.04	-20.70	-20.26	-20.86	-20.36	-19.37	0.82	-0.35	-0.89
VA 3	-20.28	-19.91	-18.94	-20.44	-19.63	-18.47	0.16	-0.29	-0.47
VA 30	-19.25	-18.53	-17.36	-18.95	-18.24	-17.22	-0.30	-0.29	-0.14
VA 120	-19.05	-18.05	-16.92	-19.00	-18.09	-16.98	-0.05	0.04	0.06

Table 6.1.4.5.1.3-2: Effective Rx Ec/No with TBS=510, carrier frequency=2000 MHz

Channel	Effective Rx Ec/No(dB)								
	N=2			N=1			Gain of N=2 over N=1		
	Gating Ratio (%)			Gating Ratio (%)			Gating Ratio (%)		
	75	50	0	75	50	0	75	50	0
PA 3	-15.56	-16.47	-16.30	-16.42	-16.26	-15.56	0.87	-0.21	-0.74
VA 3	-15.91	-15.92	-15.25	-16.24	-15.68	-14.80	0.33	-0.24	-0.45
VA 30	-14.77	-14.31	-13.47	-14.58	-14.12	-13.50	-0.19	-0.19	0.03
VA 120	-14.81	-14.15	-13.28	-14.65	-14.05	-13.26	-0.15	-0.10	-0.02

Table 6.1.4.5.1.3-3: Effective Rx Ec/No with TBS=3119, carrier frequency=2000 MHz

Channel	Effective Rx Ec/No(dB)								
	N=2			N=1			Gain of N=2 over N=1		
	Gating Ratio (%)			Gating Ratio (%)			Gating Ratio (%)		
	75	50	0	75	50	0	75	50	0
PA 3	-8.25	-9.65	-9.63	-9.31	-9.36	-8.94	1.06	-0.30	-0.69
VA 3	-8.49	-8.88	-8.47	-8.74	-8.51	-8.02	0.25	-0.36	-0.45
VA 30	-7.13	-6.82	-6.28	-6.90	-6.75	-6.66	-0.23	-0.07	0.38
VA 120	-7.13	-6.84	-6.25	-7.01	-6.71	-6.19	-0.12	-0.13	-0.06

6.1.4.5.1.4 Carrier frequency 900 MHz case

Figures 6.1.4.5.1.4-1~6.1.4.5.1.4-3 show the effective Rx Ec/No vs. T2P, when DPCCH 0%, 50%, 75% gating patterns are used for carrier frequency 900 MHz.

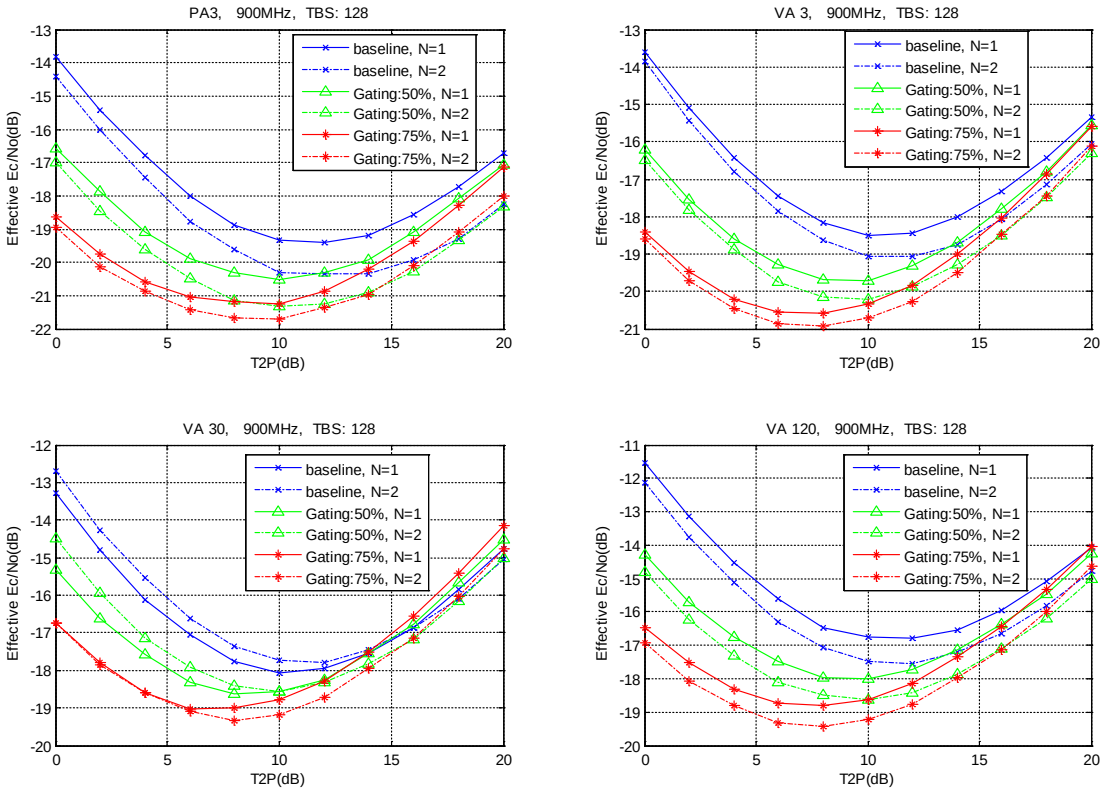


Figure 6.1.4.5.1.4-1: Effective Ec/No for TBS=128

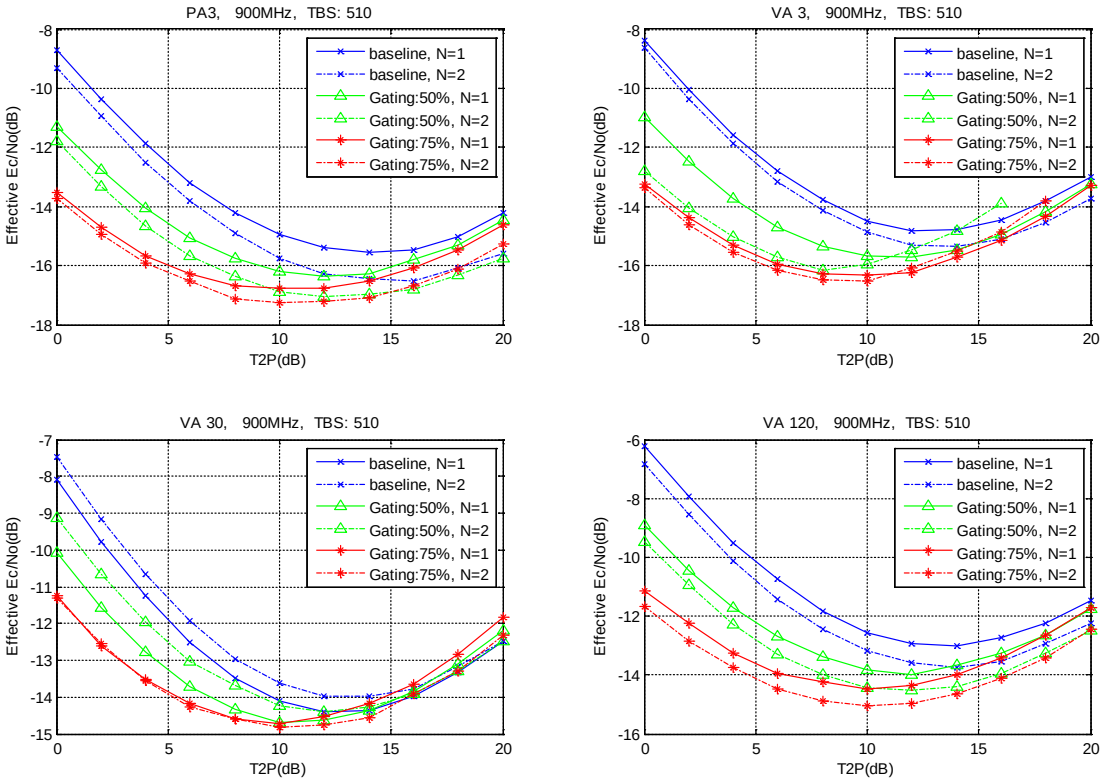


Figure 6.1.4.5.1.4-2: Effective Ec/No for TBS=510

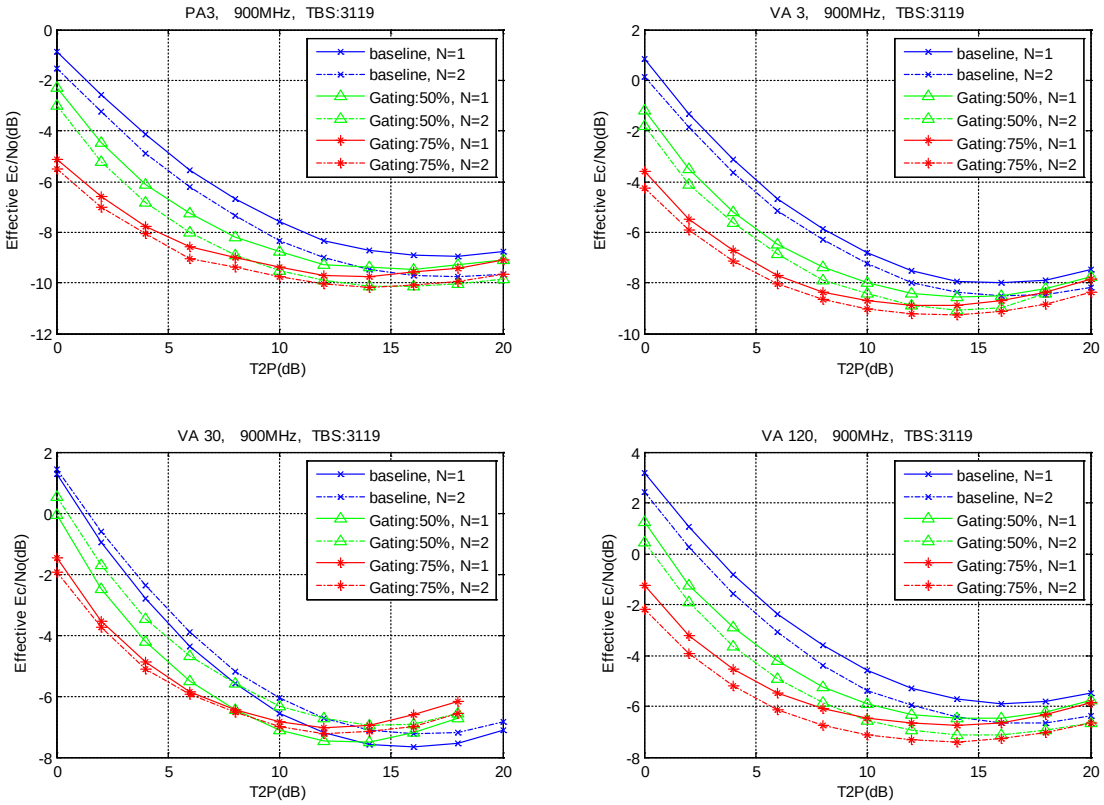


Figure 6.1.4.5.1.4-3: Effective Ec/No for TBS=3119

Tables 6.1.4.5.1.4-1~6.1.4.5.1.4-3 provide the performance comparison between UMTS (N=1) and time-dilated UMTS (N=2) at 900 MHz. time-dilated UMTS has gain for all gating pattern in PA3, VA3, VA120.
On the other hand it has loss for VA30 in case of 0%, 50% gating pattern.

Table 6.1.4.5.1.4-1: Effective Rx Ec/No with TBS=128, carrier frequency=900 MHz

Channel	Effective Rx Ec/No(dB)								
	N=2			N=1			Gain of N=2 over N=1		
	Gating Ratio (%)			Gating Ratio (%)			Gating Ratio (%)		
	75	50	0	75	50	0	75	50	0
PA 3	-21.69	-21.33	-20.35	-21.24	-20.50	-19.40	-0.45	-0.83	-0.96
VA 3	-20.93	-20.21	-19.07	-20.57	-19.70	-18.49	-0.37	-0.51	-0.58
VA 30	-19.34	-18.55	-17.79	-19.01	-18.62	-18.06	-0.32	0.08	0.27
VA 120	-19.44	-18.62	-17.55	-18.81	-17.99	-16.80	-0.63	-0.63	-0.75

Table 6.1.4.5.1.4-2: Effective Rx Ec/No with TBS=510, carrier frequency=900 MHz

Channel	Effective Rx Ec/No(dB)								
	N=2			N=1			Gain of N=2 over N=1		
	Gating Ratio (%)			Gating Ratio (%)			Gating Ratio (%)		
	75	50	0	75	50	0	75	50	0
PA 3	-17.26	-17.05	-16.52	-16.78	-16.36	-15.55	-0.48	-0.69	-0.98
VA 3	-16.52	-16.15	-15.36	-16.33	-15.70	-14.82	-0.19	-0.44	-0.54
VA 30	-14.83	-14.40	-13.99	-14.72	-14.67	-14.40	-0.11	0.28	0.41
VA 120	-15.04	-14.53	-13.73	-14.47	-14.00	-13.02	-0.57	-0.53	-0.71

Table 6.1.4.5.1.4-3: Effective Rx Ec/No with TBS=3119, carrier frequency=900MHz

Channel	Effective Rx Ec/No(dB)								
	N=2			N=1			Gain of N=2 over N=1		
	Gating Ratio (%)			Gating Ratio (%)			Gating Ratio (%)		
	75	50	0	75	50	0	75	50	0
PA 3	-10.17	-10.14	-9.76	-9.75	-9.49	-8.95	-0.42	-0.65	-0.81
VA 3	-9.27	-9.07	-8.53	-8.87	-8.56	-8.01	-0.40	-0.52	-0.52
VA 30	-7.25	-6.97	-7.24	-7.06	-7.52	-7.68	-0.19	0.54	0.44
VA 120	-7.40	-7.14	-6.66	-6.73	-6.47	-5.88	-0.67	-0.67	-0.78

The achieved data rate of N=2 is half of the data rate of N=1 with equal TB sizes and equal gating ratios.

6.1.4.5.2 Impact to on-percentage due to time-dilation

The impact to on-percentage when CPC is enabled can be evaluated as described in the following. The analysis focuses on the DL but is also applicable to UL. Three cases can be distinguished:

1. **Light traffic** period
In this case each burst is transmitted in one TTI. As the same CPC parameters (in terms of TTI) are configured for legacy- and time-dilated UMTS, the on-time percentage is the same. The on-time percentage increase is zero.

2. **Moderate traffic** period
In this case, each burst can be completely transmitted before the next burst arrives. In spite of time dilation, the TBS transmitted in each TTI remains roughly the same. Therefore the same numbers of TTIs are required in legacy- and time-dilated UMTS. Given that the inter-burst time is the same, time-dilated UMTS is occupied for twice as long. Therefore time-dilated UMTS would have less idle time. In this case time-dilated UMTS would see increase in on-time percentage.

3. **Heavy traffic** period
In this case, the next burst arrives before the previous burst is completed. The DL is constantly active until the last burst arrives. The same numbers of TTIs are required to deliver the traffic in legacy- and time-dilated UMTS, but for the same heavy traffic period both systems would see 100% on-time. As a result, the on-time percentage increase is nearly zero.

The real scenario is a statistical mix of the 3 cases. The chosen traffic profiles cover all of them.

Table 6.1.4.5.2-1: Simulated traffic profiles and their characteristics

Traffic	Case focused on
Ping	Mix of light to moderate traffic
Web browsing (Amazon)	Mix of moderate to heavy traffic
Web browsing (CNN)	Mix of moderate to heavy traffic
YouTube	Mainly heavy traffic

Consequently, there is not much difference in on-time percentage for Ping or YouTube. More pronounced difference can be seen for web browsing.

The battery performance is not only a function of the CPC on-time, but it is also a function of the time the UE spends in different RRC states.

6.1.4.5.2.1 Simulation Results

The on-time percentage of DL/UL is listed in Table 6.1.4.5.2.1-1 for different combinations of traffic, time-dilation factor, number of Rx antennas and geometry.

Table 6.1.4.5.2.1-1: On-time percentage of legacy- and time-dilated UMTS systems with respect to different traffic types

Traffic	On-time percentage for DL				On-time percentage for UL			
Ping	DL	Geo			UL	Geo		
		0dB	3dB	10dB		0dB	3dB	10dB
	N=1, single Rx	6.85%	6.85%	6.85%	N=1, single Rx	6.65%	6.65%	6.65%
	N=2, single Rx	7.48%	7.48%	7.48%	N=2, single Rx	7.04%	7.04%	7.04%
	N=1, dual Rx	6.85%	6.85%	6.85%	N=1, dual Rx	6.65%	6.65%	6.65%
	N=2, dual Rx	7.48%	7.48%	7.48%	N=2, dual Rx	7.04%	7.04%	7.04%
Amazon	DL	Geo			UL	Geo		
		0dB	3dB	10dB		0dB	3dB	10dB
	N=1, single Rx	23.99%	24.39%	18.12%	N=1, single Rx	13.76%	13.71%	13.13%
	N=2, single Rx	36.05%	34.34%	26.63%	N=2, single Rx	19.96%	19.91%	18.46%
	N=1, dual Rx	18.67%	17.88%	16.49%	N=1, dual Rx	13.32%	13.13%	12.78%
	N=2, dual Rx	27.51%	26.77%	23.79%	N=2, dual Rx	18.81%	18.33%	18.02%
CNN	DL	Geo			UL	Geo		
		0dB	3dB	10dB		0dB	3dB	10dB
	N=1, single Rx	45.33%	44.84%	38.88%	N=1, single Rx	24.09%	24.75%	26.11%
	N=2, single Rx	64.63%	64.09%	56.58%	N=2, single Rx	34.57%	34.75%	38.32%
	N=1, dual Rx	39.53%	38.61%	35.77%	N=1, dual Rx	25.92%	25.72%	26.15%
	N=2, dual Rx	58.73%	57.96%	51.16%	N=2, dual Rx	38.91%	38.87%	37.51%
YouTube	DL	Geo			UL	Geo		
		0dB	3dB	10dB		0dB	3dB	10dB
	N=1, single Rx	93.97%	93.79%	63.39%	N=1, single Rx	45.60%	47.56%	48.77%
	N=2, single Rx	96.96%	96.95%	73.23%	N=2, single Rx	48.27%	50.28%	56.20%
	N=1, dual Rx	70.29%	65.52%	43.53%	N=1, dual Rx	49.14%	49.03%	40.00%
	N=2, dual Rx	89.53%	76.27%	50.96%	N=2, dual Rx	61.29%	57.15%	46.81%

With the Ping traffic, on-time is increased from 6.85% for legacy UMTS to 7.48% for time-dilated UMTS (N=2) regardless of geometry and the number of Rx antennas. This is because each burst (320 bits on the DL, 320 bits on the UL) is always small enough to fit in the currently scheduled TBS. The on-time percentage is small in light traffic. Consistent on-time increase in time-dilated UMTS is seen as compared to legacy UMTS.

With web browsing traffic (CNN), the on-time is increased from around 40% for legacy UMTS to around 60% for time-dilated UMTS (N=2) on the DL and from around 25% to 35% on the UL. The increase is more significant on the DL where data are transmitted than on the UL where TCP requests and acknowledgements are transmitted. With web browsing traffic (Amazon), the numbers are more uneven, but in general an increase of 9% on the DL and 6% on the UL from legacy UMTS to time-dilated UMTS (N=2) can be observed.

With YouTube traffic, the on-time percentage on the DL for legacy UMTS is fairly high, especially at low geometry and for single Rx. Consequently, for single Rx, the largest difference occurs in the 10dB geometry case where the on-time percentage on the DL increases from 63% for UMTS to 73% for time-dilated UMTS (N=2). The difference is larger for dual Rx, especially at 0dB geometry where the on-time percentage increases from 70% for legacy UMTS to 89% for time-dilated UMTS (N=2).

6.1.4.6 Impact on network performance

6.1.4.6.1 Impact on physical layer procedures

The time-dilated UMTS utilized dilated time units, e.g. chip, slot, TTI, and frame, so that all time-related physical layer parameters in time-dilated UMTS are scaled accordingly (i.e. dilated N times relative to UMTS), and also time

consumption of physical procedures are scaled accordingly, such as synchronization, power control, random access, HARQ transmission (HS-DSCH-related and E-DCH-related procedures) etc.

The impact of longer time duration on synchronization procedure is that the time consumption will be extended. For cell search, it is assumed that the SCH codes will not be changed and hence the time duration of cell search operation will be extended accordingly. For synchronization parameters, such as synchronization window length 40 ms and 160 ms are better to be dilated for time-dilated UMTS, e.g. 240 slots instead of 160 ms, and 60 slots instead 40 ms. In addition, considering the usage of post-verification (as mentioned in Synchronization procedure A in TS 25.214), the increase of initial synchronization time due to time-dilated UMTS could be further reduced, i.e. 10 ms for N=2 and 30 ms for N=4.

From the link performance point of view, the impact of reduced ILPC (Inner Loop Power Control) frequency is captured in the evaluation on voice and data service in subclause 6.1.2. The reduced ILPC frequency due to time-dilated UMTS is expected to have small impact on low and high speed UE since the power control frequency tends to be sufficient for low speed UE and the power control target is to track relative long term fading for high speed UE, and is expected to have larger impact on moderate speed UE. It is for further study if this can be improved by optimizing the power control step size for time-dilated UMTS.

The impact of longer time duration on random access is that the time consumption will increase, which is captured in subclause 6.1.1.4.

From the link performance point of view, the impact of increased HARQ-RTT is shown in the evaluation on voice and data service in subclause 6.1.2. For HSDPA, UE needs to feedback CQI, which is calculated based on a 3-slot reference before the TTI where CQI is transmitted, and the CQI reference length will be time-dilated by N times in time-dilated UMTS system. It is for further study if the CQI reference length may be further optimized by implementation, e.g. setting to other values such as 1 slot.

6.1.4.6.2 Impact on higher layer timers

Longer time duration of sub-frame and frame has impact on the MAC timers such as T2, Backoff timer TBO1, AG_Timer, and Non_Serving_RG_Timer, which are set according to the length of TTI. These timers are expected to be dilated by N times for time-dilated UMTS.

For RRC layer timers, since they are set to a large time granularity (in hundreds of millisecond, second or minute), these values are sufficient enough even for time-dilated UMTS. Hence it is not necessary to modify the value sets of RRC timers.

6.1.4.6.3 Impact on radio resource management

The radio resource management in RNC needs to be extended to support time dilation.

As is the case for all optional features, RNC needs to keep track of which time_dilated features are supported in different cells (e.g., standalone time dilation N=2 with speech, standalone time dilation N=4 without speech, etc.) and take that into account together with UE capabilities when determining where to setup radio links and what EUL/HS connection capabilities to configure on those radio links.

New UE categories for UEs supporting time dilation will be introduced. It is for further study exactly how these UE categories will be defined. The relation between support of time dilation and support of other features needs to be clarified as well, since it is unclear which of the already specified features that are applicable to time-dilated operation. Potentially the RNC will have to decide between steering a call towards a normal UMTS carrier with a certain set of connection capabilities or a time-dilated UMTS carrier with another set of connection capabilities. Further, such traffic steering needs to take into account that the different carriers can be placed in different bands, with different band characteristics. It is expected that proprietary traffic steering load sharing implementations will have to be extended.

Depending on exactly what time-dilation alternatives are supported, the number of different carrier types will differ, e.g.: standalone time-dilated N=2 with speech, standalone time-dilated N=4 without speech, time-dilated N=2 as aggregation carrier, time-dilated N=4 as aggregation carrier, time-dilated N=2 used as both standalone and aggregation carrier with speech support, etc.

If standalone time-dilated carriers do not support DCH speech (e.g. for N=4), then inter-frequency handover needs to be triggered for UEs with ongoing packet data connections on the time-dilated carrier when a request to setup speech arrives from core network.

6.1.4.6.3a Other issues relating to introduction of less time-dilated carriers

The fact that time-dilated carriers will inherently be less capable than normal UMTS carriers in terms of maximum bitrate, user plane latency, capacity etc is a challenge that needs to be addressed. UEs supporting both normal and time-dilated UMTS will at times be serviced by a time-dilated carrier, depending upon RRM, thereby resulting in a lower maximum bitrate and increased user plane latency than would otherwise be the case if the UE is serviced by normal UMTS. Strategies (e.g. incentives) need to be developed and executed by an operator that will ensure a good penetration of time-dilated UMTS capable UEs even though the end user experience at times will be worse than if time dilation was not supported taking the above issues into account. How the operator can mitigate these negative consequences for end users is outside the scope of this technical report. However, in any case it is expected that traffic steering mechanisms would need to be extended to ensure good system capacity with balanced end user performance.

The problem with lacking end user incentive to buy a UE capable of time dilation is most clear for standalone operation. However, also in the carrier aggregation case this is an issue, since then the main alternative to set up e.g. a 5+2.5 MHz aggregation is to set up a 5+5 MHz aggregation if the required bandwidth is available.

6.1.4.6.4 KPI impact

Due to the longer radio frames, the SCH code words will also be spread over time, and it will take longer time to acquire the synchronization channel during cell search. Longer cell identification times may result in delayed mobility procedures, which may have an impact on call retainability. However, this has not been evaluated.

In general, unless absolute bitrates are kept for SRB signalling when going to the narrower bandwidth, there will be negative impact on RRC procedure delays, which in turn may result in delayed mobility procedures, which may have an impact on call retainability. Further, as described in subclause 6.5.1.1, if no solution to reduce SRB signalling delay is adopted the air-interface portion of the call setup time procedure will double for time-dilation with N=2 compared to normal UMTS.

End user perception may be impacted by the increased Round Trip Time (RTT) and the lower bitrate capability on time-dilated carriers, see subclause 6.1.7.

It has been identified that there may be impact on the BCH mapped on P-CCPCH. If P-CCPCH bitrate is decreased due to time dilation, then access latency will increase. The exact impact, if any, depends on if absolute bitrate is kept or not in the final specified solution.

A changed SFN clock can impact the DRX cycle for paging since that is based on SFN. It is for further study what the impact on signalling is to be able to keep the existing DRX cycles also with time-dilated UMTS. If DRX cycles become inherently longer with time dilation this will lead to increased latency, e.g. for mobile terminated speech calls.

It is assumed that a normal UMTS carrier is deployed whenever the available bandwidth is sufficient for that, and that radio resource management and mobility algorithms do not have to consider handover between a normal UMTS carrier and two N=2 time-dilated carriers in the same frequency allocation. Such a deployment would lead to soft handover being replaced by inter-frequency handover between carriers of different types, which could be expected to have impact on KPIs.

6.1.4.6.5 Hardware complexity impact - summary

[Editor's Note: This text is put here as a general discussion on hardware complexity.
The current structure of the present document splits complexity into four different clauses,
and the discussion presented here is valid for all.]

As described in subclause 6.1.4.1-6.1.4.4 there is impact on both radio and baseband hardware both in NodeB and UE to support the new bandwidth and chip rate. Since the chip rate is a very fundamental parameter in any CDMA system, it is not unlikely that the hardware impact can be very large for certain implementations. It is also possible that other implementations offer the possibility to change the chip rate quite flexibly.

6.1.4.6.6 Site migration

Deploying additional time-dilated carriers within a NodeB site with existing normal UMTS carriers will lead to one of several possible site migration scenarios when it comes to radio equipment (power amplifiers etc.):

- Installation of new power amplifier hardware to supported the added time-dilated carrier;

- Share power with already existing carriers on already installed power amplifier hardware.
  This will lead to reduced power capability of the existing normal UMTS carriers.

- Utilizing unused power capability in already installed power amplifier hardware.

Hence, the impact on the site at migration depends on the operator's detailed migration scenario and the installed hardware capabilities.

It should be noted that the overall capacity and end user performance impact of a migration where power is moved from normal UMTS carriers to time-dilated carriers will depend on the penetration of time-dilation capable UEs.
If this penetration is low the capacity loss on normal UMTS carriers can be larger than the capacity benefit from the additional time-dilated carrier.

6.1.4.6.7 UE battery consumption

An implication of longer radio frames is that for fixed packet size type traffic, especially when the packet sizes are relatively small, the transmitter and receiver on times in the UE will be lengthened due to the longer transmission times and HARQ cycles, which will have an impact on UE battery life. There is also likely to be an increase in the amount of packets handled by the network simultaneously, which could lead to an increase in overhead or decrease in efficiency.

The burst rate of a time-dilated carrier will be lower than that of a normal UMTS carrier. Therefore, the total time the UE spends in CELL_DCH to transfer a certain amount of bits will be higher with time-dilated UMTS.

6.1.4.6.8 O&M, parameter management

As mentioned in subclause 6.1.5.5, a set of new RB combinations needs to be defined. The time-dilated RB combinations would need to be managed in RNC. In addition to physical layer parameters, new MAC/RLC parameters and timer values for time-dilated UMTS cells need to be managed (see subclause 6.6). Earlier, the MAC/RLC and timer values used were typically aligned between all cells, while with time-dilated UMTS, an additional set of optimal parameter values need to be introduced. Some parameters can maybe be scaled directly as a function of the time dilation factor (and RTT), but others use optimal values that do not depend solely on the RTT and hence maybe be difficult to decide by simple rules. Simulations may be required to derive optimal values for those parameters.

Also other parameters in various areas may need to be updated and managed separately for time-dilated UMTS cells. Tentative examples include:

- Power control parameters due to the new power control update rate (no longer 1500 Hz)

- Compressed mode parameters. What impact the inter-frequency and inter-RAT measurements have on compressed mode operation needs further study. E.g., reasonable compressed mode patterns need to be found, taking the limitation of one transmission gap per radio frame into account. If it is not possible to get reasonable measurement performance with this limitation when radio frames become longer, then multiple transmission gaps may need to be enabled in one radio frame. The need and feasibility of this is left for further study.

- CPC parameters. Due to the time dilation optimal parameters may differ from legacy UMTS CPC.

- Synchronization parameters due to the new radio frame length

- Power-related parameters. E.g. if the same cell size is required for time-dilated UMTS cells as for normal UMTS cells, then the values of various power related information elements are decreased by $10\log_{10}(N)$,
  where N is the dilation factor. Examples of such parameters include e.g. Qrxlevmin.

6.1.4.6.9 Timing relations

So far it has been assumed that all control loops like inner loop power control, HARQ, etc. are simply scaled in time. However, since the current control loops requirements have been derived with assumptions on processing times in UE and NodeB, and these processing times do not scale linearly with time dilation factor N, there exist some optimization possibilities in these control loops for time-dilated UMTS. This can be done in order to reduce the inner loop power control delay, the HARQ retransmissions delay, etc. It is for further study if such optimizations shall be applied to the time dilation scheme.

In the multi-RAT carrier aggregation case, where a UMTS cell is serving cell and a time-dilated UMTS cell is secondary serving cell, the two cells involved in communication to one dual-cell UE will have different subframe lengths. This may lead to some complications, since earlier it has been assumed that serving and secondary serving cells

have identical timings (all subframes perfectly aligned through use of same Tcell values). This may impact NodeB and UE implementations.

6.1.4.6.10 Scheduler impact

In general, with a longer TTI length the degrees of freedom available to the scheduler in meeting differing QoS requirements of different traffic types will be reduced and the impact of this reduced flexibility on system efficiency and KPIs should be investigated. There may be a need to improve scheduler implementation in NodeB to avoid negative effects in this area.

It is also foreseen that the different TTI lengths on serving and secondary serving cells in an aggregation scenario will impact the HS scheduler implementation. The exact impact depends on the baseline scheduler implementation.

The time dilation may also have impact on the EUL scheduler, depending on if there is a need to modify grant scheduling for different time dilation factors.

6.1.4.6.11 Positioning

With time dilation, the chip time is increased. This can negatively impact the resolution of time measurements, such as RTT measurement for positioning. The detailed impact due to the reduced time resolution is for further study.

6.1.4.6.12 Impact on system information

With time-dilated UMTS, information about the time dilation factor (or chip rate) needs to be associated with every cell. This information has to be signalled to the UE in some use cases, both in idle mode (in system information) and in connected mode (in signalling radio bearers).

No conclusion on exactly how this information shall be represented has been agreed between RAN2 and RAN4. However, it cannot be ruled out that this information will result in some additional bits to be transmitted in system information. Depending on how full the BCH channel is this may result in need for changed SIB scheduling or reduction of other information in the existing SIBs (e.g. number of neighbours in neighbour lists).

6.1.4.6.13 Impact on other RATs

Time dilation will impact RRM procedures, particularly in the area of inter-frequency and inter-RAT measurements. As stated in subclause 6.1.5.2.4 and its subclauses, there is a tradeoff between keeping measurement duration and keeping measurement requirements. For now it remains unclear how the final requirements would be formulated. In any case, measurement performance needs to be secured for measurements on normal UMTS FDD, time-dilated UMTS FDD, LTE, GERAN and the various UMTS TDD chip rate options. There is impact in both directions, i.e. a UE operating on a time-dilated UMTS carrier needs to be able to measure on e.g. LTE carriers and a UE operating on LTE carrier needs to be able to measure on a time-dilated UMTS carrier. Hence, impact in this area is not limited only to WCDMA RAN, but also other RATs will be impacted by introduction of time-dilated UMTS.

6.1.5 Impacts on specifications

6.1.5.1 Impact to RAN1 specifications

The assumptions made include the following:

- HS-SCCH and HS-PDSCH TTI: N*2 ms on time-dilated cell
- No MBMS support in time-dilated cell
- No STTD support on dedicated channels in time-dilated cell
- No change is done to uplink/downlink timing relation at UE to enable e.g. lower TPC delay in time-dilated cells
- SFN (and also CFN) is increased by one every radio frame, i.e. SFN clock is running with different absolute rate on UMTS and time-dilated UMTS cells
- No need for compressed mode patterns with more than one transmission gap per radio frame when time-dilated UMTS is introduced
- No impact on ACK/NACK & CQI coding with introduction of time-dilated cells.
- Maximum carrier aggregation is one UMTS carrier + one time-dilated UMTS carrier

If the above assumptions would not hold, there may be additional specification impact.

Further, it has been assumed that time-dilated UMTS shall offer similar level of functionality as normal UMTS, so that the existing specifications and structure can be reused.

TS 25.201

The clauses of TS 25.201 that are impacted by the time-dilated UMTS solution are listed in Table 6.1.5.1-1.
The changes required primarily comprise scaling all time values by a factor N and the FDD bandwidth/chip-rate value by a factor 1/N (e.g., 10 ms becomes N*10 ms and 3.84 Mcps becomes 3.84/N Mcps where N=1, 2 or 4).
In addition, the entire concept of additional operation modes for UMTS FDD needs to be introduced. These additional operation modes can be described as different chip rate options similar to the different UMTS TDD chip rates.
A complication here is that with carrier aggregation multiple chip rates are used simultaneously, so exactly how to introduce and describe these new modes of operation is TBD.

Table 6.1.5.1-1: Impacts to TS 25.201 specification

Clause number	Clause title
4.2.1	Multiple Access
4.2.3	Modulation and spreading

TS 25.211

The clauses of TS 25.211 that are impacted by the time-dilated UMTS solution are listed in Table 6.1.5.1-2.
The changes primarily comprise scaling all TTI values and all radio frame time values by a factor N (e.g. 10 ms becomes N*10 ms where N=1, 2 or 4), and these changes are not explicitly mentioned below.
See comment below clause title in Table 6.1.5.1-2 for other types of changes in TS 25.211.

Table 6.1.5.1-2: Impacts to TS 25.211 specification

Clause number	Clause title
3.1	Symbols
3.3	Definitions Most likely something is needed in here to define concepts related to different operation modes of UMTS and aggregation of normal UMTS carriers and time-dilated UMTS carriers.
5	Physical channels and physical signals
5.2.1.1	DPCCH and DPDCH
5.2.1.2	HS-DPCCH
5.2.1.3	E-DPCCH and E-DPDCH
5.2.2.1.1	Overall structure of random-access transmission If it is concluded that improvements are needed to improve time-dilated UMTS access latency there may be additional changes needed, e.g. introducing a shorter radio frame to keep the message part at 10 ms even with scaling factor N.
5.2.2.1.3	RACH message part See 5.2.2.1.1 comment. Further, if there is a need to keep the current RACH data rate even with scaling factor N, there may be a need for additional slot formats, lower spreading factors, etc.
5.3.1	Downlink transmit diversity Applicability of transmit diversity on time-dilated UMTS carriers shall be listed.
5.3.2	Dedicated downlink physical channels
5.3.2.4	E-DCH Relative Grant Channel
5.3.2.5	E-DCH Hybrid ARQ Indicator Channel
5.3.2.6	Fractional Dedicated Physical Channel (F-DPCH)
5.3.3.1	Common Pilot Channel (CPICH)
5.3.3.3	Primary Common Control Physical Channel (P-CCPCH) If P-CCPCH spreading factor reduction is required to fit all SIB data with acceptable impact on latency then a new slot format with lower spreading factor needs to be specified.
5.3.3.4	Secondary Common Control Physical Channel (S-CCPCH)
5.3.3.5	Synchronisation Channel (SCH)
5.3.3.7	Acquisition Indicator Channel (AICH)
5.3.3.10	Paging Indicator Channel (PICH)
5.3.3.12	Shared Control Channel (HS-SCCH)
5.3.3.13	High Speed Physical Downlink Shared Channel (HS-PDSCH)
5.3.3.14	E-DCH Absolute Grant Channel (E-AGCH)
5.3.3.14B	E-DCH Rank and Offset Channel (E-ROCH)
7.1	General
7.3A	UL/DL timing relation for Enhanced Uplink in CELL_FACH state and IDLE mode
7.7.1	Timing when Multiflow is not configured Since the uplink DPCH/HS-DPCCH on normal UMTS carrier have a different radio frame duration than HS-PDSCH on time-dilated UMTS carrier, care needs to be taken in specifying these timing relations.
7.7.2	Timing when Multiflow is configured See 7.7.1 comment.
7.8	HS-SCCH/HS-PDSCH timing See 7.7.1 comment.
7.10	E-HICH/P-CCPCH/DPCH timing relation
7.11	E-RGCH/P-CCPCH/DPCH timing relation
7.12	E-AGCH/P-CCPCH timing relation

TS 25.212

The clauses of TS 25.212 that are impacted by the time-dilated UMTS solution are listed in Table 6.1.5.1-3.
The changes required primarily comprise scaling all TTI values and all radio frame time values by a factor N (e.g. 10 ms becomes N*10 ms where N=1, 2 or 4), and these changes are not explicitly mentioned below.
See comment below clause title in Table 6.1.5.1-3 for other types of changes in TS 25.212.

Table 6.1.5.1-3: Impacts to TS 25.212 specification

Clause number	Clause title
3.1	Definitions Most likely something is needed in here to define concepts related to different operation modes of UMTS and aggregation of normal UMTS carriers and time-dilated UMTS carriers.
3.2	Symbols
4.2	General coding/multiplexing of TrCHs
4.2.5.2	1st interleaver operation
4.2.6	Radio frame segmentation
4.2.7.2.2.1	Calculations for normal mode, compressed mode by higher layer scheduling, and compressed mode by spreading factor reduction
4.2.7.3	Bit separation and collection in uplink
4.2.8	TrCH multiplexing
4.2.13.2	Random Access Channel (RACH)
4.2.13.6	Broadcast channel (BCH) Contents of this subclause may need update if new P-CCPCH format is employed. It may e.g. be reasonable to have more than one transport block per TTI.
4.2.13.7	Forward access and paging channels (FACH and PCH)
4.2.13.8	High Speed Downlink Shared Channel (HS-DSCH) associated with a DCH
4.2.13.9	Enhanced Dedicated Channel (E-DCH)
4.3.1	Blind transport format detection
4.4	Compressed mode
4.4.3	Transmission time reduction method
4.4.5	Transmission gap position for E DCH
4.4.5.1	E DPDCH Transmission Gap Position during Initial Transmissions
4.4.5.3	E DPCCH Transmission Gap Position
4.5	Coding for HS-DSCH
4.7.4.1	Physical Channel mapping for HS-DPCCH HARQ-ACK How the HARQ-ACKs are mapped onto HS-DPCCH for the case of aggregation of one time-dilated UMTS carrier needs to be specified. A complication is that the subframe length will be different on the two carriers.
4.7.4.2	Physical Channel mapping for HS-DPCCH PCI/CQI How the PCI/CQIs are mapped onto HS-DPCCH for the case of aggregation of one time-dilated UMTS carrier needs to be specified. A complication is that the subframe length will be different on the two carriers.
4.7.4.3.1	Physical Channel mapping for HS-DPCCH HARQ-ACK and PCI/CQI when the UE is configured with one serving and one assisting serving HS-DSCH cell Potentially some updates are needed here as well due to the same reasons as in 4.7.4.1 and 4.7.4.2
4.7.4.4.1	Physical Channel mapping for HS-DPCCH HARQ-ACK How the HARQ-ACKs are mapped onto HS-DPCCH for the case of aggregation of one time-dilated UMTS carrier needs to be specified. A complication is that the subframe length will be different on the two carriers.
4.7.4.4.2	Physical Channel mapping for HS-DPCCH NTBP/PCI/CQI How the NTBP/PCI/CQIs are mapped onto HS-DPCCH for the case of aggregation of one time-dilated UMTS carrier needs to be specified. A complication is that the subframe length will be different on the two carriers.
4.8.4.1	Determination of SF, modulation scheme and number of PhCHs needed
4.8.4.3	HARQ Rate Matching Stage
4.8.7	Physical channel mapping for E DCH
4.9.2.2	Information field mapping of retransmission sequence number
4.9.5	Physical channel mapping for E DPCCH
4.10.5	Physical channel mapping for E AGCH
B.1	Idle lengths for DL, UL and DL+UL compressed mode for DPCH

TS 25.213

The clauses of TS 25.213 that are impacted by the time-dilated UMTS solution are listed in Table 6.1.5.1-4.
The changes required primarily comprise scaling all TTI values and all radio frame time values by a factor N (e.g. 10 ms becomes N*10 ms where N=1, 2 or 4), and these changes are not explicitly mentioned below.
See comment below clause title in Table 6.1.5.1-4 for other types of changes in TS 25.213.

Table 6.1.5.1-4: Impacts to TS 25.213 specification

Clause number	Clause title
3.1	Symbols
4.2.2.2	PRACH message part If it is concluded that improvements are needed to improve time-dilated UMTS access latency there may be additional changes needed, e.g. introducing a shorter radio frame to keep the message part at 10 ms even with scaling factor N.
4.3.1.3	Code allocation for PRACH message part If there is a need to keep the current RACH data rate even with scaling factor N, there may be a need for additional lower spreading factors, new code mapping rules etc
4.3.2.5	PRACH message part scrambling code See comment for 4.2.2.2
4.3.3.3	Preamble signature See comment for 4.3.2.5. With lower SF the number of signatures may be reduced.
4.4.1	Modulating chip rate
5.2.1	Channelization codes If P-CCPCH spreading factor reduction is required to fit all SIB data with acceptable impact on latency then a new slot format with lower spreading factor needs to be specified. Then there is a need to define a new channelization code mapping for P-CCPCH.
5.2.2	Scrambling code
5.3.1	Modulating chip rate

TS 25.214

The clauses of TS 25.214 that are impacted by the time-dilated UMTS solution are listed in Table 6.1.5.1-5.
The changes required primarily comprise scaling all TTI values and all radio frame time values by a factor N (e.g. 10 ms becomes N*10 ms where N=1, 2 or 4), and these changes are not explicitly mentioned below.
See comment below clause title in Table 6.1.5.1-5 for other types of changes in TS 25.214.

Table 6.1.5.1-5: Impacts to TS 25.214 specification

Clause number	Clause title
3.1	Definitions Most likely something is needed in here to define concepts related to different operation modes of UMTS and aggregation of normal UMTS carriers and time-dilated UMTS carriers.
4.2.5	HS-DSCH cell timing when Multiflow is configured "Same radio frame timing" is currently assumed between serving and secondary serving HS-DSCH cell. This is no longer possible when the radio frame themselves have different lengths, so some new concept is needed here.
4.3.1.2	Downlink synchronization primitives Values for the thresholds Qin and Qout (to be defined implicitly by TS 25.101) are for further study. Synchronization related times like "previous 40 ms period", "160 ms period", "previous 240 slots", "20 most recently received transport blocks" etc most likely needs modification and are for further study.
4.3.2.3A	Synchronisation procedure AA Values for the thresholds Qin and Qout (to be defined implicitly by TS 25.101) are for further study. Synchronization related times like "first 40 ms period" etc most likely needs modification and are for further study.
4.3.2.4	Synchronisation procedure B It is for further study if frame timing margin of ±148 chips is needed when chips are longer in time with time-dilated UMTS.
4.3.4	Transmission timing adjustments Values for the maximum rate of uplink TX time adjustment (to be defined implicitly by TS 25.101) are for further study.
5.1.2.2.1	General It is for further study if new TPC step sizes are required with the reduced inner loop power control update frequency that comes with time-dilated UMTS.
5.1.2.2.1.1	Out of synchronization handling Values for the thresholds Qin and Qout (to be defined implicitly by TS 25.101) are for further study. Synchronization related times like "last 160 ms period", "last 240 slots", "40 ms period" etc most likely needs modification and are for further study.
5.1.2.2.3.1	Derivation of TPC_cmd when only one TPC command is received in each slot It is for further study if still 5 TPC commands shall be combined with the reduced inner loop power control update frequency that comes with time-dilated UMTS.
5.1.2.2.3.3	Combining of TPC commands from radio links of different radio link sets It is for further study if still 5 TPC commands shall be combined with the reduced inner loop power control update frequency that comes with time-dilated UMTS.
5.1.2.3	Transmit power control in compressed mode It is for further study if behaviour needs to be changed due to the reduced inner loop power control update frequency that comes with time-dilated UMTS. E.g., is the formula $\delta_i = 0.9375\delta_{i-1} - 0.96875 TPC_cmd_i \Delta_{TPC} k_{sc}$ $\delta_{i-1} = \delta_i$ and power steps like "If PCA has the value 1, $\Delta_{RP\text{-}TPC}$ is equal to the minimum value of 3 dB and $2\Delta_{TPC}$. If PCA has the value 2, $\Delta_{RP\text{-}TPC}$ is equal to 1 dB." still valid? Simulations used to derive these values have assumed 1500 Hz power control update rate.
5.1.2.5B.1	E-DPCCH/DPCCH
5.1.2.5B.2.4	E-DPDCH/DPCCH adjustments relating to compressed mode
5.2.1.2.2	UTRAN behaviour It is for further study if new TPC step sizes (or mandatory step sizes) are required with the reduced inner loop power control update frequency that comes with time-dilated UMTS.

5.2.1.3	Power control in compressed mode It is for further study if behaviour needs to be changed due to the reduced inner loop power control update frequency that comes with time-dilated UMTS. E.g., are power steps like "Δ_{RP-TPC} is equal to the minimum value of 3 dB and $2\Delta_{TPC}$." still valid? Simulations used to derive these values have assumed 1500 Hz power control update rate.
6.1	Physical random access procedure
6.1.1	RACH sub-channels
6.1.2	RACH access slot sets
6.1A	Physical random access procedure for Enhanced Uplink in CELL_FACH state and IDLE mode
6A.1	General procedure Most likely the list of parameters signalled to physical layer in UE and Node B has to be extended with information about time dilation factors. Clarify statements like "This ordered deactivation or activation of the HS-SCCH-less operation is applied by the UE 12 slots after the end of the HS-SCCH subframe delivering the order." "If the higher layers set DTX_DRX_STATUS to TRUE (as described in [5]) then UE_DTX_DRX_Enabled is FALSE until Enabling_Delay radio frames have passed. After the higher layers have set DTX_DRX_STATUS to TRUE (as described in [5]) and Enabling_Delay radio frames have passed then UE_DTX_DRX_Enabled is TRUE. Otherwise UE_DTX_DRX_Enabled is FALSE." "If the UE is not configured with multiple uplink frequencies, HS-SCCH ordered deactivation or activation of the secondary serving HS-DSCH cell(s) is applied by the UE 12 slots after the end of the HS-SCCH subframe delivering the order, and any transient behaviour related to this change should take place before this point in time." "If the UE is configured with multiple uplink frequencies, HS-SCCH ordered deactivation or activation of the secondary serving HS-DSCH cell(s) is applied by the UE 18 slots after the end of the HS-SCCH subframe delivering the order, and any transient behaviour related to this change should take place before this point in time." "The maximum allowed interruption time for the downlink cells and uplink frequencies configured in this frequency band is 1 slot. The interrupt shall take place during the next downlink HS-SCCH slot after the end of the HS-DPCCH slot that contains the HARQ-ACK information acknowledging the HS-SCCH order. The corresponding change of the HS-DPCCH channel coding scheme as specified in [2] is applied by the UE at the first HS-DPCCH subframe boundary after the activation or deactivation has been applied." when different slot length is applied to different cells. In general this is a completely new aspect with time-dilated UMTS that needs careful specification.
6A.1.1	UE procedure for receiving HS-DSCH and HS-SCCH in the CELL_DCH state Clarify statements like "From the serving HS-DSCH cell, the UE shall be able to receive up to one HS-DSCH if MIMO mode and MIMO mode with four transmit antennas is not configured or two HS-DSCHs if MIMO mode is configured or four HS-DSCHs if MIMO mode with four transmit antennas is configured or one HS-SCCH order. - In addition, from each of the activated secondary serving HS-DSCH cells, the UE shall be able to simultaneously receive up to one HS-DSCH if MIMO mode and MIMO mode with four transmit antennas is not configured or two HS-DSCHs if MIMO mode is configured or four HS-DSCHs if MIMO mode with four transmit antennas is configured or one HS-SCCH order. - The maximum number of HS-SCCH orders simultaneously received by the UE across the serving HS-DSCH cell and all the activated secondary serving HS-DSCH cells is 2." when different slot length is applied to different cells, thus making statements referring to "simultaneous" ambiguous. In general this is a completely new aspect with time-dilated UMTS that needs careful specification.
6A.1.2.1	CQI reporting procedure in case the UE is not configured in MIMO mode
6A.1.2.2	Composite PCI/CQI reporting procedure in case the UE is configured in MIMO mode
6A.1.2.3	Composite NTBP/PCI/CQI reporting procedure in case the UE is configured in MIMO mode with four transmit antennas
6A.2	Channel quality indicator (CQI) definition It is for further study if a 3-slot reference period is still valid when slots become longer in time with time-dilated UMTS.
6A.2.1	CQI definition when the UE is not configured in MIMO mode and not configured in MIMO mode with four transmit antennas It is for further study if a 3-slot reference period is still valid when slots become longer in time with time-dilated UMTS.
6A.2.2	CQI definition when the UE is configured in MIMO mode It is for further study if a 3-slot reference period is still valid when slots become longer in time with time-dilated UMTS.
6A.2.2A	CQI definition when the UE is configured in MIMO mode with four transmit antennas It is for further study if a 3-slot reference period is still valid when slots become longer in time with time-dilated UMTS.

6A.2.3	CQI tables time-dilated UMTS will introduce new UE categories, and this needs to be reflected in table 7a. If new UE categories use different N_IR values than existing, new CQI mapping tables are needed.
6A.3	Operation during compressed mode on the associated DPCH or F-DPCH Behaviour due to different subframe lengths on the serving and secondary serving cell needs to be clarified. It is for further study if a 3-slot reference period is still valid when slots become longer in time with time-dilated UMTS.
6B	E-DCH related procedures
6B.3.1	10 ms E-DCH TTI
6B.3.2	2 ms E-DCH TTI
6B.4.1	Uplink compressed mode
6C	Discontinuous transmission and reception procedures Complications for CPC due to different slot/subframe lengths on serving and secondary serving cells due to time-dilated UMTS are for further study.
6C.2.1	Uplink DPCCH burst pattern
6C.3	Discontinuous downlink reception Complications for CPC due to different slot/subframe lengths on serving and secondary serving cells due to time-dilated UMTS are for further study.
6C.3.1	Discontinuous downlink reception when the UE is in Multiflow mode Complications for CPC due to different slot/subframe lengths on serving and secondary serving cells due to time-dilated UMTS are for further study.
6C.4	HS-SCCH orders Complications for CPC due to different slot/subframe lengths on serving and secondary serving cells due to time-dilated UMTS are for further study.
6C.5	Operation during compressed mode Complications for CPC due to different slot/subframe lengths on serving and secondary serving cells due to time-dilated UMTS are for further study.
8.2	Parameters of IPDL
10.2	Downlink TPI transmission and control timing It is for further study if a 3-slot TPI information update rate is still valid when slots become longer in time with time-dilated UMTS.
10.6	HS-SCCH orders It is for further study if a maximum allowed interruption time of 2 slots is still valid when slots become longer in time with time-dilated UMTS.
11	Uplink MIMO
Annex C	Cell search procedure Text should be extended with information that all the chip rates need to be covered in cell search

TS 25.215

The clauses of TS 25.215 that are impacted by the time-dilated UMTS solution are listed in Table 6.1.5.1-6.
The changes required primarily comprise scaling all TTI values and all radio frame time values by a factor N (e.g. 10 ms becomes N*10 ms where N=1, 2 or 4), and these changes are not explicitly mentioned below.
See comment below clause title in Table 6.1.5.1-6 for other types of changes in TS 25.215.

Table 6.1.5.1-6: Impacts to TS 25.215 specification

Clause number	Clause title
5.1.8	SFN-CFN observed time difference The current definition of this measurement only works if radio frame length is same on all involved cells. With time-dilated UMTS this will no longer be true, so there will be complications for this measurement. It is for further study how to make this to work.
5.1.9	SFN-SFN observed time difference The current definition of this measurement only works if radio frame length is same on all involved cells. With time-dilated UMTS this will no longer be true, so there will be complications for this measurement. Another complication is that the SFN clocks will be running at different speeds in different cells, so the OFF value cannot be measured as a difference between two SFNs since the SNF values are diverging over time. Also, relative chip number comparisons do not make sense when the chips are of different lengths. It is for further study how to make this to work.
5.1.10	UE Rx-Tx time difference It is for further study if this measurement is impacted by time-dilated UMTS.
5.1.12	UE GPS Timing of Cell Frames for UE positioning It is for further study if this measurement is impacted by time-dilated UMTS, due to the longer radio frames.
5.1.15	UE GANSS Timing of Cell Frames for UE positioning It is for further study if this measurement is impacted by time-dilated UMTS, due to the longer radio frames.
5.2.8	Round trip time It is for further study if this measurement is impacted by time-dilated UMTS, due to the longer radio frames.
5.2.9	UTRAN GPS Timing of Cell Frames for UE positioning It is for further study if this measurement is impacted by time-dilated UMTS, due to the longer radio frames.
5.2.10	PRACH Propagation delay It is for further study if this measurement is impacted by time-dilated UMTS, due to the worse chip resolution in time.
5.2.14	SFN-SFN observed time difference The current definition of this measurement only works if radio frame length is same on all involved cells. With time-dilated UMTS this will no longer be true, so there will be complications for this measurement. It is for further study how to make this to work. It cannot be excluded that a completely new measurement has to be defined.
5.2.18	UTRAN GANSS Timing of Cell Frames for UE positioning It is for further study if this measurement is impacted by time-dilated UMTS, due to the longer radio frames.
6.1.1.1	Use of compressed mode for monitoring It is for further study if the statement "one single measurement purpose for one transmission gap pattern" still holds with time-dilated UMTS. Can inter-frequency measurements on normal UMTS and time-dilated UMTS carriers be done with one pattern?
6.1.1.2	Parameterisation of compressed mode It is for further study if these parameters are impacted by time-dilated UMTS. Note that both cases of UE on normal UMTS carrier measuring on time-dilated UMTS carrier and vice versa need to be considered. It is for further study if measurement purpose "FDD" needs to be split into "FDD 3.84 Mcps" and "FDD 3.84/N Mcps". It is for further study if the statement "UE shall support one compressed mode pattern sequence for each measurement purpose while operating in FDD mode" still holds with time-dilated UMTS. Can inter-frequency measurements on normal UMTS and time-dilated UMTS carriers be done with one pattern? In addition, it is for further study if the total number of transmission gap patterns running in parallel needs to be increased.

6.1.5.2 Impact to RAN4 specifications

In summary RAN4 foresees impact on the following RAN4 specifications with introduction of time-dilated UMTS.

Base Station:

25.104: Base Station (BS) radio transmission and reception (FDD).
The impact is due to new BS core requirements (or extension of the existing requirements to time-dilated UMTS case) and new BS performance requirements.
25.141: Base Station (BS) conformance testing (FDD)
The BS conformance testing specification will be affected accordingly. Additionally the corresponding MSR specifications will be affected:
37.104: E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) radio transmission and reception
37.141: E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) conformance testing

User Equipment:

25.101: User Equipment (UE) radio transmission and reception (FDD).
The impact is due to new UE core requirements (or extension of the existing requirements to time-dilated UMTS case) and new UE performance requirements.

25.133: Requirements for support of radio resource management (FDD).
RRM core and performance requirements.

36.133: Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management.

Additionally RAN4 foresees potential impact on other RAT specification which needs to be further investigated as follows:

36.104: "Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception", because of coexistence and also depending on whether new interferer types need to be introduced.

36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception", because of coexistence and also depending on whether new interferer types need to be introduced.

Additionally RAN4 foresees potential impact on the following specifications, however detailed analysis has not been provided and needs to be further investigated:

25.106: "UTRA repeater radio transmission and reception" (and accordingly the repeater conformance testing specification **25.107**).

25.111: Location Measurement Unit (LMU) performance specification; User Equipment (UE) positioning in UTRAN.

25.113: "Base Station (BS) and repeater electromagnetic compatibility (EMC)" and the corresponding MSR specification **37.113**.

25.144: User Equipment (UE) and Mobile Station (MS) over the air performance requirements.

6.1.5.2.1 General

Time-dilated UMTS carriers with 1/2 or 1/4 of the chip rate of a normal carrier need to be distinguished from each other and from the normal carrier that has the same center frequency. This means the same UARFCN alone cannot be used for all cases. Several solutions could be considered, i.e. to assign a new UARFCN to each new chip-rate variation for every possible channel position or other solutions. The solution defined in RAN4 may have implications in RAN2.

RAN4 also has identified open aspects related to UARFCN as follows:

- Discuss whether the current UARFCN range is sufficient (currently the UARFCN range is 0…16383. The largest reserved value to date is 10849 (from TS 25.101).

- Whether to consider the same channel raster or additional channel raster finer than 200 kHz may be considered for time-dilated UMTS in order to provide deployment flexibility within the spectrum operator owns.

- The final decision on the channel raster has implication on the multi-carrier scenarios agreed in RAN1. It may or may not affect conclusions in RAN1 study for the multi-carrier scenario.

- It should be noted that if a finer frequency raster is necessary for the RF analog part of the radio, the comparator frequency of the synthesizer may need to be lowered depending on implementation.
  In this case the synthesizer spurs will have a lower frequency content and the loop filter of the synthesizer needs to be lowered. This may have implications related to phase noise on some implementations.

It should be noted that this aspect requires coordination with RAN2.

6.1.5.2.2 BS RF core and performance requirements

For BS core and test requirements, the specifications impacted due to introducing time-dilated UMTS include TS 25.104, TS 25.141, TS 37.104 and TS 37.141.

The time-dilated UMTS configurations will be introduced in the specification depending on the feasibility analysis. The same Tx-Rx separation as in legacy UMTS would be applicable for time-dilated UMTS.

6.1.5.2.2.1 BS transmitter core requirements

Due to the new bandwidth for time-dilated UMTS, the majority of the transmitter requirements will need to be redefined.

The BS output power of small power class may need some modifications to take into account the decision on PSD level.

No impact is foreseen for frequency error, primary and secondary CPICH power accuracy requirement.

The available power range for the code domain compared to the total power shall be kept unchanged in order to keep the same flexibility of code domain power adjustment for time-dilated UMTS. The minimum total power when no traffic channels are activated is determined by the minimum power of basic control channel and also shall be kept unchanged for time-dilated UMTS. Therefore, power control dynamic range and total power dynamic range compared to the maximum total power can be unchanged.

Output RF spectrum emissions will be highly affected by the introduction of time-dilated UMTS. In particular this will depend on the assumptions related to time-dilated UMTS, i.e.:

- nominal bandwidth;

- assumptions in terms of PSD.

The following provides a brief initial assessment of the impact for each individual requirement present in TS 25.104.

- Occupied bandwidth requirement for time-dilated UMTS with new scalable chip rates needs to be introduced.

- New SEM requirements for time-dilated UMTS should be defined. The definition should take into account co-existence study result and BS implementation feasibility. See subclause 6.1.6.1.
  The ACLR is a direct measure of the interference which is leaking in adjacent spectrum. New ACLR requirements for time-dilated UMTS should be defined. The type of adjacent channel should be studied for time-dilated UMTS carrier when defining ACLR requirement for each chip rate of time-dilated UMTS. ACLR is directly linked to ACIR which directly impact the interference generated by time-dilated UMTS to other carriers, other RATs or other operators and hence it should be studied carefully. Note also that the ACLR is defined by considering an integration bandwidth of 5MHz for both the wanted signal and the interfering adjacent carrier. With the introduction of time-dilated UMTS new type of adjacent channel should be considered. In particular ACLR may be defined for symmetric adjacent channels (same channel bandwidth as the wanted time-dilated UMTS carrier) and for legacy UMTS adjacent carriers.

- Spurious emission requirements include regulatory and co-existence requirement. Regulatory requirements are mandatory for deployment and must therefore be met. Co-existence requirements depend on the noise figure of the receiver of protected system. Appropriate values and measurement bandwidth for the spurious emission need to be considered by taking into account the time-dilated UMTS itself and other RATs systems protection needs. Additionally, the introduction of time-dilated UMTS may impact other RATs spurious emissions (to protect scalable UMTS systems).

- The transmit intermodulation is the capability of the transmitter to inhibit the generation of signals in its non-linear elements caused by presence of the wanted signal and an interfering signal reaching the transmitter via the antenna. The interfering signal is defined currently as a UTRA modulated signal. The transmit intermodulation requirements will be affected by the introduction of time-dilated UMTS. Namely, the type of interfering signal and offset values needs to be redefined for time-dilated UMTS carrier.

- Transmit modulation requirements are determined by the system performance requirement. Analysis has not been conducted to understand whether the same EVM requirements as for legacy UMTS can be considered also for time-dilated UMTS. Hence, while it is desirable to keep them unchanged, analysis is needed in order to understand the implication of this choice.

- The transmit pulse shape filter can be reused for time-dilated UMTS if the same roll-off factor as for legacy is considered. However, the chip rate needs to be modified for time-dilated UMTS.

- The peak domain error may need to be re-evaluated in order to take into account the new waveform corresponding to the new nominal bandwidth.

- Time alignment error requirement is for ensuring the demodulation performance of diversity, MIMO and carrier aggregation. For time-dilated UMTS, the TAE requirement between each branch in MIMO and the TAE between UMTS and time-dilated UMTS carrier may be kept unchanged. It should be noted that multi-carrier operations should be taken into account for the definition of the core requirements, by considering TS 37.104 and TS 25.104.

6.1.5.2.2.2 BS receiver core requirements

The time-dilated UMTS can be deployed either as stand-alone or in carrier aggregation with UMTS carriers. In case of standalone time-dilated UMTS deployment the uplink follows the time-dilated UMTS carrier scaling. Due to the new bandwidth for time-dilated UMTS, all the receive requirements will need to be redefined. In case of multi-carrier operation when time-dilated UMTS is deployed together with legacy UMTS, the study item considers a single uplink carrier anchored to the 5MHz downlink carrier. Hence for multi-RAT scenarios a limited impact is foreseen.

The following provides a brief initial assessment of the impact for each individual requirement.

- New reference measurement channels for time-dilated UMTS need to be defined first and all the receiver requirement need to be specified based on the new reference measurement channels.

- REFSENS is specified so far supporting that modulated signal is occupying 5MHz case. For time-dilated UMTS carrier, the same noise figure of base station receiver should be kept (due to the same hardware design) but new study would be needed on the demodulated SNR. Hence new REFSENS values will be defined.

- Receiver dynamic range is the receiver ability to handle a rise of interference in the reception frequency channel. The wanted signal power needs to be studied on the demodulated SNR for time-dilated UMTS and interference level should be determined depending on UE power decision. The ACS, in-band blocking and intermodulation requirement is defined in current specification for an interferer with 5MHz UMTS modulated signal. When introducing time-dilated UMTS, the interferer bandwidth shall be changed in order to consider the presence of time-dilated UMTS interferer, the offset levels should be changed in order to take into account new bandwidth. Moreover the interferer power level should be studied further, depending on the uplink PSD decision.

- The narrow-band blocking and out-of-band blocking requirement is defined in current specification for an interferer either GMSK modulated signal or CW signal to capture the co-existence with GSM system in the same band and any other system in other bands. These two requirements will need to be redefined for time-dilated UMTS. The offset level should be changed in order to take into account new bandwidth. The interferer levels can be reused.

- The RX spurious emissions follow the TX spurious emissions. Therefore, the same applies.

New test requirements for time-dilated UMTS, corresponding to the core requirements which are mentioned above should also be introduced. Test model defined in TS 25.141 also need to be changed for time-dilated UMTS.

Table 6.1.5.2.2-1 summarizes the requirements impact for BS core specification:

Table 6.1.5.2.2-1: Summary of the requirements impact for BS core specification

Requirement	No of carriers	Requirements for time-dilated UMTS	New requirements for UMTS carrier
Base station output power	Standalone	New requirements need to be introduced for certain cases.	No
	Multi-RAT scenarios	New requirements need to be introduced for certain cases.	No
Frequency error	Standalone	Current requirement can be reused	No
	Multi-RAT scenarios	Current requirement can be reused	No
Occupied bandwidth	Standalone	New scalable chip rates needs to be introduced	No
	Multi-RAT scenarios	New scalable chip rates need to be introduced	No
Spectrum emission mask	Standalone	New requirements need to be introduced.	No
	Multi-RAT scenarios	New requirements need to be introduced.	No
ACLR	Standalone	New requirements need to be introduced.	New requirement may need to be considered to protect time-dilated UMTS.
	Multi-RAT scenarios	New requirements need to be introduced.	New requirement may need to be considered to protect time-dilated UMTS.
Tx Spurious emissions	Standalone	New Co-existence requirement may need to be introduced to protect time-dilated UMTS.	New Co-existence requirement may need to be considered to protect time-dilated UMTS.
	Multi-RAT scenarios	New Co-existence requirement may need to be introduced to protect time-dilated UMTS.	New Co-existence requirement may need to be considered to protect time-dilated UMTS.
Transmit intermodualtion	Standalone	New requirement need to be introduced.	No
	Multi-RAT scenarios	New requirement need to be introduced.	No
EVM	Standalone	Analysis need to be done.	No
	Multi-RAT scenarios	Analysis need to be done.	No
PCDE	Standalone	Analysis need to be done.	No
	Multi-RAT scenarios	Analysis need to be done.	No
transmit pulse shape filter	Standalone	New scalable chip rates needs to be introduced	No
	Multi-RAT scenarios	New scalable chip rates needs to be introduced	No
TAE	Standalone	Current requirement can be reused	No
	Multi-RAT scenarios	Current requirement can be reused	No
Reference sensitivity level	Standalone	New requirement need to be introduced.	No
Dynamic range	Standalone	New requirement need to be introduced.	No
Adjacent Channel selectivity	Standalone	New requirement need to be introduced. New time-dilated UMTS interferer may need to be introduced.	New time-dilated UMTS interferer may need to be considered.
In band blocking characteristics	Standalone	New requirement need to be introduced. New time-dilated UMTS interferer may need to be introduced.	New time-dilated UMTS interferer may need to be considered.
Out of band blocking characteristics	Standalone	New requirement need to be introduced.	No
Narrow band blocking characteristics	Standalone	New requirement need to be introduced.	No
Intermodulation characteristics	Standalone	New requirement need to be introduced. New time-dilated UMTS interferer may need to be introduced.	New time-dilated UMTS interferer may need to be considered.
Rx Spurious emission	Standalone	Current requirement can be reused	No

6.1.5.2.2.3 BS performance requirements

The BS performance requirements will be affected for standalone time-dilated UMTS scenarios when the UE uses time-dilated UMTS to transmit the data. Both legacy UMTS and HS-related requirements would be affected, as time-dilated UMTS would be used to carry both HS traffic and UMTS.

BS performance requirements in TS 25.104 are currently defined under several assumptions specifically developed for the 5 MHz channel bandwidth. Changing the bandwidth would imply changes of some of the assumptions (depending on RAN 1/RAN 4 agreements), which in turn will impact the BS performance requirements. Extensive simulation work is needed to set new requirements in accordance to the new assumptions.

For the time being no impacts on BS performance requirements for multicarrier time-dilated UMTS scenarios is foreseen.

The channel propagation conditions and the path positions should be carefully reviewed to avoid more adverse conditions. The fading propagation channels which are aligned with the chip rate shall be redefined (Case 3, 4). For these channels the path delay position is the chip positions for 3.84 Mcps, that is, 260 * N [ns]. If the chip rate is changed, the path delays are put on the sub-chip position because of the possible extended chip duration and it causes inter-symbol interference which may lead to different demodulation performance. Also in cases of other multipath propagation conditions, where the path delays are not assigned to chip positions, extension of chip duration will lead to different timing relations between the delay of particular path and chip positions, however in these cases redefinition of channel models is not required. Nevertheless, this behaviour may cause different demodulation performance as well.

All BS performance requirements are defined for particular reference measurement channels which shall be modified due to chip rate scaling. Modifications of reference channels shall apply at least to spreading factor or information bit rate which scale with the same factor as chip rate.

Taking the above into account, the table below presents a list of BS performance requirements of TS 25.104 which would need additional minimum values due to potential introduction of time-dilated UMTS.

Table 6.1.5.2.2.3-1: BS performance requirements of TS 25.104 which would need new minimum values for time-dilated UMTS

Subclause	Requirement	Justification
8.2	Demodulation in static propagation conditions	New minimum requirement needed due to: modification of reference measurement channels for UL DCH (12.2 kbps, 64 kbps, 144 kbps, 384 kbps).
8.3	Demodulation of DCH in multipath fading conditions	New minimum requirement needed due to: modification of reference measurement channels for UL DCH (12.2 kbps, 64 kbps, 144 kbps, 384 kbps), different timing relations between the delay of particular path and chip positions in multi-path fading propagation conditions (Case 1, Case 2), redefinition of path delays positions aligned with chip positions in multi-path fading propagation conditions (Case 3, Case 4).
8.4	Demodulation of DCH in moving propagation conditions	New minimum requirement needed due to: modification of reference measurement channels for UL DCH (12.2 kbps, 64 kbps), different timing relations between the delay of Path1 and chip positions in moving propagation conditions.
8.5	Demodulation of DCH in birth/death propagation conditions	New minimum requirement needed due to: modification of reference measurement channels for UL DCH (12.2 kbps, 64 kbps), different timing relations between the delay of Path1/Path2 and chip positions in Birth-Death propagation conditions.
8.5A	Demodulation of DCH in high speed train conditions	New minimum requirement needed due to: modification of reference measurement channels for UL DCH (12.2 kbps).
8.7	Performance requirement for RACH	New minimum requirement needed due to: redefinition of path delays positions aligned with chip positions in multi-path fading propagation conditions (Case 3).
8.10	Performance of ACK/NACK detection for HS-DPCCH	New minimum requirement needed due to: modification of reference measurement channel for HS-DPCCH, different timing relations between the delay of particular path and chip positions in multi-path fading propagation conditions (Case 1, Case 2), redefinition of path delays positions aligned with chip positions in multi-path fading propagation conditions (Case 3).
8.10A 8.10B	Performance of ACK/NACK detection for 4C-HSDPA HS-DPCCH Performance of ACK/NACK detection for 8C-HSDPA HS-DPCCH	New minimum requirement needed due to: modification of reference measurement channel for 4C-HSDPA HS-DPCCH, different timing relations between the delay of particular path and chip positions in multi-path fading propagation conditions (Case 1).
8.11	Demodulation of E-DPDCH in multipath fading condition	New minimum requirement needed due to: modification of E-DPDCH Fixed reference channels (FRC1, FRC2, FRC3, FRC4, FRC5, FRC6, FRC7, FRC8). different timing relations between the delay of particular path and chip positions in multipath fading propagation conditions for E-DPDCH and E-DPCCH (PA3, PB3, VA30, VA120).
8.12	Performance of signalling detection for E-DPCCH in multipath fading condition	New minimum requirement needed due to: modification of E-DPDCH Fixed reference channels (FRC1, FRC4), different timing relations between the delay of particular path and chip positions in multipath fading propagation conditions for E-DPDCH and E-DPCCH (PA3, PB3, VA30, VA120).

Table 6.1.5.2.2.3-2: Additional modifications of TS 25.104 required by time-dilated UMTS

Subclause	Measurement channels	Justification
A.1	Summary of UL reference measurement channels	Change of spreading factor or other parameters due to scaling of chip rate.
A.2	UL reference measurement channel for 12.2 kbps	Change of spreading factor or other parameters due to scaling of chip rate.
A.3	UL reference measurement channel for 64 kbps	Change of spreading factor or other parameters due to scaling of chip rate.
A.4	UL reference measurement channel for 144 kbps	Change of spreading factor or other parameters due to scaling of chip rate.
A.5	UL reference measurement channel for 384 kbps	Change of spreading factor or other parameters due to scaling of chip rate.
A.8	Reference measurement channel for HS-DPCCH	Change of values of parameters connected with data rate (information bit rate and physical channel bit rate) due to scaling of chip rate.
A.8A	Reference measurement channel for HS-DPCCH for 4C-HSDPA	Change of values of parameters connected with data rate (information bit rate and physical channel bit rate) due to scaling of chip rate.
A.9	Summary of E-DPDCH Fixed reference channels	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
A.10	E-DPDCH Fixed reference channel 1 (FRC1)	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
A.11	E-DPDCH Fixed reference channel 2 (FRC2)	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
A.12	E-DPDCH Fixed reference channel 3 (FRC3)	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
A.13	E-DPDCH Fixed reference channel 4 (FRC4)	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
A.14	E-DPDCH Fixed reference channel 5 (FRC5)	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
A.15	E-DPDCH Fixed reference channel 6 (FRC6)	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
A.16	E-DPDCH Fixed reference channel 7 (FRC7)	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
A.17	E-DPDCH Fixed reference channel 8 (FRC8)	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
Subclause	**Propagation conditions**	**Justification**
B.2	Multi-path fading propagation conditions	Redefinition of path delays positions aligned with chip positions in multi-path fading propagation conditions (Case 3, Case 4) due to scaling of chip rate.

Additional minimum values of BS performance requirements in TS 25.104 caused by introduction of time-dilated UMTS have to be followed by appropriate changes in BS conformance testing specification. Due to that, the following subclauses of TS 25.141 have to be modified.

Table 6.1.5.2.2.3-1: BS conformance testing requirements of TS 25.141 which would be affected by modifications of corresponding requirements in TS 25.104 due to introduction of time-dilated UMTS

Subclause	Requirement	Justification
8.2	Demodulation in static propagation conditions	Modifications due to corresponding changes in subclause 8.2 of TS 25.104.
8.3	Demodulation of DCH in multipath fading conditions	Modifications due to corresponding changes in subclause 8.3 of TS 25.104.
8.4	Demodulation of DCH in moving propagation conditions	Modifications due to corresponding changes in subclause 8.4 of TS 25.104.
8.5	Demodulation of DCH in birth/death propagation conditions	Modifications due to corresponding changes in subclause 8.5 of TS 25.104.
8.5A	Demodulation of DCH in high speed train conditions	Modifications due to corresponding changes in subclause 8.5A of TS 25.104.
8.6	Verification of the internal BLER calculation	Appropriate scaling of values of parameters connected with data rate and signal level due to scaling of chip rate.
8.8	RACH performance	Modifications due to corresponding changes in subclause 8.7 of TS 25.104.
8.11	Performance of signalling detection for HS-DPCCH	Modifications due to corresponding changes in subclause 8.10 of TS 25.104.
8.11A 8.11B	Performance of signalling detection for 4C-HSDPA HS-DPCCH Performance of signalling detection for 8C-HSDPA HS-DPCCH	Modifications due to corresponding changes in subclauses 8.10A and 8.10B of TS 25.104.
8.12	Demodulation of E-DPDCH in multipath fading condition	Modifications due to corresponding changes in subclause 8.11 of TS 25.104.
8.13	Performance of signalling detection for E-DPCCH in multipath fading conditions	Modifications due to corresponding changes in subclause 8.12 of TS 25.104.

Table 6.1.5.2.2.3-2: Additional modifications of TS 25.141 required by time-dilated UMTS

Subclause	Measurement channels	Justification
A.1	Summary of UL reference measurement channels	Change of spreading factor or other parameters due to scaling of chip rate.
A.2	UL reference measurement channel for 12.2 kbps	Change of spreading factor or other parameters due to scaling of chip rate.
A.3	UL reference measurement channel for 64 kbps	Change of spreading factor or other parameters due to scaling of chip rate.
A.4	UL reference measurement channel for 144 kbps	Change of spreading factor or other parameters due to scaling of chip rate.
A.5	UL reference measurement channel for 384 kbps	Change of spreading factor or other parameters due to scaling of chip rate.
A.9	Reference measurement channel for HS-DPCCH	Change of values of parameters connected with data rate (information bit rate and physical channel bit rate) due to scaling of chip rate.
A.9A	Reference measurement channel for HS-DPCCH for 4C-HSDPA	Change of values of parameters connected with data rate (information bit rate and physical channel bit rate) due to scaling of chip rate.
A.10	Summary of E-DPDCH Fixed reference channels	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
A.11	E-DPDCH Fixed reference channel 1 (FRC1)	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
A.12	E-DPDCH Fixed reference channel 2 (FRC2)	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
A.13	E-DPDCH Fixed reference channel 3 (FRC3)	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
A.14	E-DPDCH Fixed reference channel 4 (FRC4)	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
A.15	E-DPDCH Fixed reference channel 5 (FRC5)	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
A.16	E-DPDCH Fixed reference channel 6 (FRC6)	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
A.17	E-DPDCH Fixed reference channel 7 (FRC7)	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
A.18	E-DPDCH Fixed reference channel 8 (FRC8)	Change of values of parameters connected with data rate (max information bit rate) due to scaling of chip rate.
Subclause	**Propagation conditions**	**Justification**
D.2	Multi-path fading propagation conditions	Redefinition of path delays positions aligned with chip positions in multi-path fading propagation conditions (Case 3, Case 4) due to scaling of chip rate.

According to presented study, most of existing UTRA BS performance requirements need modification due to introduction of time-dilated UMTS.

Impact on BS performance requirements of TS 36.104 and BS conformance testing requirements of TS 36.141 due to introduction of time-dilated UMTS is not foreseen.

Direct impact on BS performance requirements of TS 37.104 and BS conformance testing requirements of TS 37.141 due to introduction of time-dilated UMTS is not foreseen.

6.1.5.2.3 UE RF core and performance requirements

6.1.5.2.3.1 UE transmitter core requirements

Several transmitter core requirements will be affected by the introduction of time-dilated UMTS. Note that the only in case of standalone time-dilated UMTS the UE is required to transmit by using a reduced bandwidth. In the following the analysis is mainly applicable to standalone time-dilated UMTS case.

The maximum transmit power depends on the PA characteristics. Unless a dedicated PA is considered as baseline architecture the maximum achievable transmit power could be considered to be the same also for time-dilated UMTS. However, the maximum transmit power used by the UE for time-dilated UMTS may be affected pending the decisions on same PSD or higher PSD for time-dilated UMTS.

The CM characteristics will change for time-dilated UMTS. The ranges of CM will need to be revisited as well as the reference waveform. Consequently the amount of allowed MPR will need to be re-discussed.

No major changes foreseen for relative code domain power accuracy.

For the following requirements:

- frequency error,
- minimum output power,
- output power dynamics,
- inner loop power control,
- out of synchronization handling of output power,
- transmit ON/OFF time mask,
- change of TFC,
- power setting in uplink compressed mode,
- HS-PDCCH transmitter power step tolerances.

Transients and measurement periods are defined according to the legacy WCDMA system. Depending on the final solution chosen in RAN1, e.g. dilation of timing, these will need to be revisited in order to achieve similar performance as for legacy UMTS.

Additionally minimum output power and ON/OFF time mask may be affected because of the required power level when a reduced bandwidth is considered.

The occupied bandwidth will change according to the decided nominal bandwidths.

SEM may need to be redesigned by taking into account that for time-dilated UMTS the bandwidth is reduced wrt to the 5MHz bandwidth used so far (the requirements are defined starting from 2.5MHz away from the carrier).
See subclause 6.1.6.3 for some initial discussion on SEM. Note that the SEM is a regulatory requirements and the emission levels of time-dilated UMTS will need to comply with the necessary limits in various country.

The ACLR is a direct measure of the interference which is leaking in adjacent spectrum. The same analysis as for BS ACLR for standalone time-dilated UMTS is applicable for UE ACLR.

For spurious emissions it should be noted that new values may need to be defined in order to protect Scalable UMTS systems (e.g. changing on the integration bandwidth and analysis of the value needed to protect other Scalable UMTS is required).

For transmit intermodulation the same discussion as for BS transmitter is applicable.

For transmit modulation (pulse shape filter, EVM, peak and relative code domain power) the same discussion as for BS transmitter is applicable.

If the same PA is considered for the UE supporting time-dilated UMTS phase discontinuity requirements may not be affected.

A table capturing the detailed summary of the new requirements which need to be introduced is missing.

6.1.5.2.3.2 UE receiver core requirements

In the time-dilated UMTS downlink, the UE would be required to receive the signal according to several possible configurations. In particular, the UE can receive a single time-dilated UMTS carrier in a *standalone* configuration, or a time-dilated UMTS carrier as a supplemental downlink carrier in a multi-carrier configuration. The scenarios and the configurations agreed will need to be introduced in the specifications and captured depending on the capability of the UE.

Changes in channel bandwidth may require changes in the UE RX RF filters. Since the concept of *flexible bandwidth* is already used in LTE, there is no technical reason why this cannot be done in UMTS; however, ,the receive channel filtering may need to be optimized for UMTS with the new bandwidth. In the following an initial assessment of the impact of time-dilated UMTS on the UE receiver core specification is provided for main RF UE core requirements.

Multi-carrier scenarios can be introduced in the specification by considering the exact operator scenario as shown in the above subclause or by considering the nominal spacing between the center carriers. In case exact operator configurations are considered the spacing between the center carriers is reduced.

REFERENCE SENSITIVITY LEVEL: New requirements need to be specified for time-dilated UMTS for both standalone and multi-carrier scenarios. If the multi-carrier scenarios as described in the above subclauses are introduced as such into the specification then new REFSENS requirements may be needed for the legacy UMTS carrier in the multi-carrier scenarios for some cases (potential impact for N=2).

One of the main UE receive core requirement is the Reference Sensitivity level (REFSENS).
REFSENS is the basis for most of the UE receiver core requirement. ACS, Blocking and Intermodulation requirements in fact are all based on the sensitivity level. These values are defined with units of dBm/3.84MHz, i.e. they assume UMTS chip rate. These requirements should be re-written for any change in chip rate and bandwidth. In addition, a new corresponding Reference Measurement Channel (RMC) for each new time-dilated UMTS chip rate needs to be defined in order to be able to measure REFSENS. Since the SNR requirement for these new RMCs may differ from the existing one for 3.84 Mcps, the REFSENS requirements need to be re-evaluated for each new chip rate.

The REFSENS depends on how the physical layer will be defined in RAN1.New requirements will be needed also for the multi-carrier configuration agreed with time-dilated UMTS and UMTS carriers.

REFSENS values could be influenced by the exact filter design of the front-end analog filter for time-dilation UMTS. However, these aspects are subject to implementation.

MAXIMUM INPUT LEVEL: New requirements need to be specified for time-dilated UMTS.

The maximum input level is defined in TS 25.101 equal to -25dBm /3.84MHz. The maximum input level is implicitly a requirement on the ADC to make sure that the ADC is capable of handling a certain dynamic range. If the ADC linearity region can be considered the same as for legacy UE then the time-dilated UMTS UE will be able to handle the corresponding input level (wrt to nominal bandwidth which will be agreed). It can be discussed further whether the maximum input level is rescaled depending on the nominal bandwidth (as it is done for multi-carrier aggregation in legacy WCDMA up to dual carrier) or if it is considered as an absolute value (independent from the bandwidth as in LTE and for legacy WCDMA for number of carriers>2).

The minimum requirements in terms of throughput vs. Ec/Ior will need to be re-evaluated for both standalone carriers and multi RAT-configurations.

ADJACENT CHANNEL SELECTIVITY: New requirements need to be specified for time-dilated UMTS for standalone and multicarrier configurations. New requirements may need to be considered for legacy UMTS carrier in the multi-carrier scenarios depending on the blocker assumption. New requirements for the legacy UMTS carrier when time-dilated UMTS is the blocker may be needed.

The introduction of time-dilated UMTS may require the definition of new interferer types which corresponds to time-dilated UMTS carrier with different nominal bandwidth. The ACS is defined in two different cases with a UMTS modulated interferer located at 5MHz wrt the center of the wanted carrier. In the case of time-time-dilated UMTS the same requirements will need to be defined at least for a time-time-dilated UMTS wanted carrier with a time-time-dilated UMTS modulated interferer located at an offset which is at least equal to the time-time-dilated UMTS bandwidth. It will need to be discussed further whether the power levels of the interferers with respect to the wanted signal could be possibly maintained, or whether changes are needed. Additionally the characteristics of the time-dilated modulated interferer may need further discussion pending decisions in RAN1 (compared to the WCDMA modulated interferer defined in Table C.7 in TS 25.101).

The requirement will need to be defined for all the time-dilated UMTS bandwidths which will be introduced in the specifications.

Whether or not to introduce ACS requirement for all the combinations of time-dilated UMTS bandwidth for the wanted signal and the interference signal need to be decided. It may be possible to limit the number of test cases as done in E-UTRA specification (ACS requirements for carrier bandwidth xMHz are defined only for an interferer xMHz wide).

New requirement will need to be defined also for the multi-carrier scenarios for configurations based on the aggregation of time-Dilation UMTS and UMTS carriers. The definition of new time-dilated UMTS interferer types may have some implications also on other RAT specifications, e.g. discussions are needed whether the

introduction of new interferer types requires the introduction of new requirements for legacy UMTS (and other RATs) in the presence of time-dilated UMTS interferers.

BLOCKING REQUIREMENTS: New requirements need to be specified for time-dilated UMTS standalone and multi-carrier configurations. New requirements may be needed for legacy UMTS carrier in the multi-carrier scenarios.

Blocking requirements include in-band blocking, out of band blocking and narrowband blocking requirements. In general new definitions of blocking requirements are required for a time-dilated UMTS carrier when the blocker is a time-dilated UMTS carrier with at least equal bandwidth for both standalone and multi-carrier scenarios.

The requirement will need to be rewritten by taking into account new channel bandwidths for the interferer and the wanted signal. As for ACS power levels and offset values need further discussions and evaluations.

In LTE for example the offset wrt the REFSENS value depends on the channel bandwidth, while the interferer is kept constant. The same approach could be considered for time-dilated UMTS; more analysis is needed on this topic. The requirement (the BER level) shall be re-evaluated depending on the new test conditions.

For all the blocking requirements, in case of multi-carrier scenarios new requirements need to be defined not only for the time-dilated UMTS carrier but also for the legacy UMTS carrier.

The in-band blocking requirement is defined for a W-CDMA modulated interferer. The new requirements shall be based on a new time-dilated UMTS modulated interferer whose characteristics may need to be modified to capture differences in power settings for the time-dilated UMTS system. The out of band blocking requirement is defined for a CW interferer located at frequencies which are more than 15MHz below or above the UE receive bands for legacy UMTS systems. The out of band blocking requirements for standalone time-dilation UMTS and for multi-carrier scenarios will need to be defined. Note that the number of exceptions for the out of band blocking requirements may need to be re-evaluated when time-dilated UMTS is considered.

The aim of the narrowband blocking requirement is to make sure that the legacy UMTS UE can cope with a GSM-like interfering signal located very close to the wanted carrier. Hence, so far, this requirement is defined only for certain bands where GSM deployment is possible. In particular the requirement is defined for Bands II, IV, V, X, XXV, XXVI, III, VIII, XII, XIII and XIV. New narrowband blocking requirements need to be specified for the time-dilated UMTS wanted signal with appropriate frequency offsets.

SPURIOUS RESPONSE: New requirements need to be specified for time-dilated UMTS standalone and multi-carrier scenarios.

Same comments apply as for blocking requirements and in particular out of band blocking.

INTERMODULATION CHARACTERISTICS: new requirements need to be specified for time-dilated UMTS standalone and multi-carrier scenarios. New requirements needed for legacy UMTS carrier in the multi-carrier scenario. New requirements for legacy UMTS may be needed (with different configuration compared to legacy narrowband intermodulation test) at least in all the bands where no narrowband intermodulation is defined.

For wideband intermodulation the same comments as for the blocking requirements (in particular in-band blocking) apply.

For narrowband intermodulation the same comments as for the blocking requirements (in particular narrowband blocking) apply.

SPURIOUS EMISSIONS: Evaluation of the applicability of the existing requirement is needed for time-dilated UMTS. The new measurement granularity may need to be considered.

Spurious emissions depend on the RF circuitry and RF filters in the UE receive chain. It is needed to verify whether the same levels are applicable for time-dilated UMTS. Additionally the measurement bandwidth and measurement granularity (200 kHz) may need to be modified to take into account new time-dilated UMTS bandwidth.

It should be noted that most of the blocking requirements (a part from out of band blocking) are defined for both single uplink and dual uplink for legacy multi-carrier UMTS. If use cases are defined in the future with more than one downlink legacy UMTS carrier aggregated to time-dilated UMTS, dual uplink case would be applicable. Hence, in this case, the blocking requirements for time-Dilation UMTS may be affected by dual

uplink depending on the position of the time-Dilation UMTS carrier in the multi-carrier configuration. In case dual uplink case is considered within the scope of the work, these requirements will need to be introduced.

Summary

Requirement	No of carriers	Requirements for time-dilated UMTS	New requirements for UMTS carrier
REFSENS	Single carrier/Standalone	New requirement needed	No
	Multi-carrier scenarios	New requirement needed	New requirement needed for the UMTS carrier(s) participating in the multi-carrier aggregation configuration with a time-Dilation UMTS carrier for N=2.
Maximum input level	Single carrier/Standalone	New requirement needed	No
	Multi-carrier scenarios	New requirement needed	No
ACS	Single carrier/Standalone	New requirements needed. Bandwidth of interferer may be considered	New requirement may be needed with time-dilated UMTS interferer for legacy UMTS.
	Multi-carrier scenarios	New requirements needed. Different bandwidths of interferer may be considered	New requirement may be needed for the UMTS carrier participating in the multi-carrier configuration with a time-dilation UMTS carrier.
In-band Blocking	Single carrier/Standalone	New requirements needed. Different bandwidths of interferer may be considered	No
	Multi-carrier scenarios	New requirements needed. Different bandwidths of interferer may be considered	New requirement may be needed for the UMTS carrier participating in the multi-carrier configuration with a time-dilation UMTS carrier.
Out of band Blocking	Single carrier/Standalone	New requirement needed	No
	Multi-carrier scenarios	New requirement needed	No
Narrowband Blocking	Single carrier/Standalone	New requirement needed	No
	Multi-carrier scenarios	New requirement needed	No
Spurious Response	Single carrier/Standalone	New requirement needed	No
	Multi-carrier scenarios	New requirement needed	No
Wideband Intermodulation	Single carrier/Standalone	New requirement needed	No
	Multi-carrier scenarios	New requirement needed	No New requirements may be needed for legacy UMTS carrier in the multi-carrier scenario.
Narrowband Intermodulation	Single carrier/Standalone	New requirement needed	New requirements for legacy UMTS may be needed (with different configuration compared to legacy narrowband intermodulation test) at least in all the bands where no narrowband intermodulation is defined.
	Multi-carrier scenarios	New requirement needed	New requirements may be needed for legacy UMTS carrier in the multi-carrier scenario. No
Spurious emissions	Single carrier/Standalone	Evaluation of the applicability of the existing requirement is needed. The new measurement granularity need to be considered.	No
	Multi-carrier aggregation	Evaluation of the applicability of the existing requirement is needed. The new measurement granularity need to be considered.	No

6.1.5.2.3.3 UE performance requirements

General

In TS 25.101, existing demodulation requirements are organised into clause 8 (performance requirements for R99 channels), clause 9 (performance requirements for HSDPA, clause 10 (performance requirements for E-DCH) and clause 11 (performance requirements for MBMS). Depending on RAN1 decisions on the functionality of a possible Scalable UMTS work item, it is anticipated that these clauses would need to be extended with requirements for time-dilated UMTS operating at all relevant chip rates. In general, the following tasks would need to be performed to extend the specification for other chip rates.

- Discussion and agreement on the relevant reference receiver types for time-dilated UMTS, e.g. whether all of type 0, type 1, type 2, type 3 and type 3i receiver types are relevant for time-dilated UMTS implementations. However, since all enhanced receiver requirements currently defined in TS 25.101 are extensions and enhancement of type 0 requirements, it is anticipated that the baseline type 0 performance needs to be accounted.

- Discussion and agreement of the general framework and test case list for time-dilated UMTS. Not all test cases for 3.84 Mcps may be relevant for time-dilated UMTS depending on future decisions about the functionalities that are defined for time-dilated UMTS. For example, it is necessary to understand whether Rel-11 or Rel-12 UTMS features are included in time-dilated UMTS in the first instance. In addition, the UE demodulation performance may be considered partially verified already by the existing test cases, assuming that all time-dilated UMTS UEs are also required to support 3.84 Mcps operation. However, it would also be necessary to ensure good requirements coverage at fractional chip rates, to ensure the expected time-dilated UMTS system performance in practical deployments.

- Discussion and agreement of reference measurement channels and OCNS modelling for time-dilated UMTS

- Discussion and agreement of propagation conditions for time-dilated UMTS. This has been discussed to an extent during the study item and further considerations are provided below

- Alignment simulations of time-dilated UMTS cases.

- Simulation of impairment margins and agreement of requirements based on some agreed methodology e.g. averaging of results.

- Change requests to introduce time-dilated UMTS requirements to TS 25.101

Channel modelling

Existing test cases in clause 8 of TS 25.101 use chip spaced channel models for case 1-4 and case 6 as shown in table 6.1.5.2.3.3-1.

Table 6.1.5.2.3.3-1: Propagation conditions for multi-path fading environments (Cases 1 to 6)

Case 1		Case 2		Case 3		Case 4		Case 5 (Note 1)		Case 6	
Speed for Band I, II, III, IV, IX, X and XXV: 3 km/h		Speed for Band I, II, III, IV, IX, X and XXV: 3 km/h		Speed for Band I, II, III, IV, IX, X and XXV: 120 km/h		Speed for Band I, II, III, IV, IX, X and XXV: 3 km/h		Speed for Band I, II, III, IV, IX, X and XXV: 50 km/h		Speed for Band I, II, III, IV, IX, X and XXV: 250 km/h	
Speed for Band V, VI, VIII, XIX, XX and XXVI: 7 km/h		Speed for Band V, VI, VIII, XIX, XX and XXVI: 7 km/h		Speed for Band V, VI, VIII, XIX, XX and XXVI: 282 km/h (Note 2)		Speed for Band V, VI, VIII, XIX, XX and XXVI: 7 km/h		Speed for Band V, VI, VIII, XIX, XX and XXVI: 118 km/h		Speed for Band V, VI, VIII, XIX, XX and XXVI: 583 km/h (Note 2)	
Speed for Band VII: 2.3 km/h		Speed for Band VII: 2.3 km/h		Speed for Band VII: 92 km/h		Speed for Band VII: 2.3 km/h		Speed for Band VII: 38 km/h		Speed for Band VII: 192 km/h	
Speed for Band XI, XXI: 4.1 km/h		Speed for Band XI, XXI: 4.1 km/h		Speed for Band XI, XXI: 166 km/h		Speed for Band XI, XXI: 4.1 km/h		Speed for Band XI, XXI: 69 km/h		Speed for Band XI, XXI: 345 km/h (Note 2)	
Speed for Band XII, XIII, XIV 8 km/h		Speed for Band XII, XIII, XIV 8 km/h		Speed for Band XII, XIII, XIV 320 km/h		Speed for Band XII, XIII, XIV 8 km/h		Speed for Band XII, XIII, XIV 133 km/h		Speed for Band XII, XIII, XIV 668 km/h	
Speed for Band XXII: 1.7 km/h		Speed for Band XXII: 1.7 km/h		Speed for Band XXII: 69 km/h		Speed for Band XXII: 1.7 km/h		Speed for Band XXII: 29 km/h		Speed for Band XXII: 143 km/h	
Relative Delay [ns]	**Relative Mean Power [dB]**	**Relative Delay [ns]**	**Relative Mean Power [dB]**	**Relative Delay [ns]**	**Relative Mean Power [dB]**	**Relative Delay [ns]**	**Relative Mean Power [dB]**	**Relative Delay [ns]**	**Relative Mean Power [dB]**	**Relative Delay [ns]**	**Relative Mean Power [dB]**
0	0	0	0	0	0	0	0	0	0	0	0
976	-10	976	0	260	-3	976	0	976	-10	260	-3
		20000	0	521	-6					521	-6
				781	-9					781	-9

NOTE 1: Case 5 is only used in TS 25.133.
NOTE 2: Speed above 250 km/h is applicable to demodulation performance requirements only.

Case channel models are also used for CQI test in multi-path fading and HS-SCCH-less demodulation of HS-DSCH as shown in table 6.1.5.2.3.3-2

Table 6.1.5.2.3.3-2: Propagation conditions for CQI test in multi-path fading and HS-SCCH-less demodulation of HS-DSCH

Case 8, **Speed for Band I, II, III, IV, IX, X and XXV: 30 km/h** **Speed for Band V, VI, VIII, XIX, XX and XXVI: 71 km/h** **Speed for Band VII: 23 km/h** **Speed for Band XI, XXI: 41 km/h** **Speed for Band XII, XIII, XIV: 80 km/h** **Speed for Band XXII: 17 km/h**	
Relative Delay [ns]	Relative mean Power [dB]
0	0
976	-10

To develop corresponding channel models for time-dilated UMTS, two possible approaches can be envisaged. The relative delay may be scaled according to the chip rate (e.g. multiplied by 2 or 4 for ½ or ¼ chip rate time-dilated UMTS). In principle, this should give quite similar performance to the 3.84 Mcps performance level since the channel profile is scaled equivalently to the chip rate itself. Alternatively, if the channels are considered to have physical meaning based on typical conditions experienced in deployments, they may be used unscaled which means that the time-dilated UMTS receiver will experience shorter relative delays in units of chips, compared to the full chip rate receiver. Thus, somewhat different performance levels can be anticipated.

For HSDPA, ITU channel models are used to verify the performance as shown in table 6.1.5.2.3.3-3.

Table 6.1.5.2.3.3-3: Propagation conditions for multi-path fading environments for HSDPA performance requirements

ITU Pedestrian A Speed 3 km/h (PA3)		ITU Pedestrian B Speed 3 km/h (PB3)		ITU vehicular A Speed 30 km/h (VA30)		ITU vehicular A Speed 120 km/h (VA120)	
Speed for Band I, II, III, IV, IX, X and XXV 3 km/h		Speed for Band I, II, III, IV, IX, X and XXV 3 km/h		Speed for Band I, II, III, IV, IX, X and XXV 30 km/h		Speed for Band I, II, III, IV, IX, X and XXV 120 km/h	
Speed for Band V, VI, VIII, XIX, XX and XXVI 7 km/h		Speed for Band V, VI, VIII, XIX, XX and XXVI 7 km/h		Speed for Band V, VI, VIII, XIX, XX and XXVI 71 km/h		Speed for Band V, VI, VIII, XIX, XX and XXVI 282 km/h (Note 1)	
Speed for Band VII 2.3 km/h		Speed for Band VII 2.3 km/h		Speed for Band VII 23 km/h		Speed for Band VII 92 km/h	
Speed for Band XI, XXI: 4.1 km/h		Speed for Band XI, XXI: 4.1 km/h		Speed for Band XI, XXI: 41 km/h		Speed for Band XI, XXI: 166 km/h (Note 1)	
Speed for Band XII, XIII, XIV 8 km/h		Speed for Band XII, XIII, XIV 8 km/h		Speed for Band XII, XIII, XIV 80 km/h		Speed for Band XII, XIII, XIV 320 km/h	
Speed for Band XXII: 1.7 km/h		Speed for Band XXII: 1.7 km/h		Speed for Band XXII: 17 km/h		Speed for Band XXII: 69 km/h	
Relative Delay [ns]	**Relative Mean Power [dB]**	**Relative Delay [ns]**	**Relative Mean Power [dB]**	**Relative Delay [ns]**	**Relative Mean Power [dB]**	**Relative Delay [ns]**	**Relative Mean Power [dB]**
0	0	0	0	0	0	0	0
110	-9.7	200	-0.9	310	-1.0	310	-1.0
190	-19.2	800	-4.9	710	-9.0	710	-9.0
410	-22.8	1200	-8.0	1090	-10.0	1090	-10.0
		2300	-7.8	1730	-15.0	1730	-15.0
		3700	-23.9	2510	-20.0	2510	-20.0

Since the ITU channel models have relative delays which are not related to the chip rate of the UE and are representative of conditions experienced in deployment, it would not be appropriate to scale the relative delays of channel taps. Therefore, the UE performance can be expected to be somewhat different from 3.84 Mcps performance, even in alignment simulations, since the UE receiver experiences a different tap delay relative to its own chip rate.

Subject to the availability of MBMS and MBSFN with time-dilated UMTS in the work item, similarly channel models used for MBMS (TS 25.101 table B.1.D) and MBSFN (TS 25.101 table B.1.E) testing are based on conditions which may be considered relevant for practical deployment, and would not be scaled for time-dilated UMTS.

A number of channels have been defined for stress testing of the UE receiver and need special consideration. These are moving propagation conditions (B.2.3), birth death propagation conditions (B.2.4) and high speed train condition (B.2.5). For moving propagation conditions and birth death propagation conditions, RAN4 should discuss the relevant stress tests for a lower chip rate receiver. For high speed train condition, the characteristics depend on train velocity, distances between the node Bs and distance between each node B and the track. Therefore it is not anticipated that high speed train propagation condition would be modified for the work on time-dilated UMTS, although the UE performance with the different chip rates needs to be simulated.

Finally, MIMO propagation conditions defined in TS 25.101 annex B.2.6.1, B.2.6.2 and B.2.6.3 may be straightforwardly reused for time-dilated UMTS since the channels are all single tap channel.

6.1.5.2.4 RRM requirements

A number of existing RRM requirements defined for the UE and Node B measurements are met over certain physical layer measurement period or evaluation time. These existing RRM requirements are defined for the current chip rate and bandwidth of 3.84 Mcps and 5 MHz respectively. Furthermore a number of RRM requirements are defined under certain side conditions or signal levels e.g. SCH Ec/Io, CPICH Ec/Io, CPICH RSCP, Io levels etc.

In time-dilated UMTS due to reduction in chip rate for bandwidths smaller than 5 MHz the information will be sent over a time period longer than that used in case of legacy UMTS (i.e. 5 MHz) assuming the spreading factor remains the same. For example P-CPICH in time-dilated UMTS is sent using the existing SF=256 but will be spread over time if the chip rate is reduced to 1.92 Mcps for channel bandwidth of 2.5 MHz. For time-dilated UMTS, it is desirable to keep the side conditions the same to ensure same coverage as in the legacy UMTS. Impact on UE and Node B related RRM requirements due to introduction of time-dilated UMTS is analyzed in the next sub clauses.

In order to verify the RRM core and performance requirements a number of test cases are defined in the annex A of TS 25.133 and TS 36.133. Therefore any impact on the RRM core or performance requirements will affect the corresponding test cases defined in the annex A of TS 25.133 and annex A of TS 36.133. The RRM conformance tests in TS 34.121 and TS 36.521-3 are developed by RAN5 based on RRM tests in the annex A of TS 25.133 and TS 36.133 respectively. Therefore any impact on the RRM core or performance requirements will also affect RAN5 specifications TS 34.121 and TS 36.521-3.

6.1.5.2.4.1 UE RRM requirements

Two major concerns were raised on time-dilated UMTS RRM performance:

- L1 measurement period and corresponding measurement accuracy;
- Additional signalling overhead wrt the time-dilated factor.

Both aspects have been extensively addressed in [10] and [11].

Based on one company's extensive simulation results, it was shown that almost all UE RRM measurement requirements defined in TS 25.133 are not affected if the measurements on time-dilated UMTS carrier are also time-dilated. The exception was the measurement requirements in CELL_FACH state when HS-DSCH discontinuous reception is ongoing with 2nd DRX. It should be noted that 2nd DRX is an optional feature in Rel-11 and this impact may be eliminated by some searcher optimization. The analysis assumed a natural time-dilated of measurements compared to the legacy UMTS measurements implying potential additional current consumption due to the increase in "ON" time for measurements.

On the other hand, if the duration of each measurement on time-dilated UMTS carrier is kept the same as the existing UMTS [12], [13], the following list of UE RRM requirements defined in TS 25.133 may be expected to be affected if measurement is done on time-dilated UMTS carrier. Due to lack of adequate studies and analysis under this assumption, it will require detailed analysis to confirm the impact.

- Evaluation period in cell reselection:
  - Intra-frequency case in idle, CELL_PCH and URA_PCH states
  - Inter-frequency case in idle, CELL_PCH and URA_PCH states
- Cell identification delay related requirements:
  - Intra-frequency cell identification delay in CELL_FACH and CELL_DCH states
  - Inter-frequency cell identification delay in CELL_FACH and CELL_DCH states
- UE measurement related requirements: delay and measurement accuracies:
  - Intra-frequency CPICH measurements (CPICH RSCP and Ec/No)
  - Inter-frequency CPICH measurements (CPICH RSCP and Ec/No)
  - Intra-frequency SFN-CFN observed time difference
  - Inter-frequency SFN-CFN observed time difference

- Intra-frequency SFN-SFN observed time difference Type 1 and Type 2
- Inter-frequency SFN-SFN observed time difference Type 1 and Type 2
- UE Rx-Tx time difference Type 1
- UE Rx-Tx time difference Type 2
- UE transmission power headroom
- System information acquisition for intra-frequency CSG cell
- System information acquisition for inter-frequency CSG cell

- Inter-RAT time-dilated UMTS carrier when serving cell is E-UTRA.
  - Evaluation period in cell reselection:
    - Inter-RAT UTRA FDD case in RRC_IDLE state
  - Cell identification delay related requirements:
    - Inter-RAT UTRA FDD cell identification delay in RRC_CONNECTED state
  - UE measurement related requirements: delay and measurement accuracies:
    - Inter-RAT UTRA FDD CPICH measurements
      - CPICH RSCP and
      - CPICH Ec/No
    - System information acquisition for inter-RAT UTRA FDD CSG cell

6.1.5.2.4.2 BS RRM requirements

Similarly to UE RRM requirements impact, it is expected that NodeB RRM measurement requirements defined in TS 25.133 are not affected if the measurements on time-dilated UMTS carrier are also time-dilated. This implies potential additional current consumption due to the increase in ON time for measurements.

On the other hand, if the duration of each measurement on time-dilated UMTS carrier is kept the same as the existing UMTS, a number of base station related RRM measurement requirements defined in TS 25.133 is expected to be affected for measurements on time-dilated UMTS carrier. These measurement requirements are defined in terms of physical layer measurement period and corresponding accuracy to be met under certain side conditions.
The BS measurement related requirements potentially to be affected are:

- Received total wideband power
- SIR
- Transmitted carrier power
- Transmitted code power
- Round trip time
- UTRAN GPS Timing of Cell Frames for UE positioning
- SFN-SFN time difference
- Transmitted carrier power of all codes not used for HS-PDSCH, HS-SCCH, E-AGCH, E-RGCH or E-HICH transmission
- DL Transmission Branch Load
- Received Scheduled E-DCH Power Share (RSEPS)

Due to lack of adequate studies and analysis under this assumption, it will require detailed analysis to confirm the impact.

6.1.5.2.4.3 Additional observation related to RRM

For the signalling overhead wrt the time-dilated factor, an efficient signalling mechanism could be designed for the communication of the Scalable UMTS time-dilated factor N, where N is equal to 2 or 4 for Scalable UMTS N=2 and Scalable UMTS N=4, respectively. For example, a signalling mechanism has been proposed in [11]. Hence a Scalable UMTS carrier becomes nothing but an inter frequency in a different band from an existing RAT perspective. As a result, the work required for introducing additional band can be expected to happen in standards to introduce Scalable UMTS in certain bands.

A time-dilated UMTS capable UE will have to perform blind search of the chip rate used on UMTS carriers searched during an initial cell search procedure aka frequency search or band scanning. However, it should be noted that this is similar to have additional band scanning for a multi-band capable UE compared to a single-band capable UE.
For example, if the UE supports legacy UMTS and time-dilated UMTS N=2 in the same band, the complexity of band scanning would be similar to the case when the UE supports legacy UMTS in two different bands.

6.1.5.3 Impact to GERAN1 specifications and coexistence

Void.

6.1.5.4 Impact to RAN3 specifications

Different NodeBs may not support the same chip rates. Furthermore, there will also be mixture of legacy NodeB and new NodeB capable of additional chip rate(s) operating in the same coverage area. In order for the RNC to communicate chip rates on different cells or carriers to the UE for measurements, the RNC will have to acquire the NodeBs capability of supporting different chip rates and also the currently used chip rate in the NodeBs. This may also affect signalling and procedures defined in RAN3 specifications covering NBAP, Iur, and Iu; e.g. TS 25.433, TS 25.423, TS 25.434, TS 25.435 etc. Therefore we foresee implication of time-dilated solution also on the procedures defined in RAN3.

- It is foreseen that the RNC needs to communicate chip rates on different cells or carriers to the UE for measurements. Therefore the RNC also needs to acquire the NodeB's capability of supporting different chip rates and also the currently used chip rate used by different NodeBs, which are included in the neighbour cell list signalled to the UE for measurements.
- Capability signalling (impact AUDIT RESPONSE message);
- SRNC needs to find out the time-dilated UMTS related parameters (e.g. chip rate, …) for external cells.
- The "Neighbouring UMTS Cell Information" IE needs be modified to contain time-dilated UMTS information.
- The INFORMATION EXCHANGE INITIATION REQUEST message which can be used by one RNC to request another RNC to provide information about indicated cells.
- The Requested Data Value IE or the ANR Cell Information IE in the Requested Data Value IE in the INFORMATION EXCHANGE INITIATION RESPONSE message needs be updated to allow inclusion of time-dilated UMTS information for the requested cells.
- Potential need to update the UPLINK SIGNALLING TRANSFER INDICATION.

6.1.5.5 Impact to RAN5 specifications

For all impact on L1, L2, L3 and RF/RRM, this will spread to the RAN5 test cases to:

1) provide test coverage for time-dilated UMTS aspects; and
2) to create variants or update existing test cases that do not specifically verifies time-dilated UMTS to be able to be run on UEs supporting time-dilated UMTS.

NOTE: One cannot just insert a scaling factor of "N" everywhere. E.g. TS 34.108 needs to be updated with all new bearer combinations that are needed.

New tests specific to time-dilated UMTS would be introduced, but also a number of basic or legacy tests will not work. Hence, there is a need to redefine all tests for any core/performance requirements which would be affected by time dilation solution. For instance, with introduction of MIMO, one does not have to add new tests for legacy requirements, like cell reselection, measurement accuracy, cell search, etc. For time-dilated UMTS, there might be a need to redefine lots of basic tests for each new chip rate introduced (I.e. even those tests which were developed in R99).
A particular challenge arises in TS 34.108 if absolute bit rate should be kept same with time-dilated UMTS solution. Doing 12.2 kbps AMR requires new RB mapping since one needs to have one AMR frame per 20 ms (UMTS: 2 radio frames, time-dilated UMTS: 1 radio frame). Also, SRB 3.4 kbps is low already today, reducing that to 1.7 kbps is not good, hence new mappings of SRB are needed. Thus, there might be a need to create variants for a number of prioritized DCH RB combinations. Any impact on the RRM core or performance requirements will affect the corresponding test cases defined in the annex A of TS 25.133 and annex A of TS 36.133. For example, if cell identification delay is extended for lower chip rate, then test requirements in the tests verifying such requirements will have to be modified. For example, test times that are tailored for the test requirements (e.g. delay/measurement period) need to be modified, new reference measurement channels to be defined and new parameters like chip rate, bandwidth, etc., will have to be included. For clarity, a good approach would be to redefine a new set of test cases for all lower chip rates. This will however heavily affect RAN5 conformance testing.

Impacted specifications are:

- TS 34.108 (common test environment, default messages, radio bearer definitions);
- TS 34.121-1 (RF/RRM test cases);
- TS 34.121-2 (Applicability, Implementation Conformance Statements (ICS) for RF/RRM test cases);
- TS 34.123-1 (Protocol test cases);
- TS 34.123-2 (Applicability, Implementation Conformance Statements (ICS) for protocol test cases);
- TS 34.123-3 (TTCN test model for time-dilated UMTS solution).

6.1.6 Impacts on coexistence

According to an LS sent by RAN1, the following scenarios are possible for time-dilated UMTS deployment:

Table 6.1.6-1: Potential scenarios for time-dilated UMTS

Mode of Operation	Bandwidth	Comments	Bands
Standalone	2.5Mhz (corresponds to N=2)	Support for DCH shall be considered.	Band VIII as the first band to consider
Standalone	1.25Mhz (corresponds to N=4)	HSPA data only	Band VIII as the first band to consider
Multi-carrier	5MHz + 2.5 MHz (corresponds to N=2) 5 MHz+ 1.25 MHz (corresponds to N=4)	6 MHz of contiguous band to consider first	Band VIII as the first band to consider
Standalone	2.5Mhz (corresponds to N=2)	To understand the impact of band	Band I as the first band to consider

NOTE 1: Multi-carrier 5 MHz + 2.5 MHz in 6 MHz can be de-prioritized.

NOTE 2: Assumption on Occupied BW for a single Scalable UMTS carrier:
- $B_{Scalable\ UMTS}(x) = (5MHz/N - x)$, x=0 as the common assumption.
- Interested companies can study x>0. Results and conclusion can be captured in the present document for each case.

NOTE 3: For multi-carrier case, half of the occupied BW of each carrier shall be maintained toward the edge of the available spectrum.

In RAN4 #67 it was decided to investigate the following area:

- NodeB transmitter characteristics against the existing TS 25.104 (Standalone) and TS 37.104 (Multi-carrier)
  - Metric: ACLR, UEM
  - Scenarios: Multi-carrier and Standalone
- UE transmitter characteristics against the existing TS 25.101
  - Metric: ACLR, SEM
  - Scenarios: Standalone
- NodeB receiver blocking compared to the existing TS 25.104 (Standalone) and TS 37.104 (Multi-carrier)
  - Metric:
    - Band I: ACS and in-band blocking
    - Band VIII: ACS, in-band blocking and narrow band blocking
  - Scenarios: Standalone
- UE receiver blocking compared to the existing TS 25.101
  - Metric
    - Band I: ACS and in-band blocking
    - Band VIII: ACS, in-band blocking and narrow band blocking
  - Scenarios: Multi-carrier and Standalone

Under the following assumptions

- PSD: Same PSD, Same Power, Other PSD
- PA for multi-carrier BS: A common PA, separate PAs
- BS: Wide area BS
- Multi-carrier BW assumption
  - Nominal spacing
  - 6 MHz
- Note that the following assumptions are considered in RAN1 for the analysis:
  - The distance from the center carrier frequency to the band edge should be at least 2.5 MHz for legacy UMTS carriers and 2.5/N MHz for 5/N MHz scalable UMTS carriers.
  - A 5 MHz nominal bandwidth shall be considered for legacy UMTS
  - For the 3.84/N Mcps carrier, a 5/N MHz bandwidth is assumed. The carrier separation depends on the specific scenario.

6.1.6.1 BS transmitter characteristics

ACLR and SEM are two requirements which limit the interference level to adjacent systems. RAN4 has conducted initial evaluation considering current UMTS SEM and ACLR requirement for time-dilated UMTS carrier.
The following observations were made:

- As the bandwidth decrease, the margin between signal spectrum and UMTS mask at the bandwidth edge also decrease;
- The margin between spectrum and UMTS mask at the bandwidth edge is smaller for the same power case than that for the same PSD case;
- For FCC regulatory requirement, -13dBm requirements shall be fulfilled in narrower bandwidth.

In addition, several options of spectrum emission mask for time-dilated UMTS are also discussed [4][5][6]:

Option 1: UMTS mask

- One company's results show that UMTS mask (without additional offset) can be met [4][5]. However, UMTS mask feasibility for time-dilated UMTS as minimum requirements requires further study.

Option 2: MSR BC2 mask applied for all the bands

- It is feasible to meet MSR BC2 mask defined in TS 37.104 for time-dilated UMTS for all the bands.

Option 3: Follow MSR specification (as done for LTE with narrow carrier), i.e. BC1 mask for BC1 bands such as band I and BC2 mask for BC2 bands such as band VIII

- It is feasible to meet MSR BC1 mask for BC1 bands time-dilated UMTS and BC2 mask for BC2 bands time-dilated UMTS
- According to BC1 mask defined in 37.104 the requirements for receiver and transmitter shall apply with a frequency offset from the lowest and highest carriers to the RF bandwidth edges ($F_{offset, RAT}$) equal to $BW_{Channel}/2$ + 200 kHz . This implies that the distance from the center carrier frequency to the band edge should be at least 2.5/N MHz +200 kHz for 5/N MHz time-dilated UMTS carriers. Additional offset introduced by this mask may have implication on the multi-carrier scenarios agreed in RAN1. It may or may not affect conclusions in RAN1 study for the multi-carrier scenario.

Option 4: MSR BC1 mask for all the bands

- It is feasible to meet MSR BC1 mask for time-dilated UMTS. Same comments as for option 3 apply.

For ACLR requirement, based on one company's measurement results [4], we have observations as below:

- Time-dilated UMTS (same PSD or same power) has comparable ACLR toward UMTS and time-dilated UMTS systems when compared to UMTS.

- UMTS has comparable ACLR toward time-dilated UMTS systems when compared to UMTS to UMTS ACLR.

6.1.6.2 BS receiver characteristics

From BS receiver side, legacy UMTS/LTE BS receiver performance such as ACS and in-band blocking requirements should be investigated in presence of time-dilated UMTS interference because of the closer interference frequency offset from the RF bandwidth edge and possible higher interference PSD level. It may cause additional interference to the receiver and impact performance of existing receivers of those in-field BS as currently there is no requirement to satisfy rejection of signal with such parameters.

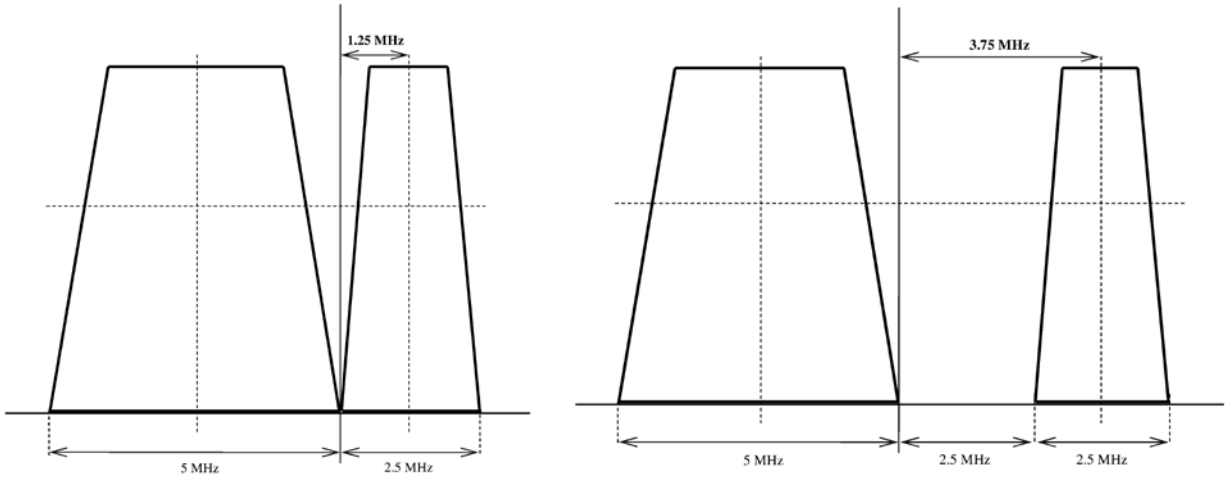


Figure 6.1.6.2-1 Minimum offset of adjacent channel signal for 2.5 MHz scalable UMTS

Based on the analysis from two companies [8][14], in the current specifications, the narrow band blocking requirement is more stringent than the ACS requirement with interference of time-dilated UMTS carrier. The narrow band blocking interference with GMSK modulated signal has higher interfering power, narrower interfering bandwidth and closer frequency offset compared with adjacent time-dilated UMTS interference, but shares the same sensitivity degradation with current ACS requirement (6 dB desensitisation). From this point of view, for the BS in the band which has narrow band blocking requirement like Band VIII, the impact of introducing time-dilated UMTS carrier would be further reduced because of the stricter design to resist narrow band blocking interference. For the band which has no narrow band blocking requirement, further analysis needs to be done, for example for Band I. Another issues might be connected with existing blocking performance as currently there are no requirements to satisfy rejection of -40 dBm interfering signal with the offset of 3.75 MHz for N=2 and 1.875 MHz for N=4 (see Figure 6.1.6.2-1).

Based on the test results on some commercial BS provided by one company [7], it is shown that time-dilated UMTS interfering signal affects legacy BS receiver in a similar way as the legacy UMTS interferer, regardless of whether the time-dilated UMTS interfering signal has the same power or the same PSD as the legacy UMTS interfering signal. The same conclusion is expected to be valid for LTE and GSM.

6.1.6.3 UE transmitter characteristics

One company has provided analysis on coexistence in [15, 16] against the existing TS 25.101 requirements.

From the analysis provided in [15, 16] the following observations can be done:

- For occupied bandwidth: Measurements in [16] show that the requirements for time-dilated UMTS occupied bandwidth is consistent with UMTS/N
- SEM: One company observation is that measurements in [16] and simulation results in [15] show that UMTS mask can be met without additional offset. As the bandwidth decrease, the margin between signal spectrum and UMTS mask at the bandwidth edge also decrease;
  - The margin between spectrum and UMTS mask at the bandwidth edge is smaller for the same power case than that for the same PSD case;
  - UMTS mask feasibility for time-dilated UMTS as minimum requirements requires further study.

- ACLR values are comparable to those obtained with legacy UMTS carrier for the first adjacent carrier.
  The legacy UMTS cannot maintain the performance of legacy alternate channel rejection ratio if the first and second adjacent carriers are time-dilated UMTS carriers.

6.1.6.4 UE receiver characteristics

One company has provided analysis on UE rx requirements related to coexistence against the existing TS 25.101 requirements. The following observations are derived from the results shown in [17] by one company, they may not represent averaged results across the companies in RAN4.

From the analysis provided in [17] the following observations can be done:

- Time-dilated UMTS UE shows degraded margins wrt to REFSENS compared to legacy UMTS UE.
- For ACS when a time-dilated UMTS jammer (with same power offset as in legacy test) interferes with a legacy UMTS victim, an increased margin is observed compared with legacy UMTS reception in presence of legacy UMTS jammer.
  - When the jammer level is decreased (such that the PSD of time-dilated UMTS jammer is same as the PSD of the UMTS jammer) an increased margin is observed.
  - ACS for legacy UMTS carrier in presence of N time-dilated interference has not be addressed.
- Time-dilated UMTS (N=2) receiver has decreased margin compared to an UMTS receiver in presence of a UMTS jammer.
- For in-band scenarios, comparable performance was observed for time-dilated UMTS receiver performance.
- time-dilated UMTS receiver shows comparable results for narrowband blocking compared to legacy UMTS carrier
- The observation above is applicable for multi-carrier scenarios when the nominal spacing is maintained.
  If the multi-carrier scenarios as described in the above clauses are introduced as such into the specification, further study is needed.

6.1.7 User plane latency analysis

6.1.7.1 Downlink user plane latency analysis

Figure 6.1.7.1-1 illustrates the HS-DSCH HARQ process timing with 2 ms TTI and 8 HARQ processes.

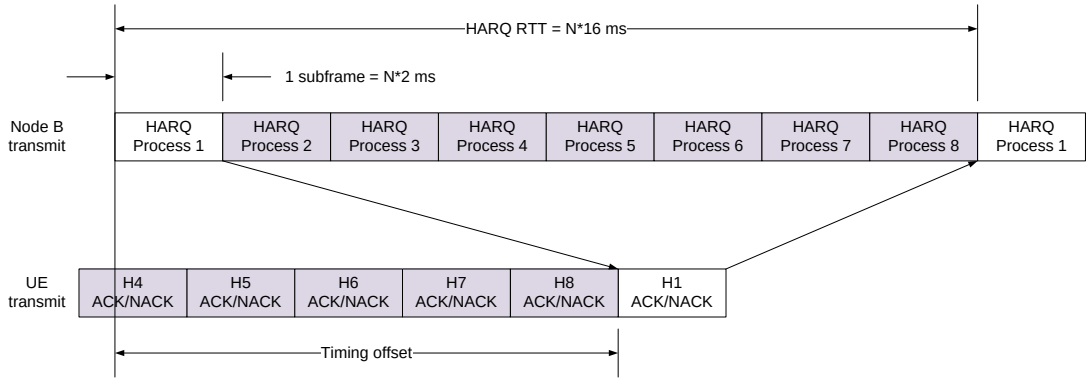


Figure 6.1.7.1-1: HS-DSCH HARQ process timing with normal UMTS TTI = 2 ms and 8 HARQ processes

Table 6.1.7.1-1 captures the HS-DSCH user plane latency impact per HARQ process for time-dilated UMTS. Here we assume a target of 10% BLER after the 1st transmission and a maximum of 2 transmissions.

Table 6.1.7.1-1: HS-DSCH user plane latency impact per HARQ process

Item	Normal UMTS latency (ms)	Time-Dilated UMTS N=2 latency (ms)	Time-Dilated UMTS N=4 latency (ms)	ΔN=2 (ms)	ΔN=4 (ms)
Time taken for MAC PDU transmission	2	4	8	2	6
Time to allow for HARQ	1.4 (=0.9*2+0.1*8*2 – 2)	2.8	5.6	1.4	4.2
Queuing delay (e.g., TTI/2)	1	2	4	1	3
HS-SCCH delay (i.e. 2 slots)	1.33	2.67	5.33	1.33	4
Total	**5.73**	**11.47**	**22.93**	**5.73**	**17.2**

6.1.7.1.1 Example: web page download user plane latency over Uu interface

The median Web page sizes used in this analysis are ≈ 150 kbyte to 1500 kbyte. Assuming that there are 1500 byte per IP packet, this translates into ≈ 100 to 1000 IP packets per Web page.

An estimate of the Web page download user plane latency over the Uu interface is shown in Table 6.1.7.1.1-1 for normal UMTS and the time-dilated UMTS. Two cases are analyzed:

- Case A: 100 IP packets per Web page;
- Case B: 1000 IP packets per Web page.

The Web page download user plane latency over the Uu interface ($Web_page_{latency_Uu}$) was estimated as a function of the number of MAC PDUs per IP packet (MAC_PDU_{IP}).

Not captured in Table 6.1.7.1.1-1 is the fact that the request-response nature of HTTP leads to multiple round trips being required to retrieve objects such as an image, JavaScript, CCS file, etc., where the median number of objects per Web page is **≈** 13 for a 150 kbyte Web page and **≈** 95 for a 1500 kbyte Web page. During this time the Uu interface may be under-utilized. This, coupled with Web browser processing delays and server load, leads to Web browsing delays saturating once the channel rate is sufficiently high (i.e., when the number of MAC PDUs per IP packet is small).

Table 6.1.7.1.1-1: Web page download user plane latency over Uu interface

Number of MAC PDUs per IP packet (MAC_PDU_{IP})	Number of MAC PDUs required for Web page download ($MAC_PDU_{Web_page}$)		Web page download user plane latency over Uu interface (s) ($Web_page_{latency_Uu}$) NOTE					
			Case A			Case B		
	Case A	Case B	N=1	N=2	N=4	N=1	N=2	N=4
1	100	1000	1.013	2.026	4.052	10.13	20.26	40.52
2	200	2000	2.026	4.052	8.104	20.26	40.52	81.04
3	300	3000	3.039	6.078	12.156	30.39	60.78	121.56
4	400	4000	4.052	8.104	16.208	40.52	81.04	162.08
5	500	5000	5.065	10.13	20.26	50.65	101.30	202.60
6	600	6000	6.078	12.156	24.312	60.78	121.56	243.12
7	700	7000	7.091	14.182	28.364	70.91	141.82	283.64
8	800	8000	8.104	16.208	32.416	81.04	162.08	324.16
NOTE: Assuming E-DCH TTI=2 ms, $Web_page_{latency} = MAC_PDU_{IP} \times MAC_PDU_{Web_page} \times ((0.00573 + 0.0044) \times N)$								

6.1.7.1.2 Lab test results

Figure 6.1.7.1.2-1 illustrates the test lab setup used during testing of normal UMTS and time-dilated UMTS N=2.
In the test lab setup, the two main parameters that were controlled were channel type and cell geometry. Fading was introduced using a channel emulator. Geometry was controlled using a single source of interference. A laptop PC was connected to the UE and it was the client for all of the applications evaluated. UE dual antenna receive diversity was used during testing.

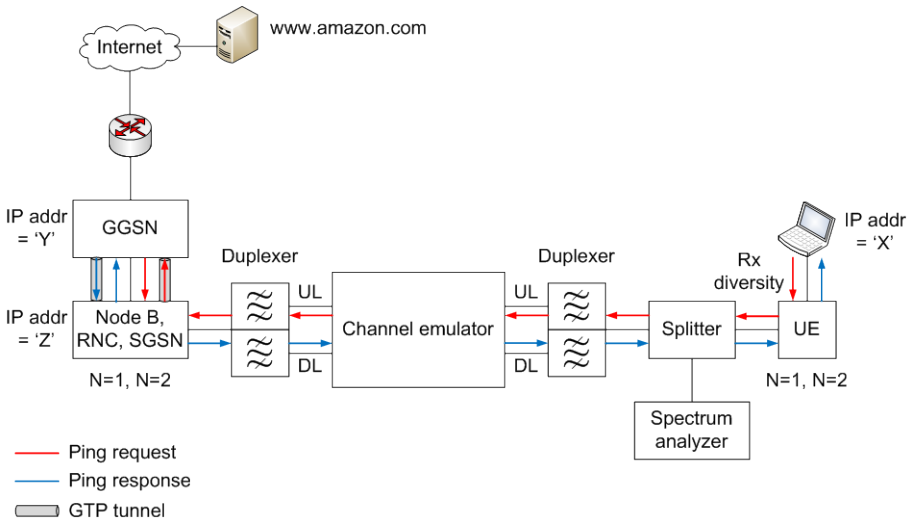


Figure 6.1.7.1.2-1: Test lab setup used for testing of normal UMTS and time-dilated UMTS N=2

Table 6.1.7.1.2-1 provides the Node B transmit power allocation used during testing.

Table 6.1.7.1.2-1: Node B transmit power allocation used during testing

Node B transmit power allocation	Normal UMTS (N=1)	Time-Dilated UMTS N=2	Comments
Maximum total Node B transmit power	$P_{t_max_N=1}$ = 'X' dBm	$P_{t_max_N=2} = P_{t_max_N=2} - 3$ dB	Time-Dilated UMTS N=2 PSD same as normal UMTS
PCCPCH_1 transmit power	Ec/Ior = -12 dB (6.3% of $P_{t_max_N=1}$)	Ec/Ior = -12 dB (6.3% of $P_{t_max_N=2}$)	For Time-Dilated UMTS N=2, a single PCCPCH was used with Ec/Ior = - 9 dB (12.6% of $P_{t_max_N=2}$)
PCCPCH_2 transmit power	Not applicable	Ec/Ior = -12 dB (6.3% of $P_{t_max_N=2}$)	
CPICH transmit power	$P_{t_CPICH_N=1}$ = 'Y' dBm	$P_{t_CPICH_N=2} = P_{t_CPICH_N=1} - 3$ dB	Time-Dilated UMTS N=2 PSD same as normal UMTS
HS-PDSCH, HS-SCCH, E-AGCH, E-RGCH and E-HICH total transmit power	$P_{t_HS\text{-}PDSCH_N=1}$ = 'Z' dBm	$P_{t_HS\text{-}PDSCH_N=2} = P_{t_HS\text{-}PDSCH}$ - 3 dB – PCCPCH_2 (NOTE)	Time-Dilated UMTS N=2 PSD same as normal UMTS
NOTE: Values need to be converted from dBm to W before calculating $P_{t_HS\text{-}PDSCH_N=2}$.			

Table 6.1.7.1.2-4 provides the lab test results.

Table 6.1.7.1.2-4: Lab test results

Channel type	Cell Geometry (dB)	Ping latency (ms) (NOTE)		Web page download time (s) amazon.com			
		N=1	N=2	N=1	N=1	N=2	N=2
AWGN	0	41-82 (63)	56-79 (62)	4	4	7	6.5
	5	57-76 (60)	41-82 (63)	2.5	3	4	4
	10	57-80 (63)	57-76 (60)	2.5	2.5	2.5	3
	20	57-81 (65)	51-82 (65)	2	2	2	2
PA3	0	41-82 (63)	56-78 (63)	4	4	8.5	7.5
	5	50-87 (61)	41-82 (63)	3	3	4	4
	10	41-82 (59)	49-89 (63)	2	2.5	4	4
	20	57-80 (60)	51-82 (65)	2	2.5	2	2
VA30	0	41-82 (63)	48-98 (62)	4	4	8.5	8.5
	5	42-100 (64)	41-109 (61)	3	2.5	4	4.5
	10	51-82 (65)	44-84 (63)	2	2	3.5	3.5
	20	41-80 (59)	41-74 (60)	2	2.5	2.5	3

NOTE: Ping test was performed between the UE and Node B via the GGSN, where the Node B, RNC and SGSN have the same IP address (see Figure 6.1.7.1.2-1).

Figure 6.1.7.1.2-2, Figure 6.1.7.1.2-3 and Figure 6.1.7.1.2-4 show the Web page download times for an AWGN, PA3 and VA30 channel, respectively.

For low cell geometries (0 dB), the Amazon Web page download time for time-dilated UMTS N=2 is approximately double that for normal UMTS. At higher cell geometries (5 and 10 dB), the Amazon Web page download time for time-dilated UMTS N=2 is approximately 30% longer than that for normal UMTS. At very high cell geometries (20 dB), the Amazon Web page download times for time-dilated UMTS N=2 and normal UMTS are similar.

Note that the request-response nature of HTTP leads to multiple round trips being required to retrieve objects such as an image, JavaScript, CCS file, etc. During this time the Uu interface may be under-utilized. This, coupled with Web browser processing delays and server load, leads to Web browsing delays saturating once the channel rate is sufficiently high (i.e. very high cell geometries).

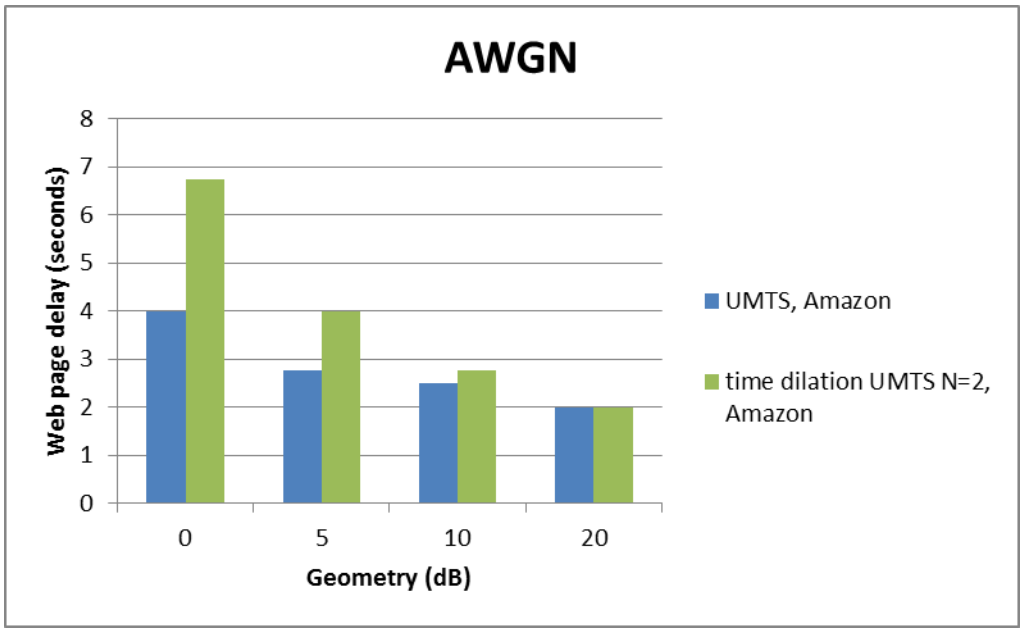


Figure 6.1.7.1.2-2: Web page download time (AWGN channel)

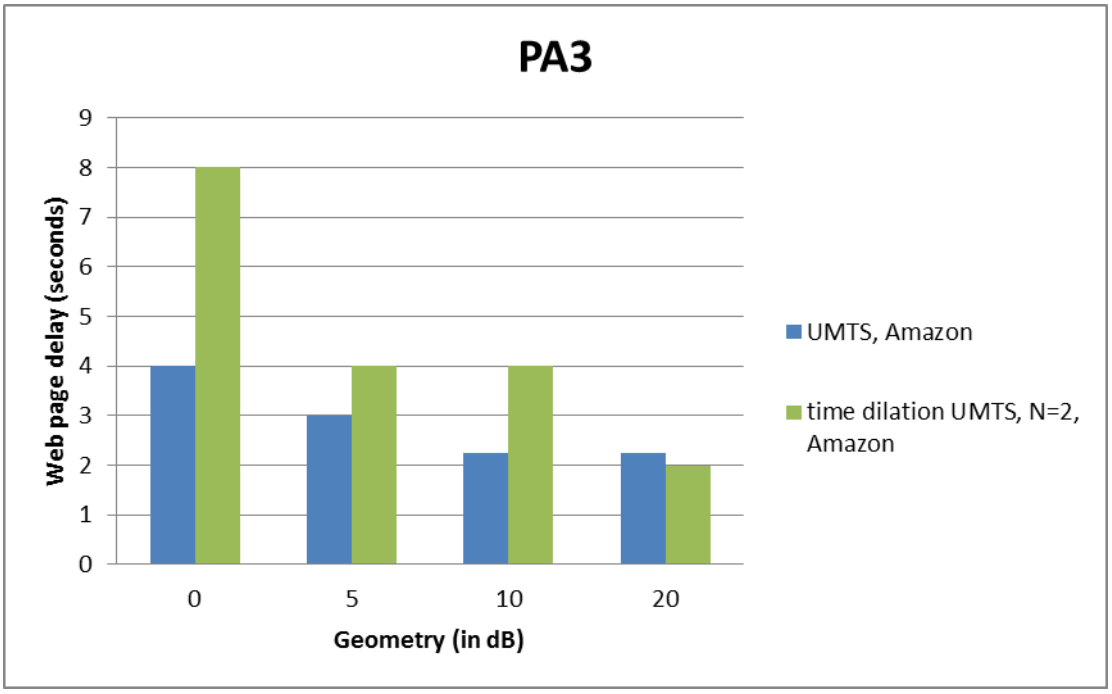


Figure 6.1.7.1.2-3: Web page download time (PA3 channel)

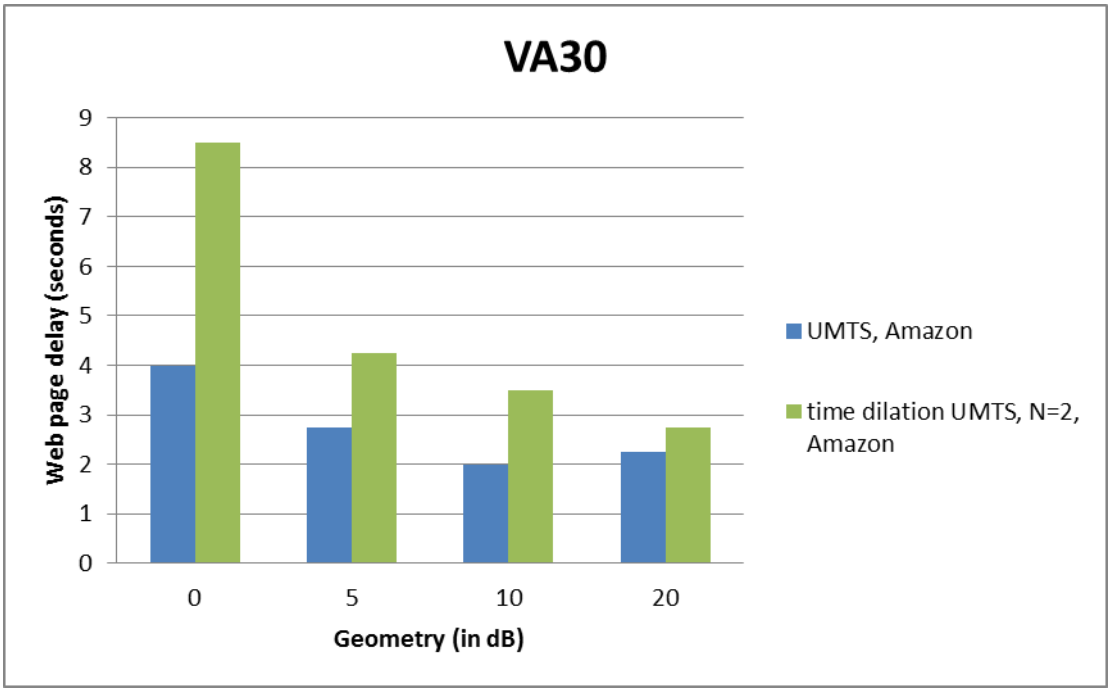


Figure 6.1.7.1.2-4: Web page download time (VA30 channel)

6.1.7.2 Uplink user plane latency analysis

Figure 6.1.7.2-1 illustrates the E-DCH HARQ process timing with normal UMTS TTI = 10 ms and four HARQ processes.

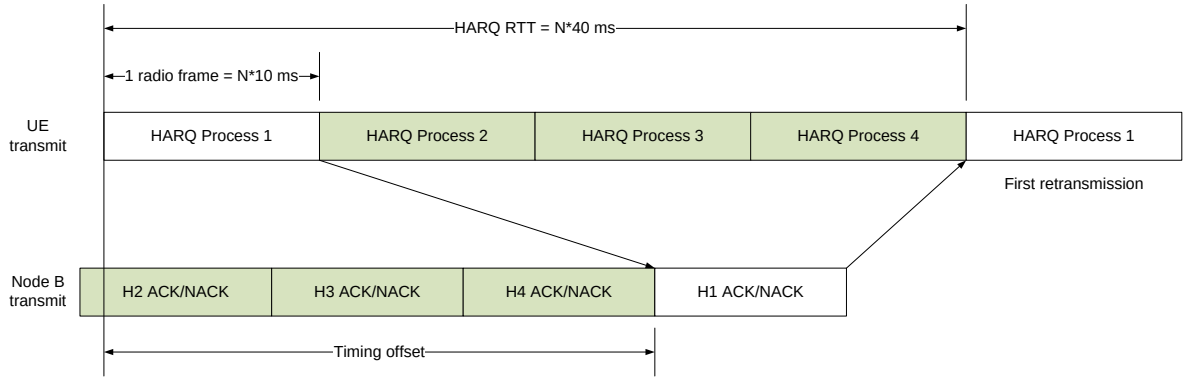


Figure 6.1.7.2-1: E-DCH HARQ process timing with normal UMTS TTI = 10 ms and 4 HARQ processes

Figure 6.1.7.2-2 illustrates the E-DCH HARQ process timing with normal UMTS TTI = 2 ms and 8 HARQ processes.

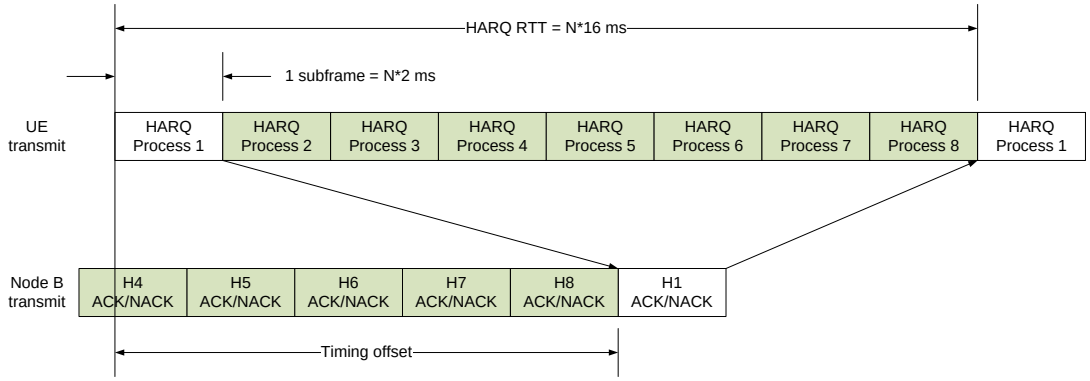


Figure 6.1.7.2-2: E-DCH HARQ process timing with normal UMTS TTI = 2 ms and 8 HARQ processes

Table 6.1.7.2-1 and Table 6.1.7.2-2 capture the E-DCH user plane latency impact per HARQ process for time-dilated UMTS with 10 ms and 2 ms TTIs for normal UMTS, respectively. Here we assume a target of 10% BLER after the 1st transmission and a maximum of 2 transmissions.

Table 6.1.7.2-1: E-DCH normal UMTS TTI=10 ms user plane latency impact per HARQ process

Item	Normal UMTS latency (ms)	Time-Dilated UMTS N=2 latency (ms)	Time-Dilated UMTS N=4 latency (ms)	$\Delta_{N=2}$ (ms)	$\Delta_{N=4}$ (ms)
Time taken for MAC PDU transmission	10	20	40	10	30
Time to allow for HARQ	3 (=0.9*10+0.1*4*10 – 10)	6	12	3	9
Queuing delay (e.g., TTI/2)	5	10	20	5	15
Total	18	36	72	18	54

Table 6.1.7.2-2: E-DCH normal UMTS TTI=2 ms user plane latency impact per HARQ process

Item	Normal UMTS latency (ms)	Time-Dilated UMTS N=2 latency (ms)	Time-Dilated UMTS N=4 latency (ms)	$\Delta_{N=2}$ (ms)	$\Delta_{N=4}$ (ms)
Time taken for MAC PDU transmission	2	4	8	2	6
Time to allow for HARQ	1.4 (=0.9*2+0.1*8*2 – 2)	2.8	5.6	1.4	4.2
Queuing delay (e.g., TTI/2)	1	2	4	1	3
Total	4.4	8.8	17.6	4.4	13.2

6.1.7.2.1 Uplink user plane latency mitigation techniques

When the PSD of time-dilated UMTS is scaled by a factor N (as shown in Figure 6.1.7.2.1-1) then the extra power available for time-dilated UMTS can be used to overcome data rate and/or latency impacts and achieve a performance that is comparable to normal UMTS. The extra power may be applied in this manner when the UL is not interference limited; in other words, it may be applied within the UL RoT budget. In what follows, two cases for latency are analyzed. In one case, referred to as the "same rate" case, the extra power is used to make the time-dilated UMTS data rate be the same as normal UMTS. In the second case, referred to as the "reduced rate" case, the extra power in time-dilated UMTS is used to overcome the latency impact of HARQ at the cost of reduced data rate (reduced by a factor of 1/N) relative to normal UMTS. It should be noted that these mitigation techniques would have a corresponding impact on capacity due to the reduced rate since additional RoT would be required.

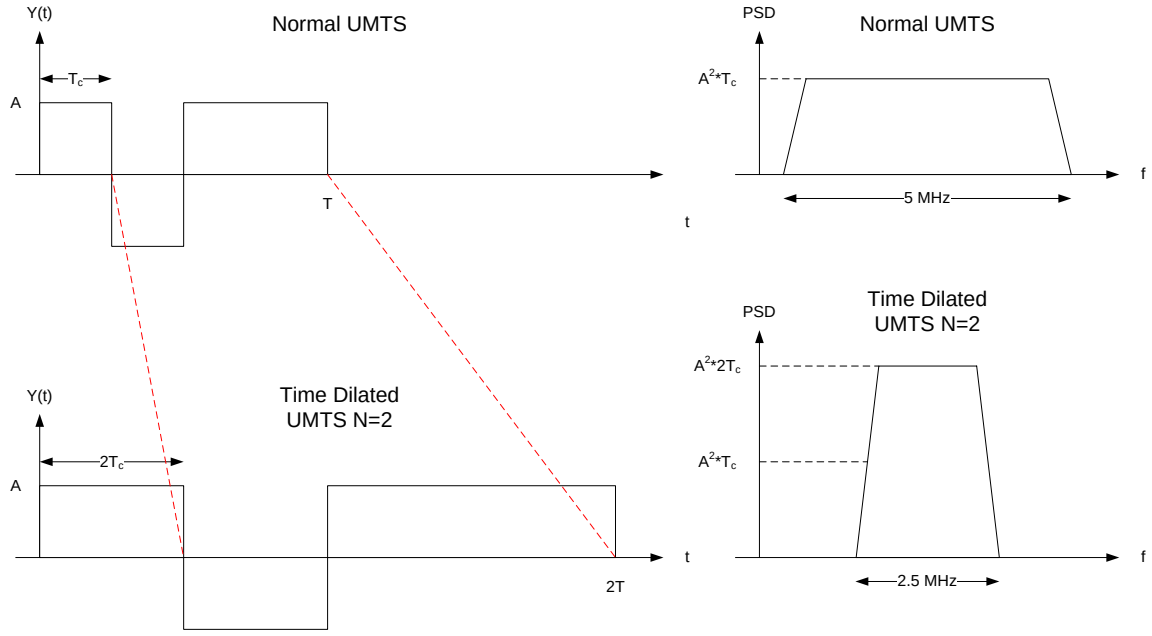


Figure 6.1.7.2.1-1: Time-Dilated UMTS PSD scaled by N relative to normal UMTS (i.e. Time-Dilated UMTS transmit power same as normal UMTS)

Table 6.1.7.2.1-1 lists the user plane latency impact due to HARQ for the "same rate" case. Here we assume a target of 10% BLER after 1st transmission and a maximum of 2 transmissions.

Table 6.1.7.2.1-1: Normal UMTS and Time-Dilated UMTS E-DCH user plane latency due to HARQ for "same rate" case

E-DCH TTI duration (ms)	N	UMTS E-DCH User-plane Latency (ms)	Time-Dilated UMTS E-DCH User-plane Latency (ms)	Time-Dilated UMTS E-DCH Excess Latency (ms)
2	2	1.4 (=0.9*2+0.1*8*2 - 2)	2.8	1.4
10	2	3 (=0.9*10+0.1*4*10 - 10)	6	3
2	4	1.4	5.6	4.2
10	4	3	12	9

Table 6.1.7.2.1-2 lists the user plane latency impact due to HARQ for the "reduced rate" case, where the extra power available for time-dilated UMTS is used to increase the probability that only a single HARQ transmission is required relative to normal UMTS. Here we assume a target of 10% BLER after 1st transmission and a maximum of 2 transmissions for normal UMTS and a single transmission for time-dilated UMTS.

Table 6.1.7.2.1-2: Normal UMTS and Time-Dilated UMTS E-DCH user plane latency due to HARQ for "reduced rate" case

E-DCH TTI Duration (ms)	N	UMTS E-DCH User-plane Latency (ms)	Time-Dilated UMTS E-DCH User-plane Latency (ms)	Time-Dilated UMTS E-DCH Excess Latency (ms)
2	2	1.4 (=0.9*2+0.1*8*2 - 2)	0	-1.4
10	2	3 (=0.9*10+0.1*4*10 - 10)	0	-3
2	4	1.4	0	-1.4
10	4	3	0	-3

Table 6.1.7.2.1-3 captures the overall user plane latency impact with E-DCH in CELL_DCH in time-dilated UMTS for the "same rate" case. Table 6.1.7.2.1-4 captures the overall user plane latency impact with E-DCH in CELL_DCH in time-dilated UMTS for the "reduced rate" case.

Table 6.1.7.2.1-3: Overall user plane latency with E-DCH in CELL_DCH for "same rate" case

Item	Normal UMTS latency (ms)		Time-Dilated UMTS N=2 latency (ms)		Time-Dilated UMTS N=4 latency (ms)		$\Delta_{N=2}$ (ms)		$\Delta_{N=4}$ (ms)		Comments
Time taken for message transmission	2	10	4	20	8	40	2	10	6	30	TTI = 2 ms in first sub-column and TTI = 10 ms in second sub-column
Time to allow for HARQ	1.4	3	2.8	6	5.6	12	1.4	3	4.2	9	
Queuing delay (e.g., TTI/2)	1	5	2	10	4	20	1	5	3	15	
Total	4.4	18	8.8	36	17.6	72	4.4	18	13.2	54	

Table 6.1.7.2.1-4: Overall user plane latency with E-DCH in CELL_DCH for "reduced rate" case

Item	Normal UMTS Latency (ms)		S-UMTS N=2 Latency (ms)		S-UMTS N=4 latency (ms)		$\Delta_{N=2}$ (ms)		$\Delta_{N=4}$ (ms)		Comments
Time taken for message transmission	2	10	4	20	8	40	2	10	6	30	TTI = 2 ms in first sub-column and TTI = 10 ms in second sub-column
Time to allow for HARQ	1.4	3	0	0	0	0	-1.4	-3	-1.4	-3	
Queuing delay (e.g., TTI/2)	1	5	2	10	4	20	1	5	3	15	
Total	4.4	18	6	30	12	60	1.6	12	7.6	42	

6.1.7.3 User plane latency analysis in CELL_FACH state

The main impact of time-dilated UMTS on CELL_FACH is on latency. The functional operation in CELL_FACH in time-dilated UMTS is the same as that for UMTS. An analysis of the latency in CELL_FACH is provided in the following subclauses. It should be noted that the UE power consumption in CELL_FACH would be higher in time-dilated UMTS as compared with UMTS even when DRX in CELL_FACH is used. This is due to the longer transmission times required in time-dilated UMTS.

6.1.7.3.1 Uplink

6.1.7.3.1.1 RACH

The user-plane latency in case of uplink transmissions on RACH is introduced from the physical random access preamble ramping procedure and the transmission of the data message part i.e. TTI duration.

Since the latency aspects related to the reading of the SIB have been dealt with in RAN2, we focus on the other aspects that contribute to the latency. Table 6.1.7.3.1.1-1 provides an estimate of the average latency values. It is assumed that 4 preambles per preamble ramping cycle and 1 preamble cycle are needed during the Random Access procedure.

Table 6.1.7.3.1.1-1: Estimated average latency values for UMTS and time-dilated UMTS

TTI	UMTS Latency (ms)	Time-Dilated UMTS N=2 latency (ms)	Time-DilatedTime-Dilated UMTS N=4 latency (ms)	$\Delta_{N=2}$ (ms)	$\Delta_{N=4}$ (ms)	Comments
10ms TTI	44 + 0.67 = 44.67	58 + 1,33 = 59.33	104 + 2.67 = 106,67	Δ_{T1+T_align} = 14.67	Δ_{T1+T_align} = 62	Latency = T1 + T_align T1 is the time it takes the UE to perform the Random Access procedure. Assume that there are 4 preambles per preamble ramping cycle, 1 preamble cycle. T1 is computed as: $3^* \max(\tau_2, \tau_{p\text{-}p}) + \tau_{p\text{-}m} + \tau_{RACH}$ (message part) T_align is the access slot align time and is computed as: 0.5*access slot length (where access slot length = 5120 chips = 1.33 ms for normal UMTS)
20ms TTI	54 + 0.67 = 54.67	78 + 1.33 = 79.33	144 + 2.67 = 146.67	Δ_{T1+T_align} = 24.67	Δ_{T1+T_align} = 92	

6.1.7.3.1.2 Common E-DCH

Common E-DCH utilizes E-DPDCH/E-DPCCH physical channels for uplink transmissions in CELL_FACH state. With Common E-DCH, it can be assumed that the UE is not required to read SIB7 since the UE will likely be camping in CELL_FACH state thus having an up to date value (of SIB7) already. Also, if the IE "UL interference" is included in SIB5/5bis, the UE is not required to read SIB7. The access procedure and the message part still contribute to the latency. Two other sources of latency need to be considered for this case:

- Latency due to pilot (DPCCH) only transmission duration i.e. DPCCH preamble;
- Latency due to interlace structure of HARQ.

The resources needed for control signalling for time-dilated UMTS is the same as for UMTS despite supporting half the number of users.

Table 6.1.7.3.1.2-1 lists the user plane delay impact for the message part of Common E-DCH.

Table 6.1.7.3.1.2-1: Normal UMTS and time-dilated UMTS common E-DCH User-plane latency due to TTI elongation

E-DCH TTI duration (ms)	N	UMTS Common E-DCH User-plane Latency (ms)	Time-Dilated UMTS Common E-DCH User-plane Latency (ms)	Time-Dilated UMTS Common E-DCH Excess Latency (ms)
2	2	2	4	2
10	2	10	20	10
2	4	2	8	6
10	4	10	40	30

Table 6.1.7.3.1.2-2 lists the user plane latency impact due to the DPCCH preamble. Here we assume preamble transmission duration of 20 ms.

Table 6.1.7.3.1.2-2: Normal UMTS and time-dilated UMTS common E-DCH User-plane latency due to DPCCH preamble

E-DCH TTI duration (ms)	N	UMTS Common E-DCH User-plane Latency (ms)	Time-Dilated UMTS Common E-DCH User-plane Latency (ms)	Time-Dilated UMTS Common E-DCH Excess Latency (ms)
2	2	20	40	20
10	2	20	40	20
2	4	20	80	60
10	4	20	80	60

The analysis above assumes no change to the physical layer processing (except for time dilation) to achieve synchronization at the Node-B, i.e. the number of chips of DPCCH only transmission remains the same between UMTS and time-dilated UMTS. Due to the excess energy accumulated over given amount of time in time-dilated UMTS, the duration of the DPCCH only preamble (configured in SIB5/5bis/22) could be reduced from that listed in Table 6.1.7.3.1.2-2 for time-dilated UMTS.

Table 6.1.7.3.1.2-3 lists the user plane latency impact due to HARQ for a target of 10% BLER after 1st transmission.

Table 6.1.7.3.1.2-3: Normal UMTS and time-dilated UMTS common E-DCH User-plane latency due to HARQ

E-DCH TTI duration (ms)	N	UMTS Common E-DCH User-plane Latency (ms)	Time-Dilated UMTS Common E-DCH User-plane Latency (ms)	Time-Dilated UMTS Common E-DCH Excess Latency (ms)
2	2	2.4 (=0.9*2+0.1*8*2+1 - 2)	4.8 (2.8+2)	2.4
10	2	8 (=0.9*10+0.1*4*10+5 - 10)	16 (6+10)	8
2	4	2.4	9.6	7.2
10	4	8	32	24

Table 6.1.7.3.1.2-4 captures the overall user-plane latency impact with common E-DCH in time-dilated UMTS.

Table 6.1.7.3.1.2-4: Overall u-plane latency for UMTS and time-dilated UMTS with common E-DCH

Item		Normal UMTS latency (ms)	Time-Dilated UMTS N=2 latency (ms)	Time-Dilated UMTS N=4 latency (ms)	$\Delta_{N=2}$ (ms)	$\Delta_{N=4}$ (ms)	Comments
Time taken to perform the PRACH preamble ramping		34.67	39.33	66.67	4	30	Same as Table 6.1.7.3.1.1-1 minus TTI of RACH message part.
Time taken for message transmission	Common E-DCH TTI=2ms	2	4	8	2	6	From Table 6.1.7.3.1.2-1.
	Common E-DCH TTI=10ms	10	20	40	10	30	
Time taken for pilot preamble only transmission		20	40	80	20	60	From Table 6.1.7.3.1.2-2
Time to allow for HARQ	Common E-DCH TTI=2ms	2.4	4.8	9.6	2.4	7.2	From Table 6.1.7.3.1.2-3.
	Common E-DCH TTI=10ms	8	16	32	8	24	
Total	**Common E-DCH TTI=2ms**	**59.07**	**88.13**	**164.27**	**29.06**	**105.2**	
	Common E-DCH TTI=10ms	**72.67**	**115.33**	**218.67**	**42.66**	**146**	

6.1.7.3.2 Downlink

6.1.7.3.2.1 FACH

For FACH transport channel, SCCPCH is used at the physical layer for downlink transmissions to the UE in CELL_FACH state. Unlike the uplink, there are no delays associated with SIB acquisition or preamble ramping to transmit data to the UE in the downlink in CELL_FACH. The excess latency introduced in the user-plane is due to the actual transmission duration, i.e. the SCCPCH TTI elongation. In UMTS, the SCCPCH TTI is 10 ms which would get elongated to 20 ms and 40 ms for time-dilated UMTS N=2 and N=4 cases. This is captured in Table 6.1.7.3.2.1-1 below.

Table 6.1.7.3.2.1-1: Estimated overall U-plane latency for UMTS and time-dilated UMTS with FACH

Item	Normal UMTS Latency (ms)	Time-Dilated UMTS N=2 latency (ms)	Time-Dilated UMTS N=4 latency (ms)	$\Delta_{N=2}$ (ms)	$\Delta_{N=4}$ (ms)
Time taken for message transmission	10	20	40	10	30
Queuing delay (e.g., TTI/2)	1	2	4	1	3
Total	11	22	44	11	33

6.1.7.3.2.2 HS-DSCH in CELL_FACH

For HS-DSCH downlink transmissions in CELL_FACH state, apart from the TTI elongation, the HARQ structure would add to the user-plane latency in time-dilated UMTS compared to UMTS.

Table 6.1.7.3.2.2-1 lists the user plane latency impact due to HARQ for a target of 10% BLER after 1st transmission

Table 6.1.7.3.2.2-1: Normal UMTS and time-dilated UMTS HS-DSCH User-plane latency due to HARQ

HS-DSCH TTI Duration (ms)	N	UMTS HS-DSCH User-plane Latency (ms)	Time-Dilated UMTS HS-DSCH User-plane Latency (ms)	Time-Dilated UMTS HS-DSCH Excess Latency (ms)
2	2	2.4 (=0.9*2+0.1*8*2+1 - 2)	4.8 (2.8+2)	2.4
2	4	2.4	9.6 (5.6+4)	7.2

Table 6.1.7.3.2.2-2 captures the overall user-plane latency impact with HS-DSCH in CELL_FACH in time-dilated UMTS.

Table 6.1.7.3.2.2-2: Overall u-plane latency with HS-DSCH in CELL_FACH

Item	Normal UMTS Latency (ms)	Time-Dilated UMTS N=2 latency (ms)	Time-Dilated UMTS N=4 latency (ms)	$\Delta_{N=2}$ (ms)	$\Delta_{N=4}$ (ms)
Time taken for message transmission	2	4	8	2	6
Time to allow for HARQ	2.4	4.8	9.6	2.4	7.2
Total	**4.4**	**8.8**	**17.6**	**4.4**	**13.2**

6.1.7.3.2.3 HS-DSCH in CELL_FACH example: e-mail download user plane latency over Uu interface

The median e-mail size used in this analysis is ≈ 150 kbyte. Assuming that there are 1500 byte per IP packet, this translates into ≈ 100 IP packets per e-mail.

An estimate of the e-mail download user plane latency over the Uu interface is shown in Table 6.1.7.3.2.3-1 for normal UMTS and the time-dilated UMTS.

The e-mail download user plane latency over the Uu interface ($Web_page_{latency_Uu}$) was estimated as a function of the number of MAC PDUs per IP packet (MAC_PDU_{IP}).

Table 6.1.7.3.2.3-1: E-mail download user plane latency over Uu interface

Number of MAC PDUs per IP packet (MAC_PDU_{IP})	Number of MAC PDUs required for e-mail download ($MAC_PDU_{E\text{-}mail}$)	E-mail download user plane latency over Uu interface (s) ($E\text{-}mail_{latency_Uu}$) NOTE		
		N=1	N=2	N=4
1	100	6.347	12.694	25.388
2	200	12.694	25.388	50.776
3	300	19.041	38.082	76.164
4	400	25.388	50.776	101.552
5	500	31.735	63.470	126.94
6	600	38.082	76.164	152.328
7	700	44.429	88.858	177.716
8	800	50.776	101.552	203.104

NOTE: Assuming E-DCH TTI=2 ms, $E\text{-}mail_{latency} = MAC_PDU_{IP} \times MAC_PDU_{E\text{-}mail} \times ((0.0044 + 0.05907) \times N)$

6.1.8 Impact on mobility (idle mode and connected mode)

6.1.8.1 Carrier identification and UE capability

Time-dilated carriers with N=2 or N=4 of the bandwidth of a normal carrier need to be distinguished from each other and from the normal carrier that has the same centre frequency. This means the same UARFCN alone cannot be used for all cases. The same issues apply to UE capability signalling. For various inter-frequency and inter-RAT procedures and measurement setups, the network needs to know if a UE supports a certain time-dilated carrier.

The RAN2 solution depends on what RAN4 agrees with regards carrier identification. The complexity of this solution may, hence, also depend on the RAN4 solution. Some solutions have been submitted but not yet discussed in RAN2. The impact on RAN2 work depends on the solution(s), once the concrete solution(s) are known better, a more detailed evaluation of the impacts can be performed.

6.1.8.2 Inter-frequency mobility

Introduction of time-dilated UMTS carriers will impact mobility procedures where there is a need to handover the UE to carriers with different bandwidth. For example:

- Inter-frequency handover within the same frequency band, or to another frequency band;
- IRAT Handover to UTRAN from LTE/GSM;
- RRC Connection Reject with redirection to other frequency;
- RRC Connection Release with redirection to other frequency.

For all these use-cases there is a need to provide additional information so that the UE is able to identify the target carrier. For example, if the same frequency band contains both time-dilated and normal UMTS carriers proper signalling indication must be included in all RRC messages that can be used to execute the mobility procedures. In addition, neighbour cell information in NBAP / RNSAP Radio Link Addition/Setup Response / Failure also needs to be extended with information to identify the time-dilated UMTS carrier. There could also be a signalling impact on the corresponding LTE and GERAN specifications in order to support a handover or a redirection to a time-dilated UMTS carrier

To avoid the situation whereas the RNC might redirect the UE to a carrier using a non-supported bandwidth, the UE needs to provide information about supported bandwidths already in the RRC Connection Request message. However, the size of RRC connection request is a limiting factor and the needs for its extension should be evaluated

6.1.8.3 Impact on Cell Selection and Cell Reselection

The time it takes to detect and evaluate the serving cell and neighbouring cells listed in System Information are controlled by the measurement requirements specified in TS 25.133.

Measurement requirements may increase the measurement periods for intra-frequency and inter-frequency measurements performed in Idle mode, URA_PCH, CELL_PCH and CELL_FACH states. For a time-dilated UMTS carrier both the DRX cycle as well as the FACH measurement occasion cycle may increase by a factor of N (this is pending on RAN4 analysis).

Longer measurement periods will impact the cell reselection performance.

6.1.8.4 Positioning

Impact on Positioning should also be evaluated to make sure that countries and regulators requirements are fulfilled.

6.1.8.5 Other mobility aspects

6.1.8.5.1 RL failure or RLC unrecoverable error

Assuming a longer SRB latency, there will be an increased risk to detect Radio link failure and RLC unrecoverable error procedures for time-dilated UMTS Upon detection of a RL failure or RLC unrecoverable error, the UE can move to state CELL_FACH and initiate the Cell Update procedure in order to try to recover. When this happens, there is an interruption time which can be broken down in:

- time to find a suitable cell;
- time to acquire system information in case no stored information is available for the selected cell;
- transmission of cell update and reception of cell update confirm;
- synchronization procedure.

For time-dilated UMTS all these components will take longer time and, hence, the total interrupt time may increase.

6.1.9 Impact on SIBs acquisition

If no latency mitigation techniques are used, the BCH user data rate is scaled by 1/N relative to normal UMTS.
This impacts SIBs acquisition time (e.g. assuming a SIB repetition period of 1.28 s, for N=2 the total SIB acquisition time is estimated to be at least 2.56 s and for N=4 it will take 5.12 s for the UE to read all the SIBs).
Longer acquisition time will impact, for example, cell reselection and CS Fallback from LTE (CSFB).

Some solutions have been submitted but not yet discussed in RAN2. For example, the following latency mitigation techniques may be used: (1) optimized SIB structure and/or scheduling mechanism; (2) multiple PCCPCH mechanism or single PCCPCH mechanism with SF scaled by 1/N; (3) limit the features which time-dilated UMTS can be configured for.

Feasibility of (1) may depend on if and how much the repetition periods can be optimized, whilst (2) would have an impact of the overall control channel overhead as the existing power and code spent on P-CCPCH needs to be multiplied by a factor of N. New radio configurations for the P-CCPCH would also need to be defined. RAN2 has not evaluated the above solutions.

6.1.10 Impact on signalling and user plane data

6.1.10.1 SRB performance

The impact on latency for time-dilated UMTS has been analysed for a few example use-cases.

Only the Uu signalling delay (including TTI alignment) is considered in the analysis.
It is assumed that the NBAP/RNSAP and RANAP signalling delay and also the processing times in the UE, RBS, RNC and CN will be the same in both the UMTS and the time-dilated UMTS scenario.

With a scaling factor of N=2 and a minimum radio frame of 20 ms the signalling time will be doubled.

6.1.10.1.1 Call setup delay for speech AMR NB MM multi-rate 12.2/7.4/5.9/4.95 from idle

For this use case, a stand-alone signalling bearer of 13.6 kbps and TTI 10 ms (TS 34.108, subclause 6.10.2.4.1.3) is established for the initial signalling. In order to improve the UL coverage and DL capacity a multi-mode multi-rate AMR NB speech configuration is likely to be used in a time-dilated UMTS system. When the speech radio bearers are established the SRB is reconfigured to 3.4 kbps with a TTI of 40 ms (TS 34.108, subclause 6.10.2.4.1.4a).

The speech call setup sequence can be broken down in the following RRC signalling:

Table 6.5.1.1:

RRC message	Nr of PDUs	NAS message	UMTS time (ms)	T-D UMTS time (ms), N=2
Read SIB7 (average time)	-	-	80	160
1. RRC Connection Request	1 (+ramping)	-	50	100
2. RRC Connection Setup	8	-	45	90
4. RRC Connection Setup Comp.	5	-	55	110
5. Initial Direct Transfer	2	CM Service Request	25	50
6. DL Direct Transfer	3	Authentication Req.	35	70
7. UL Direct Transfer	2	Authentication Resp.	25	50
8. Security Mode Command	2		25	50
9. Security Mode Complete	2	-	25	50
10. DL Direct Transfer	1	Identity Request	15	30
11. UL Direct Transfer	3	Setup	35	70
12. UL Direct Transfer	2	Identity Response	25	50
13. DL Direct Transfer	1	Call Proceeding	15	30
14. Radio Bearer Setup	11		115	230
15. RB Setup Complete on 3.4	1		60	120
16. DL Direct Transfer on 3.4	1	Alerting	60	120
17. UL Direct Transfer on 3.4	4	Connect	180	360
18. DL Direct Transfer on 3.4	1	Connect Ack	60	120
Total time:			**930**	**1860**

NOTE: DCH synchronization time not included

For scenarios where the complete System Information needs to be read, the speech call setup time will increase even more

If no solution is adopted, SRB latency would be, logically, scaled up by N.

Some solutions have been submitted but not discussed in RAN2. For example, one option could be to scale SRBs' SF by 1/N (or using additional available power, for the SRBoHS case, by scaling the Scalable UMTS Power Spectral Density). Changing SF may require introducing new radio bearer configurations. RAN2 has not evaluated the above solutions.

It is proposed that solutions for reducing the long speech setup delay for time-dilated UMTS are studied together with consequences for each solution. In specific in relation to emergency calls the increased delay of establishing a speech call needs to be mitigated.

6.1.10.2 User plane performance

The detailed impacts of time-dilated carriers on user-plane performance have not yet been studied.
The expected impacts are:

- Peak Rate: Decrease in peak rate by the same factor as the time-dilation.
- Data Rate and Latency:
  - For PS/data traffic, when the PSD of the Scalable UMTS time-dilated solution is the same as normal UMTS, then the Scalable UMTS data rate and latency are scaled accordingly (i.e., by a factor of 1/N for data rate and N for latency, assuming that the number of UEs served by Scalable UMTS and normal UMTS are the same). This increase in latency could have an impact on TCP performance.

- However, some solutions to address these issues have been presented in RAN2 but not discussed or evaluated.

- If the spreading factor of the BCCH and other DL control channels are reduced proportionally maintain the same bitrate for performance reason, the number of codes available for HS transmissions may be reduced, which would impact the maximum DL bitrate.

6.1.10.3 New radio configurations

For a time-dilated UMTS system where the radio frames are scaled by a factor N=2 or N=4, there is a need to use other radio bearer configurations than those that are specified in TS 34.108 and TR 25.993.

6.1.11 Impact on MAC, RLC and RRC performance, including impact on timers and procedures

RLC impact

RLC protocol may not be impacted, however, this is dependent on the concrete solutions. .

From the performance point of view, RLC and higher protocol performance (TCP) may be affected due to the longer time to receive their SDUs.

MAC impact

MAC impacts will also depend on the concrete solutions Potentially, MAC entities may be impacted if HARQ entities and/or number of HARQ processes are modified, for instance. Performance simulations may be needed in case the number of HARQ processes is reduced as efficiency may be reduced. This may also affect higher layers.

The MAC entities are responsible for in-sequence delivery of data up to the RLC layer. The HARQ Round-Trip Time (RTT) for a regular carrier for the EUL 2 ms TTI is 16 ms. For a 1/4-chip-rate carrier, this becomes 64 ms. In multi-carrier operations with a 1/4-chip-rate carrier and a regular carrier, two data streams of quite different rates and RTTs are feeding the same MAC entity. While waiting for a HARQ retransmission on the 1/4-chip-rate carrier, an additional 32 PDUs from the regular carrier will be accumulating in the MAC buffer. Under such a situation, larger buffer size may be needed to avoid overflow of the MAC buffer. A similar situation occurs also on the DL, with slightly different RTT and higher bitrates. Some work may be needed.

RRC performance

Some of the RRC impacts have been outlined in the clauses above. It is clear that RRC specifications will be impacted by the introductions of time-dilated UMTS. RRC, RLC, MAC, and layer 1 timers need to be checked to understand if the values in those timers are suitable.

Time and Timers

Certain time/TTI/Timer values can be implicitly or explicitly scaled, or signalled with a different value, to account for the inherent time scaling of the Scalable UMTS time-dilated solution. Scaling would apply especially for the MAC layer timers. RLC timing impacts are expected to be less as compared to MAC.

6.2 Time-dilated solution for Carrier Aggregation scenarios

6.2.1 Solutions for Carrier Aggregation scenarios

6.2.1.1 Timing relation of HS-PDSCHs and HS-DPCCHs

Assuming the CPICHs (also HS-SCCHs) of both legacy primary carrier and the small bandwidth secondary carrier are time aligned, the timing relation of HS-PDSCHs is shown in Figure 6.2.1.1-1. The start of any subframe of the small bandwidth carrier with N=2 begins 4/3 ms after the start of the nearest subframe of the legacy carrier; and the start of any subframe of the small bandwidth carrier with N=4 is aligned with the start of one subframe of legacy carrier.

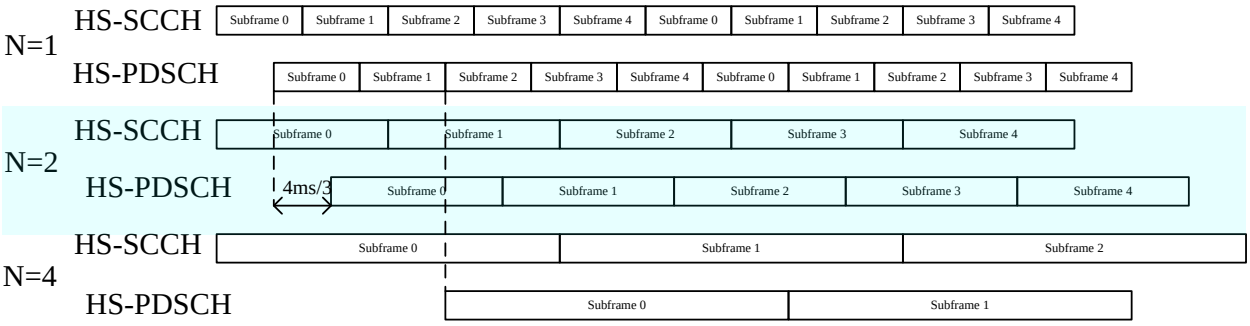


Figure 6.2.1.1-1: Timing relation of HS-PDSCHs

Assuming the timing between HS-PDSCH and HS-DPCCH is kept as Rel-5 (approximately 7.5 slots) in the cell where HS-PDSCH belongs to, the timing of HS-DPCCH for legacy carriers and small bandwidth carriers will be not aligned any more. The timing relation is shown in Figure 6.2.1.1-2.

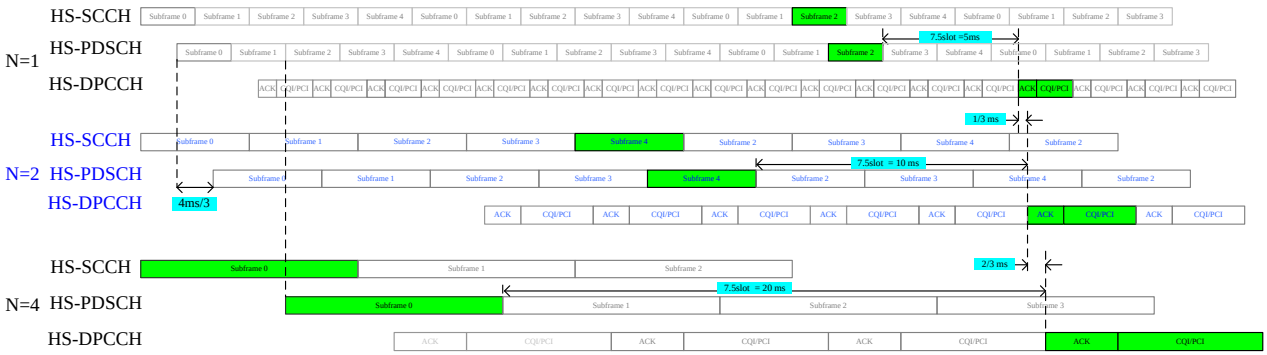


Figure 6.2.1.1-2: Timing relation of HS-DPCCHs

6.2.1.2 HS-DPCCH solutions

For CA of a legacy UMTS carrier with a time-dilated UMTS carrier, both single and dual code design solutions can be considered.

Solutions of HS-DPCCH design

- Solution 1: Single HS-DPCCH with joint encoding for ACK and TDM for CQI of carriers;
- Solution 2: Dual HS-DPCCHs with each corresponding to one downlink carrier.

The illustration of Solution 1 is shown in Figure 6.2.1.2-1 and Figure 6.2.1.2-2 for scaling factor N=2.
In Solution 1 joint encoding for ACK and TDM for CQI is adopted and time adjustment is used to follow the timing based on legacy UMTS feedback occasions. The exact time adjustment for ACK or CQI can be further studied.

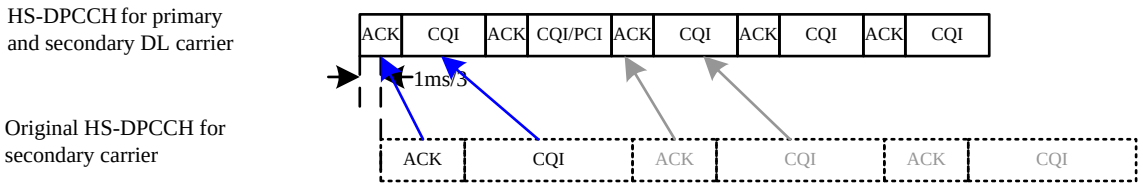


Figure 6.2.1.2-1: Single HS-DPCCH for dual carrier with time-dilated UMTS as secondary carrier, N=2

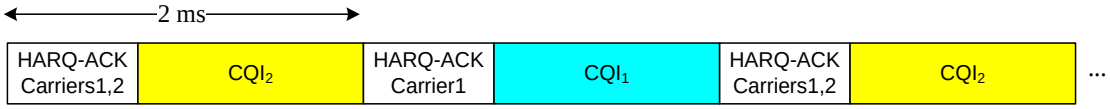


Figure 6.2.1.2-2: Single code HS-DPCCH design, ACK joint encoding and CQI TDM, N=2

The illustration of Solution 1 is shown in Figure 6.2.1.2-3 and Figure 6.2.1.2-4 for scaling factor N=4.
In this solution joint encoding for ACK and TDM for CQI is adopted and time adjustment is used to follow the timing based on legacy UMTS feedback occasions. The exact time adjustment for ACK or CQI can be further specified.

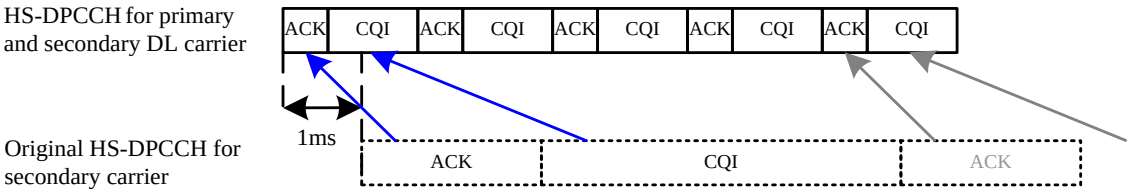


Figure 6.2.1.2-3: Single HS-DPCCH for dual carrier with time-dilated UMTS as secondary carrier, N=4

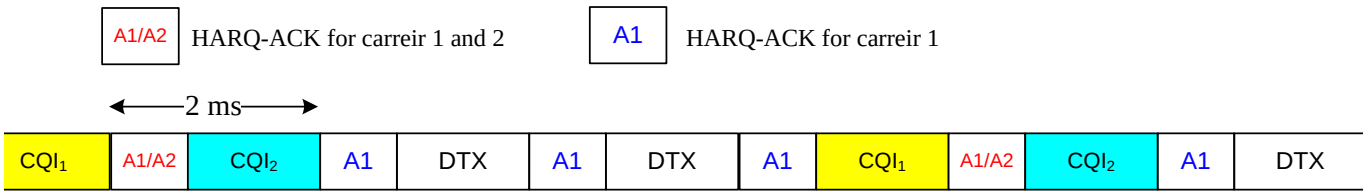


Figure 6.2.1.2-4: Single code HS-DPCCH design, ACK joint encoding and CQI TDM, N=4

The illustration of Solution 2 is shown in Figure 6.2.1.2-5 for scaling factor N=2. In this solution two separate HS-DPCCHs are used corresponding to different HS-DPCCH timings in different carriers, wherein for each cell legacy HS-DPCCH feedback delay (approximately 7.5 slots is kept.)

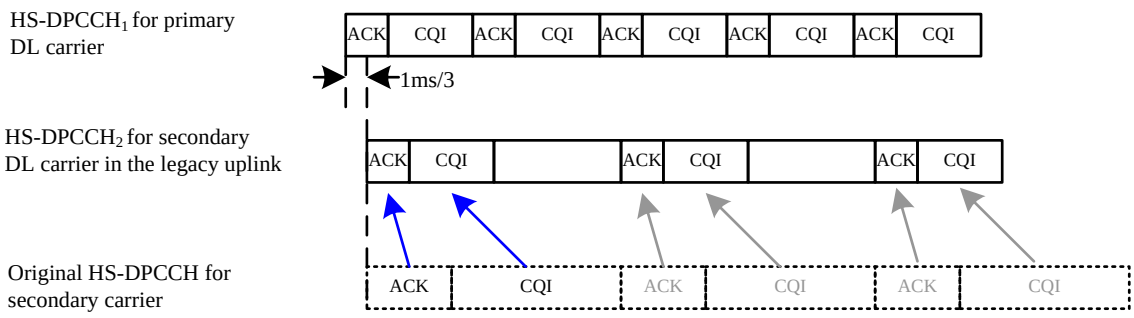


Figure 6.2.1.2-5: Dual code HS-DPCCHs for dual carrier with time-dilated UMTS as secondary carrier, N=2

The illustration of Solution 2 is shown in Figure 6.2.1.2-6 for scaling factor N=4. In this solution two separate HS-DPCCHs are used corresponding to different HS-DPCCH timings in different carriers, wherein for each cell 7.5 slots HS-DPCCH feedback delay is kept.

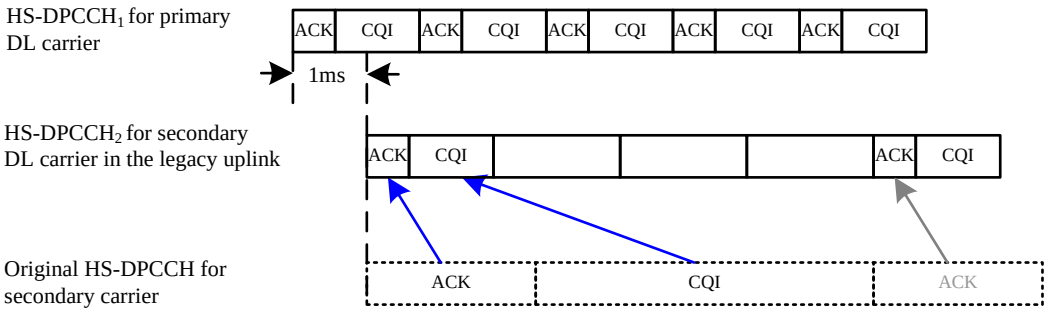


Figure 6.2.1.2-6: Dual code HS-DPCCHs for dual carrier with time-dilated UMTS as secondary carrier, N=4

6.2.2 Evaluation results

6.2.2.1 Link level results for carrier aggregation of time-dilated UMTS with UMTS

Table 6.2.2.1-1 and Table 6.2.2.1-2 show the DL link level simulation results for HSDPA, comparing UMTS and S-UMTS carrier aggregation with scaling factor N =2, 4, for PA3, VA3, VA30 and VA120 channels.

The performance metrics that are shown are computed as follows:

Throughput gain = ((Throughput with time-dilated UMTS carrier aggregation) – (Throughput with UMTS))/ (Throughput with UMTS)

Table 6.2.2.1-1: Time-dilated UMTS Carrier Aggregation downlink simulation results for HSDPA in 7.5MHz spectrum (N=2), with outer loop ON

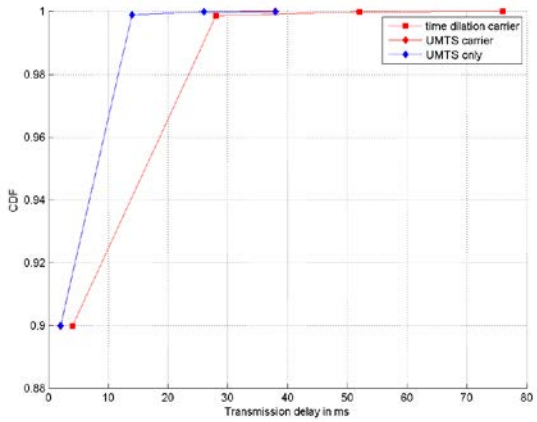
	Ior/Ioc	Throughput Gain			
		PA3	VA3	VA30	VA120
Huawei, HiSilicon	-5	54.14%	58.33%	46.74%	49.87%
	0	52.00%	54.77%	47.53%	49.88%
	5	51.81%	54.67%	48.83%	48.61%
	10	51.82%	54.17%	50.41%	49.61%
	15	52.72%	53.41%	51.29%	48.62%
	20	53.43%	51.77%	53.64%	46.79%
		PA3	VA3	VA30	VA120
Qualcomm	-5	51.73%	55.15%	48.78%	57.65%
	0	53.06%	51.57%	46.94%	56.21%
	5	52.78%	53.81%	48.90%	54.78%
	10	50.38%	52.80%	48.08%	53.91%
	15	50.70%	52.99%	50.02%	52.94%
	20	50.43%	51.58%	50.63%	50.43%
NOTE: This simulation results refer to the Carrier Aggregation of one N=1 UMTS carrier and one N=2 time-dilated UMTS carrier in a total bandwidth of 7.5 MHz					

Table 6.2.2.1-2: Time-dilated UMTS carrier aggregation downlink simulation results for HSDPA in 6 MHz spectrum (N=4), with outer loop ON

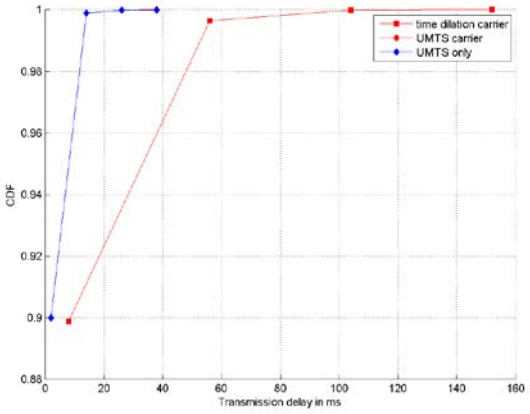
	Ior/Ioc	Throughput Gain			
		PA3	VA3	VA30	VA120
Huawei, HiSilicon	-5	19.15%	19.29%	17.90%	23.36%
	0	20.69%	20.57%	19.05%	22.71%
	5	21.89%	21.83%	20.77%	21.15%
	10	22.81%	21.24%	20.56%	19.18%
	15	23.42%	19.32%	19.60%	18.35%
	20	23.94%	17.33%	17.21%	16.01%
		PA3	VA3	VA30	VA120
Qualcomm	-5	26.86%	23.57%	20.40%	29.02%
	0	17.67%	21.97%	22.14%	27.20%
	5	21.25%	26.13%	25.40%	25.93%
	10	22.68%	23.54%	24.54%	25.75%
	15	23.77%	26.51%	25.77%	24.62%
	20	24.15%	26.02%	27.41%	22.82%
NOTE: This simulation results refer to the carrier aggregation of one N=1 UMTS carrier and one N=4 time-dilated UMTS carrier in a total bandwidth of 6 MHz.					

HSDPA latency as an additional metric for time-dilated UMTS (N=2, 4) for outer loop ON setting is presented. The latency presented is the OTA transmission delay taken to transmit a data packet. The following two figures depict the CDF and average transmission delay metrics for UMTS and the time-dilated UMTS for different Carrier Aggregation scenarios.

(a) CA configuration using UMTS + time-dilated UMTS (N=2) in 7.5 MHz



(b) CA configuration using UMTS + time-dilated UMTS (N=4) in 6.0 MHz



(c) CA configuration using UMTS + time-dilated UMTS (N=4) in 6.25 MHz

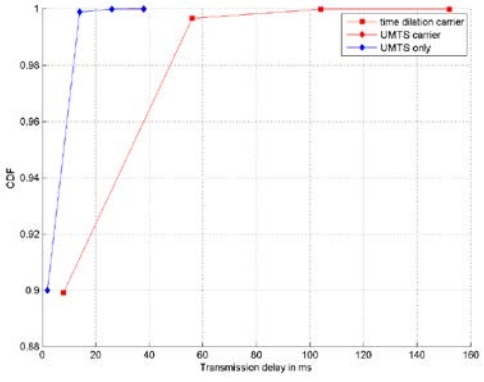


Figure 6.2.2-1: CDF of the latency in terms of transmission delay for Carrier Aggregation configurations of UMTS and time-dilated UMTS compared to UMTS; PA3 channel, 10 dB geometry

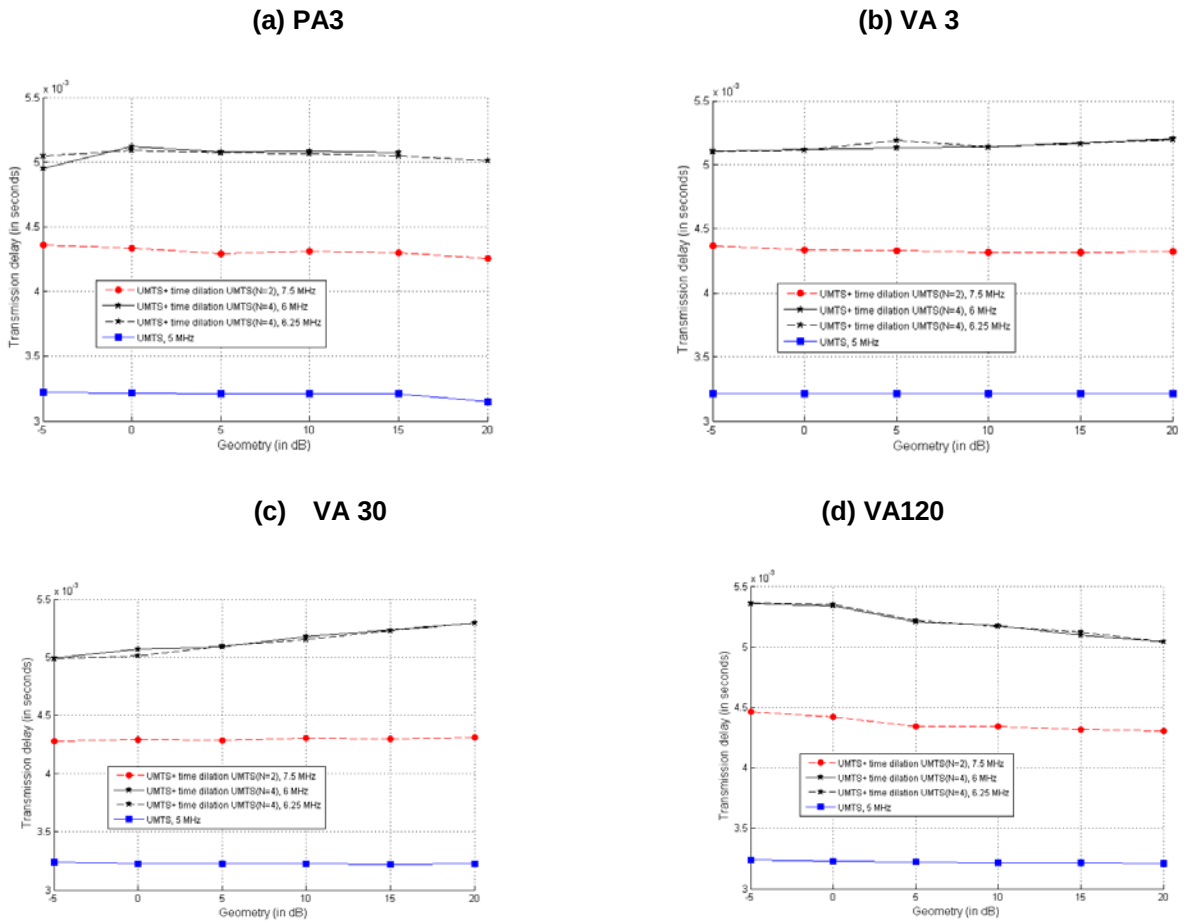


Figure 6.2.2-2: Average transmission delay for carrier aggregation configurations of UMTS and time-dilated UMTS compared to UMTS

6.2.2.2 System simulation results for Carrier Aggregation of time-dilated UMTS with UMTS

In the multicarrier case, multicarrier users can benefit from increased throughput; the extent of the benefit depends on the bandwidth and the penetration level of multicarrier users.

The bursty traffic UEs are modelled by the parameters given in simulation assumptions in subclause 6.3.1.
The same assumptions are applied to both carriers, with the exception of control channels on the second carrier where it was assumed that only P-CPICH is transmitted. The time dilation factor on the first carrier is always N =1 and the factor on the second carrier is N = 2 or N =4.

In the results for Carrier Aggregation shown below, all the UEs are assumed to be capable of Carrier Aggregation. The system performance for lower proportions of Carrier Aggregation UEs has not been evaluated.

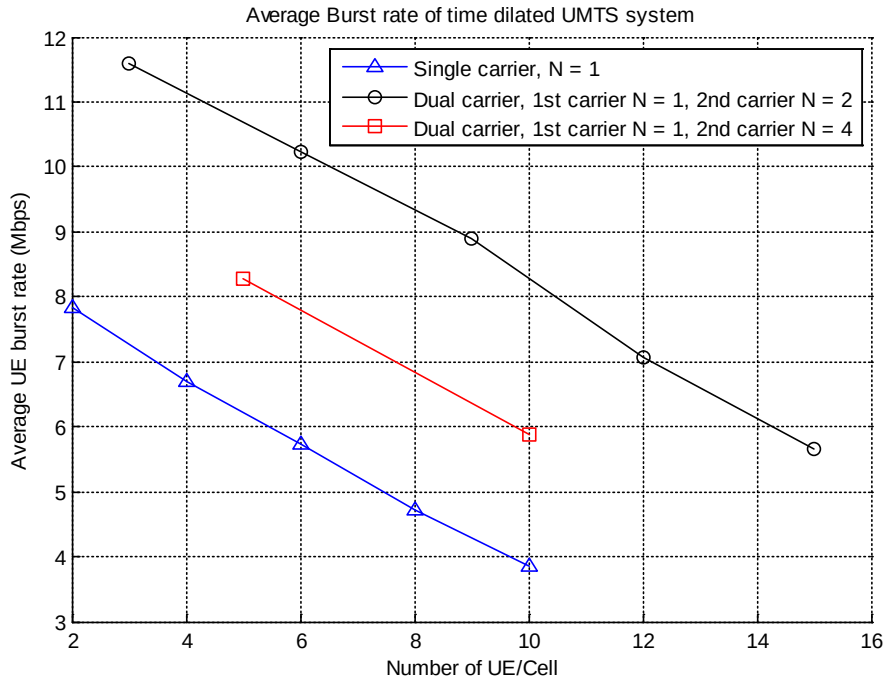


Figure 6.2.2.2-1: Average UE burst rate

In Figure 6.2.2.2-1, the average burst rate of the UEs is presented for different scenarios. From the figure it is observed that for total K UEs in single carrier case if the average burst rate is R, the dual carrier with N = 2 on the second carrier and with 1.5 K UEs has an average burst rate of approximately 1.5 R. Also, the dual carrier with N = 4 on the second carrier and with 1.25 K UEs has an average burst rate of approximately 1.25 R. To explain this observation, notice that the dual carrier system of Time Dilation factor N on the second carrier with (1+1/N)K UEs is observing a load that is (1+1/N) times the load observed by the single carrier system with K UEs. Furthermore, the service rate of the dual carrier system is (1+1/N) times the service rate of the single carrier system as the available bandwidth is scaled by (1+1/N). As a result, based on the queuing theory, the burst rate of the dual carrier system is (1+1/N) times the burst rate of the single carrier system. For a more direct comparison of different time-dilated UMTS systems the effective number UEs/Sector is defined as K for single carrier system and (1+1/N) K for the dual carrier system.

Table 6.2.2.2-1 present the average, 5%, and 50% tail value of the UEs burst rate and shows that similar ratios hold for the tail values of the burst rate.

Table 6.2.2.2-1: UE burst rate (Mbps) statistics

Eff. # UE/Sec.	Single Carrier N =1			Dual Carrier, N =1 on 1st Carrier and N =2 on 2nd Carrier			Dual Carrier, N =1 on 1st Carrier and N =4 on 2nd Carrier		
	5%	50%	Avg.	5%	50%	Avg.	5%	50%	Avg.
2	4	7.3	7.8	6	11.1	11.6	-	-	-
4	2.7	6.3	6.7	4.8	9.6	10.2	3.8	7.7	8.3
6	2	5.1	5.7	3.7	8.4	8.9	-	-	-
8	1.4	4.1	4.7	2.5	6.3	7.1	2	5.2	5.9
10	0.9	3.4	3.8	1.4	4.9	5.7	-	-	-

Finally, the following plots present the CDF of the UEs burst rate for different values of effective number of UEs per sector. As, shown by the CDFs, similar proportion holds between burst rate of different time-dilated UMTS systems across different tail values.

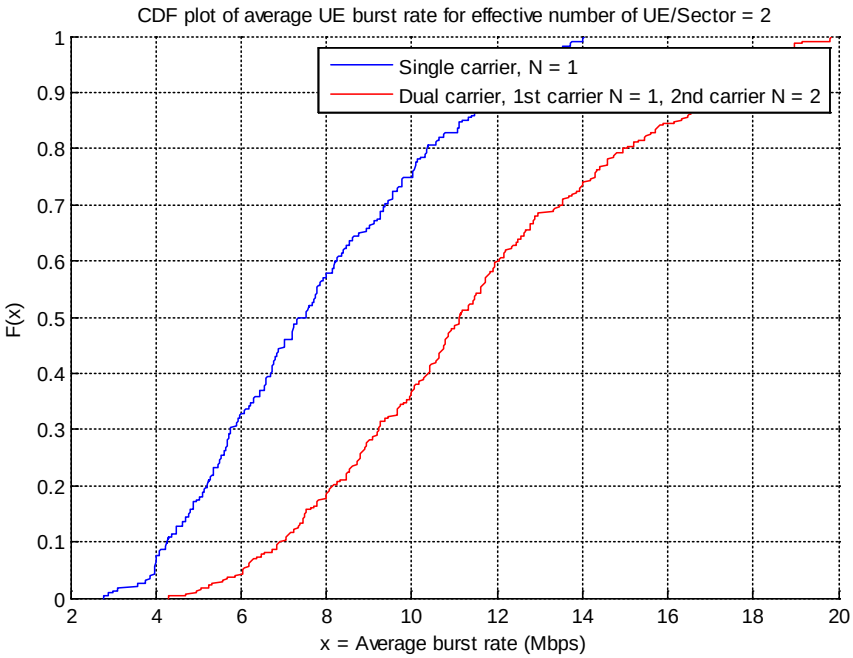


Figure 6.2.2.2-2: CDF of average UE burst rate for effective number UEs per sector = 2

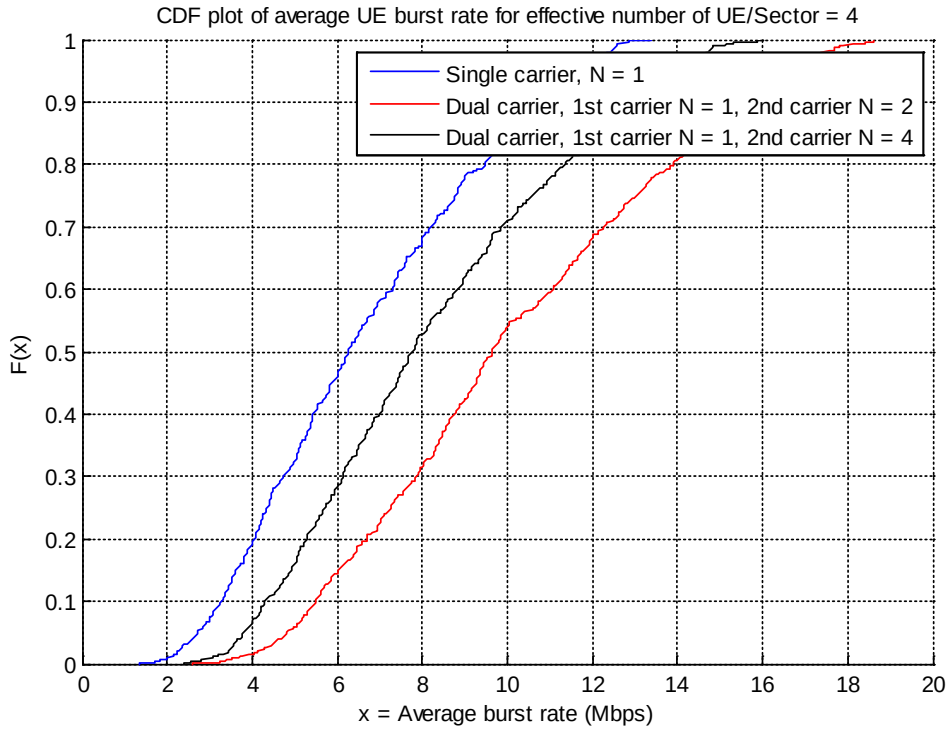


Figure 6.2.2.2-3: CDF of average UE burst rate for effective number UEs per sector = 4

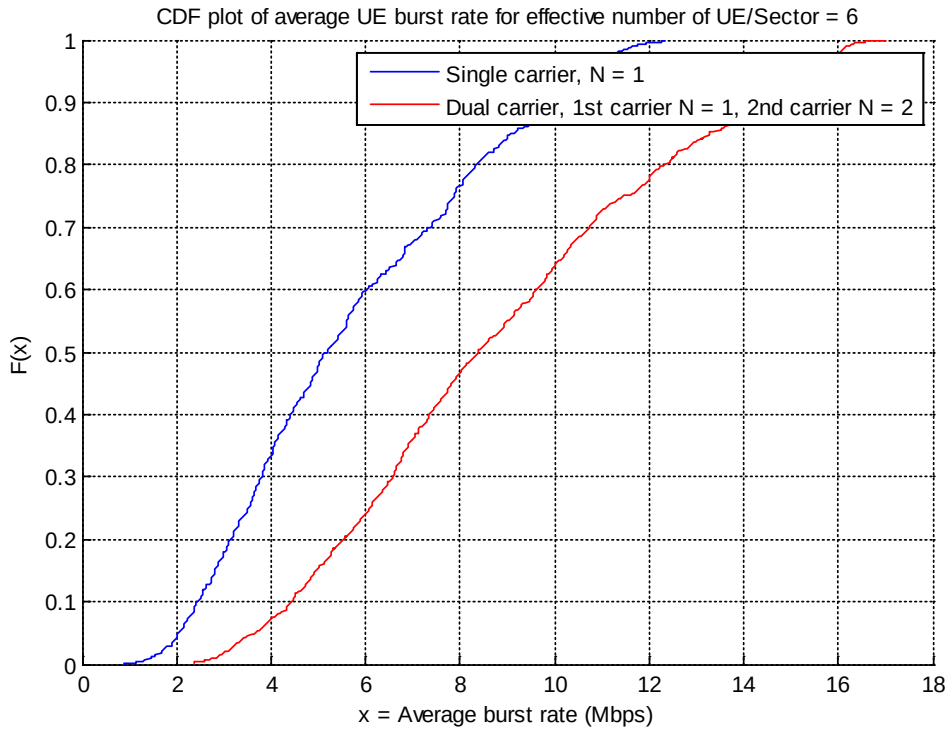


Figure 6.2.2.2-4: CDF of average UE burst rate for effective number UEs per sector = 6

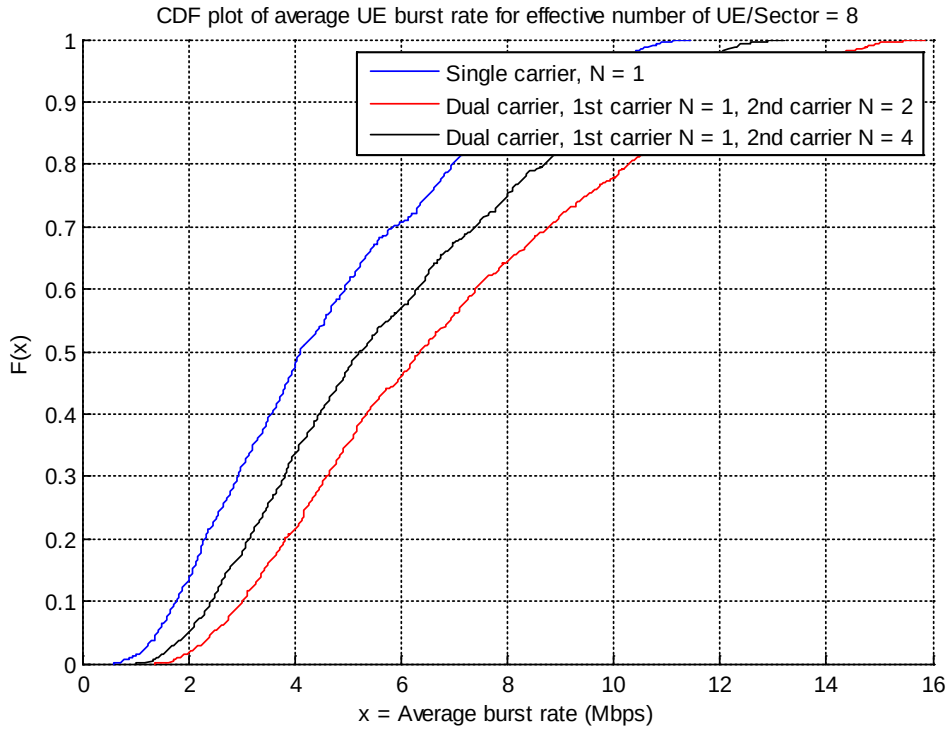


Figure 6.2.2.2-5: CDF of average UE burst rate for effective number UEs per sector = 2

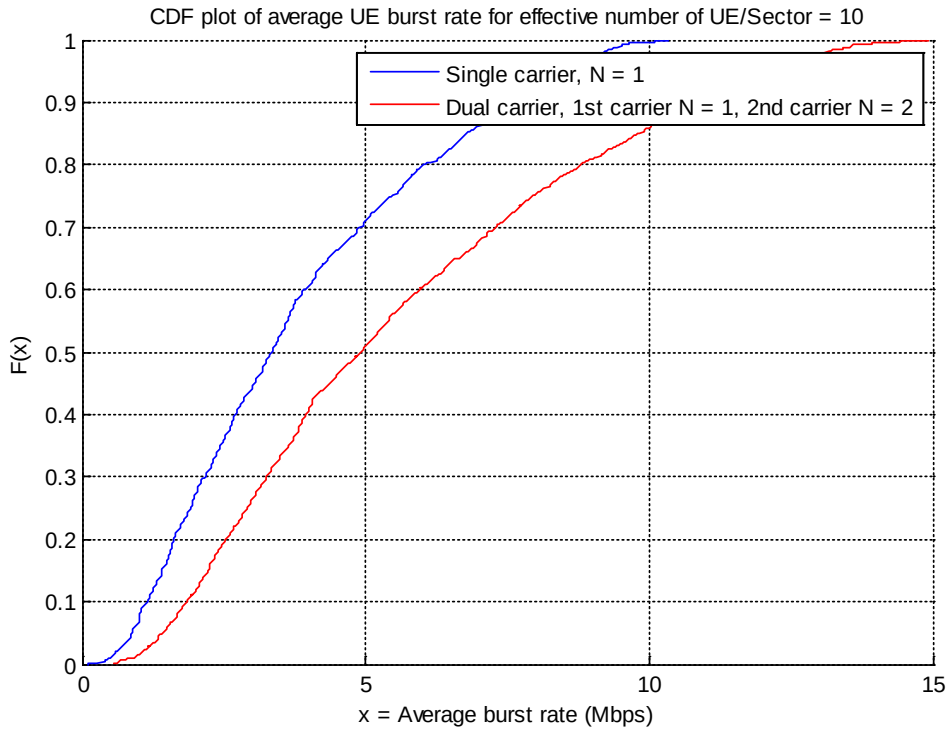


Figure 6.2.2.2-6: CDF of average UE burst rate for effective number UEs per sector = 2

6.2.2.2.1 Inter-carrier leakage

For time-dilated UMTS multiple-carrier scenarios, depending on the size of the spectrum block and case, there is a risk for Inter Carrier Leakage (ICL) between the UMTS and the time-dilated UMTS carriers assuming that the offset towards the edge of block is kept to the nominal value to avoid co-existence issues with adjacent uncoordinated operating networks.

The ICL is a combined effect of transmitter unwanted emissions, Adjacent Carrier Leakage Ratio (ACLR) and limited selectivity in the receiver, Adjacent Channel Selectivity (ACS). Figure 6.2.2.2.1-1 gives an example of DL ICL, where the BS time-dilated UMTS emissions in form of ACLR as well as selectivity of the UMTS UE would contribute to ICL on the UMTS carrier in DL. The level of ICL in a multiple-carrier scenario will depend on the level of separation/overlap between the UMTS and time-dilated UMTS carriers. Note that in DL, the minimum specified value for BS ACLR is 45 dB, while the UE ACS value is 33 dB considering nominal spacing/separation between UMTS carriers.

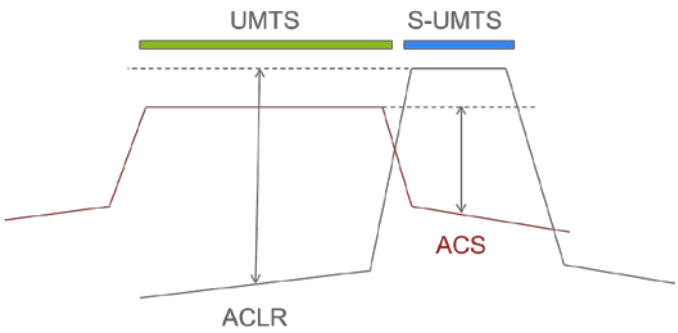


Figure 6.2.2.2.1-1: Mechanisms to calculate the ICL

The ICL is calculated as:

$$\frac{1}{ICL} = \frac{1}{ACLR} + \frac{1}{ACS}$$

It is essential to consider both BS ACLR and UE ACS since ICL in DL would in general be limited to UE selectivity and thus only considering the BS transmitter ACLR as the only source to ICL would result in wrong and extremely optimistic ICL which highly affects the conclusions.

The BS ACLR models are based on an extremely good radio transmitter dimensioned for linearization of around 60 dBc. The corresponding UMTS ACLR would be ~55 dB, which is 10 dB better than the required performance according to existing RAN4 specifications. The same transmitter was used to investigate the time-dilated UMTS carriers for both N=2 and N=4. The transmitter characteristics and the emissions outside the carrier for UMTS and time-dilated UMTS carriers are given in Figure 6.2.2.2.1-2.

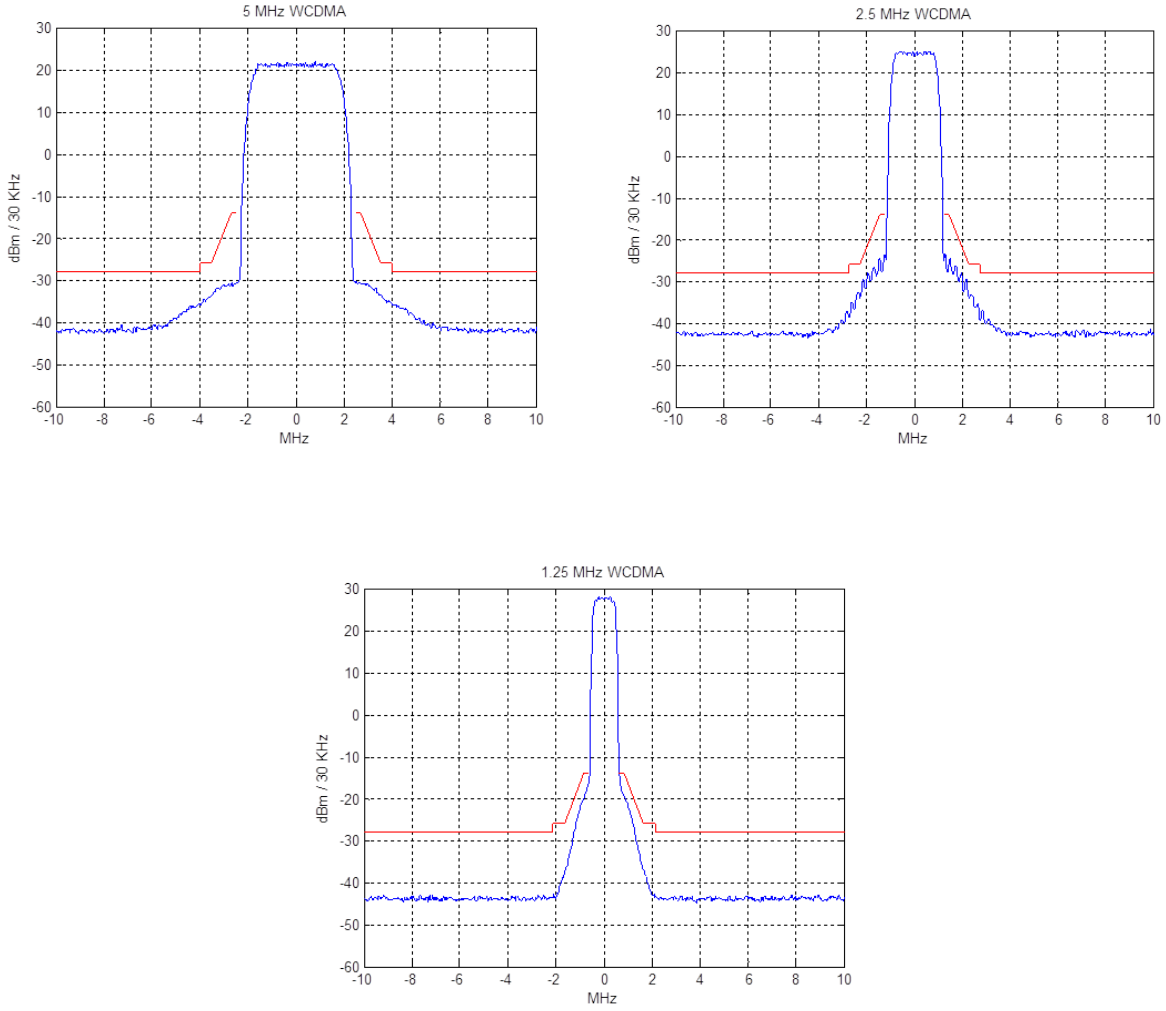


Figure 6.2.2.2.1-2: UMTS and time-dilated UMTS transmitter characteristics (blue) and UMTS spectrum emission mask (red)

The BS ACLR values for time-dilated UMTS carriers are based on measurement in adjacent UMTS carrier and are given for 2.5 MHz and 1.25 MHz time-dilated UMTS carriers respectively. Various centre-to-centre separations between UMTS and time-dilated UMTS carriers are considered. A simple UE ACS model is given below and similar to the BS ACLR models, the ACS values for the UMTS carrier are based on the presence of a time-dilated UMTS carrier in the adjacent channel. The UE ACS values are shown for various centre-to-centre separations between UMTS and time-dilated UMTS carriers. The UMTS ACS value is ~50 dB, which is significantly better than the standardized minimum value of 33 dB. The ACS model does not, however, include possible improvements, such as, employing advanced receivers (e.g. interference cancellation capable receivers, Type 3i). Nevertheless, it should be emphasized that the BS ACLR and UE ACS models used for these simulations represent very good radios that are significantly

better than what is required by the RAN4 specifications, and consequently the presented results are overly optimistic. Other companies are encouraged to investigate the impact of using other radio impairment models to derive the effective ICL.

Figures 6.2.2.2.1-3, 6.2.2.2.1-4 and 6.2.2.2.1-5 show the BS ACLR, UE ACS and the effective DL ICL towards a victim UMTS carrier for different aggressor bandwidth carriers as a function of victim and aggressor centre carrier separation (frequency offset).

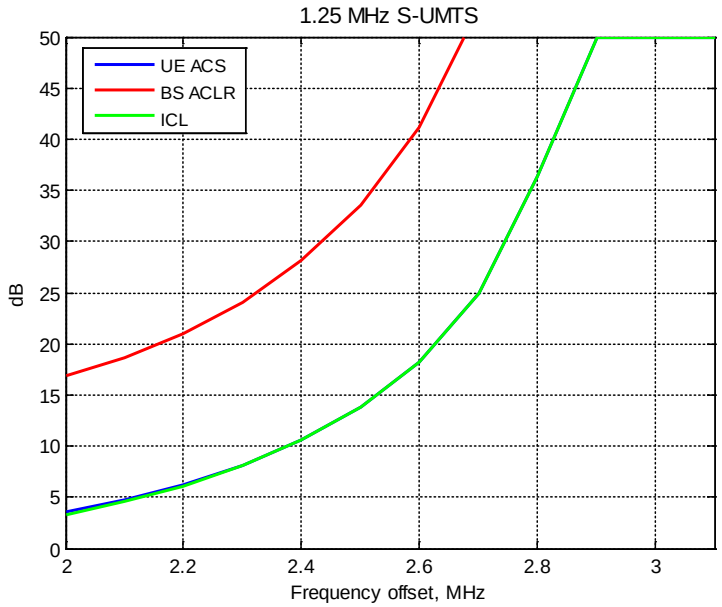


Figure 6.2.2.2.1-3: UE ACS, BS ACLR and ICL.
The frequency offset represents the frequency distance between the centre of the UMTS carrier and the centre of the time-dilated UMTS carrier.
As an example, the minimum frequency offset that results in no overlap is given by 5/2+1.25/2 = 3.125 MHz.

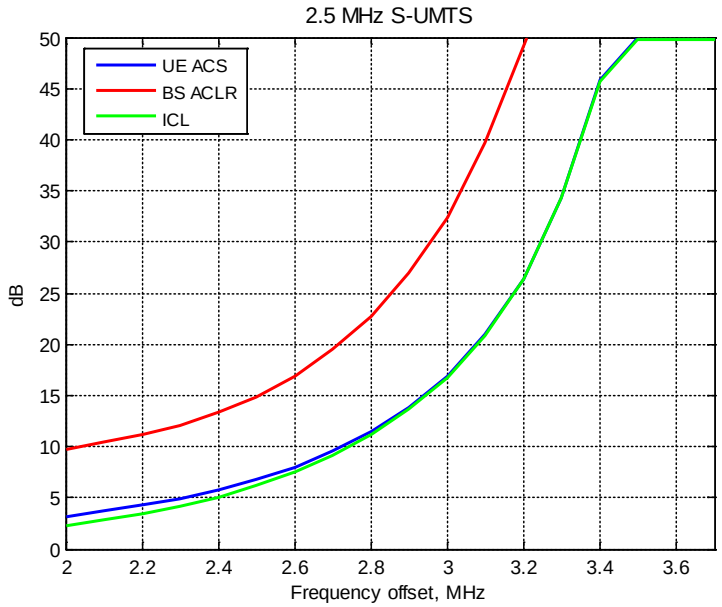


Figure 6.2.2.2.1-4: UE ACS, BS ACLR and ICL.
The frequency offset represents the frequency distance between the centre of the UMTS carrier and the centre of the time-dilated UMTS carrier.
As an example, the minimum frequency offset that results in no overlap is given by 5/2+2.5/2 = 3.75 MHz.

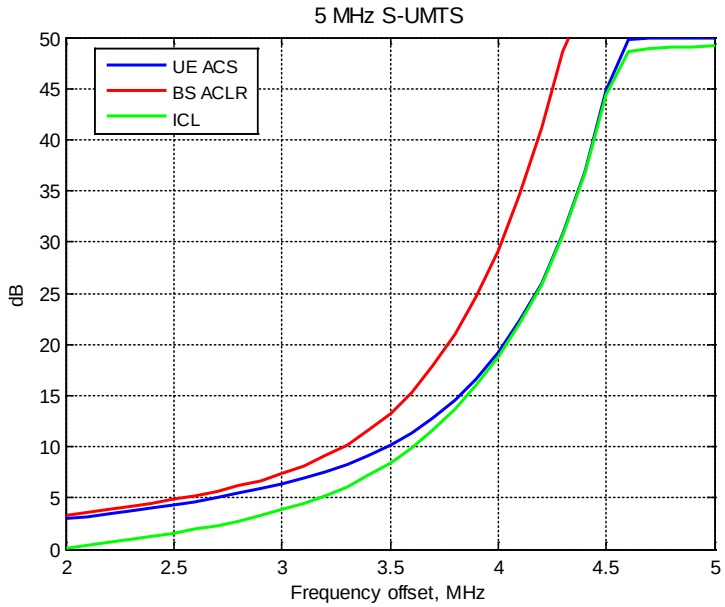


Figure 6.2.2.2.1-5: UE ACS, BS ACLR and ICL.
The frequency offset represents the frequency distance between the centre of the UMTS carrier and the centre of the time-dilated UMTS carrier.
As an example, the minimum frequency offset that results in no overlap is given by 5/2+5/2 = 5 MHz.

6.2.2.2.2 Results for UMTS + 1.25 MHz time-dilated UMTS in 6 MHz block assuming equal PSD

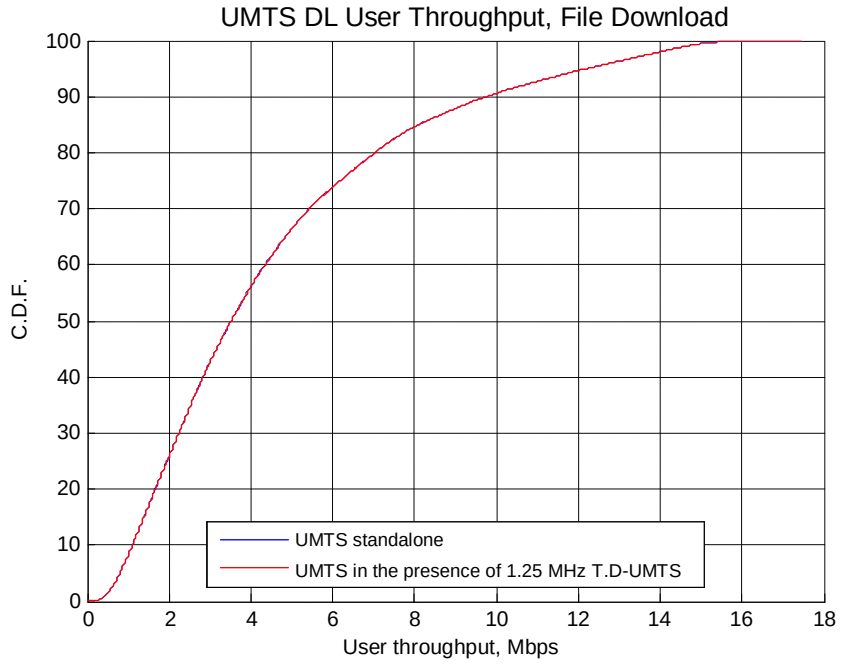


Figure 6.2.2.2.2-1: UMTS DL user throughput, file download

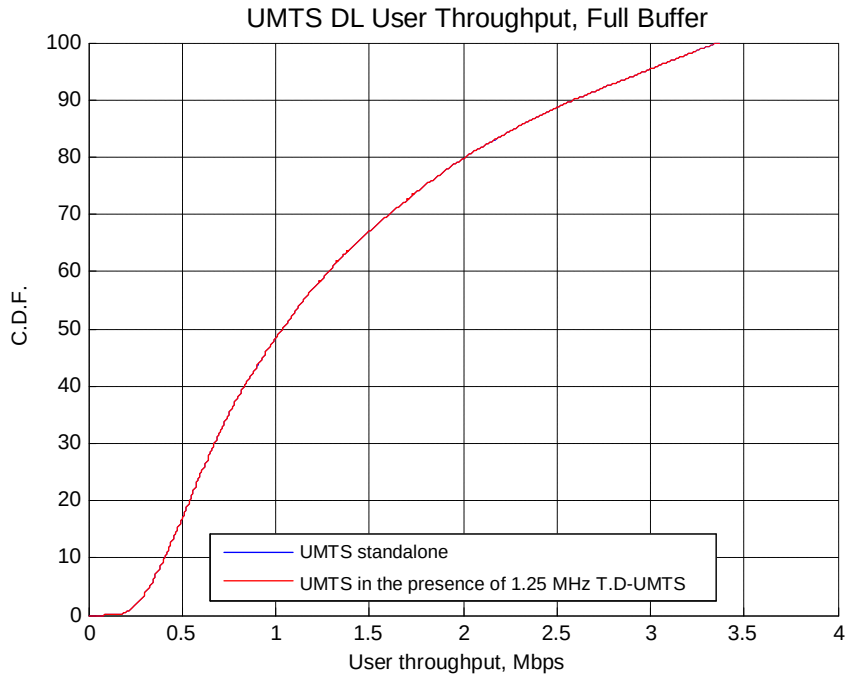


Figure 6.2.2.2.2-2: UMTS DL user throughput, full buffer

The system simulation results for the multiple-carrier scenario of UMTS + 1.25 MHz time-dilated UMTS in 6 MHz show that impact on the UMTS carrier is negligible when using extremely good radios.

6.3 Void

6.4 Void

6.5 Void

6.6 Void

6.7 Void

6.8 Scalable Bandwidth UMTS by Filtering

6.8.1 Description

The "Scalable Bandwidth UMTS solution by Filtering" comprises of using the same BB processing and the typical 3.84 Mcps chip rate used in UMTS FDD systems, and filtering the signal to fit to a channel bandwidth below 3.84 MHz. That is, the filtering is used to trade off signal quality and occupied bandwidth.
In the present document, this solution is referred to as "Scalable Bandwidth UMTS by Filtering".

Figure 6.8.1-1 illustrates the concept, where the filtered UMTS pass-bandwidth is narrower than the 3.84 Mcps signal. For illustration purposes 2.5 MHz filter has been shown, but the filter pass bandwidth could be selected to best fit a given deployment scenario.

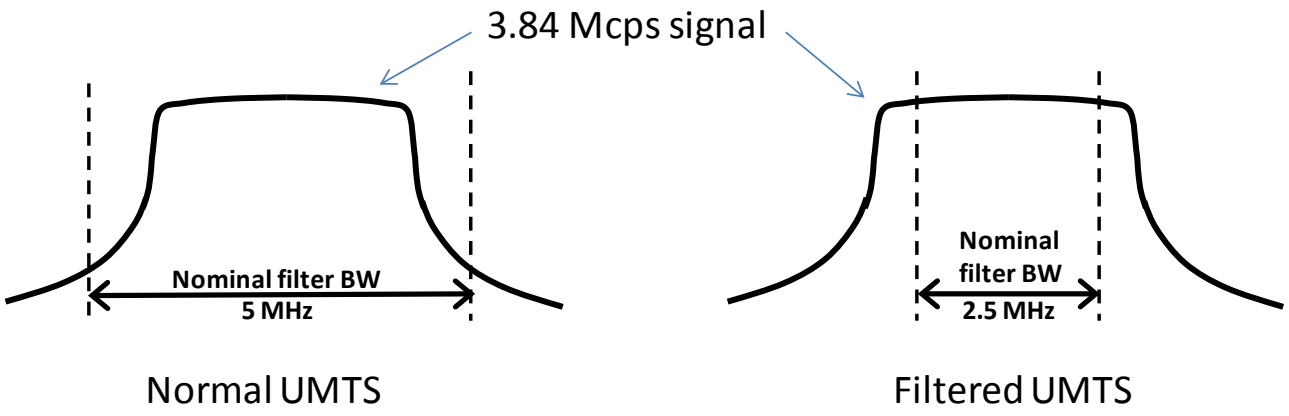


Figure 6.8.1-1: Normal and 2.5 MHz filtered UMTS waveforms

The "Scalable Bandwidth UMTS solution by Filtering" uses the UMTS FDD physical layer specifications as is, with the only difference being the transmit and receive filters.

6.8.2 Preliminary evaluation results on filtered UMTS motivating further study

6.8.2.1 Downlink link level results

NOTE: The following results were obtained during the first SI on scalable UMTS bandwidths [3] as a motivation to consider pure and enhanced filtering solutions further. These simulations differ from more realistic results in their assumptions on P-CPICH overhead, SCH overhead, PICH overhead.

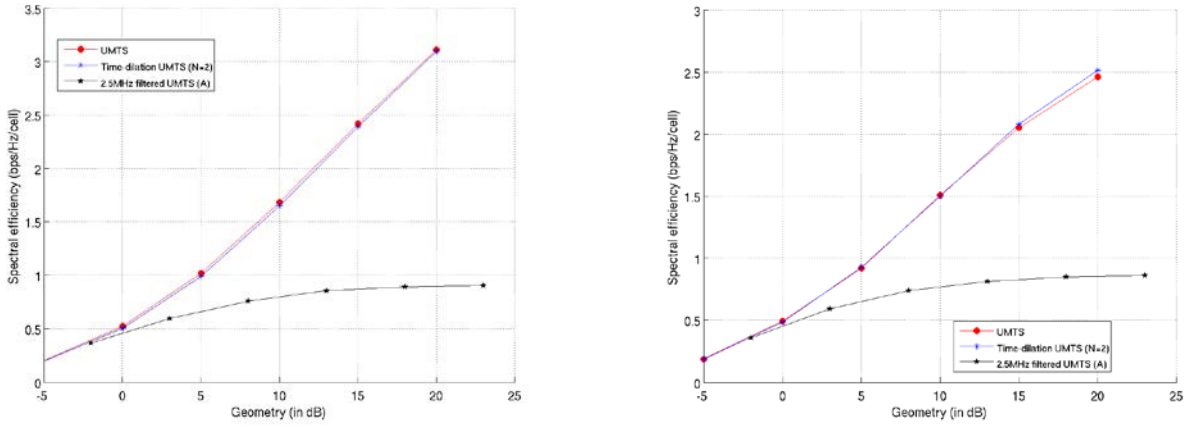
6.8.2.1.1 HSDPA link analysis

The spectral efficiency comparison between regular UMTS (5.0 MHz deployment) with the filtering solution (2.5 MHz) and time-dilation UMTS (2.5 MHz) is given in Figures 6.8.2.1.1-1~2.

From Figure 6.8.2.1.1-1, it can be observed that UMTS and time-dilation UMTS have comparable spectral efficiencies. On the other hand, the filtering solution has lower spectral efficiency that saturates at high geometry.
This can be attributed to the Inter-Symbol Interference (ISI) that results from the filtering operation.
Note that while there is a type 3i equalizer utilized, it is still insufficient to combat the large ISI and spectral efficiency caps below 1 bps/Hz/cell for PA3 channel. Other channels based on VA models recorded even lower spectral efficiencies (0.6 bps/MHz/cell for VA 120 channel) owing to the fact that filtering-induced ISI is now compounded with the channel induced ISI.

Results for 1.25 MHz bandwidth in Fig 6.8.2.1.1-2 re-iterate the same issue with filtering solution, albeit in a stronger sense with lower spectral efficiencies due to increased ISI compared to filtering solution (2.5 MHz).
Note that in this setting, the RRC (1.25 MHz) has main-lobe that spans 4 symbols on the right and 4 symbols on the left. On the other hand, the main-lobe spans 2 symbols on each side for RRC(2.5 MHz) whence the ISI is relatively lower.

(a) PA3 **(b) VA3**



(c) VA30 **(d) VA120**

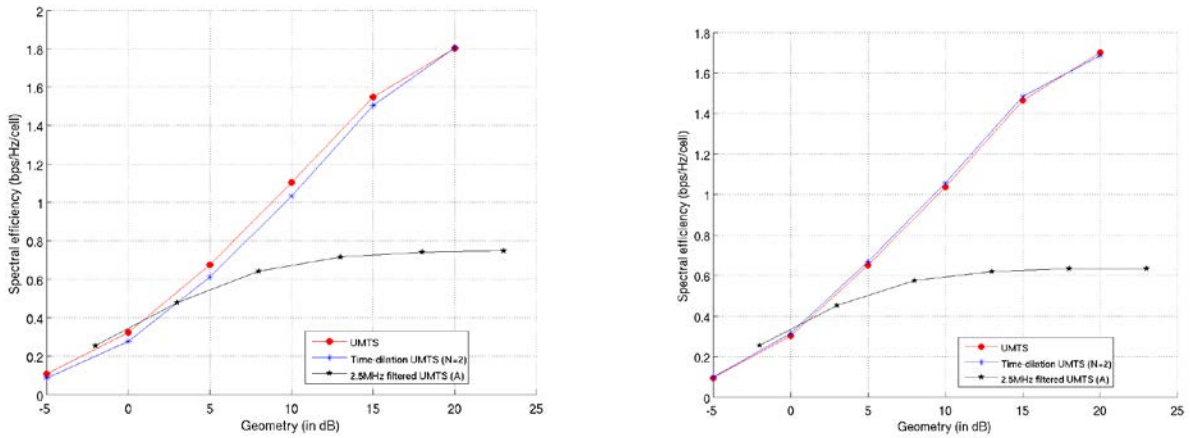
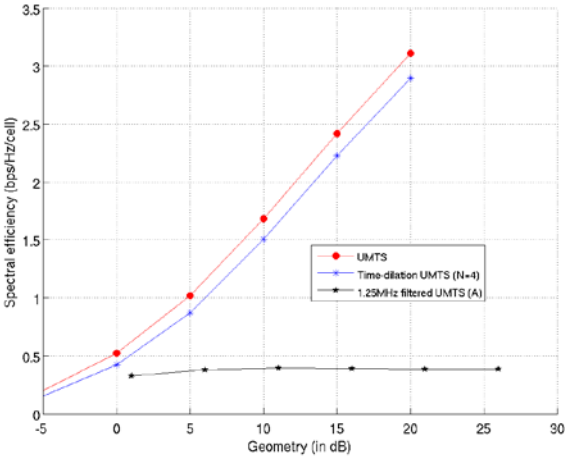
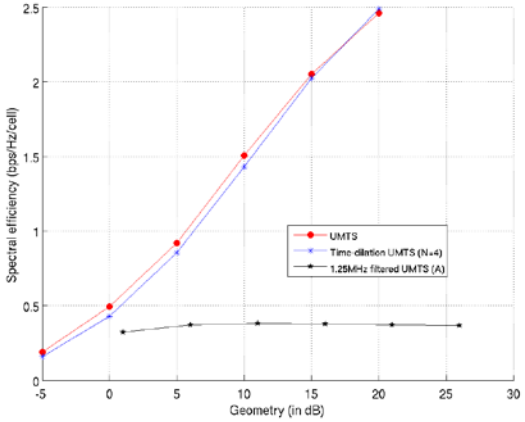


Figure 6.8.2.1.1-1: Spectral efficiency (bps/Hz/cell) of HSDPA (2.5 MHz solutions versus UMTS (5.0 MHz))

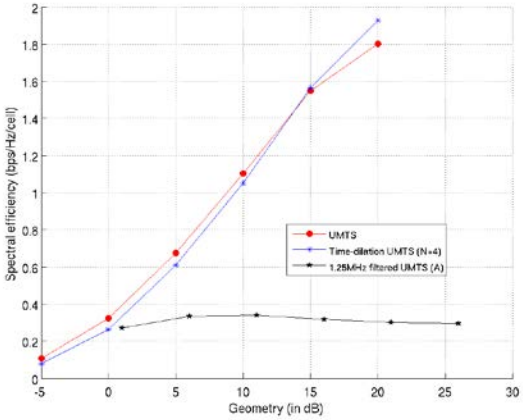
(a) PA3



(b) VA3



(c) VA30



(d) VA120

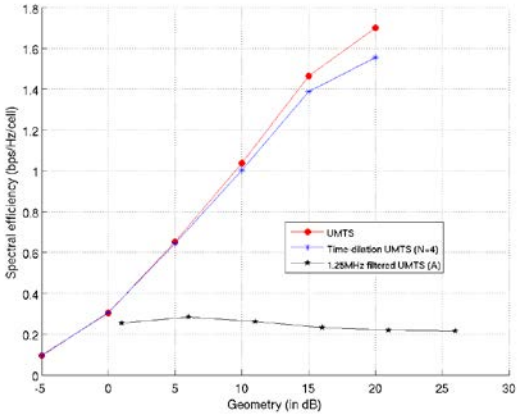


Figure 6.8.2.1.1-2: Spectral efficiency (bps/Hz/cell) of HSDPA (1.25 MHz solutions versus UMTS (5.0 MHz))

6.8.2.1.2 DCH simulation results

Scalable UMTS with 2.5 MHz filtering is considered to be able to carry AMR 12.2 kbps DCH voice.
In order to compare the performance of UMTS with Filtering and the original UMTS, the following performance metrics are computed as:

- *UMTS with Filtering gain (UL) =(Rx Ec/No with UMTS) - (Rx Ec/No with UMTS with Filtering -3dB)*
- *UMTS with Filtering gain (DL) =(Tx Ec/Ior with UMTS) - (Tx Ec/Ior with UMTS with Filtering -3dB)*

Table 6.8.2.1.2-1: Uplink performance of AMR 12.2 kbps voice

Carrier Frequency (MHz)	Channel	UMTS		2.5MHz filtered UMTS	
		Rx EcNo (dB)	Tx EcNo (dB)	Rx EcNo Loss (dB)	Tx EcNo Loss (dB)
900	PA3	-18.12	-19	-0.1	0
900	VA3	-17.388	-19.6	0	0.4
900	VA30	-17.298	-19.5	0.3	0.3
900	VA120	-17.017	-19.7	0.1	-0.1
2000	PA3	-18.323	-19.2	0.3	0.9
2000	VA3	-17.354	-19.3	0.3	0.8
2000	VA30	-17.018	-19.5	0.1	0.1
2000	VA120	-16.543	-19.3	-0.1	-0.3

Table 6.8.2.1.2-2: Downlink performance of AMR 12.2 kbps voice

Carrier Frequency (MHz)	Channel	Geometry	UMTS	2.5 MHz filtered UMTS
			DPCH Eclor	Eclor Loss
900	PA3	0	-12.9	
900	PA3	5	-17.1	-0.2
900	PA3	10	-20.5	1.1
900	VA3	0	-14.9	0
900	VA3	5	-18.1	1.3
900	VA3	10	-19.8	1.5
900	VA30	0	-15.5	1.1
900	VA30	5	-18.5	1.5
900	VA30	10	-20.5	2.2
900	VA120	0	-14.7	-0.5
900	VA120	5	-18	0.8
900	VA120	10	-19.7	1.3
2000	PA3	0	-12.3	
2000	PA3	5	-17	0.7
2000	PA3	10	-20.4	0.9
2000	VA3	0	-15.7	1
2000	VA3	5	-18.9	2.1
2000	VA3	10	-20.5	2.3
2000	VA30	0	-15.8	1.1
2000	VA30	5	-18.7	1.4
2000	VA30	10	-20.4	2
2000	VA120	0	-14.5	-0.6
2000	VA120	5	-17.8	0.7
2000	VA120	10	-19.7	1.5

6.8.2.2 Uplink link level results

The following results were obtained during the first SI on scalable UMTS bandwidths [3] as a motivation to consider pure and enhanced filtering solutions further. The results may differ from more realistic results in their assumptions on the UL receiver type, HARQ operating point, code tree utilisation, and number of parallel users.

6.8.2.2.1 Uplink E-DCH performance of Scalable Bandwidth UMTS by filtering in 2.5 MHz channel BW

Link simulation is performed for different E-DCH transport block sizes and channel models with a 2.5 MHz filter that is achieved by halving the pass-band of a nominal 5 MHz filter, i.e. the transmitted signal is a regular 3.84 Mcps E-DCH signal with a filter that is narrower than the bandwidth of the signal and no other filter optimizations have been introduced. The required received C/I needed for 90% nominal throughput (e.g. for 1 Mbps instantaneous data rate, 900 kbps data rate is achieved after HARQ) is logged for a given data rate and power control is turned off.
A dual-Rx Rake receiver was used.

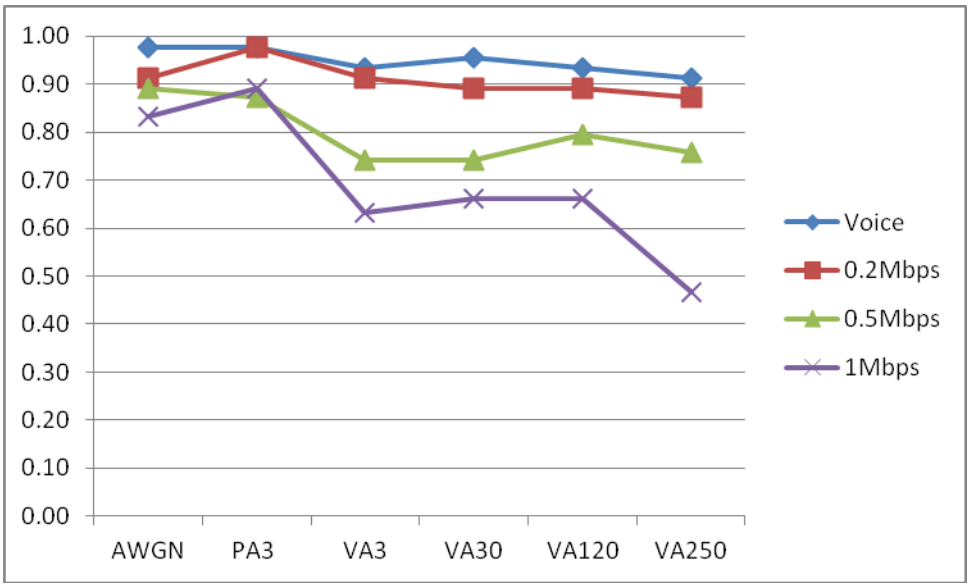


Figure 6.8.2.2.1-1: Spectral efficiency of a filtered 2.5 MHz 3.84 Mcps E-DCH link relative to 5 MHz link

A small link performance loss can be observed for low data rates. The loss appears to increase as a function of data rate for other channels, but less so for the PA3 channel. However, it should be noted that there was no attempt to optimize the transmit filter or the receiver to the narrower bandwidth, so drawing firm conclusions based on these results may be premature.

6.8.2.2.2 Uplink E-DCH performance of Scalable Bandwidth UMTS by filtering and zeroing every second chip in 2.5 MHz channel BW

Link simulation is performed for different E-DCH transport block sizes and channel models with a 2.5 MHz filter that is achieved by halving the pass-band of a nominal 5 MHz filter. In addition to this, every second chip is set to zero in the transmitter. No other optimizations have been introduced. The required received C/I needed for 90% nominal throughput (e.g. for 1 Mbps instantaneous data rate, 900 kbps data rate is achieved after HARQ) is logged for a given data rate and power control is turned off. A dual-Rx Rake was used.

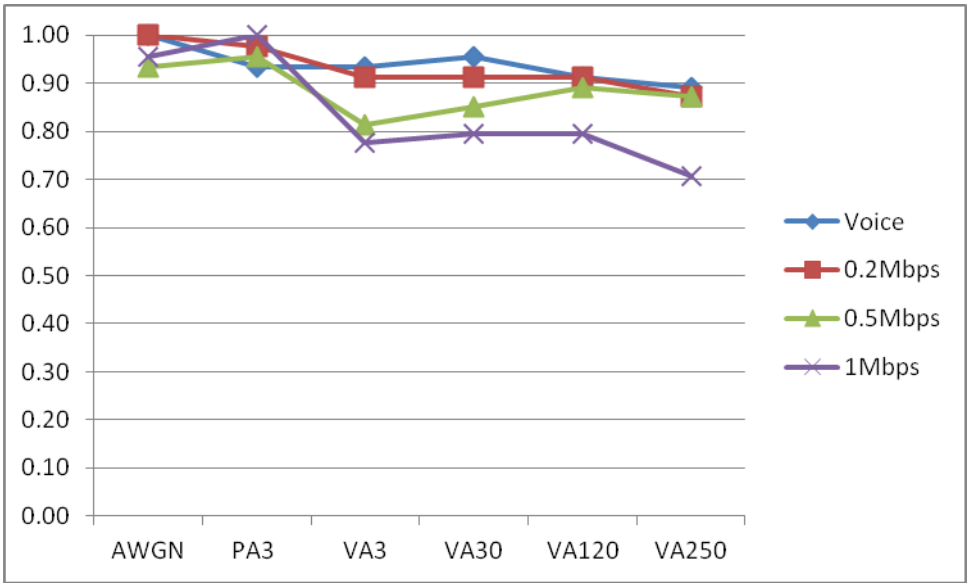


Figure 6.8.2.2.2-1: Spectral efficiency of a filtered 2.5 MHz 3.84 Mcps E-DCH link with zeroing every second chip relative to 5 MHz link

The negative impacts of over-filtering have been largely mitigated by the chip-zeroing. A small link performance loss can be observed for low to medium data rates, and even 1 Mbps link performs well in a good channel, but more significant loss can be observed in more difficult channel conditions.

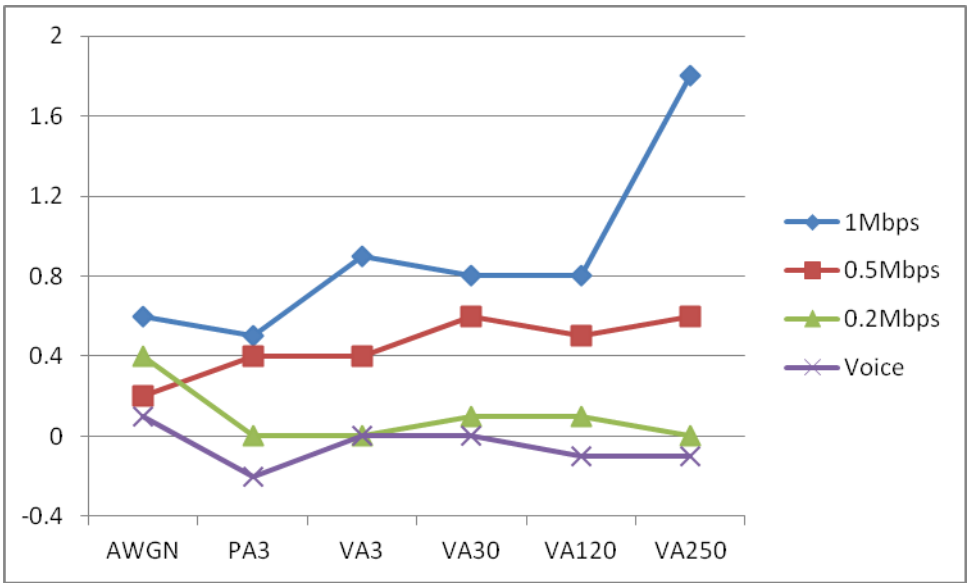


Figure 6.8.2.2.2-2: Gain from setting every second chip to zero in a 3.84 Mcps signal and 2.5 MHz filter [dB]

Chip-zeroing does not provide any meaningful benefits for low rates. With higher data rates, more loss is observed from filtering, and the chip zeroing is mitigating this effect, and the negative impacts of over-filtering have been largely mitigated by the chip-zeroing.

6.8.2.2.3 EUL link analysis

This subclause presents EUL simulation results with regular UMTS (5.0 MHz deployment) with the filtering solution (2.5 MHz) and time-dilation UMTS (2.5 MHz) and provides comparison between these two schemes in terms of throughput and spectral efficiency. Table 6.8.2.2.3-1 shows the throughput for UMTS, time dilation UMTS, and 2.5 MHz filtered UMTS. It is observed in Table 6.8.2.2.3-2 that the performance with UMTS and time-dilation UMTS

are observed to be comparable. On the other hand, the 2.5 MHz filtered UMTS inducing ICI has spectral efficiency losses by 20-33% compared to UMTS as provided in Table 6.8.2.2.3-3. In these simulations, there is 10% target BLER setting after 1 HARQ with 2 ms TTI.

Table 6.8.2.2.3-1: Throughput

Channel	Rx Ec/No=5dB					
	Throughput (kbps) @10% BLER after 1 HARQ					
	UMTS		Time Dilation UMTS		2.5 MHz filtered UMTS	
	Carrier Frequency (MHz)		Carrier Frequency (MHz)		Carrier Frequency (MHz)	
	900	2000	900	2000	900	2000
PA3	3267.5	3244.4	1701.6	1686.4	1267.7	1264.3
VA 3	2695.2	2675.9	1413.6	1397.2	1073.2	1054.8
VA 30	2601.4	2309.1	1225.6	954.6	1015.8	862.9
VA 120	1890.7	1880.2	959.7	902.6	639.7	628.9

Table 6.8.2.2.3-2: Spectral Efficiency in case of Time Dilation UMTS

Channel	Spectral Efficiency					
	UMTS		Time Dilation UMTS		Gain (%)	
	Carrier Frequency (MHz)		Carrier Frequency (MHz)		Carrier Frequency (MHz)	
	900	2000	900	2000	900	2000
PA3	0.65	0.65	0.68	0.67	4.15	3.96
VA 3	0.54	0.54	0.57	0.56	4.90	4.43
VA 30	0.52	0.46	0.49	0.38	-5.77	-17.32
VA 120	0.38	0.38	0.38	0.36	1.52	-3.99

Table 6.8.2.2.3-3: Spectral Efficiency in case of 2.5 MHz filtered UMTS

Channel	Spectral Efficiency					
	UMTS		2.5 MHz filtered UMTS		Gain (%)	
	Carrier Frequency (MHz)		Carrier Frequency (MHz)		Carrier Frequency (MHz)	
	900	2000	900	2000	900	2000
PA3	0.65	0.65	0.51	0.51	-22.41	-22.06
VA 3	0.54	0.54	0.43	0.42	-20.36	-21.16
VA 30	0.52	0.46	0.41	0.35	-21.90	-25.26
VA 120	0.38	0.38	0.26	0.25	-32.33	-33.10

6.8.3 Impacts on the network and UE

6.8.3.1 UE receiver RF and digital front-end

Figure 6.8.3.1-1 shows an example of front-end implementation of "Scalable Bandwidth UMTS solution by Filtering". For reference Figure 6.1.4.1.1-2 illustrates an example of front-end implementation of standalone time-dilated UMTS.

- With filtered UMTS the analog Low Pass Filter (LPF) is now a narrower bandwidth (e.g. 2.5 MHz) when compared to the baseline case (5 MHz bandwidth).

- The ADC sampling rate does not change from the reference 5 MHz.

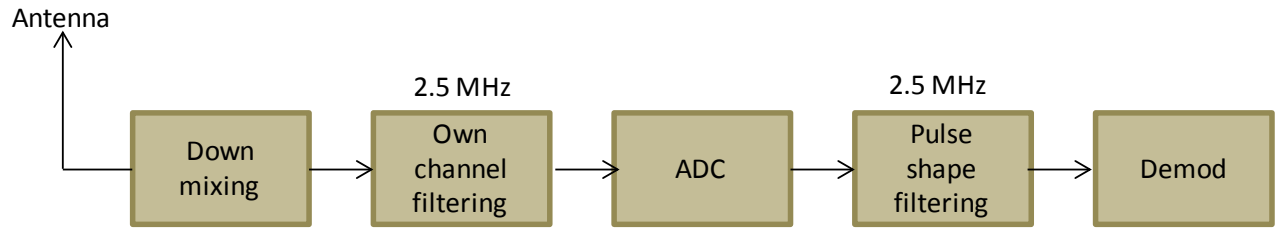


Figure 6.8.3.1-1: Front-end implementation for "Scalable Bandwidth UMTS by Filtering" (filter bandwidth of 2.5 MHz shown)

6.8.3.2 UE transmitter

As with uplink of time-dilated UMTS, changing the system bandwidth for Scalable Bandwidth UMTS by Filtering has impact to transmission filters and possibly PA implementations depending on the maximum transmission power.

6.8.3.3 BS receiver RF and digital front-end

Figure 6.8.3.3-1 shows an example of front-end implementation of Scalable Bandwidth UMTS solution by Filtering. For reference Figure 6.1.4.3.1-1 illustrates an example of front-end implementation of standalone time-dilated UMTS.

Received Signal is filtered to the LPF after RF down-conversion and then is sampled to generate digital signals (ADC) for the rest of the receiver chain, i.e. carrier separation, pulse shaping filter and demodulation.

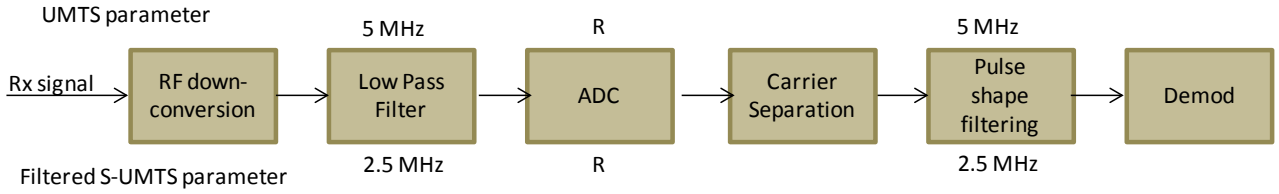


Figure 6.8.3.3-1: Example Block Diagram of RF and digital front-end (filter bandwidth of 2.5 MHz shown for Scalable Bandwidth UMTS by Filtering)

Comparison:

- The analog Low Pass Filter (LPF) handles a narrower bandwidth (2.5 MHz in the example) for Scalable Bandwidth UMTS and 5 MHz bandwidth for baseline UMTS.
- The ADC sampling rate remains the same.
- The pulse shaping filter handles a narrower bandwidth (2.5 MHz in the example) for Scalable Bandwidth UMTS and 5 MHz bandwidth for baseline UMTS.

6.8.3.4 BS transmitter RF and digital front-end

Similar to the same part of receiver, the Scalable Bandwidth UMTS by Filtering requires a narrower bandwidth (e.g. 2.5 MHz) low pass filter, and narrower bandwidth (e.g. 2.5 MHz) pulse shaping filter.

6.8A Scalable bandwidth UMTS by chip zeroing

6.8A.1 Description

The fundamental transmit waveform pulse used in CZ-UMTS is obtained by dilating the UMTS RRC pulse shaping filter.

Let $r(t)$ denote the pulse shaping filter in UMTS of unit energy, i.e, $\int |r(t)|^2 dt = 1$. Then the pulse shaping filter in CZ-UMTS is given by $r_N(t) = r(t/N)/\sqrt{N}$, for N = 2 or N = 4. See Figure 6.8A.1. Note that for N=1, this becomes identical to the UMTS pulse-shape, i.e., $r_1(t) = r(t)$, and also that $r_N(t)$ is also of unit energy, i.e. , $\int |r_N(t)|^2 dt = 1$.

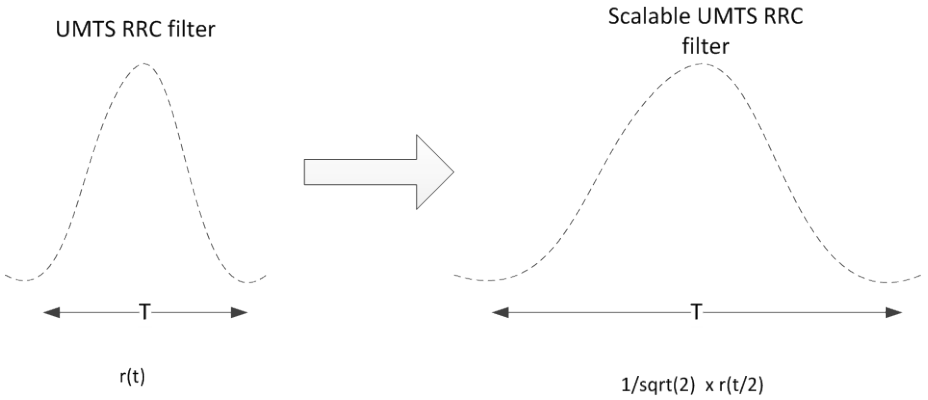


Figure 6.8A.1: Filtering CZ-UMTS pulse shaping filter, N = 2.

The block diagram in Figure 6.8A.2 show how the waveform of CZ-UMTS with enhanced filtering is constructed. Notice that although the chip rate of CZ-UMTS is the same as the UMTS, the mask 1,0,1,0 is used to zero out every alternate chips prior to pulse shaping filter.

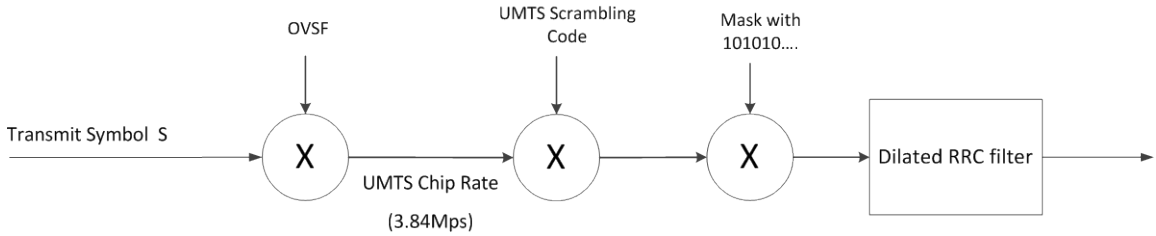


Figure 6.8A.2: CZ-UMTS with enhanced filtering (CZ-UMTS) waveform.

Due to zero-out mask, fundamentally CZ-UMTS waveform is similar to CZ-UMTS based on time dilation when compared at chip level. However, the effective PSC code sequences in CZ-UMTSand TD CZ-UMTS differ: TD CZ-UMTS effective PSC is the same as UMTS, but CZ-UMTS *effective* PSC is zeroed out every alternate chips; see Figure 6.8A.3. Note that from implementation point of view, there is no explicit need to define a new PSC sequence for CZ-UMTS system, and the legacy PSC code can be reused as shown in block diagram of Figure 6.8A.2.

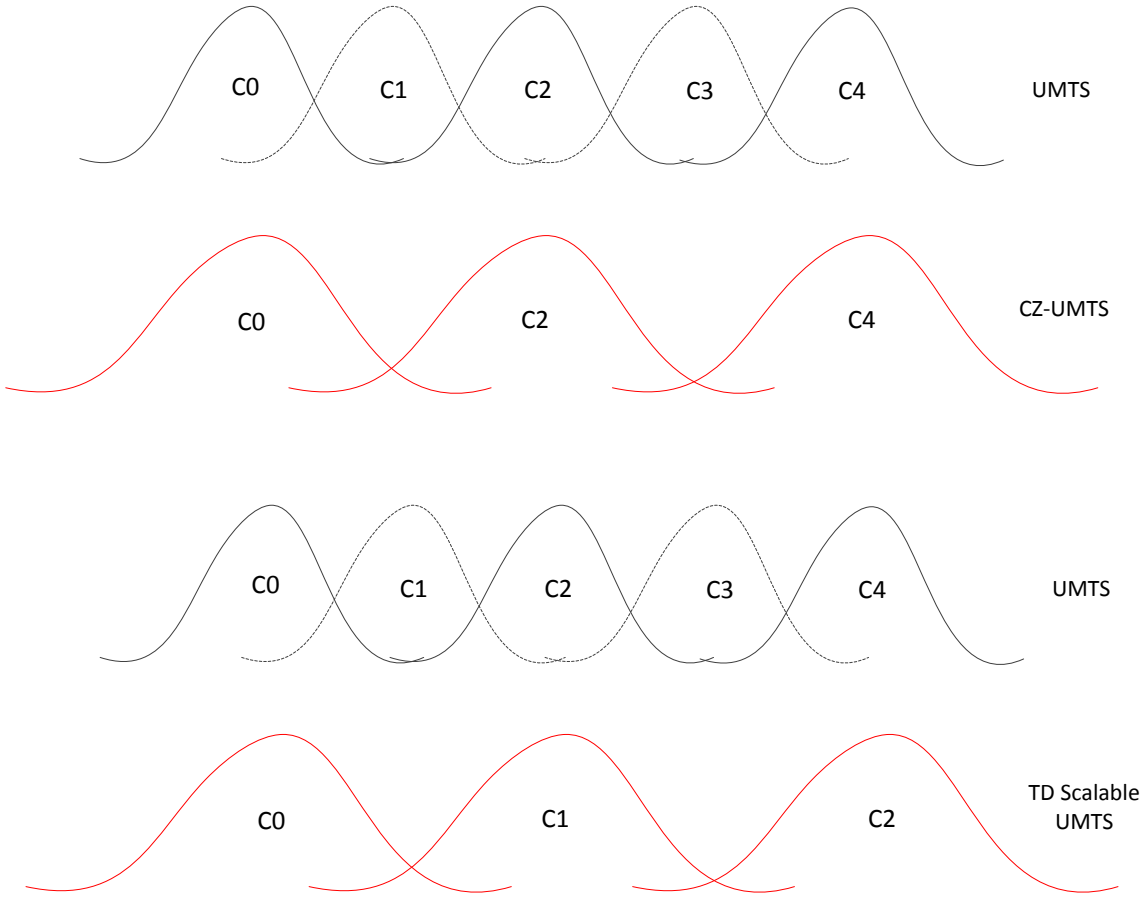


Figure 6.8A.3: Comparison between UMTS, CZ-UMTS with time dilation (TD CZ-UMTS) and CZ-UMTS with enhanced filtering (CZ-UMTS)

6.8A.2 Power Spectrum Density and SINR analysis

Figure 6.8A.4 shows a frequency domain analysis of transmission and reception of UMTS (bandwidth = W) and CZ-UMTS (bandwidth = W/N, where N=bandwidth reduction factor). The new components in CZ-UMTS relative to UMTS are the zero-out operations at transmitter and receiver (shown in the figure assuming N=2), and the new narrow-band pulse-shaping. Note that the power-spectral density (PSD) of a random process of the form $\sum_n c_n r(t-nT)$, where c_n are random variables with zero mean and variance Ec, is proportional to $Ec|R(f)|^2/T$, where $R(f)$ is the continuous-time fourier-transform of $r(t)$. The CZ-UMTS pulse-shape filter $r_N(t) = r(t/N)/\sqrt{N}$ has fourier transform $R_N(f) = R(Nf)\sqrt{N}$. Based on this, as shown in Figure 6.8A.4, when the transmit pulse-shaping filters for both UMTS and SUMTS are normalized to have unit energy, then the in-band PSD of both UMTS and CZ-UMTS is the same if they both use the same energy per chip. The in-band heights of $R(f)$ and the PSD are shown to be $1/\sqrt{W}$ and Ec respectively in Figure 6.8A.4, which assumes that $R(f)$ and the PSD have a brick-wall shape. In reality these heights are slightly different because the shape is not perfectly brick-wall but has a roll-off near the band-edge, however this constant multiplying factor does not essentially change any of the analysis, and is hence dropped for convenience.

At the receiver, the noise variance at the output of the energy-normalized matched RRC filter is No for both UMTS and CZ-UMTS. The signal amplitude when sampled at the peak, is obtained by integrating the product of the Tx and Rx SRRC filter amplitude responses, and thus this is also the same for UMTS and CZ-UMTS, i.e., equal to $\sqrt{Ec}$. Thus, the SNR for each UMTS chip is the same as the SNR for each CZ-UMTS chip, namely Ec/No. However, unlike the time-dilation solution, CZ-UMTS maintains the same absolute time durations for symbols, radio-frames, and TTIs. The

number of CZ-UMTS chips is 1/N[th] of the number of UMTS chips in the same time duration, hence the symbol SNR drops by the factor N. Similarly, the number of OVSF codes also drops by a factor of N in CZ-UMTS relative to UMTS, in order to preserve the orthogonality of all the codes after the zero-out operation.

Based on the analysis in Figure 6.8A.4, we see that the expressions for chip and symbol SNR in UMTS and CZ-UMTS are as follows:

Chip-level SNR: Ec/No (both UMTS and CZ-UMTS)

Symbol-level SNR: (SF)*Ec/No for UMTS, and (SF/N)*Ec/No for CZ-UMTS, where SF= spreading factor

Note that the UMTS and CZ-UMTS symbols occupy the same time duration given by SF *Tc where Tc is the UMTS chip duration, and SF is the UMTS spreading factor. However, while the UMTS symbol has SF UMTS chips, the CZ-UMTS symbol has SF/N CZ-UMTS chips (each CZ-UMTS chip being dilated by factor N in time, to give the same overall symbol duration).

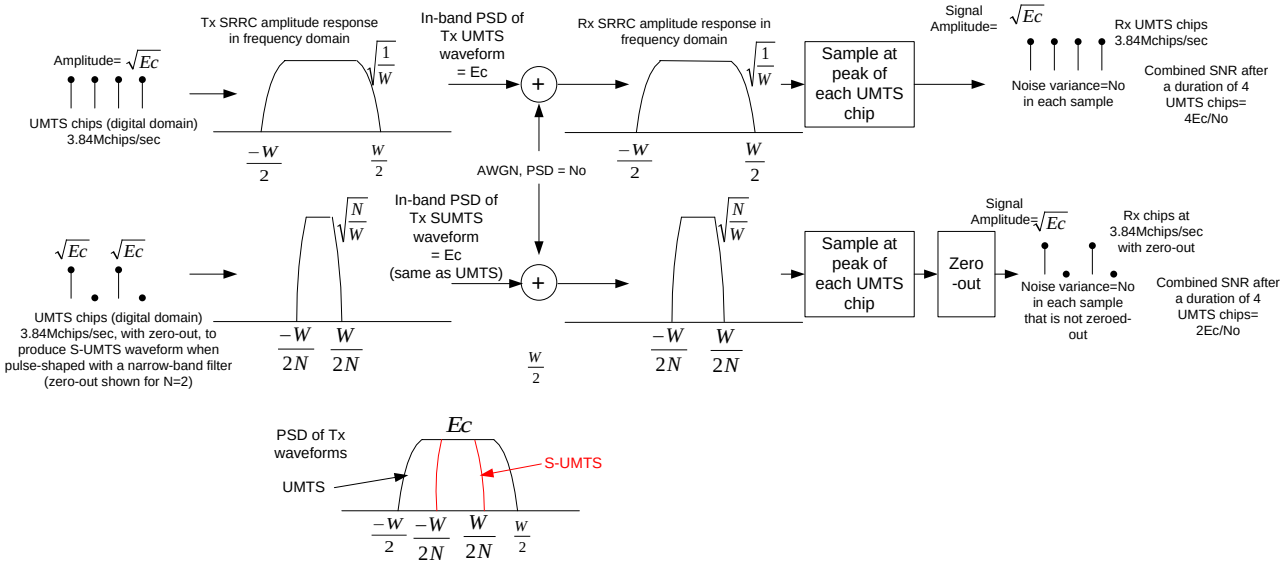


Figure 6.8A.4: CZ-UMTS with enhanced filtering (CZ-UMTS): PSD and SNR analysis.

6.8A.3 Control channel in CZ-UMTS

In CZ-UMTS, control channels in general follow the same principle of zeroing out every alternate chips prior to RRC filter. Possible alternatives for the SCH channel and PRACH preamble is to not perform the alternate chip zero-out for these two channels. However, this may create additional complexity due to the different implementation of the different data paths in transmit chain, one with chip zero-out and without.

6.8A.3.1 Control channel overhead

In general, control channels of fixed data rate sent over CZ-UMTS with bandwidth reduction factor N=2 need to boost E_c/Ior power allocation by 3dB to match the same performance, since symbol SNR of CZ-UMTS is 3dB worse than an equivalent UMTS system; see Section 6.8A.2. For N=4, the factor is 6dB. An exception is the SCH, which may need boosting by 6-10dB.
It is not clear whether the P-CPICH needs to be boosted in order to meet RRM requirement.

6.8A.3.2 PRACH preamble design options for CZ-UMTS

The Node B needs to detect the UE's PRACH preamble and respond to it with AICH for the UE to gain access to the system. The Rel'99 design for PRACH preamble is based on a 16-chip signature that is repeated 256 times to construct

a 4096-chip long PRACH preamble. There are 16 available signatures. The Rel'99 design can be used as is with the narrow-band filter and no chip-zeroing is used. This alternative is the one used with F-UMTS.

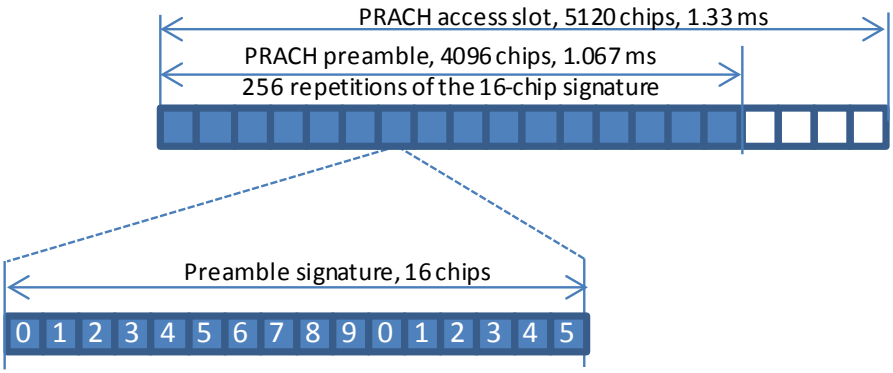


Figure 6.8A.4A: Rel'99 construction of the PRACH preamble (F-UMTS)

Alternatively the chip-zeroing approach could be used on top of the Rel'99 PRACH preamble design. There every second chip in the 16-chip signature is set to zero, and this new 16-chip signature is repeated 256 times (CZ-UMTS approach). However, when looking at the set of 16 PRACH preamble signatures, the chip-zeroing will make it impossible to separate a signature pair *i* and *i+1* from each other, when *i* = {0,2,4,6,8,10,12,14}, effectively reducing the available signature space to 8. This could lead to additional complications with Enhanced Cell_FACH in the uplink due to the need to split the PRACH preamble space to multiple sub-groups.

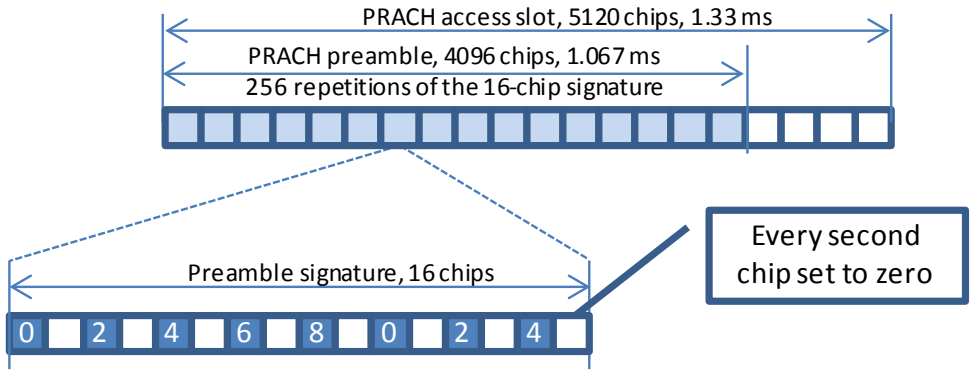


Figure 6.8A.4B: Preamble construction with chip-zeroing (CZ-UMTS)

6.8A.3.3 AICH design options for CZ-UMTS

AICH is used to acknowledge the PRACH preamble in random access procedure, and with Enhanced RACH, it may also be used to point to the UE to the common E-DCH resource. AICH is a SF256 channel, and the transmissions take place in 2-slot long access slots. The actual transmission duration is 4096 chips (1.067 ms), and the AICH transmission in a single access slot is a summation of zero to sixteen Acquisition Indications (AI) signatures and zero or one Extended Acquisition Indications (EAI) signature. The AI/EAI signatures are 32 bits long. Each AI/EAI that is transmitted is further modulated with +1 or -1. Effectively each AI/EAI carry a ternary bit (+1, -1, DTX), and is further spread with SF256 to the channel.

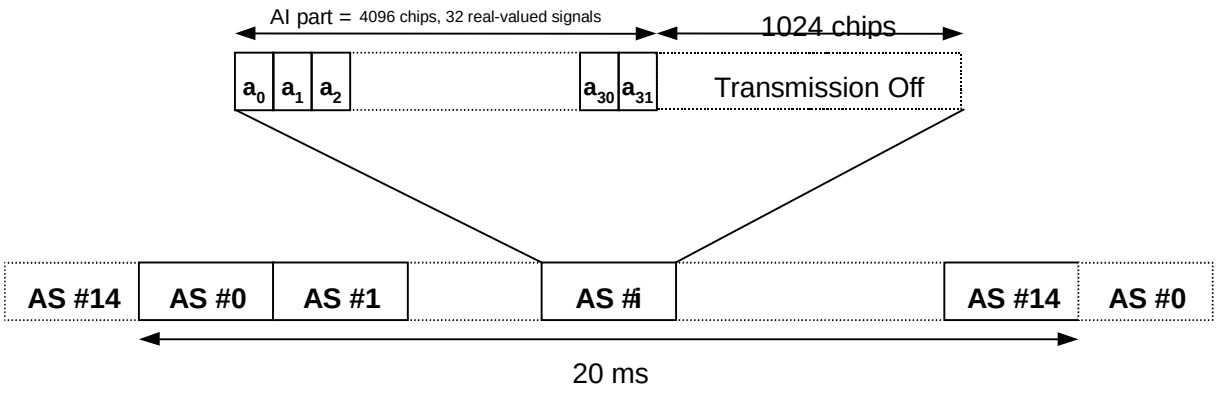


Figure 6.8A.4C: Structure of Acquisition Indicator Channel (AICH) [TS25.211]

For CZ-UMTS, the spreading is effectively reduced to SF128 and the impact is the same as with BCH/P-CCPCH. The structure of AICH does not require any modifications as the AI/EAI signature construction takes place before spreading.

As the data rate of the channel is so low and the performance is limited by interference, similar to SCH, AICH could also be transmitted without chip-zeroing. This alternative is the one used with F-UMTS.

6.8A.3.4 PICH design options for CZ-UMTS

PICH is used to page the UE to read the paging record on PCH on S-CCPCH or HS-PDSCH. PICH is a SF256 channel carrying a set of Paging Indicators (PI) identifying the UEs to be woken up. The number of PIs present in a radio frame is configurable from 18 to 144. The PIs are concatenated as a string of 144 QPSK-modulated SF256 symbols to be transmitted in a PICH frame. The remaining 6 symbols are not used. Each PI is transmitting either a positive or negative paging indication, i.e. the channel is a constant-power channel over the first 144 symbols of the radio frame regardless of how many UEs are actually being paged.

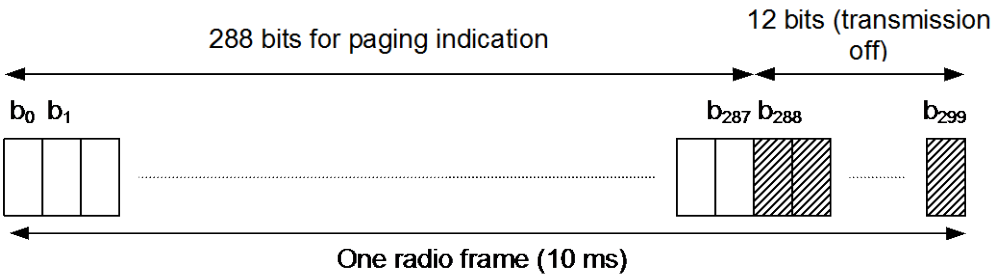


Figure 6.8A.4D: Structure of Paging Indicator Channel (PICH) [TS25.211]

Number of PIs per frame	Length of one PI
18	16 bits = 8*256 chips
36	8 bits = 4*256 chips
72	4 bits = 2*256 chips
144	2 bits = 256 chips

As with AICH, for CZ-UMTS, the PICH spreading is effectively reduced to SF128 and the impact is the same as with BCH/P-CCPCH. The structure of PICH does not require any modifications as the concatenated set of 288 PI bits to be transmitted in a radio frame is constructed before spreading.

As the data rate of the channel is so low and the performance is limited by interference, similar to SCH, PICH could also be transmitted without chip-zeroing. This alternative is the one used with F-UMTS.

6.8A.4 Impacts on network and UE

In this section, an overview of implementation impacts expected from the introduction of CZ-UMTS is reviewed.

6.8A.4.1 Impacts on network implementation

The CZ-UMTS waveform can be obtained from UMTS waveform by zeroing out every other chip and using a dilated RRC pulse shaping filter. This waveform can be constructed by applying a mask to chip sequence prior to pulse shaping.

The block diagram in Figure 6.8A.5 show how the waveform of CZ-UMTS with enhanced filtering is constructed by using chip mask at the transmitter. Notice that although the chip rate of CZ-UMTS is the same as the UMTS, the mask 1,0,1,0 (for N=2), or 1,0,0,0 (for N=4), is used to zero out every alternate chips prior to pulse shaping filter.

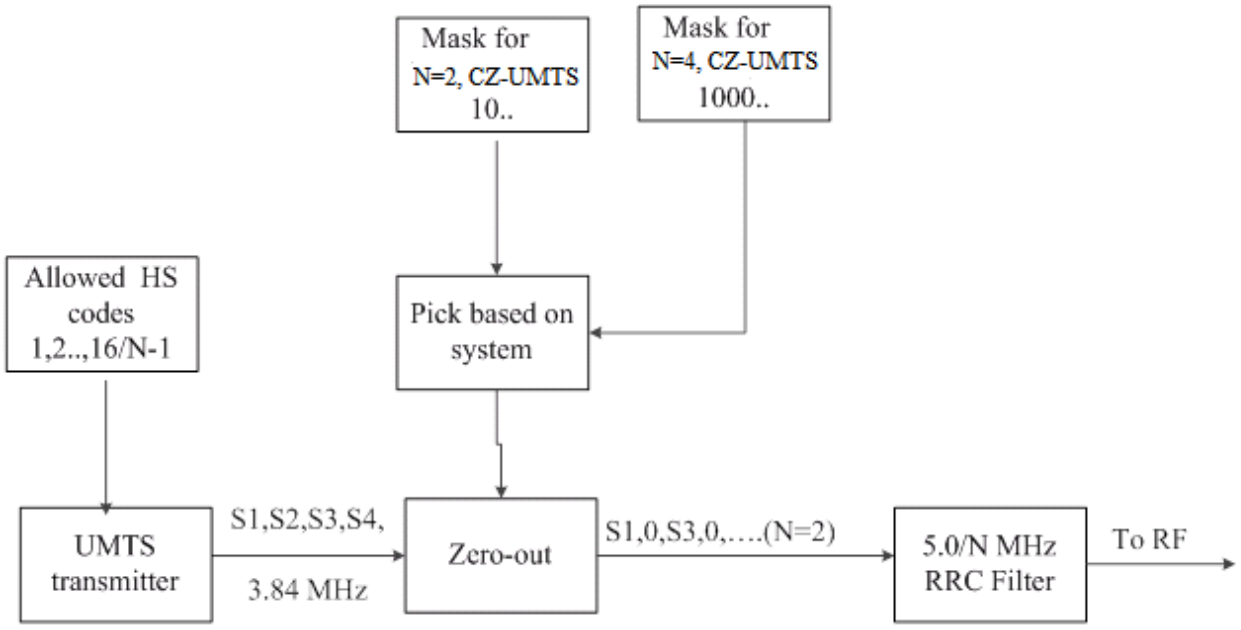


Figure 6.8A.5: CZ-UMTS with enhanced filtering (CZ-UMTS) waveform using mask

Instead of applying a zero-out mask directly at chip level, it is also possible to create the transmit waveform with alternate zeroed chips by sending a copy of each channelization code using a pair OVSF code that cancels out every alternate chip. This is illustrated in Figure 6.8A.6. The paired OVSF codes are chosen in such a way that when added, every alternate chip is cancelled. For example, by pairing two codes (1,1,1) and (1,-1,1,-), we have (1,1,1,1) + (1,-1,1,-1) = (2,0,2,0), which leads to the desired effect of zeroing out every alternate chip. This effect is illustrated in Figures 6.8A.6 and 6.8A.7.

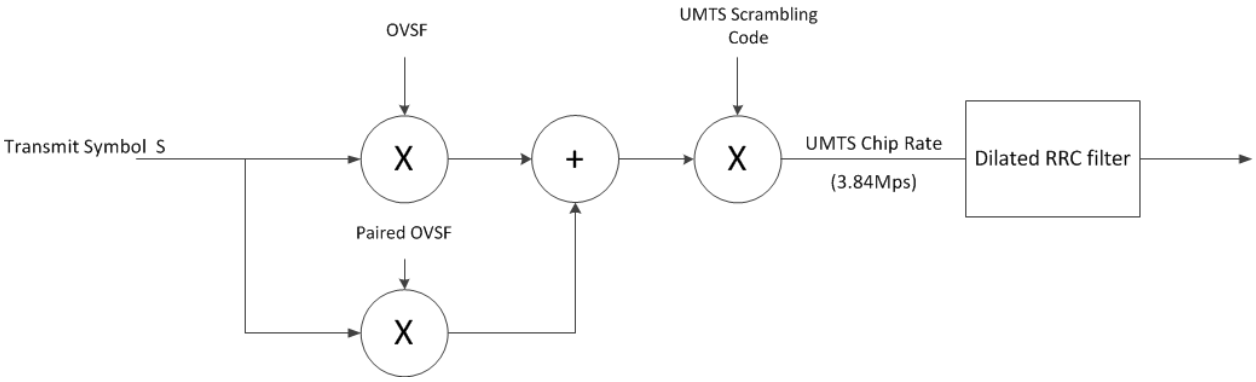


Figure 6.8A.6: CZ-UMTS using code pairing

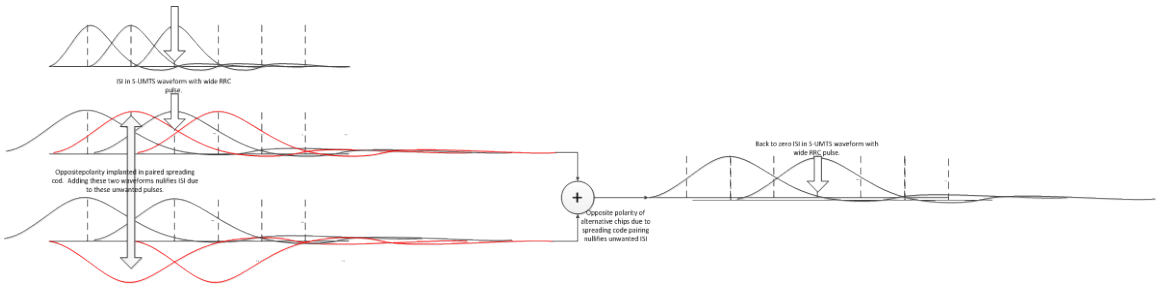


Figure 6.8A.7: OVSF code pairing to emulate chip zero out

Pairing of OVSF codes can be visualized over the Hadamard code generator tree. This is illustrated in Figure 6.8A.8, where it is shown that for every code in the upper part of the code tree, one can find a corresponding code in the lower part such that when added, the two codes cancel each other at every alternate chip location.

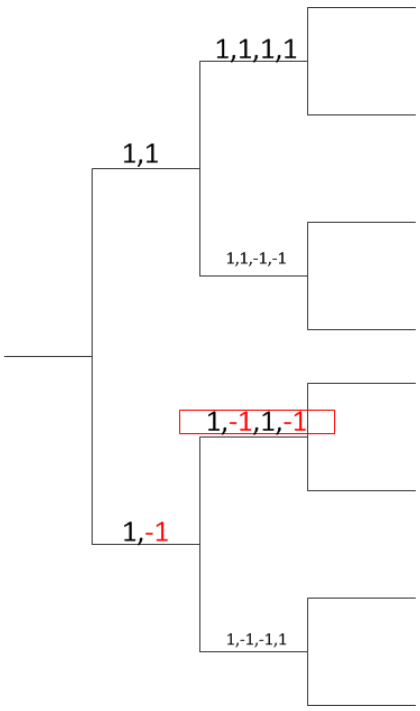


Figure 6.8A.8: OVSF code pairing

Finally, in both the above schemes, the chip sequence after the zero-out operation must then be filtered by a new RRC filter whose impulse response is a dilated version of the UMTS RRC impulse response, and thus has more coefficients, implying increased complexity. Since the input to this filter has the pattern of zeros created by the zero-out mask, a polyphase implementation is possible for this filtering, which limits the increase in complexity. Essentially the multiplication operations needed to compute the filtered output are skipped when the inputs to the multipliers are known to be zero. As another alternative, the existing UMTS RRC coefficients can be used, but the filter is operated at a decimated rate, i.e., it receives a new input every N*Tc seconds, where Tc is the UMTS chip rate and N is the CZ-UMTS bandwidth reduction factor. These options are illustrated in Figure 6.8A.9.

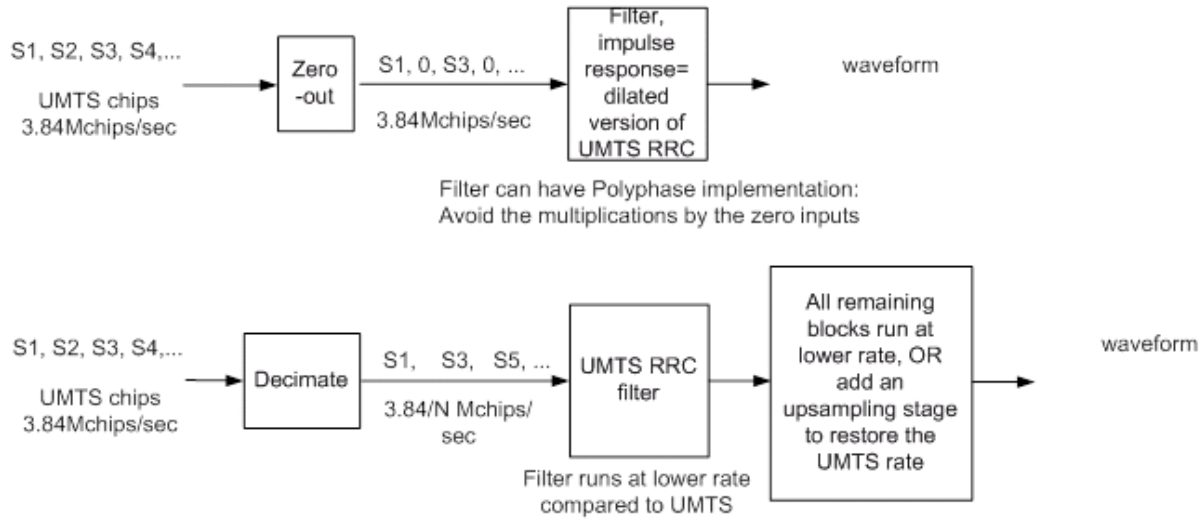


Figure 6.8A.9: Alternative implementations of Tx RRC filtering for CZ-UMTS

6.8A.4.2 UE implementation

Similar to the transmitter, the receiver of CZ-UMTS may also be based on the UMTS receiver. The key to process the half-bandwidth CZ-UMTS signal using the full bandwidth receiver of UMTS is channel equalization, since UMTS channel equalizer is designed to invert the full UMTS spectrum bandwidth. This is illustrated in Figure 6.8A.10, where it is shown that the full-bandwidth equalizer degrades the received signal by trying to invert the part of the bandwidth with no signal energy.

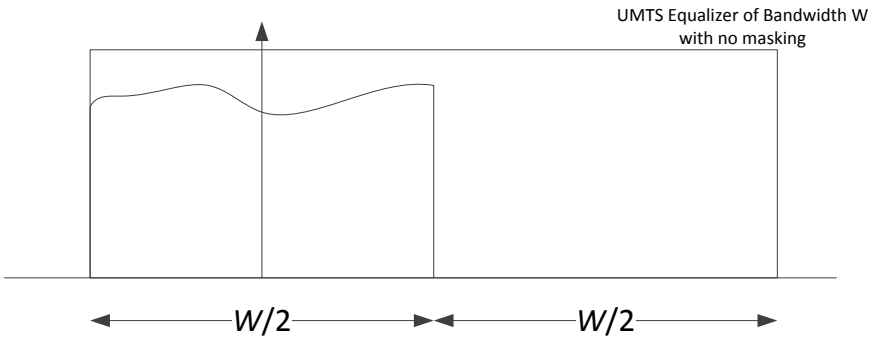


Figure 6.8A.10: UMTS equalizer of bandwidth W cannot be directly applied to equalize the channel for CZ Scalable UMTS signal.

Applying a mask of 1,0,1,0, to received signal sampled at UMTS chip rate $f_c = W$ allows to use the UMTS full spectrum equalizer for CZ-UMTS. Consider CZ-UMTS received signal of bandwidth W/N, where W denotes the bandwidth of

UMTS signal, and $N = 2$ or 4. Here W denotes the nominal bandwidth of UMTS system. Consider $N = 2$, and let the sequence $r_n = r_1, r_2,...$ denote the received samples of CZ-UMTS waveform of bandwidth $W/2$. By applying a mask of 1,0,1,0, and effectively throwing out every other sample (with sample rate of 3.84 Mps, equal to UMTS chip rate), an image copy of the CZ-UMTS received waveform in the upper part of the spectrum can be created. This is illustrated in Figure 6.8A.11. Notice that in frequency domain, the sequence

$$(1,0,1,0) = (1,1,1,1) + (1,-1,1,-1)$$

$$= (e^{j2\pi 0}, e^{j2\pi 0}, e^{j2\pi 0}, e^{j2\pi 0}) + (e^{j2\pi 0}, e^{j2\pi 1/2}, e^{j2\pi 2/2}, e^{j2\pi 3/2})$$

has a spectrum consisting of two deltas separated by half the UMTS bandwidth ($W/2$). Multiplying the received signal by this mask in time domain is equivalent to convolution in frequency domain, and thus creating an image copy of the lower W/2 spectrum in the upper part of the spectrum. Thus, the UMTS equalizer of bandwidth W can be reused to equalize the new masked CZ-UMTS signal.

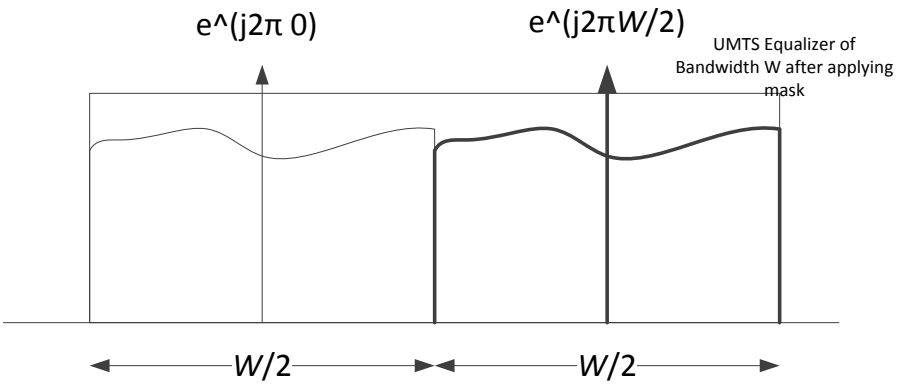


Figure 6.8A.11: Received signal spectrum after applying a mask of 1,0,1,0, for sample rate = UMTS chip rate.

In the more general case that the UMTS receiver sampling rate is more than the standard UMTS chip rate, different receiver masks may be needed. For example, in the simplified case of sub-sampling of over-sampled signal, where the equalizer subsamples a chip×2 oversampled signal, a mask of 1,1,0,0,1,1,0,0 can be applied to the chip×2 samples before sub-sampling and feeding the samples to the equalizer, as shown in Figure 6.8A.12. The corresponding receiver structure is shown in Similar technique can be applied for rake receiver. For example, if the received signal is over sampled at chip × 4, a mask of 1111,0000,1111,0000 can be applied.

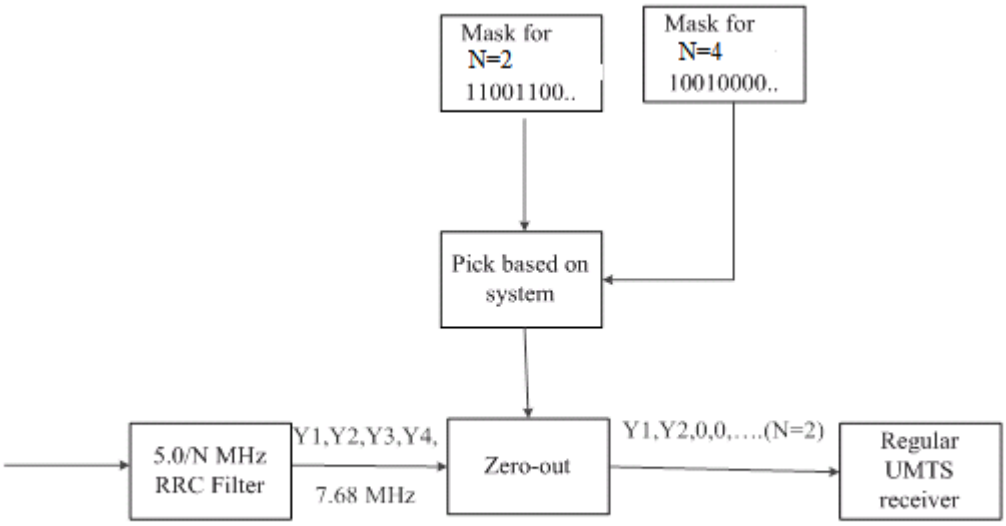


Figure 6.8A.12: Applying a 11,00,11,00 mask for UMTS chip×2 equalizer receiver.

6.8A.4.2.1 PAPR

Since the transmitted waveform is modified for CZ-UMTS and FUMTS, there is impact on PAPR and CM, see simulation results in section 6.8D. The resulting impact on the UE implementation and the Maximum Power Reduction (MPR) needs to be further studied in RAN4.

6.8A.5 Cross carrier scheduling for multi-carrier filtered CZ-UMTS

As the scalable UMTS serves as non-standalone secondary cell, most common channels can be removed and the available HS-PDSCH power increases. To further reduce overhead and improve data transmission efficiency in the secondary cell, cross carrier scheduling can be considered, as illustrated in Figure 6.8A.13.

- Cross carrier scheduling:
  - Data transmitted in the secondary cell (f_2),
  - The control information for the data is always indicated in the primary cell (f_1), and an indicator could be explicit or implicit included in the control information to notify the UE about which carrier this control information belongs to.
  - HS-SCCH can be removed from the secondary cell.

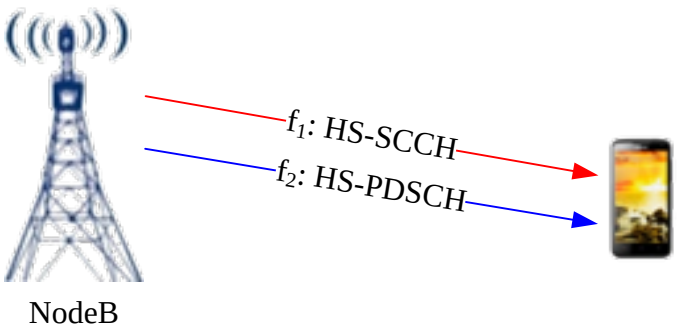


Figure 6.8A.13: Illustration of cross carrier scheduling

Table 6.8A.1: Power ratio by different scheduling method

	Non-cross-carrier scheduling	Cross-carrier scheduling
5MHz primary + 2.5MHz secondary	74% for primary, 78% for secondary	~68-74% for primary, 90% for secondary
5MHz primary + 1.25MHz secondary	74% for primary, 66% for secondary	~68-74% for primary, 90% for secondary
NOTE: The power ratios here are approximate. The impact of HS-SCCH overhead to the primary is assumed to be up to 6%. The exact overhead will depend on the joint scheduling HS-SCCH scheme adopted.		

Another benefit of cross carrier scheduling is that it possesses the potential for reducing the total number of HS-SCCH monitored by UE.

The benefits of cross-carrier scheduling for filtered scalable UMTS carrier aggregation can be summarized as:

- The available power for HS-PDSCH in the secondary cell is increased which is good for data transmission in the secondary cell and also helps to balance the control channel overhead between the primary cell and the secondary cell.
- Potential for reducing the total number of HS-SCCH monitored by UE.
- Potentially enabling UE DRX on the secondary cell when no HS-SCCH intended for the secondary cell is detected in the primary cell.

6.8A.5A Design for cross carrier scheduling for multi-carrier filtered CZ-UMTS

Assuming that non-MIMO mode is configured in any cell, it is possible to joint encode the two pieces of control information together in one HS-SCCH. The following Table 6.8A.5A-1 depicts the control information fields in Part 1 and Part 2 of type 3 HS-SCCH. Since there is no MIMO operation, the PCI fields can be released to signal other information, such as carrier identity indicator (CID) which indicates the carrier which the corresponding transport block(s) are transmitted on.

Table 6.8A.5A-1: Control information fields of type 3 HS-SCCH

HS-SCCH Part 1	**HS-SCCH Part 2**	
	One transport block	**two transport blocks**
CCS (7bits), Modulation (3 bits), ***PCI*** **(*2* bits)**	TBS(6 bits) HARQ process (4 bits) RV(2 bits)	TBS(6 bits×2) HARQ process (4 bits) RV(2 bits×2)

By reinterpreting the ***PCI*** to ***CID***, it is possible to reuse type 3 HS-SCCH design for F-UMTS carrier aggregation. The new type X HS-SCCH is summarized in Table 6.8A.5A-2.

Table 6.8A.5A-2: Control information fields of type X HS-SCCH

HS-SCCH Part 1	**HS-SCCH Part 2**	
	One transport block	**two transport blocks**
CCS (7bits), Modulation (3 bits), ***CID*** **(*2* bits)**	TBS(6 bits) HARQ process (4 bits) RV(2 bits)	TBS(6 bits×2) HARQ process (4 bits) RV(2 bits×2)

Below is an example of ***CID*** field information mapping.

Table 6.8A.5A-3: Mapping of CID

CID (value)	The carrier that the corresponding transport block(s) are transmitted on	Other information
0	Primary carrier	
1	Secondary carrier	
2	Both primary and secondary carriers	
3	Both primary and secondary carriers	Exchange the modulation of the two transport blocks

When data is scheduled on only one of the carriers, the CID is set to 0 or 1, which helps UE to identify which carrier the data is transmitted on. In this case, all the other control information in the HS-SCCH corresponds to one TB.

When data is scheduled on both carriers, the CID is set to 2 or 3, which helps UE to identify the data is transmitted on both carriers. In this case, the two TBs have independent modulation schemes, TBS and RV, and a common HARQ process, assuming the number of HARQ-process for both carriers are the same and the two TB share the same HARQ-process id.

In type X HS-SCCH, since the modulation field is inherited from type 3 HS-SCCH, the modulation order of primary TB is always higher or at least equal to that of secondary TB, so CID=3 is used to signal the contrary case, i.e. the case when the modulation order of secondary TB is higher than the primary TB.

Since there is only one CCS field, which can only indicate one TB, we may have to make a trade-off between the flexibility of scheduling 2nd TB and the control information overhead. The CCS only indicates the primary TB in this case by assuming all available HS-PDSCH codes are occupied by the 2nd TB. The assumption that all HS-PDSCH codes are occupied by the 2nd TB when data is scheduled on both carriers is based on the considerations below:

- There would be no need to CDM users on the secondary carrier. The number of available HS-PDSCH codes of the secondary carrier is much less, down to 3 especially in case of N=4 (BW=1.25MHz), it would be not necessary to apply code multiplexing on the secondary carrier in two TB scheduling case. Given each code contains 480 symbols per TTI, one code is able to provide no more than 0.48MHz (for QPSK) ~ 1.44MHz (for 64QAM) throughput for a UE. It is not worth to use dual carrier scheduling with only one code on the 2nd carrier, at the expense of control information overhead increase.

- A UE with data transmission simultaneously on both carriers is expected to be able to make full use of the HS-PDSCH codes of the secondary carrier. Given the UE is scheduled with data transmission simultaneously on both carriers, the data rate is more likely to be quite large and beyond the level the secondary carrier can bear on, i.e. the UE is able to make full use of all the HS-PDSCH codes at that TTI. Otherwise, it is not necessary to schedule the data on both carriers and may better fall back to schedule data on one carrier.

- The primary carrier is more likely to be HS-PDSCH code limited, resulting that there is a need to indicate the CCS information for the primary carrier, since the primary carrier serves as anchor cell with the support of R99 UEs, different kind of downlink control channels, CELL_FACH UEs and so on.

Since the same amount of bits will be transmitted over HS-SCCH type X as HS-SCCH type 3, the coding process of HS-SCCH type 3 can be reused. In addition, UE only has to monitor M HS-SCCH channels for cross carrier scheduling instead of 2M channels for non-cross carrier scheduling, resulting in reduced complexity.

This design option is one example solution for supporting signalling for cross-carrier scheduling, and other solutions may be considered. Several observations made on this design option are as follows:

- This solution would not allow MIMO to be supported on either the primary or secondary carriers if that were desired; other solutions which may allow MIMO to be supported are not discussed here.

- The impact of using the same HARQ process on the primary and secondary carriers has not been studied.

This solution does not support the use of the scalable carrier for multi-carrier operation for some users and standalone for others, if that were desired.

6.8A.6 Impact on 3GPP RAN1 specification

In this section, impact on 3GPP RAN1 specification due to CZ-UMTS is reviewed. Differences in RAN2/RAN4 impact compared to time-dilated S-UMTS have not been studied.

6.8A.6.1 TS 25.201

The sections of TS 25.201 that are impacted by the CZ-UMTS time dilation solution are listed in Table 6.8A.2. The changes required are applicable to FDD bandwidth.

Table 6.8A.2: CZ-UMTS impacts to TS 25.201 specification

Section number	Section title	Change
4.2.1	Multiple Access	Specifying new bandwidth options for FDD corresponding to N=2, and N=4.

6.8A.6.2 TS 25.211

Since CZ-UMTS adheres to UMTS timing, no specification modifications are required for physical channel specifications and timing relations in TS 25.211.

6.8A.6.3 TS 25.212

If cross carrier scheduling is specified, there is some chance that the HS-SCCH format could be impacted, depending on the eventual solution.

6.8A.6.4 TS 25.213

TS 25.213 specifies modulation and spreading. For CZ-UMTS, the UMTS chip rate, spreading, and scrambling are fundamentally the same as normal UMTS. CZ-UMTS is different from UMTS in number of allowed spreading codes, and modulation due to different pulse shaping and alternate chip zero out procedures. The sections of TS 25.213 that are impacted by the CZ-UMTS listed in Table 6.8A.3.

Table 6.8A.3: CZ-UMTS impacts to TS 25.213 specification

Section number	Section title
4.3.1.1	Code generation and allocation. Modifications are needed to disallow half the code tree in Figure 4.
5.3.2	Alternate chip zero out introduced in modulation block, Figure 11.

6.8A.6.5 TS 25.214

Introduction of cross carrier scheduling would impact the HS-PDSCH reception procedure.

There may be a need for updating of the CQI tables depending on the number of available codes

6.8A.6.6 TS 25.215

No impact.

6.8B Link level simulation for filtered scalable UMTS

Link-level simulation assumptions and performance metrics for filtered scalable UMTS are defined in this subclause, for the DownLink (DL). Specifically, the standalone DLand Carrier Aggregation (CA) DL cases are covered.

6.8B.1 Simulation assumptions for filtered scalable UMTS

6.8B.1.1 Downlink simulation assumptions for filtered scalable UMTS

The baseline parameters to be used for link-level simulations of standalone filtered scalable UMTS DL are listed in Table 6.8B.1.1.1-1. For all DL link-level assumptions, residual frequency error shall be 0 ppm.

Table 6.8B.1.1.1-1: General simulation assumptions for standalone filtered scalable UMTS DL

Parameter	Value
Carrier Frequency	900 MHz, 2GHz
Scaling factor	1; UMTS carrier 2; filtered scalable UMTS carrier 4; filtered scalable UMTS carrier (HSPA data only)
P-CPICH_Ec/Ior[1]	-10dB for N=1 -10dB or (-10+TBC) dB for N=2, 4
P-CCPCH_Ec/Ior	(-12+10*logN)dB (N=1,2,4)
SCH_Ec/Ior	N=1 -12dB N=2 (-12+3)dB N=4: -12+9dB
PICH_Ec/Ior[2]	-15dB for N=1 -12dB or -15dB+TBC for N=2,4
HS-SCCH_Ec/Ior	(-12+10*logN)dB (N=1,2,4)
HS-PDSCH_Ec/Ior	Remaining power so that total transmit power spectral density of Node B (Ior) adds to one
Spreading factor for HS-PDSCH	16
Modulation	QPSK, 16QAM, 64QAM
TTI [ms]	DCH: 20ms
TBS	Variable for HS-PDSCH AMR12.2K for DCH
HSDPA Scheduling Algorithm	CQI based
Geometry	[-5 0 5 10 15 20]dB
CQI Feedback Cycle	1TTI
CQI feedback error	1% CQI error means CQI erasure, in which case the Node B uses the previous CQI
HS-DPCCH ACK/NACK feedback error	1%
Maximum number of HS-DSCH codes	N=1: 15 codes per carrier for HS-PDSCH N=2: 7 codes per carrier for HS-PDSCH N=4: 3 codes per carrier for HS-PDSCH
Number of HARQ Processes	6
Maximum HARQ Transmissions Time	50ms
HARQ Combining	Incremental Redundancy
First transmission BLER	10% after 1 transmission
Number of Rx Antennas	2
Channel Encoder	3GPP Turbo Encoder for HSDPA Convolutional for DCH
Turbo Decoder	Log MAP
Number of iterations for turbo decoder	8
CQI Feedback delay	8ms
Propagation Channel Type	PA3,VA3, VA30,VA120 in specific cases AWGN simulations could be used
Channel Estimation	Realistic
Noise Estimation	Realistic
UE Receiver Type	1-Rx Rake and 2-Rx LMMSE (Type 3)
Antenna imbalance [dB]	0
Tx Antenna Correlation	0
Rx Antenna Correlation	0
Number of transmit antennas	1

Table 6.8B.1.1.1-2 lists the general parameters to be used for filtered scalable UMTS carrier aggregation DL link simulations.

Table6.8B.1.1.1-2: General simulation assumptions for filtered scalable UMTS carrier aggregation DL

Parameter	Value
Scaling factor	Primary Cell: 1; Secondary Cell: 2; 4
P-CPICH_Ec/Ior	-10dB With pilot optimisation: TBC
P-CCPCH_Ec/Ior	Primary Cell: -12dB Secondary Cell: OFF
SCH_Ec/Ior	Primary Cell: -12dB Secondary Cell: OFF
PICH_Ec/Ior	Primary Cell: -15dB Secondary Cell: OFF
HS-SCCH_Ec/Ior[3]	No cross carrier scheduling: (-12+10*logN)dB (N=2,4) secondary cell, -12dB primary cell With cross carrier scheduling: OFF for secondary cell, -12 per HS-SCCH for primary cell or set to a lower value with MIMO HS-SCCH to achieve 1% decoding error
HS-PDSCH_Ec/Ior	Remaining power so that total transmit power spectral density of Node B (Ior) adds to one on each cell
Spreading factor for HS-PDSCH	16
Modulation	QPSK, 16QAM, 64QAM
TBS	Variable for HS-PDSCH
HSDPA Scheduling Algorithm	CQI based
Geometry	[-5 0 5 10 15 20]dB
CQI Feedback Cycle	1TTI
CQI feedback error	1% CQI error should be explained to mean CQI erasure, in which case the Node B uses the previous CQI
HS-DPCCH ACK/NACK feedback error	1%
Maximum number of HS-DSCH codes	N=1: 15 codes per carrier for HS-PDSCH N=2: 7 codes per carrier for HS-PDSCH N=4: 3 codes per carrier for HS-PDSCH
Number of HARQ Processes	6
Maximum HARQ Transmissions Time	50ms
HARQ Combining	Incremental Redundancy
First transmission BLER	10% after 1 transmission
Number of Rx Antennas	2
Channel Encoder	3GPP Turbo Encoder
Turbo Decoder	Log MAP
Number of iterations for turbo decoder	8
CQI Feedback delay	8ms
Propagation Channel Type	PA3,VA3, VA30,VA120 in specific cases AWGN simulations could be used
Channel Estimation	Realistic
Noise Estimation	Realistic
UE Receiver Type	1-Rx Rake and 2-Rx LMMSE (Type 3)
Antenna imbalance [dB]	0
Tx Antenna Correlation	0
Rx Antenna Correlation	0

Notes:

More realistic assumptions could be used based on RRM requirements. Current results in the TR are indicative. The areas in which the indicative simulations differ from the assumptions are as follows:

[1]The P-CPICH is modelled as either -10dB or -10+10log(N)dB in the indicative simulations. The correct P-CPICH level is likely to be either -10dB or somewhat higher.

[2]The PICH level is modelled as -12+10log(N) dB in the indicative simulations

[3]The HS-SCCH level for cross carrier scheduling depends on the specific cross carrier scheduling scheme. In the indicative simulations, the HS-SCCH level on the primary carrier is modelled as -12 dB, which assumes that MIMO

HS-SCCH is used and power controlled to achieve 1% decoding error at the UE. More realistic simulations will use the yet to be identified P-CPICH level.

6.8B.2 Performance evaluation metrics for filtered scalable UMTS

For DCH voice traffic, the following metric should be considered:

- DL
  - BLER v/s Ec/Ior

For HSPA traffic, the following metrics should be considered:

- Throughput.
- UL Ec/No difference
- For latency:
  - Compute transmission delay CDF for L1 delay.
  - CELL_DCH latency
    - Compare the CDFs of the average number of the transmissions and then take into account the increase in the TTI lengths to evaluate the latency.
  - Access latency
    - Consider with and without additional power/overhead.
- For coverage:
  - CELL_DCH coverage
    - Examine performance at different geometries.
  - Access coverage
    - Consider with and without additional power/overhead.

Inter-Carrier Interference (ICI) should be taken into account. The ICI model is described in [9]. The interference rise metric should be considered.

In filtered scalable UMTS link-level simulation, the performance metrics shall be carrier specific.

6.8C Link simulation results of scalable bandwidth UMTS with chip zeroing

Link evaluation results for filtered UMTS with chip zeroing is considered in this section and some comparisons with filtered UMTS (FUMTS) studied in Section 6.8 are presented.

6.8C.1 HSDPA link analysis

Results for downlink link evaluation for HSDPA is presented here. These results are indicated of the relative comparisons between CZ-UMTS and FUMTS, and with UMTS, with an 8% margin of uncertainty. These results are not meant to be compared with Time Dilated UMTS. The assumptions regarding overhead are listed for each set of results; however, more realistic evaluations that are not shown here would use assumptions in Section 6.8B.

6.8C.1.1 Standalone CZ-UMTS carrier

Link analysis is presented for UMTS with filtering and filtering with chip zero out (referred to as the chip zeroing (CZ)) for DL HSDPA transmission are presented in this section. The configurations considered are listed in Table 6.8C.1 and control power assumptions are listed in Table 6.8C.2

Table 6.8C.1: Configurations evaluated for scalable UMTS with filtering

Index	Description	Bandwidth
UMTS	regular UMTS	5 MHz
filtering, plain	basic filtering proposal [1]	2.5
filtering, chip-zero (same overhead)	chip zeroing proposal [2], % control channel overhead power is same as UMTS	2.5
filtering, chip-zero (increased overhead)	chip zeroing proposal [2], % control channel overhead power is scaled by N compared to UMTS	2.5 (N=2)

Table 6.8C.2: Relative power levels allocated to the control and data channels

Parameter	Value
P-CPICH_Ec/Ior	-10dB (all)
P-CCPCH_Ec/Ior	-9 dB (chip zero filtering UMTS (2.5 MHz) with inc overhead) -12 dB (others)
SCH_Ec/Ior	-9 dB (chip zero filtering UMTS (2.5 MHz) with inc overhead) -12 dB (others)
PICH_Ec/Ior	-12 dB (chip zero filtering UMTS (2.5 MHz) with inc overhead) -15 dB (others)
HS-SCCH_Ec/Ior	-9 dB (chip zero filtering UMTS (2.5 MHz) with inc overhead) -12 dB (others)
HS-PDSCH_Ec/Ior	Remaining power so that total transmit power of Node B (Ior) (sum of relative powers allocated to all channels should add to one)

The spectral efficiency comparison between the different schemes in Table 6.8C.1 is given in Figure 6.8C.1.

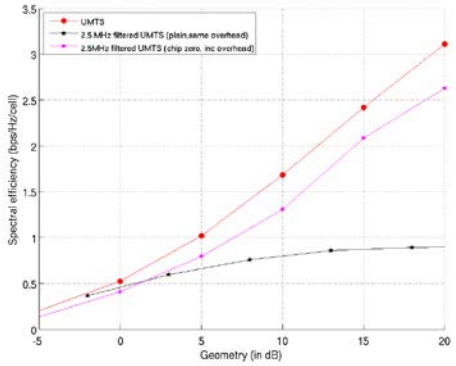
It should be noted that the code space available for chip zeroing is lower compared to UMTS. In regular UMTS, 15 out of 16 codes can be allocated for HS data resulting in 94% code utilization. On the other hand, chip zeroing solutions can only allocate 7/16 codes for N=2; when normalized with the bandwidth scaling factor, this comes out to be 87% code usage for HS data. This loss in code space does not occur for the plain filtered solution, although inter-chip self interference due to filtering of the waveform prevents achieving high-SNR high-rate regimes where all codes need to be scheduledFurther, increased loss in spectral efficiency is observed when the % overhead for the control channels is scaled up by the bandwidth reduction factor. The reasoning behind this scaling up of power is attributed to the reduced effective spreading factor for chip zeroing solutions and the desire to maintain the same control channel performance as with UMTS.

The results presented in this section will vary based on the power levels of the control channels. Hence they are only indicative of the relative comparison between chip zero filtering UMTS, filtering UMTS and UMTS.

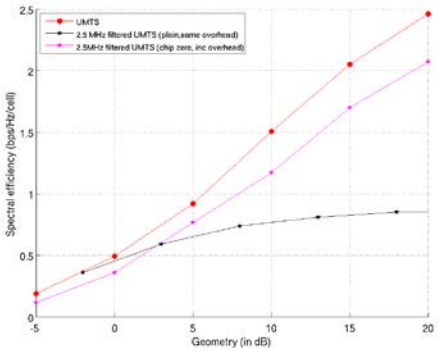
Enhancement to the plain filtering solution to narrow-bandwidth UMTS deployment in the form of chip zeroing results in spectral efficiency to levels no more than 0.5bps/Hz/cell lower than UMTS.

At geometries above 5dB, the plain filtering solution shows losses up to 60% compared to UMTS. Chip-zeroed filtered UMTS improves spectral efficiency in this geometry range (more than 5dB) to levels comparable with UMTS (i.e. 10 to 20% lower depending on control channel overhead scaling). This loss in plain filtering is a consequence of severe inter-chip interference in plain filtering resulting in saturating self interference at high geometries. At geometries below 5dB, plain filtering slightly outperforms chip zeroing. This is due tothe increase in % power overhead for control channels for chip zeroing.

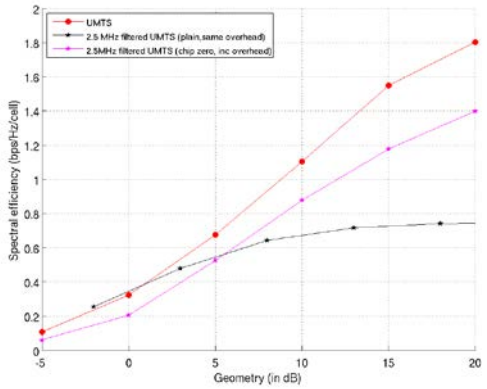
(a) PA3



(b) VA3



(c) VA30



(d) VA120

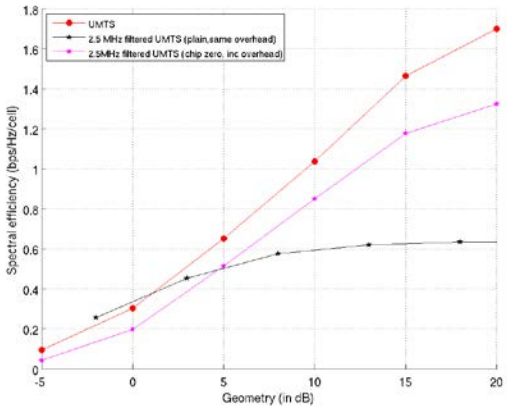


Figure 6.8C.1: Spectral efficiency (bps/Hz/cell) of HSDPA (2.5 MHz solutions versus UMTS (5.0MHz))

6.8C.1.1A HSDPA link analysis with chip zeroing assuming N times overhead power ratio

The spectral efficiency comparison between normal UMTS (5MHz deployment) and the filtered UMTS with chip zeroing (2.5 MHz) is given in Figure 6.8C.2, assuming for filtered UMTS N times power ratio is assigned to the common channels such as SCH, P-CCPCH,HS-SCCH and CPICH.

As with the results above, these results are indicative with an 8% margin of uncertainty, and are not meant to be compared with time dilated UMTS.

From Figure 6.8C.2, it can be observed that filtered UMTS with chip zeroing has lower spectral efficiency than UMTS. This can be caused by that a larger portion of power is consumed by control channels and the less availability of

channelization codes. For 5MHz normal UMTS 15 out of 16 codes are available, meanwhile for 2.5MHz filtered UMTS with chip zeroing only 7 out of 16 codes are available, which is 7/15 of normal UMTS less than 1/2.

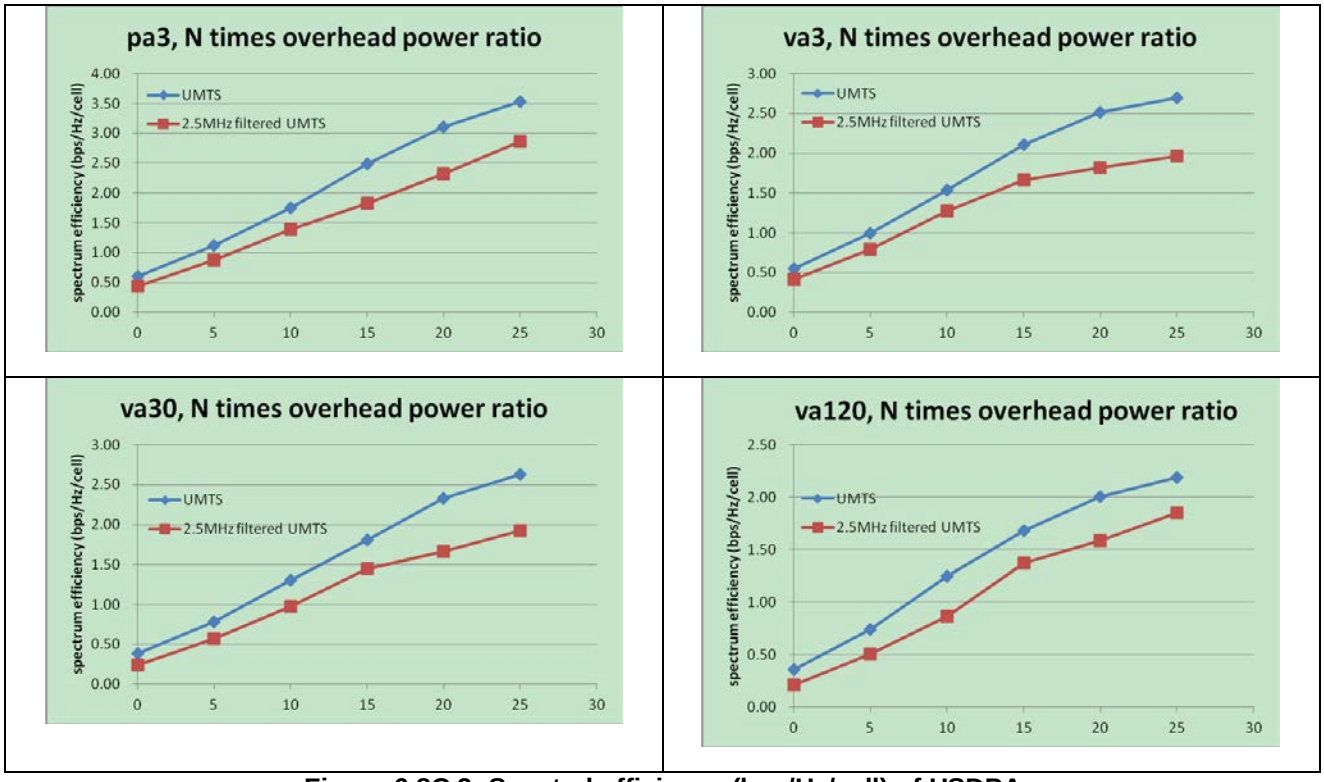


Figure 6.8C.2: Spectral efficiency (bps/Hz/cell) of HSDPA (2.5 MHz filtered UMTS with chip zeroing versus 5MHz normal UMTS)

6.8C.1.2 Multi-carrier UMTS+ CZ-UMTS configurations

The throughput improvement of multi-carrier combination of UMTS with a chip zeroing carrier of bandwidth 2.5 or 1.25 MHz compared to normal UMTS is analysed. The comparison is made with baseline UMTS in terms of the aggregate throughput and the impact on legacy users (who can only utilize the UMTS carrier in the multi-carrier combination) as a function of geometry and the wireless channel model. Two alternatives for multi-carrier configurations are considered. In the first option, narrowband carrier has HS-SCCH, and SCH as the only two control channels transmitted. All other control information for the multi-carrier UE is sent over the UMTS carrier. In the next option, even the scheduling information (HS-SCCH) of narrowband carrier is sent over the primary UMTS carrier. HS-SCCH on the primary carrier is similar to the one used for MIMO operation. The relative power offset is set such that the performance is 1% decoding error at the UE. The synchronization channel in the narrowband carrier is retained in all multi-carrier configurations.

Table 6.8C.3: Configurations evaluated in this document

Index	Configuration	Options	Bandwidth	Frequency offset between carriers
U+S_4	UMTS + CZ-UMTS (N=4)	1) Only HS-SCCH and SCH on scalable UMTS carrier 2) Only SCH on scalable UMTS carrier	6.00 MHz	2.88 MHz
U+S_4	UMTS + CZ-UMTS (N=4)	1) Only HS-SCCH and SCH on scalable UMTS carrier 2) Only SCH on scalable UMTS carrier	6.25 MHz	3.125 MHz
U+S_2	UMTS + CZ-UMTS (N=2)	1) Only HS-SCCH and SCH on S-UMTS carrier 2) Only SCH on scalable UMTS carrier	6.00 MHz	2.25 MHz
U+S_2	UMTS + CZ-UMTS (N=2)	1) Only HS-SCCH and SCH on scalable UMTS carrier 2) Only SCH on scalable UMTS carrier	7.50 MHz	2.75 MHz
U	UMTS		5.00 MHz	single carrier

The performance of multi-carrier configurations in 6, 6.25 and 7.5MHz MHz bandwidth is presented first when HS-SCCH is transmitted on both carriers, with the power for narrowband carriers scaled by N (to maintain same quality as UMTS in spite of the reduced spreading factor).

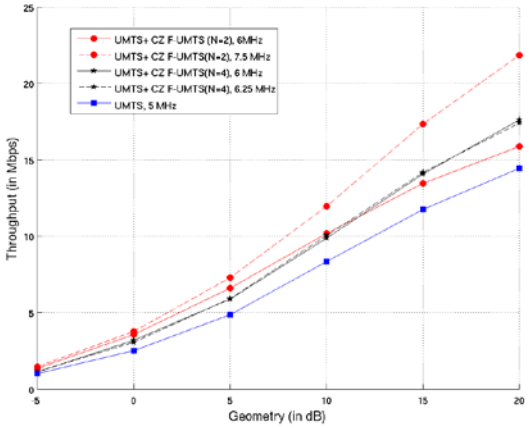
Fig. 6.8C.4 suggest that throughput gains are obtained for all multi-carrier configurations (using 6 MHz) over the baseline UMTS with gains around 20% and gains increase with geometry for U+S_4: UMTS+Filtered-UMTS (N=4). On the other hand, the configuration U+S_2: UMTS+Filtered-UMTS(N=2) achieves 44% to 4% gains with gains decreasing with geometry. Configuration U+S_4 has lower gains at low geometries due to loss of available power for HS data (note that HS-SCCH uses ~20% power for N=4, compare with 5% for UMTS). This power loss is less important at high geometries. On the other hand, configuration U+S_2 has lower gains at higher geometries because of the inter-carrier interference between the squeezed carriers in 6 MHz.

Fig. 6.8C.5 depicts the impact on legacy user due to inter-carrier interference between the two carriers. It is seen that configuration U+S_2 results in greater than 20% peak loss in legacy user throughput (with loss increasing with geometry).

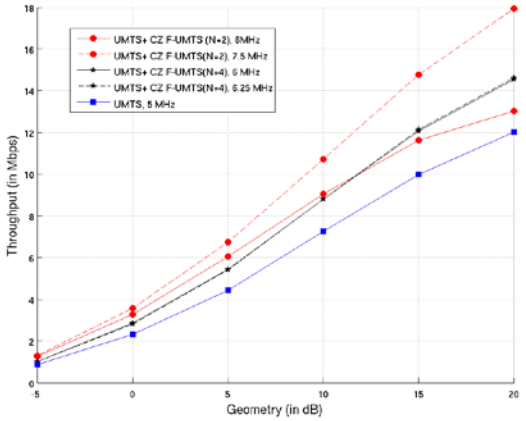
Next, the performance of multi-carrier configurations in 6 MHz bandwidth is shown when HS-SCCH is transmitted on only on the UMTS carrier. This cross-carrier scheduling mode is expected to show increased aggregate throughputs due to increased available power for HS data in the narrow band carrier. Fig. 6.8C.7 suggest that throughput gains are obtained for all multi-carrier configurations (using 6 MHz) over the baseline UMTS with gains up to 25% with gains increasing with geometry for U+S_4: UMTS+Filtered-UMTS (N=4) while the other configuration U+S_2: UMTS+Filtered-UMTS(N=2) achieves 50% to 3% gains with gains decreasing with geometry. Configuration U+S_4 has improved gains compared to when there is an SCCH overhead is present in the narrowband carrier.

Fig. 6.8C.8 depicts the impact on legacy user and it is seen that configuration U+S_2 results in greater than 20% peak loss in legacy user throughput (with loss increasing with geometry).

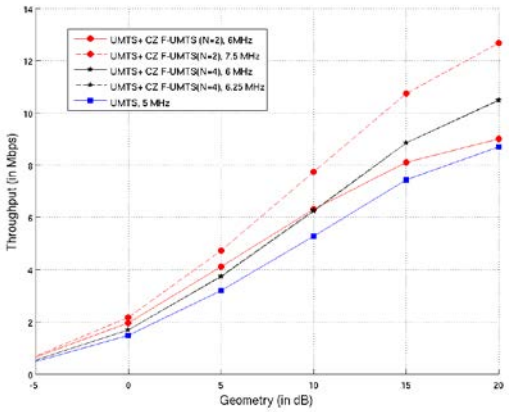
(a) PA3 (b) VA3



(c) VA30



(d) VA120



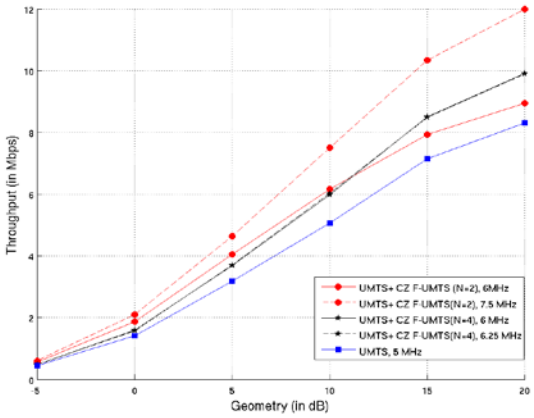
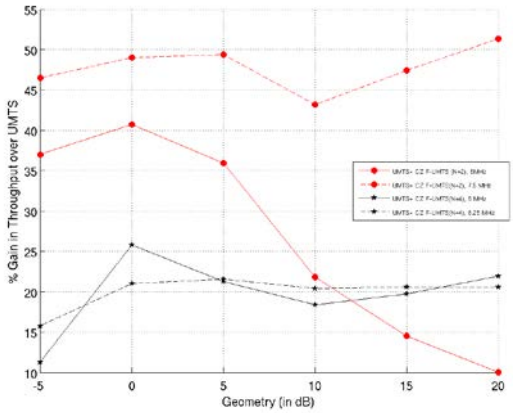
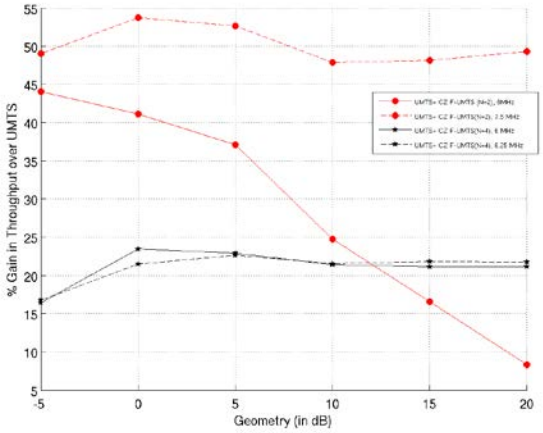


Figure 6.8C.3: HSDPA throughputs for multi-carrier combinations (option 1: HS-SCCH present on Filtered-UMTS carrier)

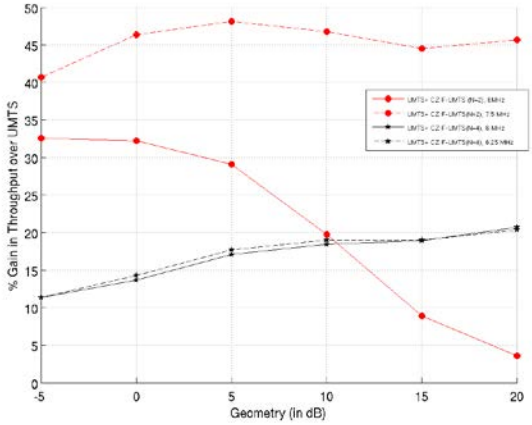
(a) PA3



(b) VA3



(c) VA30



(d) VA120

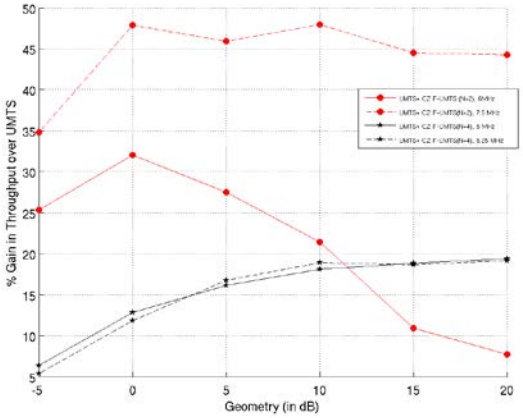
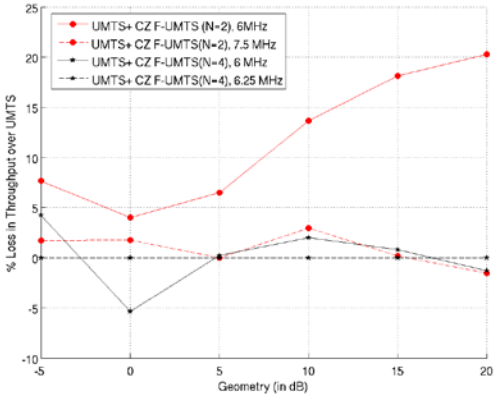
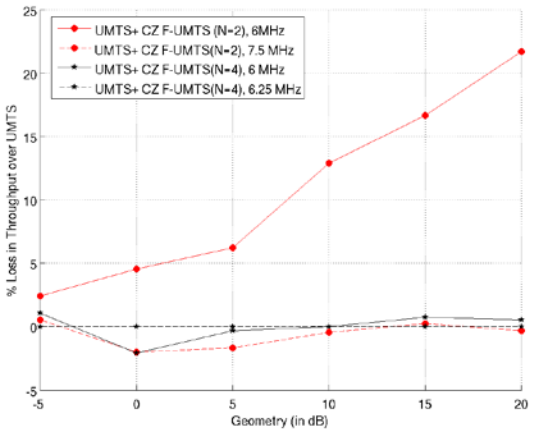


Figure 6.8C.4: Percentage gain in HSDPA throughput (over UMTS) for multi-carrier combinations (option 1: HS-SCCH present on Filtered-UMTS carrier)

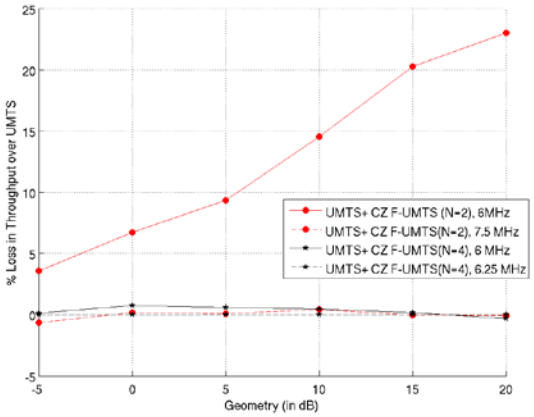
(a) PA3



(b) VA3



(c) VA30



(d) VA120

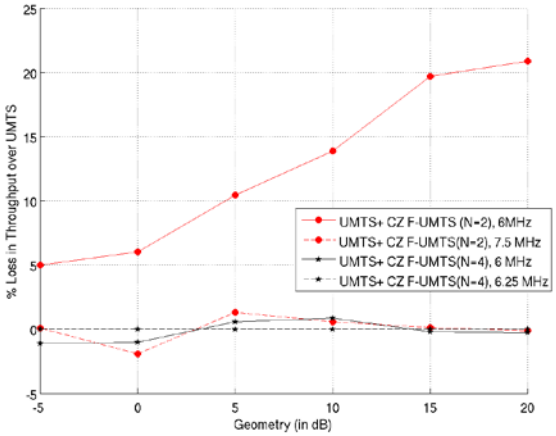
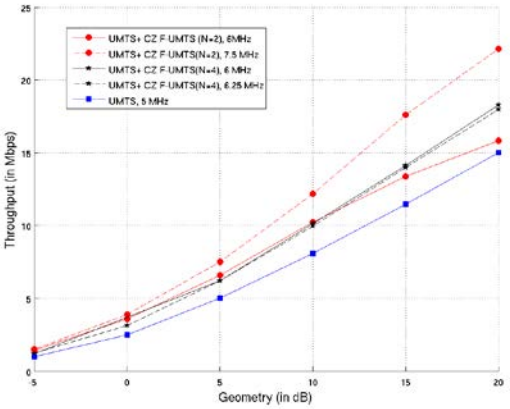
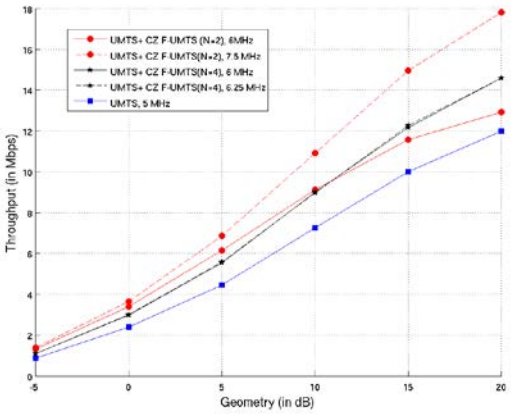


Figure 6.8C.5: Impact on legacy user's HSDPA throughput (compared to UMTS) for multi-carrier combinations (option 1: HS-SCCH present on Filtered-UMTS carrier)

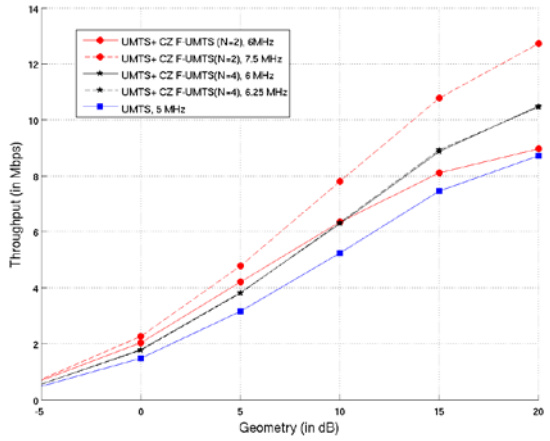
(a) PA3



(b) VA3



(c) VA30



(d) VA120

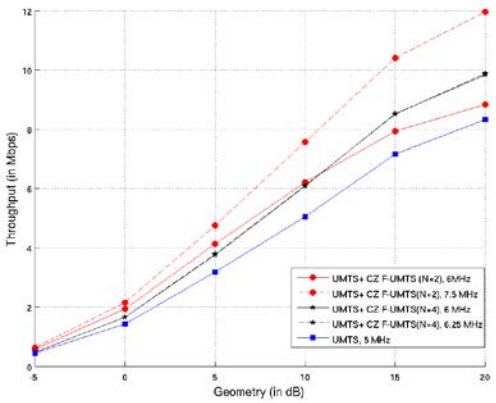
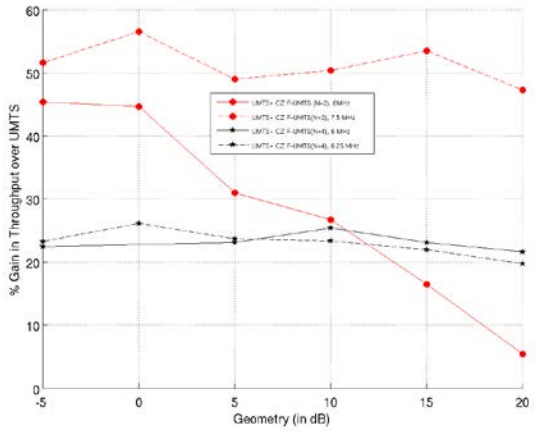
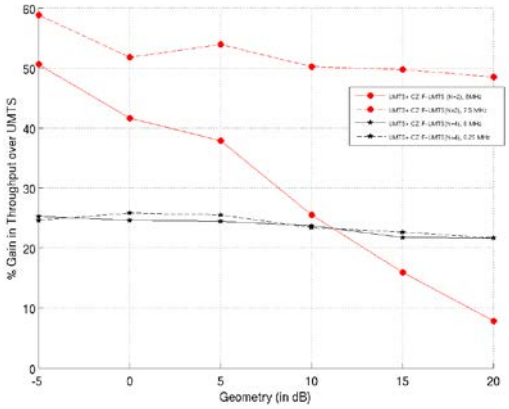


Figure 6.8C.6: HSDPA throughputs for multi-carrier combinations (option 2: HS-SCCH absent on Filtered-UMTS carrier; cross-carrier scheduling)

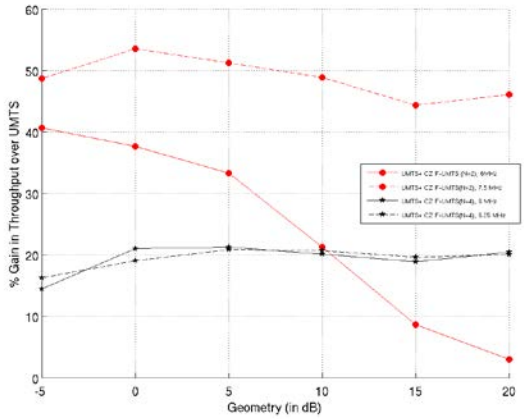
(a) PA3



(b) VA3



(c) VA30



(d) VA120

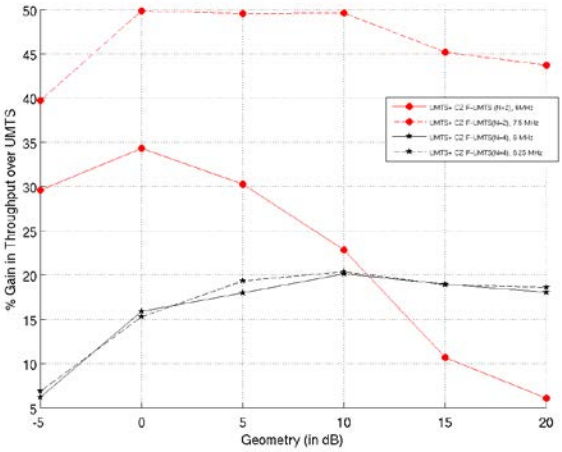
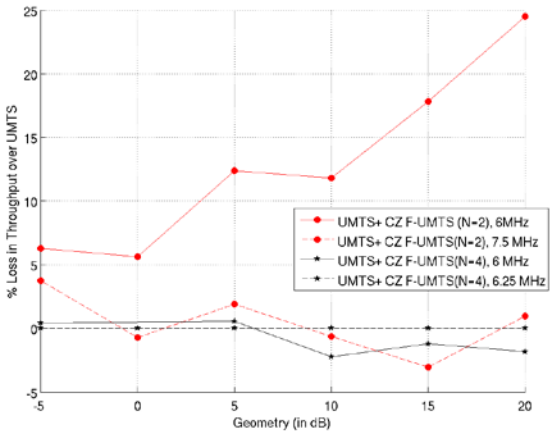
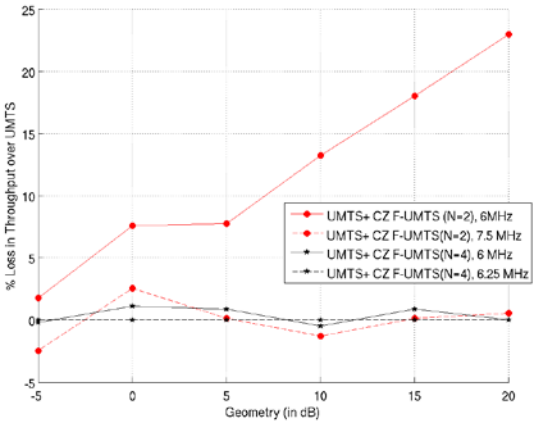


Figure 6.8C.7: Percentage gain in HSDPA throughput (over UMTS) for multi-carrier combinations (option 2: HS-SCCH absent on Filtered-UMTS carrier; cross-carrier scheduling)

(a) PA3



(b) VA3



(c) VA30 (d) VA120

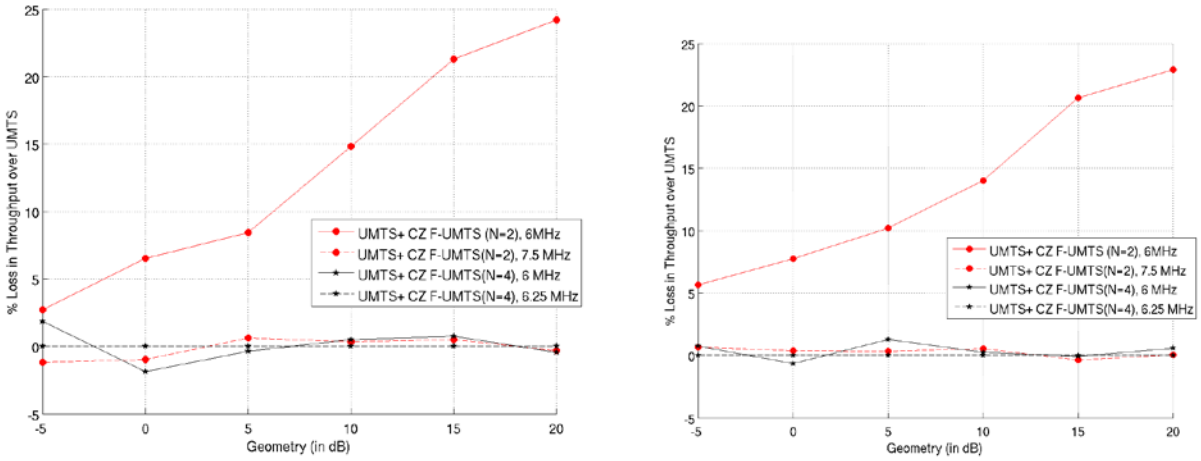


Figure 6.8C.8: Impact on legacy user's HSDPA throughput (compared to UMTS) for multi-carrier combinations (option 2: HS-SCCH absent on Filtered-UMTS carrier; cross-carrier scheduling)

6.8C.1.3 DCH analysis

The link level simulation assumptions for the DCH channel for time-dilated scalable UMTS is assumed. In particular, the performance of AMR full rate voice without DCCH in both downlink and uplink is studied.

The transport channel parameters are listed in Table 6.8C.4. Fixed position rate matching is used in the downlink. The downlink DPCH slot formats are shown in Table 6.8C.4. The DPCH slot format 8 is used for the AMR12.2k voice traffic.

In the uplink, the spreading factor of DPDCH for the FULL rate voice packet is 64. For equal comparison, the same set of rate matching attributes for all schemes is used. The amplitude scale factors for uplink physical channels are given in Table 6.8C.5.

Table 6.8C.4: Transport channel parameters for AMR 12.2kbps voice in standalone S-UMTS

Parameter	Value
Number of Transport Channels	4: TrCH{a,b,c} for AMR class {A,B,C}bits TrCH{d} for DCCH
TTI	[20ms, 20ms, 20ms, 40ms]
Number of Transport Blocks and Transport Block Sizes	TrCH#a: 1*81 TrCH#b: 1*103 TrCH#c: 1*60 TrCH#d: 0*0
CRC	12bit for TrCH#a
Channel Coding	CC Coding rate: 1/3 for TrCH#a,b; 1/2 for TrCH#c
Transport Channel Position	Fixed Position
Rate Matching Attributes	[180 175 234 180]

Table 6.8C.5: Amplitude scale factors for uplink physical channels

	β_d	β_c
UMTS and Filtered UMTS	15	12

The uplink performance is shown in Table 6.8C.6. It can be seen that the loss of filtered UMTS and filtering with chip zeroing UMTS are both around 3dB. The filtered UMTS sends chips with the original chip rate to a filter with half bandwidth. The self-interference caused by the ICI reduces the spreading gain by nearly half. So it requires 3dB higher EcNo to compensate the loss. The similar loss of spreading gain also happens to the enhanced filtered UMTS since the adjacent chips is zeroed out. So these two schemes have more or less the similar performance on the uplink.

EcNo loss = (filtered UMTS EcNo – 3dB) – UMTS EcNo

It is not yet possible to identify which filtering scheme is preferred for DCH from these results, since the results and any conclusions that might be drawn from them have sensitivities to different assumptions.

Table 6.8C.6: Uplink performance of AMR 12.2kbps voice

		UMTS		Filtered UMTS		Enhanced filtered UMTS	
Carrier Frequency (MHz)	Channel	Rx EcNo (dB)	Tx EcNo (dB)	Rx EcNo Loss (dB)	Rx EcNo Loss (dB)	Rx EcNo Loss (dB)	Tx EcNo Loss (dB)
900	PA3	-18.12	-19	-0.1	0	-0.1	0
900	VA3	-17.388	-19.6	0	0.4	0.2	0.3
900	VA30	-17.298	-19.5	0.3	0.3	0.4	0.4
900	VA120	-17.017	-19.7	0.1	-0.1	0	-0.1
2000	PA3	-18.323	-19.2	0.3	0.9	0.2	0.2
2000	VA3	-17.354	-19.3	0.3	0.8	0.2	0.3
2000	VA30	-17.018	-19.5	0.1	0.1	0	-0.1
2000	VA120	-16.543	-19.3	-0.1	-0.3	0	-0.1

The downlink performance is shown in 6.8C.2.1.2.4. As the Geometry increases, the filtered UMTS experiences higher self interference caused by the ICI. Thus, it requires higher EcIor to combat the ICI. The chip zeroing filtered UMTS doesn't suffer from ICI due to the transmit filter. But it requires additional EcIor to compensate for the loss of spreading gain. In general, it has better performance than filtered UMTS in high Geometry region. The DPCH EcIor loss is defined as

DPCH EcIor loss = (filtered UMTS DPCH EcIor – 3dB) – UMTS DPCH EcIor

Table 6.8C.7: Downlink performance of AMR 12.2kbps voice

			UMTS	Filtered UMTS	Enhanced filtered UMTS
Carrier Freq	Channel	Geometry	DPCH EcIor	EcIor Loss	EcIor Loss
900	PA3	0	-12.9		
900	PA3	5	-17.1	-0.2	-0.6
900	PA3	10	-20.5	1.1	-1.0
900	VA3	0	-14.9	0	0.3
900	VA3	5	-18.1	1.3	0.1
900	VA3	10	-19.8	1.5	-0.4
900	VA30	0	-15.5	1.1	0.9
900	VA30	5	-18.5	1.5	1.0
900	VA30	10	-20.5	2.2	0.7
900	VA120	0	-14.7	-0.5	-0.9
900	VA120	5	-18	0.8	-0.6
900	VA120	10	-19.7	1.3	-1.2
2000	PA3	0	-12.3		
2000	PA3	5	-17	0.7	-0.5
2000	PA3	10	-20.4	0.9	-1.7
2000	VA3	0	-15.7	1	-1.1
2000	VA3	5	-18.9	2.1	0.5
2000	VA3	10	-20.5	2.3	0.1
2000	VA30	0	-15.8	1.1	0.7
2000	VA30	5	-18.7	1.4	0.6
2000	VA30	10	-20.4	2	0.1
2000	VA120	0	-14.5	2.4	-1.2
2000	VA120	5	-17.8	3.7	-1.2
2000	VA120	10	-19.7	4.5	-1.8

Consider tthe performance of AMR 12.2kbps voice for filtered UMTS and chip zeroing UMTS with 2.5MHz bandwidth. In the uplink, the two schemes have comparable performance since the the uplink voice operated at low SNR region. The downlink performance of filtered UMTS is worse than the chip zeroing filtered UMTS at high geometry, but at low geometry the performance is more similar. The overall difference between pure filtering and chip zeroed filtering in terms of downlink system capacity is not clear; at high geometry there can be differences of up to 6dB, but little or no losses for low geometry UEs that need a significant amount of Ec/Ior.

6.8C.2 Uplink link level results

It is not yet possible to identify which filtering scheme for the uplink would be preferable from the results obtained, since the results and any conclusions that might be drawn from them have sensitivities to different assumptions, and these sensitivities need to be evaluated for different assumptions that are identified to be relevant.

6.8C.2A PRACH preamble simulation results

In figure 6.8C.8A the Scalable UMTS impact to false alarm rate of the PRACH preamble is shown. The UMTS cell false alarm rate is taken as the reference, and the Scalable UMTS performance difference relative to the UMTS cell is shown in percentage points. It appears that with 2-Rx receiver the Scalable UMTS false alarm rate is actually somewhat better than that of the UMTS false alarm rate. This is most likely caused by the fact that the Scalable UMTS receiver collects less noise. On the other hand, the single Rx receiver performs slightly worse for the Scalable UMTS cell than for the UMTS cell. PRACH preamble with chip-zeroing appears to perform slightly worse than the simple filtering, but the difference is very small and could be attributed to simulation noise. These results indicate PRACH performance in the presence of AWGN interference. The performance in the presence of other preambles has not been studied.

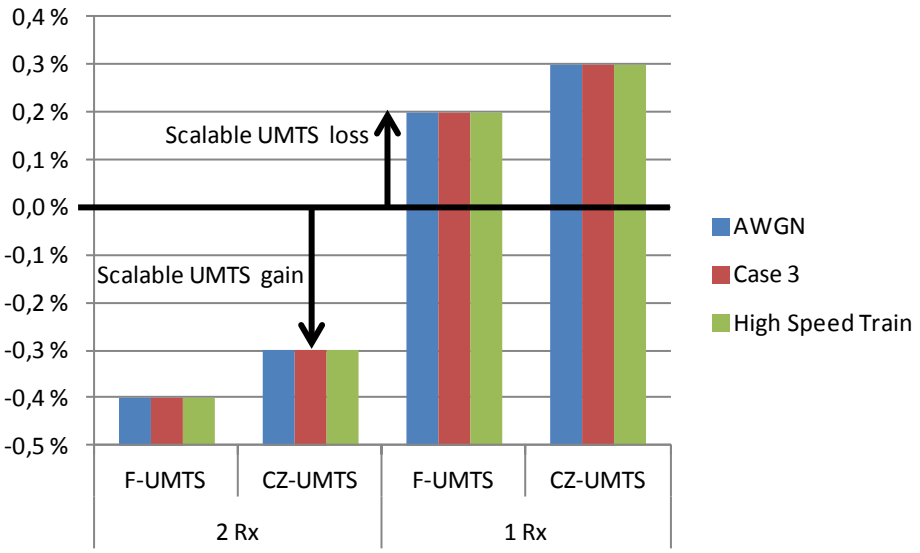


Figure 6.8C.8A: PRACH preamble false alarm rate relative to UMTS false alarm rate

In figures 6.8C.8B and 6.8C.8C the required PRACH preamble Ec/No for a given miss detection probability in Scalable UMTS is investigated. The UMTS cell's required PRACH preamble Ec/No is taken as the reference, and the Scalable UMTS performance difference relative to the UMTS is shown in dB. It appears that with 2 Rx the performance difference between UMTS and Scalable UMTS is negligible. With 1 Rx the performance difference is otherwise negligible, but with the extreme 3GPP Case 3 channel the Scalable UMTS performance is visibly degraded. The difference between F-UMTS and CZ-UMTS is non-existing.

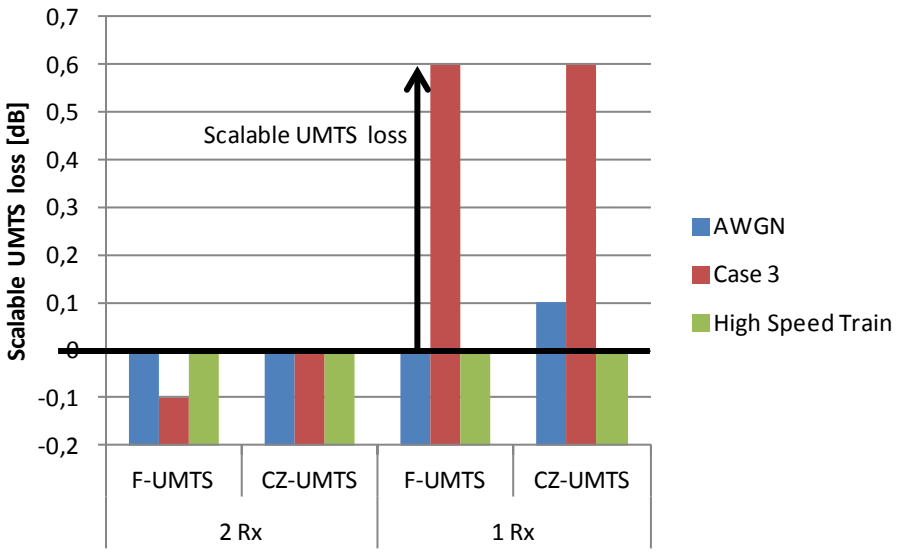


Figure 6.8C.8B: Required PRACH preamble Ec/No in Scalable UMTS relative to UMTS cell, 1% miss detection probability

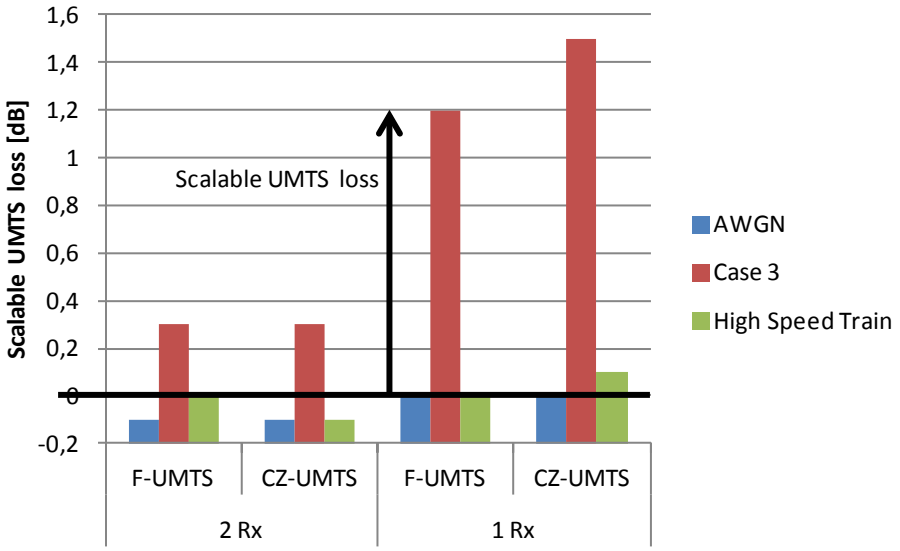


Figure 6.8C.8C: Required PRACH preamble Ec/No in Scalable UMTS relative to UMTS cell, 0.1% miss detection probability

6.8C.3 System Simulations – Bursty Traffic (Chip zeroed Filtered UMTS)

It should be noticed that for cross scheduling systems, HS-SCCH channels are transmitted on the primary carrier. Also, for multicarrier systems, it is assumed that on the first carrier N =1 and on the second carrier N = 2 or N =4. For comparison, single carrier simulations where performed with N = 1 and N = 2. N = 4 simulations are not shown. It should be noted that the results with filtering should not be directly compared to similar results for time dilated systems. For multicarrier systems the first carrier uses the same overheads as UMTS system, except for the fact that for cross carrier scheduling, the HS-SCCH overhead is modelled as in MIMO systems.

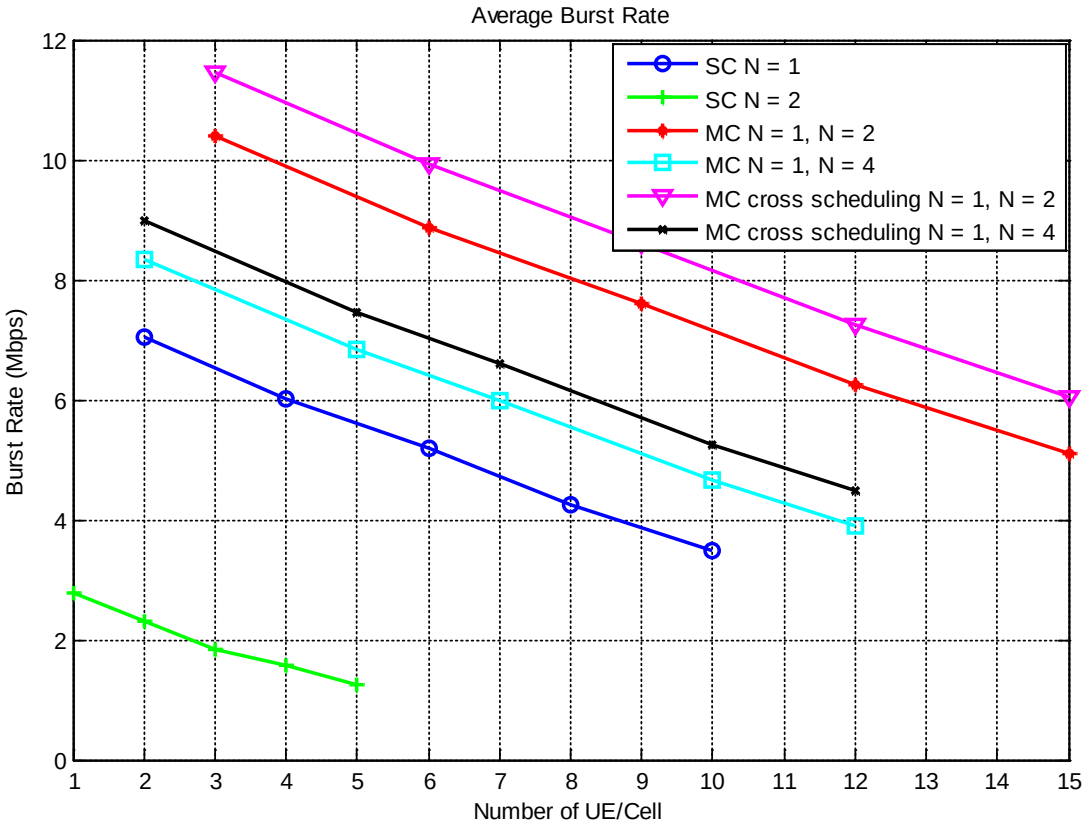


Figure 6.8C.9: Average UE burst rate

In 6.8C.9 the average burst rate of the UEs is presented for different scenarios. To compare the performance of different UMTS systems, single carrier with N = 1 system is defined as the baseline system. It is noticeable that wherever a 5MHz UMTS carrier has unused capacity, it is always better not to utilise the low bandwidth carrier as long as there is excess capacity on the 5Mhz UMTS carrier, or use multicarrier.

These results assume 100% penetration of multicarrier scalable UMTS UEs; the performance with a lower penetration of such UEs was not studied.

It can be observed that with 100% UE penetration, each multicarrier system or cross scheduling multicarrier system has a burst rate vs. number of UEs/Cell graph which can approximately be derived by expanding both X and Y axis by the same factor. Based on the results, assume K UE/cell in the baseline system yield an average burst rate of R Mbps, then the average burst rate for multi carrier with N = 1 and N =2, is 1.5 R Mbps at 1.5 K UE/cell. For cross scheduling multi carrier with N = 1 and N =2, the average burst rate is 1.6 R Mbps at 1.6 K UE/cell. At the same number of UEs, the cross scheduling system yields a higher burst rate of about 7% more which is the result of lower overhead on the second carrier.

Similar performance improvement is observed for cross scheduling multi carrier system with N = 1 and N = 4, vs. multi carrier system with N = 1, N = 4. The average burst rate of the multi carrier system with N = 1 and N = 4, is approximately 1.2 R Mbps at 1.2 UEs/ cell while the average burst rate of the cross scheduling system with N = 1 and N = 4 is 1.25 R Mbps at 1.25 UE/ cell which is about 4% improvement. In Table 6.8C.8, the average, 5% and 50% tail values of the average UE burst rate for different scenarios are presented, which exhibit similar trends as the average burst rate presented in Figure 6.8C.9.

Table 6.8C.8: UE burst rate (Mbps) statistics

# UE/Cell	SC N =1			SC N = 2			MC N = 1, N = 2			MC N = 1, N = 4			Cross carrier scheduling N = 1, N = 2			Cross carrier scheduling N = 1, N = 4		
	Avg.	5%	50%	Avg.	5%	50%	Avg.	5%	50%	Avg.	5%	50%	Avg.	5%	50%	Avg.	5%	50%
1				2.79	1.05	2.48												
2	7.05	3.30	6.45	2.31	0.75	1.98				8.34	3.99	7.64				8.99	4.34	8.24
3				1.84	0.41	1.58	10.41	4.36	9.52				11.46	5.42	10.49			
4	6.02	2.25	5.43	1.56	0.20	1.20												
5				1.24	0.10	0.95				6.84	2.50	6.13				7.45	2.77	6.71
6	5.18	1.64	4.53				8.88	3.30	9.00				9.92	3.85	8.96			
7										5.99	1.89	5.23				6.61	2.16	5.81
8	4.26	1.13	3.66															
9							7.61	2.39	6.65				8.61	2.84	7.59			
10	3.49	0.69	2.95							4.66	1.15	3.99				5.25	1.38	4.51
11																		
12							6.24	1.63	5.36	3.89	0.71	3.28	7.26	2.04	6.27	4.48	0.94	3.80
13																		
14																		
15							5.09	0.97	4.29				6.04	1.35	5.14			

The following plots present the CDF of the UEs burst rate for different number of UEs per sector.

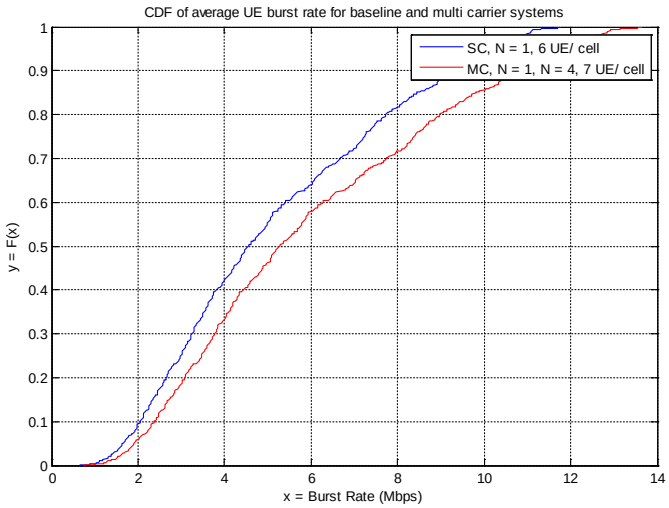


Figure 6.8C.10: CDF of Burst Rates at 6 UEs per cell

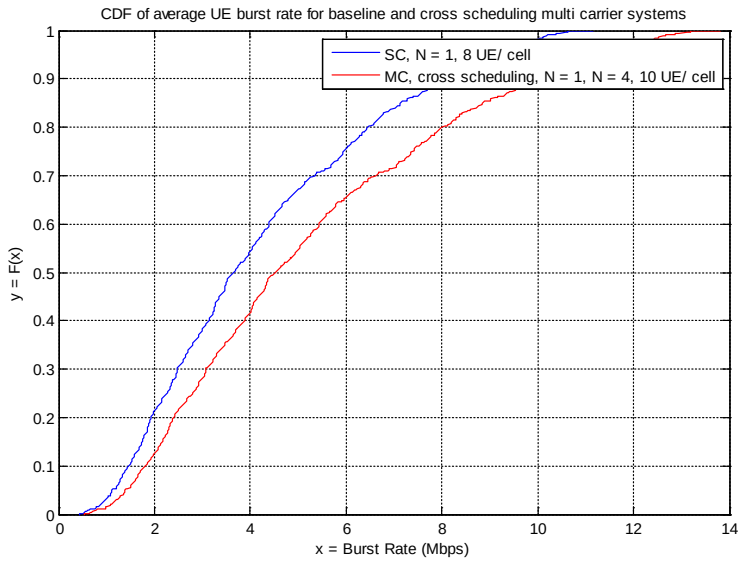


Figure 6.8C.11: CDF of Burst Rates at 8 UEs per cell

6.8C.4 Impacts on cell search

This section reviews the impacts on the cell search in CZ-UMTS system. Note that, in CZ-UMTS, the chip sequence (before the dilated RRC filter) is zeroed out every (N-1) consecutive chips out of N chips at the transmitter. At the receiver, the received signal after the RRC filter is zeroed out using some zero masking. Figure 6.8C.12 shows a block diagram of the filtered UMTS with chip zeroing.

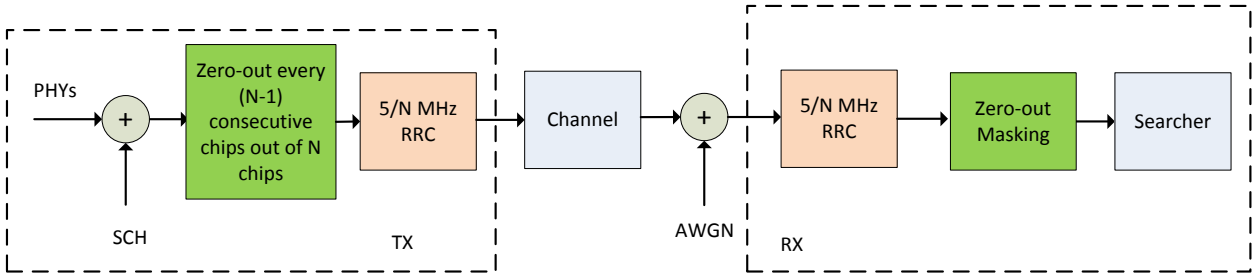


Figure 6.8C.12: Chip zeroing filtered UMTS

6.8C.4.1 Impacts on synchronization codes and primary scrambling codes

The synchronization codes and primary scrambling codes (PSCs) are zeroed out by applying some zero-out masking. For example, one can select zero-out masking with a pattern (in UMTS chip) as 1010 for N = 2 and 10001000 for N = 4. Under the zero-out masking, it can be showed that the cross-correlations of secondary synchronization codes and PSCs are equal or less than those in UMTS system. This means that the cross-correlation properties of secondary synchronization codes and PSCs are still maintained. In addition, the peak of the auto-correlation of synchronization codes and PSCs are reduced by a factor N. However, the reduced peak is still much higher than the noise floor (correlations at non-zero lags). As a result, it is expected that the zero-out operations do not affect the correlation properties of synchronization codes and PSCs, which is further verified in the cell search (searcher) performance.

6.8C.4.2 Synchronization codes

The auto-correlation of the primary synchronization code sequence is summarized inFigure 6.8C.13. It is shown that with chip zero-out, the auto-correlation peak is 3dB (N=2) lower than the auto-correlation peak in UMTS. Table 6.8C.9 further provides the ratios between the strength of first three strongest side lopes (at one-side of the auto-correlation) and the peak strength. As N increases, there are more strong side lobes. In particular, filtered UMTS N = 2 with chip

zeroing has two strong side lopes within 3dB of the peak while filtered UMTS N = 4 with zero chip has four strong side lopes within 3dB of the peak.

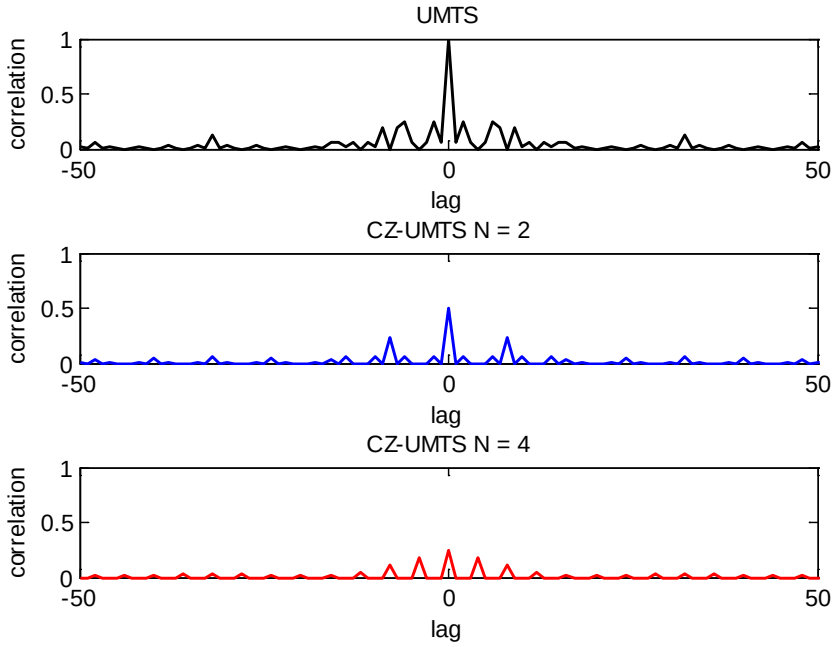
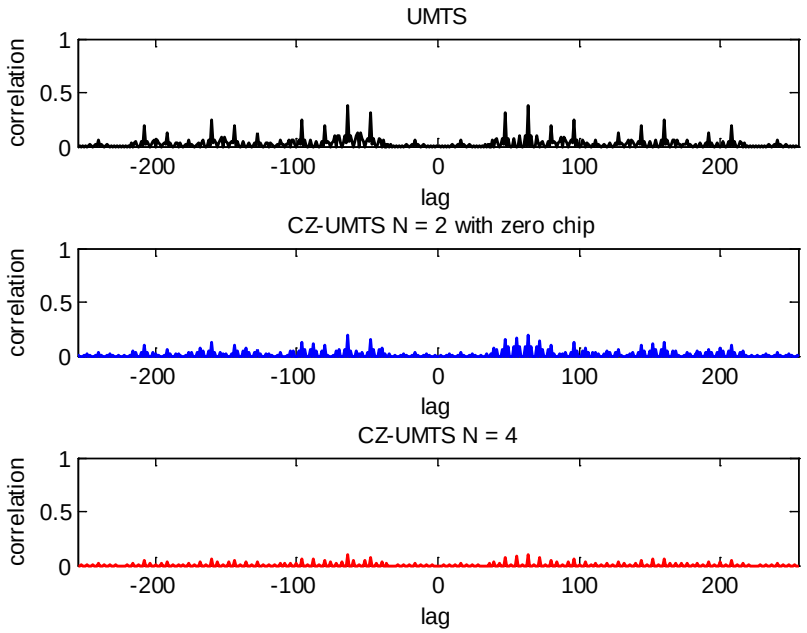


Figure 6.8C.13: The auto-correlation of the primary synchronization code

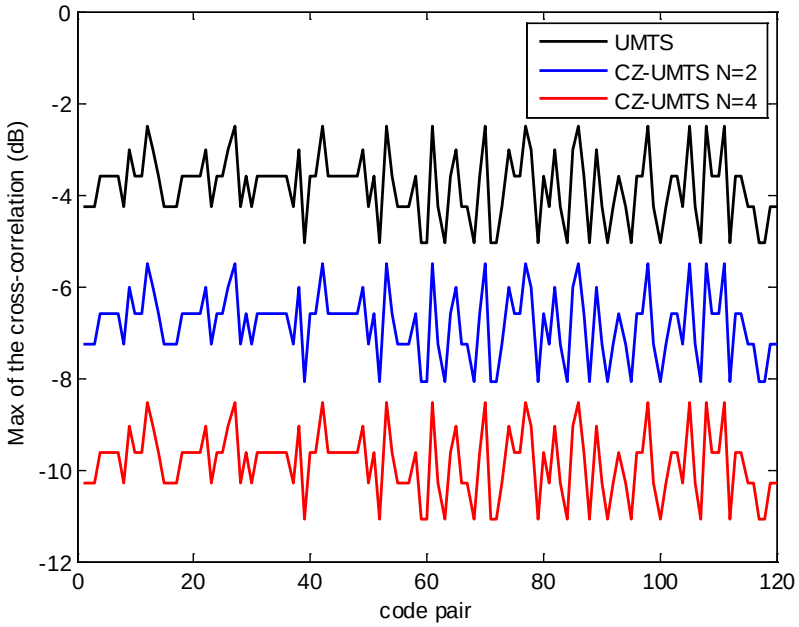
Table 6.8C.9: The ratio between the peak and three strongest side lobes of the autocorrelation

System	The strongest side lobe	The second strongest side lobe	The third strongest side lobe
UMTS	-6.0 dB	-6.0 dB	-7.0 dB
CZ-UMTS N = 2	-3.3 dB	-7.3 dB	-7.3 dB
CZ-UMTS N = 4	-1.3 dB	-3.3 dB	-6.9 dB

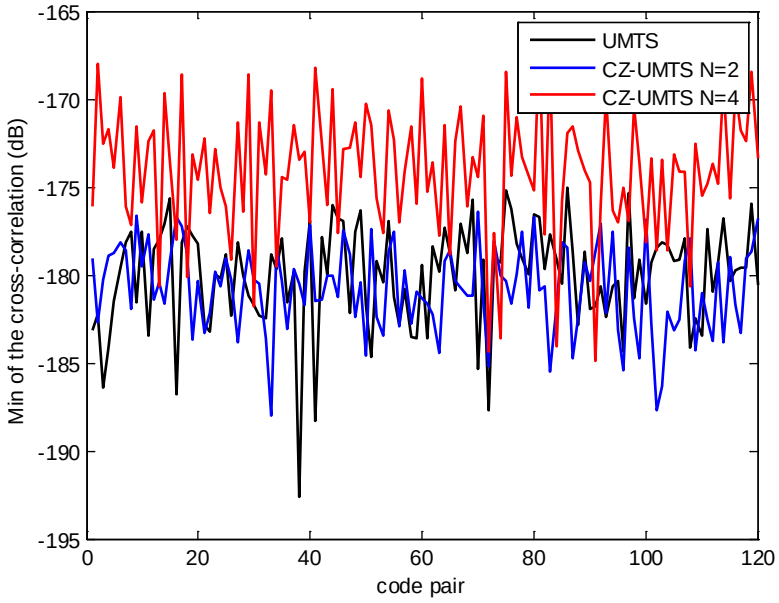
It can also be showed the auto correlation properties of any secondary synchronization code are similar to the auto correlation properties of the primary synchronization code, which are studied earlier. The cross correlation of a pair of secondary synchronization codes is demonstrated in Figure 6.8C.14. Here, the maximum and minimum values of the cross-correlation of any secondary synchronization code pair are plotted. It is observed that the cross-correlation properties of UMTS are still maintained with filtered UMTS with zero chip.



(a) Cross-correlation of a pair of secondary synchronization codes



(b) Max of the cross-correlation for code pairs

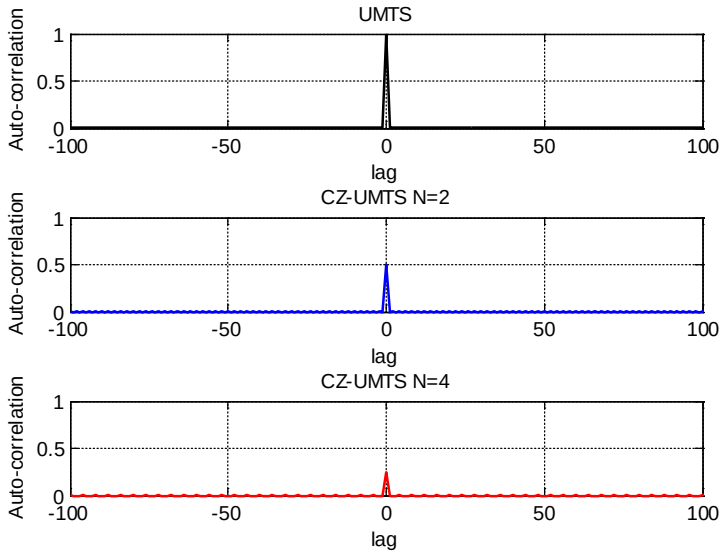


(c) Min of the cross-correlations for all code pairs

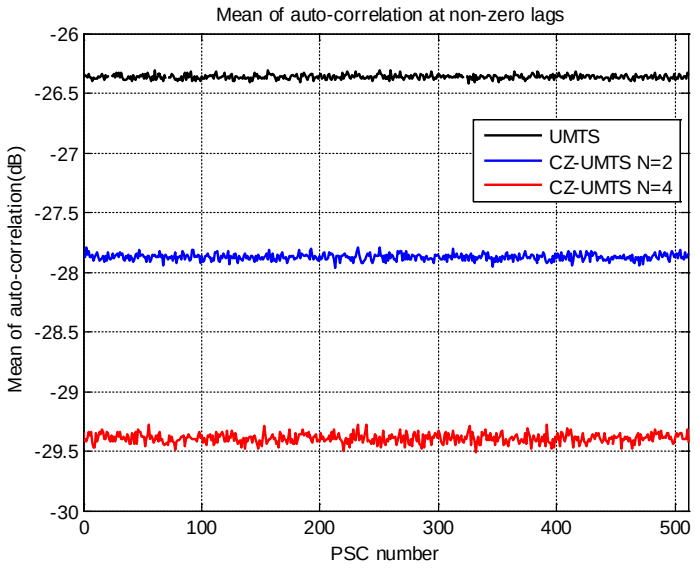
Figure 6.8C.14: The cross-correlation of the secondary synchronization code

6.8C.4.3 Primary scrambling codes

To understand the correlation properties of the primary scrambling codes (PSCs) under chip zero-out operations, the chip zeroing mask is applied to all PSCs and computed the correlation of zero-out masked PSCs. Figure 6.8C.15 and Figure 6.8C.16 demonstrates the auto-correlation and cross-correlation of such PSCs, respectively. It is observed that the CZ-UMTS reduces the peak of the auto-correlation N times. However, the CZ-UMTS has lower maximum and mean values of cross-correlation.

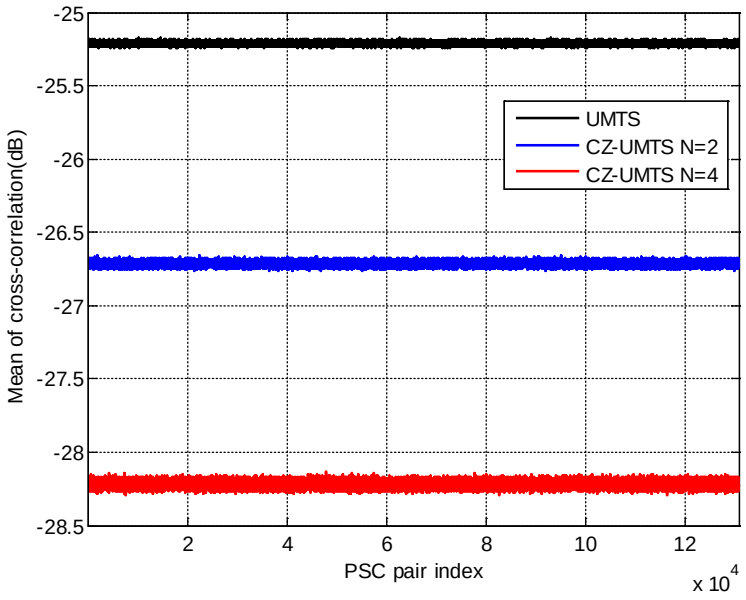


(a) The auto-correlation of PSC10

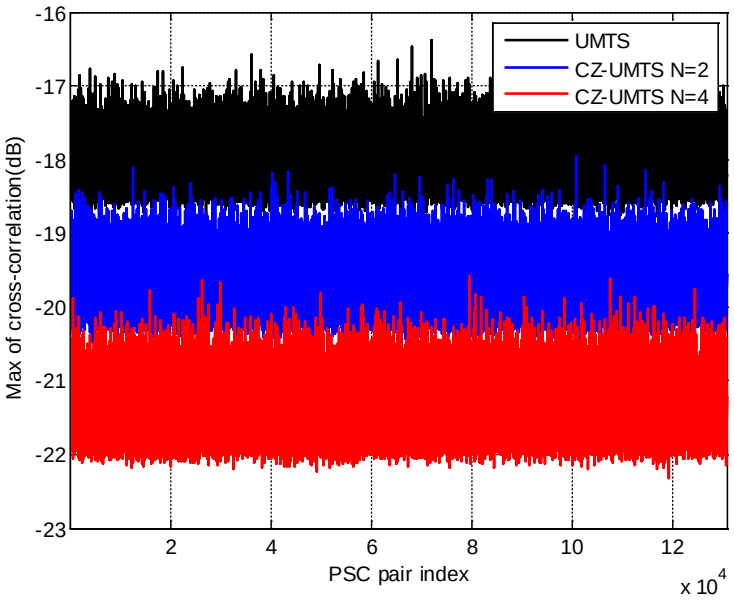


(b) The mean of auto-correlation of PSCs at non-zero lags

Figure 6.8C.15: Auto-correlation of PSCs



(a) The mean of cross-correlation for all PSC pairs



(b) The max of cross-correlation for all PSC pairs

Figure 6.8C.16: Cross-correlation of PSCs

From the analysis on the correlation properties of synchronization codes and PSCs under zero-out operations, it is observed that the peak of the auto-correlation is reduced N times while the noise floor in auto-correlation at non-zero lags and in cross-correlation is equal or less than the noise floor of the correlations in the UMTS system. However, such peak reduction does not affect the cell detection performance (assuming appropriate power scaling) since the peak is still highly separable from the noise floor. The searcher performance in the next section would further verify this.

Above design proposal 4 leads to a situation where if a UE in a 5 MHz cell starts with a 1.25 MHz SCH search a false positive my occur.

6.8C.4.4 Searcher performance

A three-stage searcher implementation was previously summarized in [3]. Note that the sampling rate after the RRC filter at the receiver is half of the UMTS chip. The simulation assumptions used to evaluate the performance of the searcher in both schemes are summarized in Table 6.8C.10. It should be noted that it is assumed that frequency synchronization is known a priori prior to receiving SCH.

Table 6.8C.10: Simulation assumptions

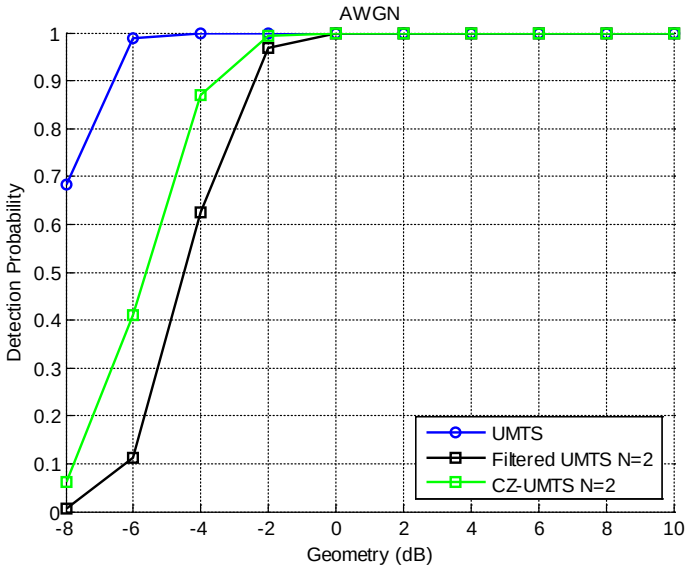
Simulation Parameters	Value
Carrier frequency	900MHz
Cell Layout	Single cell
UE Antenna	Single receive antenna
P-CPICH_Ec/Ior	-10 dB
P-SCH_Ec/Ior	-15 dB
S-SCH_Ec/Ior	-15 dB
Accumulation length	3 frames (Step1), 2 frames (Step2), 1 frame (Step3)
Frequency offset	0Hz
False alarm rates	Stage 1: 1% Stage 3: 0.1%
Zero masking	N = 2: 1100
Propagation conditions	AWGN, PA3, PB3, VA30, VA120

The searcher performance is evaluated in terms of a cell detection probability which is defined as the probability that all of following conditions satisfy:

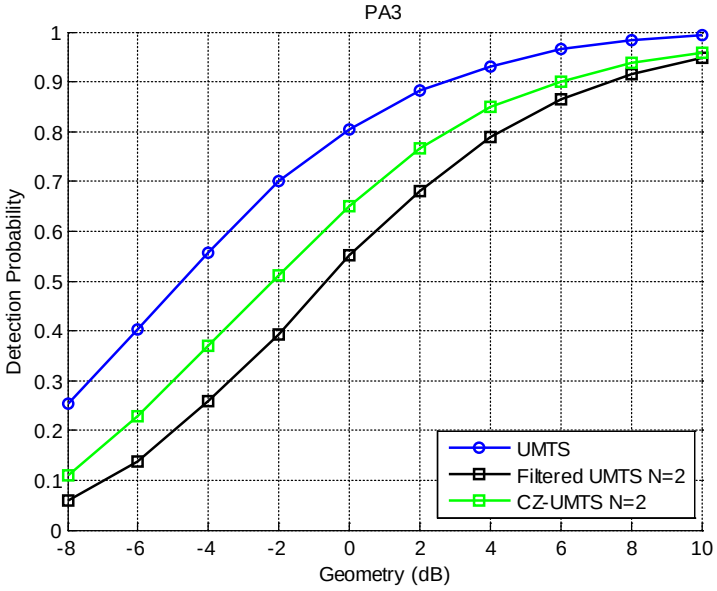
- Stage 1 is passed, i.e., the slot timing is detected
- and Stage 2 is passed, i.e., the frame timing and code group are identified
- and the correct PSC is detected in Stage 3

In other words, the cell detection performance is a joint detection probability of all three stages.

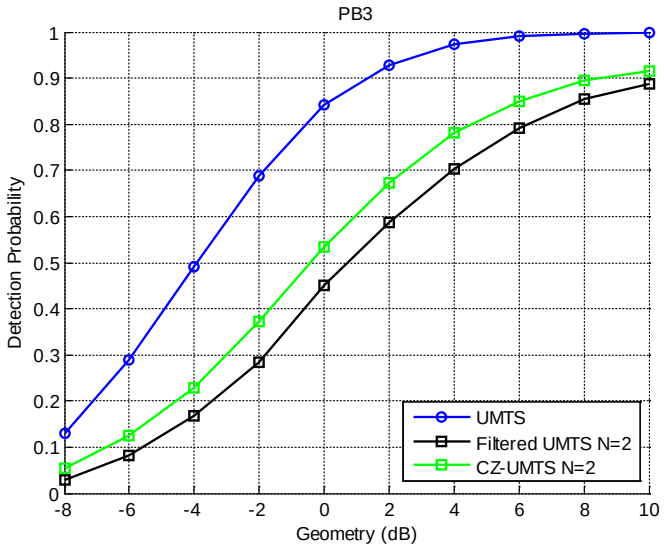
Figure 6.8C.17 provides the simulation results of the searcher performance of both schemes for N = 2. Also, their performance is compared to the performance of UMTS searcher. It is observed that the CZ-UMTS has around 1dB better performance than the filtered UMTS without zero chip. However, it has about 3dB performance loss compared to the UMTS searcher. The loss of CZ-UMTS is mostly due to the reduction in processing gain.



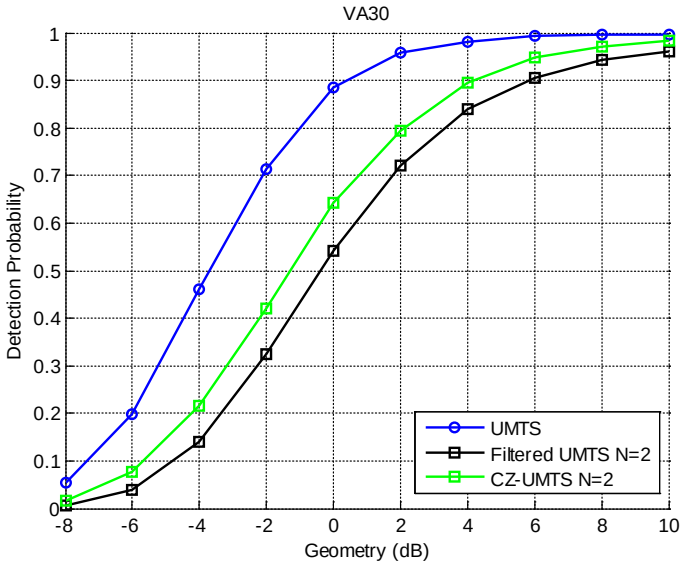
(a) Cell detection performance in AWGN



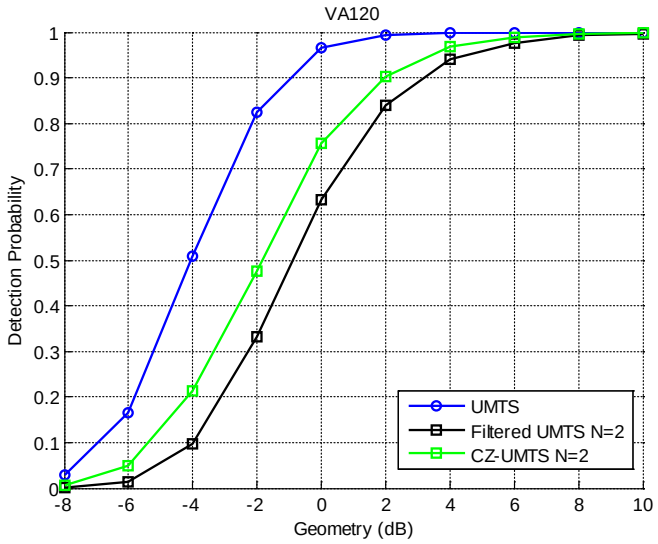
(b) Cell detection performance in PA3



(c) Cell detection performance in PB3



(d) Cell detection performance in VA30



(e) Cell detection performance in VA120

Figure 6.8C.17: Cell detection performance vs. geometry, N = 2

6.8C.4.5 Impacts on searcher implementation and performance

From the searcher implementation viewpoint, the UMTS searcher can be used in the CZ-UMTS system. The only change is to apply the zero-out masking on the synchronization codes and PSCs. Figure 6.8C.12 demonstrates the searcher in CZ-UMTS. The searcher implementation can be referred to [3].

Note that the zero-out operation reduces the processing gain by factor N. As a result, the searcher performance of CZ-UMTS has around 3dB (N=2) loss compared to the UMTS searcher performance. This loss could be recovered by boosting the transmit power of synchronization channels accordingly.

6.8D Uplink signal characteristics

6.8D.1 Background

The uplink scrambling code was designed in Rel-99 to offer a bit better peak-to-average power ratio (PAPR) performance than a pure random scrambling code. This PAPR reduction scheme was referred to as HPSK/OCQPSK, and is implemented in the uplink scrambling code generation by introducing a dependency between consecutive chips:

$$C_{long,n}(i) = c_{long,1,n}(i)\left(1 + j(-1)^i c_{long,2,n}\left(2\lfloor i/2 \rfloor\right)\right)$$

With the introduction of chip zeroing in uplink, this particular characteristic of the scrambling code is modified, since there will be no "memory" between scrambling code chips actually transmitted. Hence, it is relevant to study PAPR and cubic metric (CM) performance. A high PAPR/CM is undesirable as it typically reduces the maximum power with which the terminal may transmit in order to fulfill requirements on emissions, e.g. adjacent-channel leakage power ratio (ACLR). In fact, the CM is directly influencing in a non-linear manner the Maximum Power Reduction (MPR) requirements in RAN4, i.e. the higher the CM the higher the MPR. The reduction in maximum output power reduces the coverage and throughput. Avoiding this may be possible but might require redesign of the transmitter, at the expense of increased chip area and reduced power amplifier efficiency resulting in increased power consumption.

6.8D.2 Simulation assumptions

Simulations have been performed to study the power distribution of UMTS, F-UMTS and CZ-UMTS uplink signals. In addition, a reference case where the uplink scrambling code for normal UMTS is modified to remove the HPSK/OCQPSK component has been studied. This is done by simply applying the standardized downlink scrambling code in the uplink direction.

In all the simulations a set of channelization codes with different spreading factors and amplitude ratios (beta-factors) are used. Scrambling code number 10 was used in all cases, but additional tests indicate that the choice of code does not influence the results significantly. Random sequences of data symbols are then spread and scrambled, and a root raised cosine filter scaled to the proper bandwidth with roll-off 0.22 and 10 times oversampling is applied. The signal properties after the filter are then studied.

Three different reference bearers, i.e. sets of channelization codes / beta values, have been simulated:

12.2 kbps speech

DPCCH: SF256 code 0, mapped to Q-branch, beta_c = 8/15
DPDCH: SF64 code 16, mapped to I-branch, beta_d = 15/15

32 kbps 10 ms TTI EUL

DPCCH: SF256 code 0, mapped to Q-branch, beta_c = 15/15
E-DPCCH: SF256 code 1, mapped to I-branch, beta_ec = 8/15
E-DPDCH: SF32 code 8, mapped to I-branch, beta_ed = 21/15

1 Mbps 2 ms TTI EUL

DPCCH: SF256 code 0, mapped to Q-branch, beta_c = 15/15
E-DPCCH: SF256 code 1, mapped to I-branch, beta_ec = 15/15
E-DPDCH1: SF4 code 1, mapped to I-branch, beta_ed = 67/15
E-DPDCH2: SF4 code 1, mapped to Q-branch, beta_ed = 67/15

6.8D.3 Power distribution

One way to study the properties of the signal is to look at its envelope power distribution. In Figure 6.8D.1 we show the PDF of the transmitted signal for the 12.2 kbps speech reference bearer, where the average power of the signals have been normalized to 1 (linear scale). This shows the variability of the statistics of the signal. However, the dynamics in the time dimension cannot be seen in this type of plot.

The plot includes the PDFs for normal 5 MHz UMTS (“UL UMTS”), normal 5 MHz UMTS but using downlink scrambling code (“DL UMTS”), 2.5 MHz F-UMTS (“F-UMTS”) and 2.5 MHz CZ-UMTS (“CZ-UMTS”).

As can be seen from the figure, normal UMTS has the best properties with the least amount of variability. CZ-UMTS seems to perform similar to normal UMTS with a downlink scrambling code, which is expected since the chip-zeroing destroys the PAPR reduction properties of the uplink scrambling code. F-UMTS has a different distribution that most likely comes from the increased ISI.

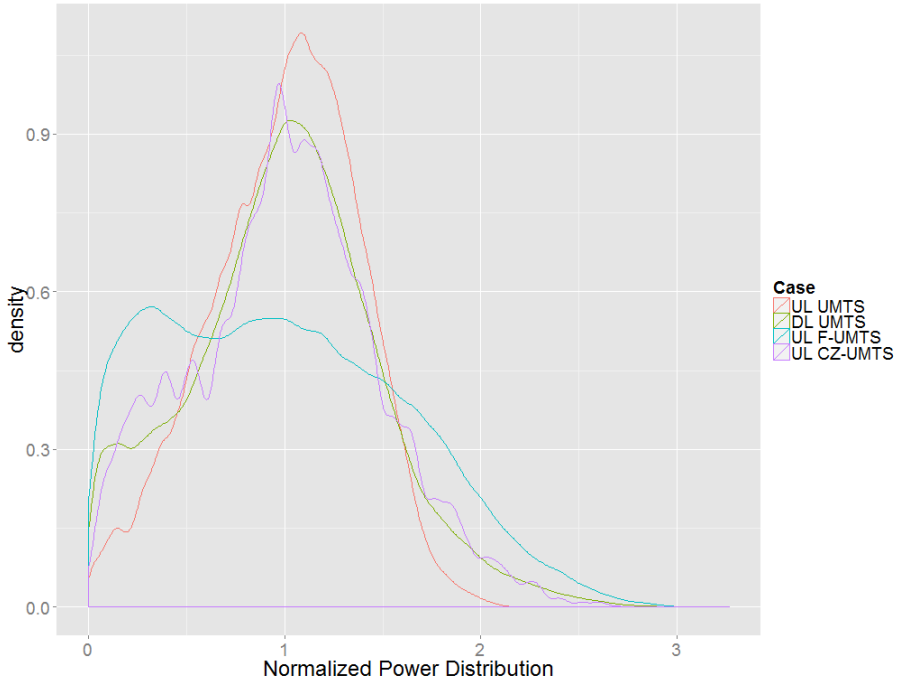


Figure 6.8D.1: PDF of the normalized envelope power for different signals. Power in linear scale, average normalized to 1.

6.8D.4 PAPR and CM

Signal characteristics have been studied for the three different reference bearers. For PAPR performance, plots of the complementary cumulative distribution function (CCDF) of the envelope power to average power ratio are presented. In addition, CM values according to the formula in TS 25.101 have been calculated and are tabulated.

6.8D.4.1 Comparing 5 MHz UMTS with 2.5 MHz F-UMTS/CZ-UMTS

First we compare normal 5 MHz UMTS ("UL UMTS"), normal 5 MHz UMTS but using downlink scrambling code ("DL UMTS"), 2.5 MHz F-UMTS ("F-UMTS") and 2.5 MHz CZ-UMTS ("CZ-UMTS"). In Figures 6.8D.2-6.8D.4 and Tables 6.8D.1-6.8D.3 below, the CCDFs and CM for the three reference bearers are presented.

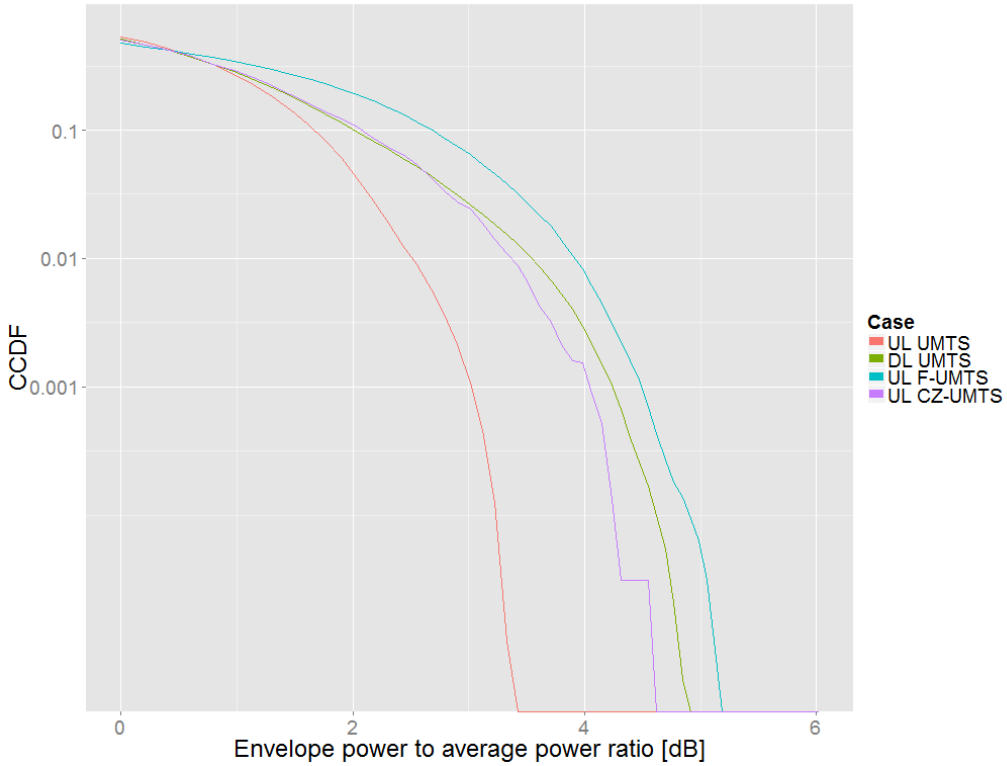


Figure 6.8D.2: CCDF for 12.2 kbps speech reference bearer

Table 6.8D.1: CM for 12.2 kbps reference bearer

	Cubic metric
UL UMTS	-0.01
DL UMTS	0.46
UL F-UMTS	1.05
UL CZ-UMTS	0.44

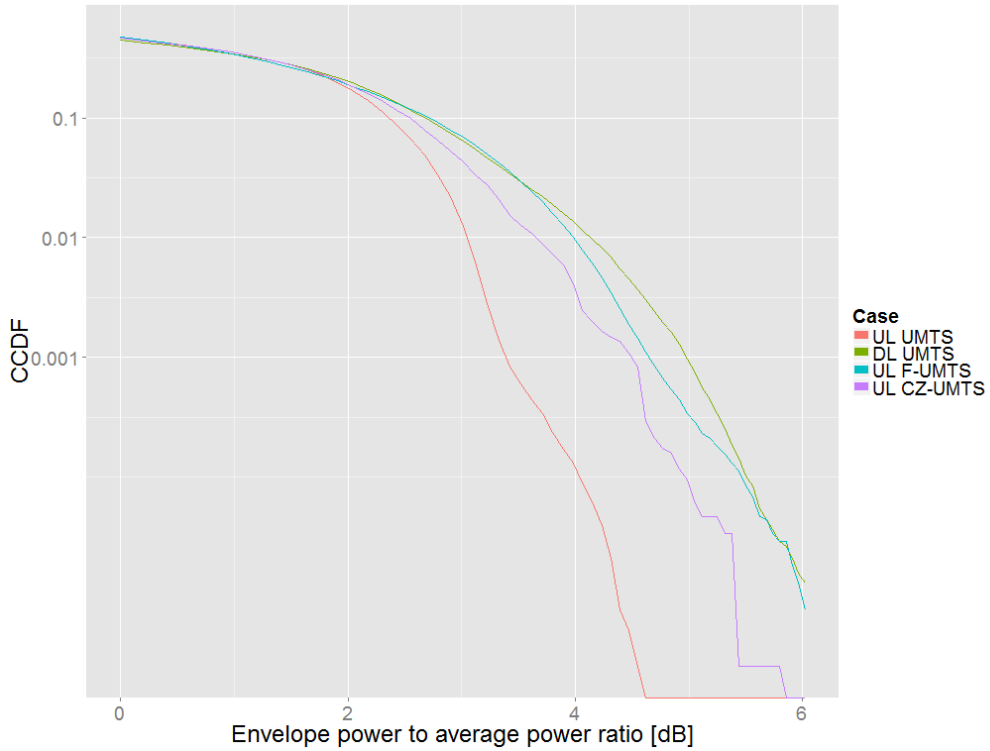


Figure 6.8D.3: CCDF for 32 kbps 10 ms TTI EUL reference bearer

Table 6.8D.2: CM for 32 kbps 10 ms TTI EUL reference bearer

	Cubic metric
UL UMTS	0.63
DL UMTS	1.13
UL F-UMTS	1.08
UL CZ-UMTS	0.88

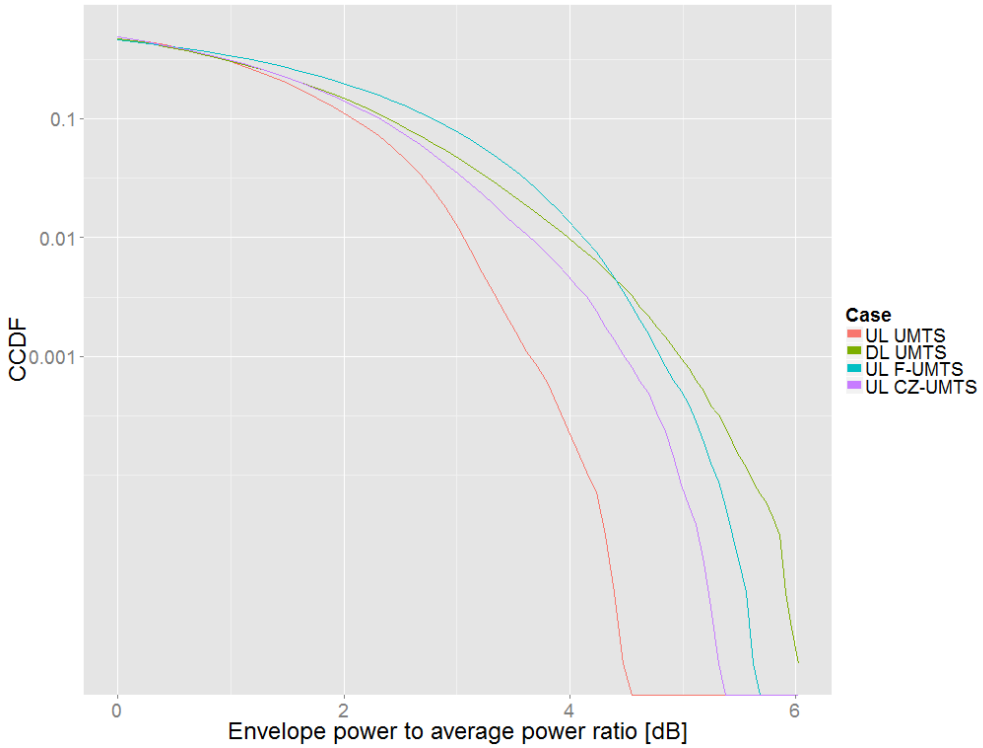


Figure 6.8D.4: CCDF for 1 Mbps 2 ms TTI EUL reference bearer

Table 6.8D.3: CM for 1 Mbps 2 ms TTI EUL reference bearer

	Cubic metric
UL UMTS	0.34
DL UMTS	0.81
UL F-UMTS	1.20
UL CZ-UMTS	0.66

6.8D.4.2 Comparing F-UMTS with CZ-UMTS in different bandwidths

As a second comparison, we look at the difference in signal characteristics between F-UMTS and CZ-UMTS as the carrier bandwidth is varied. In Figure 6.8D.5 and Tables 6.8D.4 below, the CCDFs and CM for the 1 Mbps 2 ms TTI EUL reference bearer for bandwidths varying between 2 and 5 MHz are presented.

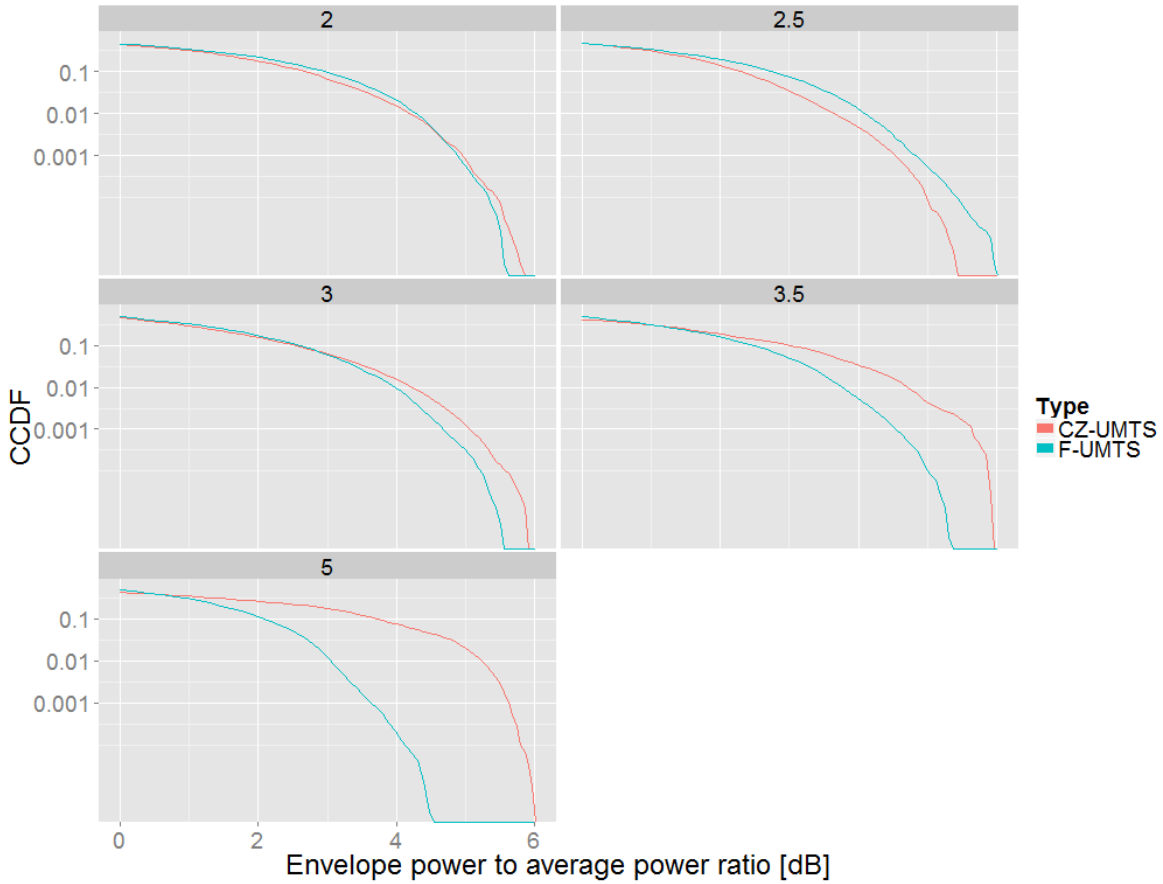


Figure 6.8D.5: CCDF for varying bandwidths

Table 4: CM for varying carrier bandwidths

	2.0 MHz	2.5 MHz	3.0 MHz	3.5 MHz	5.0 MHz
F-UMTS	1.37	1.17	0.99	0.82	0.34
CZ-UMTS	1.10	0.68	0.96	1.51	2.49

6.8D.5 Discussion

Although the simulations are simplified and e.g. have only been made for a very small subset of possible power offsets and do not include HS-DPCCH, it seems clear that both the narrowband filtering as well as the chip-zeroing result in worse PAPR/CM characteristics compared to normal UMTS. Further more detailed studies would be required to conclude on what impact the changed PAPR/CM characteristics would have on the system, in particular with respect to coverage. In general, the worse the CM is the larger MPR the UE would need to apply. However, the translation of a CM for a narrowband carrier into a MPR for this carrier would require further detailed studies in RAN4, since it is expected that there is a bandwidth dependency and hence the old values derived for 5 MHz carriers may no longer hold. In general, discussion related to CM vs MPR are rather long in RAN4 and require large amount of simulations. Also, the amount of work required depends on the features supported for scalable UMTS (uplink CLTD, uplink MIMO etc).

6.9 Less relevant simulation results

6.9.1 Time dilated UMTS configurations

The configurations evaluated in this document are summarized in Table 6.9.1-1.

Table 6.9.1-1: Configurations evaluated in the present document

Index	Configuration	Bandwidth	Frequency offset between carriers
U+S_4	UMTS + Time dilated UMTS (N=4)	6.00 MHz	2.88 MHz
U+S_2	UMTS + Time dilated UMTS (N=2)	6.00 MHz	2.25 MHz
U	UMTS	5.00 MHz	Standalone
S_2	Time dilated UMTS (N=2)	2.50 MHz	Standalone
S_4	Time dilated UMTS (N=4)	1.25 MHz	Standalone

6.9.2 System performance for full buffer traffic

6.9.2.1 Evaluations based on user geometry distribution

This subclause presents the system level throughput results using the user CDF from and link level throughput results from subclause 6.1.2.1. Inter-carrier interference between the constituent carriers is modelled for the multi-carrier configurations.

In Table 6.9.2.1-1, it is observed that both the multi-carrier options (in 6 MHz spectrum) achieve significantly higher throughput compared to UMTS for the multi-carrier users in this system. For 100% loading, the configuration U+S_2 achieves slightly higher throughputs compared to the configuration U+S_4, while when the loading in adjacent cells decreases to 20%, the configuration U+S_4 wins over U+S_2. On the other hand, there is negligible impact to legacy users with U+S_4 and fairly significant impact with U+S_2. Additionally, standalone systems record close to UMTS spectral efficiencies.

Additional PCCPCH codes help maintain the same latency as the UMTS for the PCCPCH channel. It can be seen that there is negligible throughput degradation for the standalone carriers after accounting for the PCCPCH power allocation.

Table 6.9.2.1-1: System level throughputs for time-dilated UMTS configurations

Channel	Configuration	Bandwidth	Sector HS Throughput (Mbps) (20% adjacent cell loading)		Sector HS Throughput (Mbps) (100% adjacent cell loading)	
			MultiCarrier User	Legacy User	Multi-Carrier User	Legacy User
PA 3	U+S_2	6.00 MHz	10.8	7.5	6.5	4.4
	U+S_4	6.00 MHz	11.1	9.0	6.3	5.1
	U	5.00 MHz	9.0		5.1	
	S_2	2.50 MHz	4.3		2.4	
	S_2 2 PCCPCH codes	2.50 MHz	4.2		2.3	
	S_4	1.25 MHz	2.0		1.1	
	S_4 4 PCCPCH codes	1.25 MHz	1.8		1.0	
VA 3	U+S_2	6.00 MHz	9.6	6.6	6.0	4.0
	U+S_4	6.00 MHz	9.7	7.7	5.6	4.5
	U	5.00 MHz	7.7		4.5	
	S_2	2.50 MHz	3.9		2.3	
	S_2 2 PCCPCH codes		3.7		2.1	
	S_4	1.25 MHz	1.9		1.1	
	S_4 4 PCCPCH codes		1.6		0.9	
VA 30	U+S_2	6.00 MHz	6.6	4.7	4.0	2.8
	U+S_4	6.00 MHz	7.2	5.7	4.1	3.3
	U	5.00 MHz	5.7		3.3	
	S_2	2.50 MHz	2.7		1.5	
	S_2 2 PCCPCH codes		2.6		1.4	
	S_4	1.25 MHz	1.4		0.8	
	S_4 4 PCCPCH codes		1.2		0.6	
VA 120	U+S_2	6.00 MHz	6.6	4.5	4.0	2.7
	U+S_4	6.00 MHz	6.7	5.4	3.9	3.1
	U	5.00 MHz	5.4		3.1	
	S_2	2.50 MHz	2.7		1.6	
	S_2 2 PCCPCH codes		2.6		1.5	
	S_4	1.25 MHz	1.3		0.8	
	S_4 4 PCCPCH codes		1.1		0.6	

For 50% penetration of time-dilated UMTS UEs, a weighted throughput from Table 6.9.2.1-1 is used.
These results are shown in Table 6.9.2.1-2. The configuration $U+S_4$ (highlighted in red) achieves significantly higher throughput than UMTS for all fading channels and loading fractions, for Time-Dilated UMTS capable user penetrations as small as 25%. On the other hand, the configuration $U+S_2$ can record a loss (8.3 Mbps from 9.0 Mbps in PA3 channel with lightly loaded adjacent cells) compared to baseline UMTS for 25% Time-Dilated UMTS user penetration.

Table 6.9.2.1-2: Effect of time-dilated UMTS capable UE penetration on system level throughputs of multi-carrier configurations

Channel	Configuration	Time-Dilated UMTS penetration%	Sector HS Throughput (Mbps)	
			20% adjacent cell loading	100% adjacent cell loading
PA 3	U	-	9.0	5.1
	$U+S_2$	100	10.8	6.5
	$U+S_4$	100	11.1	6.3
	$U+S_2$	50	9.2	5.5
	$U+S_4$	50	10.1	5.7
	$U+S_2$	25	8.3	5.0
	$U+S_4$	25	9.6	5.4
VA3	U	-	7.7	4.5
	$U+S_2$	100	9.6	6.0
	$U+S_4$	100	9.7	5.6
	$U+S_2$	50	8.1	5.0
	$U+S_4$	50	8.7	5.1
	$U+S_2$	25	7.3	4.5
	$U+S_4$	25	8.2	4.8
VA 30	U	-	5.7	3.3
	$U+S_2$	100	6.6	4.0
	$U+S_4$	100	7.2	4.1
	$U+S_2$	50	5.6	3.4
	$U+S_4$	50	6.4	3.7
	$U+S_2$	25	5.2	3.1
	$U+S_4$	25	6.1	3.5
VA 120	U	-	5.4	3.1
	$U+S_2$	100	6.6	4.0
	$U+S_4$	100	6.7	3.9
	$U+S_2$	50	5.5	3.4
	$U+S_4$	50	6.1	3.5
	$U+S_2$	25	5.0	3.0
	$U+S_4$	25	5.7	3.3

User Geometry distribution (for 14 k random user placements) in a 57-cell layout is given in Figure 6.9.2.1-1.
In the analysis in this subclause, an equal allocation of resources among the users and a simple averaging of link level throughputs based on the user geometry distribution were used.

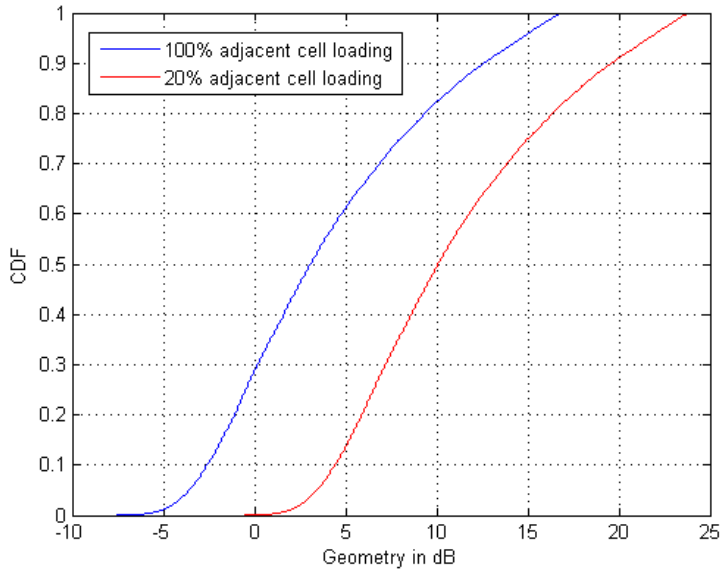


Figure 6.9.2.1-1: User geometry CDF

In another evaluation, a similar analysis was conducted where the cell throughput is computed based on the user geometry CDF (see Figure 6.9.2.1-1) and the input from link simulation results. Cell Throughput results are provided in Table 6.9.2.1-3. For multi-carrier option (in 6 MHz spectrum), about 20% throughput gain over UMTS can be observed.

The interference from small bandwidth carrier to legacy UMTS carrier in case of carrier aggregation U+S_4 is seen to be negligible. This is proved by comparing the standalone UMTS throughput with the legacy user throughput in multi-carrier.

For standalone time-dilated UMTS results, it is observed that the spectral efficiency is close to UMTS.
The observation is in accordance with the link level simulation results in subclause 6.1.2.1.

Table 6.9.2.1-3: System level throughputs for time-dilated UMTS configurations

Channel	Configuration	Bandwidth	Sector HS Throughput (Mbps) (20% adjacent cell loading)		Sector HS Throughput (Mbps) (100% adjacent cell loading)	
			MultiCarrier User	Legacy User	Multi-Carrier User	Legacy User
PA 3	U+S_4	6.00 MHz	11.96	9.71	6.71	5.47
	U	5.00 MHz	9.72		5.49	
	S_2	2.50 MHz	4.81		2.69	
VA 3	U+S_4	6.00 MHz	9.87	8.23	5.80	4.79
	U	5.00 MHz	8.24		4.80	
	S_2	2.50 MHz	4.26		2.48	
VA 30	U+S_4	6.00 MHz	8.21	6.87	4.42	3.66
	U	5.00 MHz	6.88		3.68	
	S_2	2.50 MHz	3.39		1.72	
VA 120	U+S_4	6.00 MHz	7.86	6.61	4.34	3.60
	U	5.00 MHz	6.63		3.62	
	S_2	2.50 MHz	3.21		1.78	

6.9.2.1.1 UE throughput

In this analysis, 8 UEs in a UMTS cell and 4 UEs in a time-dilated UMTS cell with round-robin scheduling is assumed. Figure 6.9.2.1.1-1 shows the average user throughput CDF for standalone UMTS and time-dilated UMTS in both 100% and 20% adjacent cell load scenarios under different propagation channels.
It is observed that the time-dilated UMTS user throughput performance is very close to UMTS performance in all scenarios, which shows that time-dilated UMTS performs very similar as UMTS in terms of UE throughput as well as data coverage.

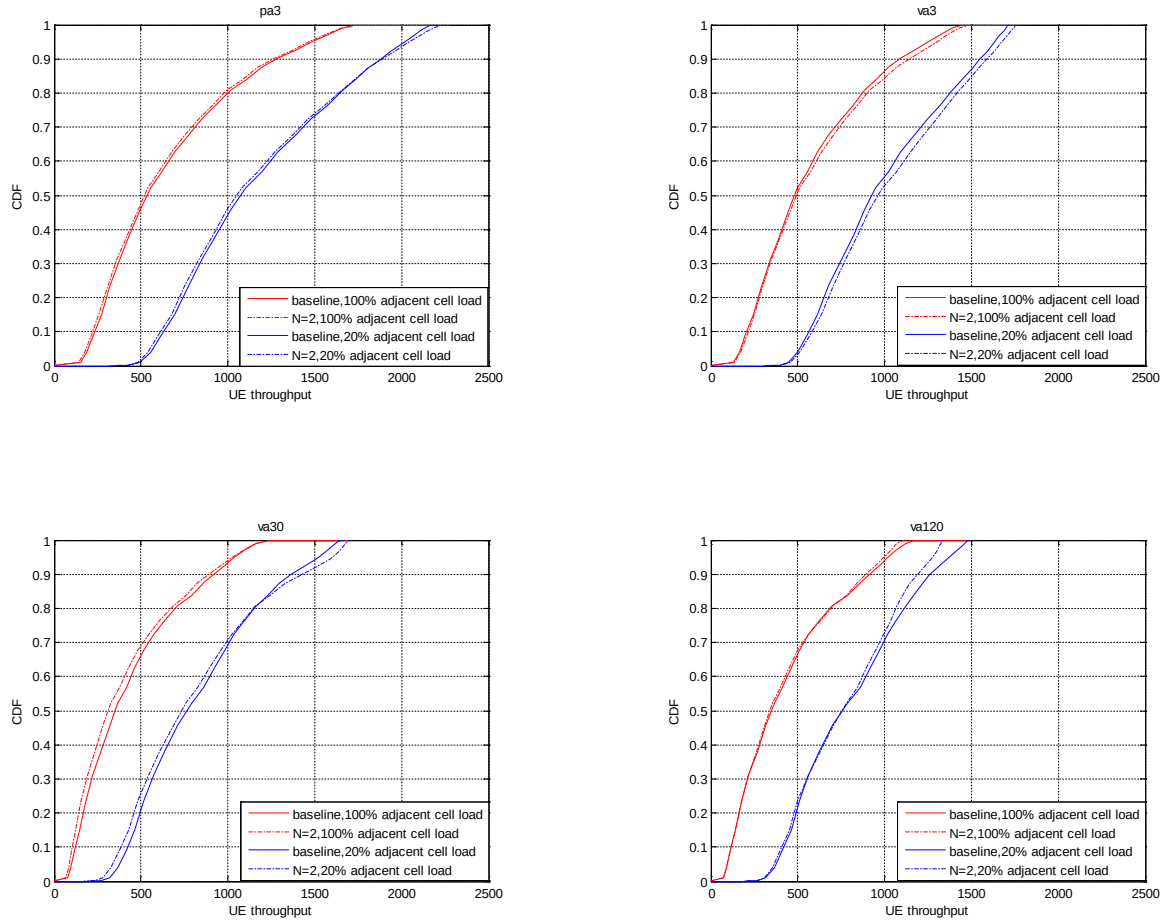


Figure 6.9.2.1.1-1: User throughput CDF

6.9.2.2 Evaluation with a practical scheduler

Table 6.9.2.2-1 shows the results from a fuller buffer system simulation for standalone time-dilated UMTS.
For standalone time-dilated UMTS results, we observe that the spectral efficiency is close to UMTS for most of the channels evaluated except for the VA30 channel where a loss of around 8.9% is observed.
These results are in accordance with the ones seen in Table 6.9.2.1-3.
UE performance is also shown under the assumption of 8 UEs in a UMTS cell and 4 UEs in a time-dilated UMTS cell where similar observations can be made.

Table 6.9.2.2-1: System level throughputs for time-dilated UMTS configurations, based on system simulation

Channel	Configuration	Bandwidth	Sector Throughput (Mbps) (100% adjacent cell loading)	UE average throughput	UE 50% CDF throughput	UE 5% throughput
PA3	U	5.00 MHz	7.38	0.92	0.73	0.25
	S_2	2.50 MHz	3.52	0.88	0.68	0.21
VA 3	U	5.00 MHz	6.32	0.79	0.60	0.19
	S_2	2.50 MHz	3.24	0.81	0.63	0.17
VA 30	U	5.00 MHz	4.79	0.60	0.46	0.09
	S_2	2.50 MHz	2.18	0.54	0.36	0.06
VA 120	U	5.00 MHz	4.57	0.57	0.44	0.08
	S_2	2.50 MHz	2.30	0.58	0.43	0.08

6.9.3 HSDPA bursty traffic simulations results

Table 6.9.3-1 shows the DL bursty traffic system level simulation results for HSPA, comparing with UMTS and Scalable UMTS implementation with scaling factor N =2, for PA3, VA3, VA30 and VA120 channels.
The number of UEs is chosen as high as up to system stability level.

Table 6.9.3-1: Standalone Scalable UMTS downlink bursty traffic simulation results for HSDPA

		PA3		VA3		VA30		VA120	
Scaling Factor		1	2	1	2	1	2	1	2
Burst Rate(kbps)		837.75	776.98	637.43	678.42	372.92	329.34	339.86	364.26
Throughput (kbps)	**Cell average**	6488.41	3017.18	5731.3	2820.91	4038.34	1763.42	3678.77	1853.76
	UE Average	324.42	301.72	286.56	282.09	201.92	176.34	183.94	185.38
	UE 50% CDF	310.84	299.31	270.41	273.56	188.17	164.77	168.12	179.73
	UE 5% CDF	163.49	165.67	126.7	144.16	51.85	32.56	40.81	32.77

The results of burst rate gains for Standalone Scalable UMTS downlink are summarized in Table 6.9.3-2.

Table 6.9.3-2: Standalone Scalable UMTS downlink simulation results for HSDPA

Gain (%)	PA3	VA3	VA30	VA120
Burst Rate	-7.25	6.43	-11.69	7.18

6.9.4 HSUPA bursty traffic simulations results

Table 6.9.4-1 shows the UL bursty traffic system level simulation results for HSPA, comparing with UMTS and Scalable UMTS implementation with scaling factor N =2, for PA3, VA3, VA30 and VA120 channels.
The number of UEs is chosen as high as up to system stability level.

Table 6.9.4-1: Standalone Scalable UMTS Uplink bursty traffic simulation results for HSUPA

	PA3		VA3		VA30		VA120	
Scaling Factor	1	2	1	2	1	2	1	2
Burst Rate (kbps)	286.79	415.83	276.97	375.63	258.42	353.74	238.67	353.40
Cell Throughput (kbps)	1237.42	644.41	1238.05	641.68	1225.14	638.59	1191.84	639.59
UE Average Throughput (kbps)	82.74	86.62	81.90	84.90	80	83.56	77.33	83.53
UE 50% CDF Throughput (kbps)	80.94	85.33	81.64	83.87	79	82.90	76.20	82.31
UE 5% CDF Throughput (kbps)	40.66	57.24	39.66	55.73	39.33	55.61	38.63	56.01
Average RoT	7.06	6.12	7.85	7.62	7.26	7.47	7.3	8.14

The results of burst rate gains for Standalone Scalable UMTS are summarized In Table 6.9.4-2.

Table 6.9.4-2: Standalone Scalable UMTS uplink bursty traffic simulation results for HSUPA

Gain (%)	**PA3**	**VA3**	**VA30**	**VA120**
Burst Rate	44.99	35.62	36.89	48.07

6.10 Less relevant simulation results

6.10.1 Results for UMTS + 2.5 MHz time-dilated UMTS in 6 MHz block assuming equal PSD

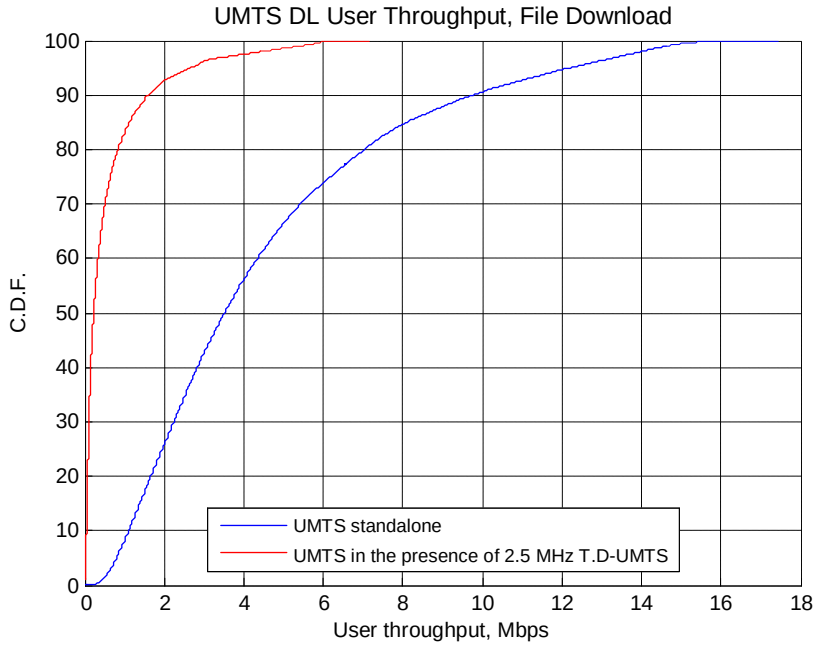


Figure 6.10.1-1: UMTS DL user throughput, file download

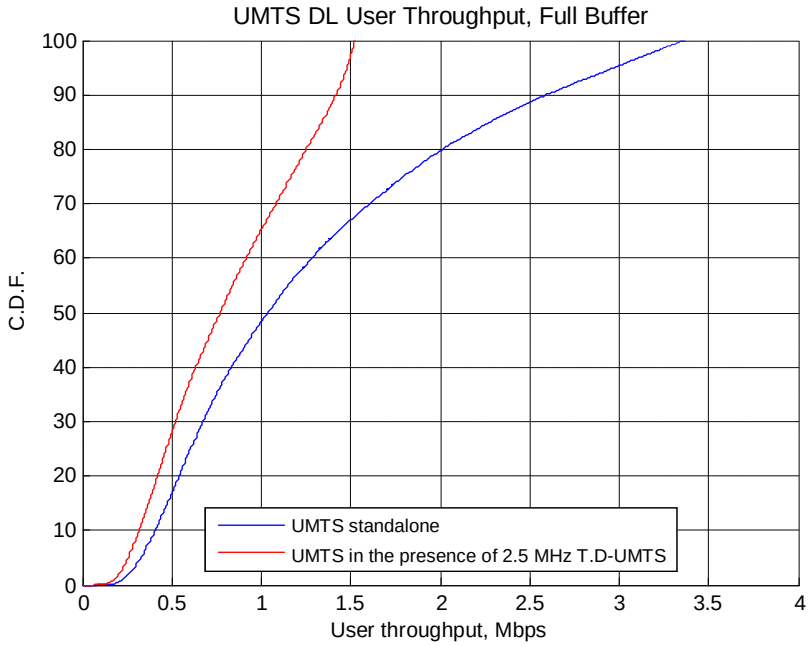


Figure 6.10.1-2: UMTS DL user throughput, full buffer

The system simulation results for the multiple-carrier scenario of UMTS + 2.5 MHz time-dilated UMTS in 6 MHz indicate significant losses in throughput for the UMTS carrier. This is due to inter-carrier leakage even though the ICL was calculated considering UE and BS with performance far better than the specified values.

6.10.2 Results for 3xUMTS + 2.5 MHz time-dilated UMTS in 15 MHz block assuming equal PSD

For this scenario, the centre frequency of the UMTS carriers and time-dilated UMTS carrier was chosen to optimize the performance considering that at least for one UMTS carrier, the ICL should be kept at a low level to obtain best performance. Other carrier allocations are not precluded and we encourage other companies to investigate these.

The frequency offset from centre of each carrier and the lower edge of any arbitrary 15 MHz spectrum block in this case was chosen to be [2.5 MHz, 5.25 MHz, 8 MHz and 12.5 MHz]. The corresponding ICL values turned out to be ~ 10, 10, and 44 dB, respectively. Note that the time-dilated UMTS carrier was allocated between the UMTS1 and UMTS2 carriers.

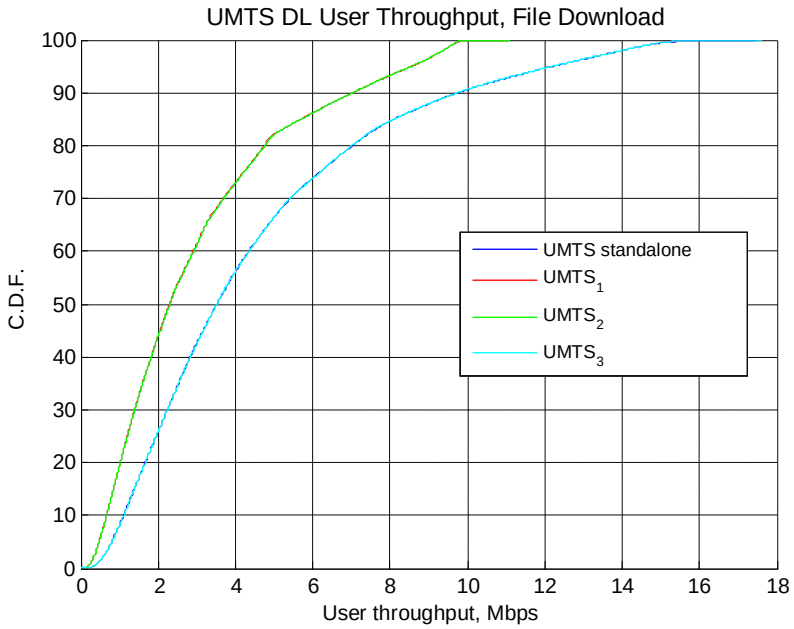


Figure 6.10.2-1: UMTS DL user throughput, file download

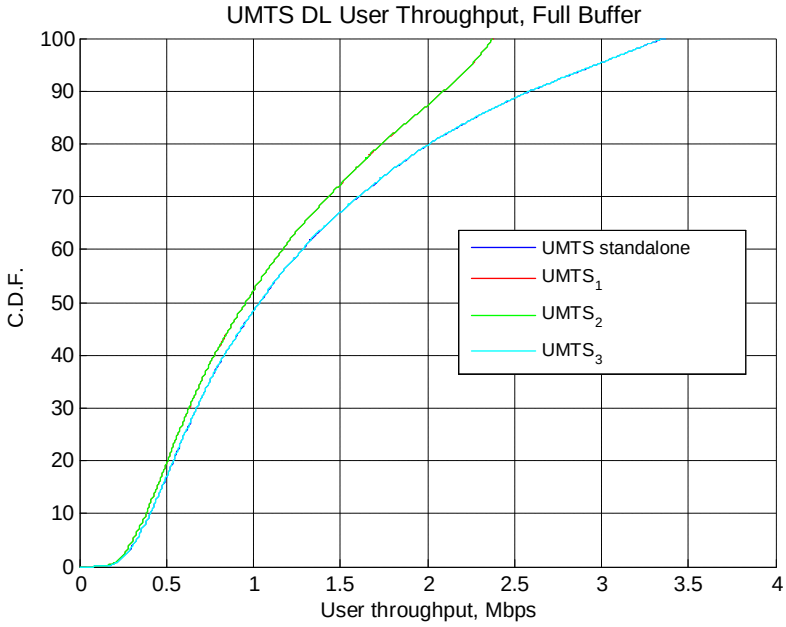


Figure 6.10.1-2: UMTS DL user throughput, full buffer

The system simulation results for multiple-carrier scenario of 3xUMTS + 2.5 MHz time-dilated UMTS in 15 MHz indicate losses on UMTS carriers 1 and 2.

6.10.3 Results for 3xUMTS + 1.25 MHz time-dilated UMTS in 15 MHz block assuming equal PSD

This scenario employs the same carrier allocation strategy as the previous scenario in subclause 3.1.3, i.e. the frequency offset from centre of each carrier and the lower edge of any arbitrary 15 MHz spectrum block in this case was chosen to be [2.5 MHz, 5.25 MHz, 8 MHz and 12.5 MHz]. The corresponding ICL values turned out to be ~ 30, 30, and 44 dB respectively. The time-dilated UMTS carrier was allocated between the UMTS1 and UMTS2 carriers.

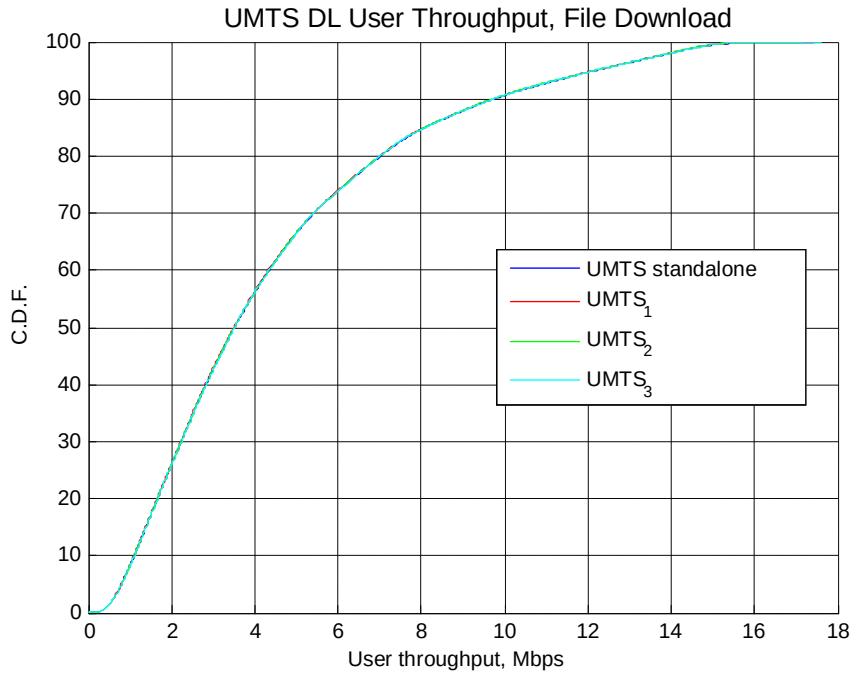


Figure 6.10.3-1: UMTS DL user throughput, file download

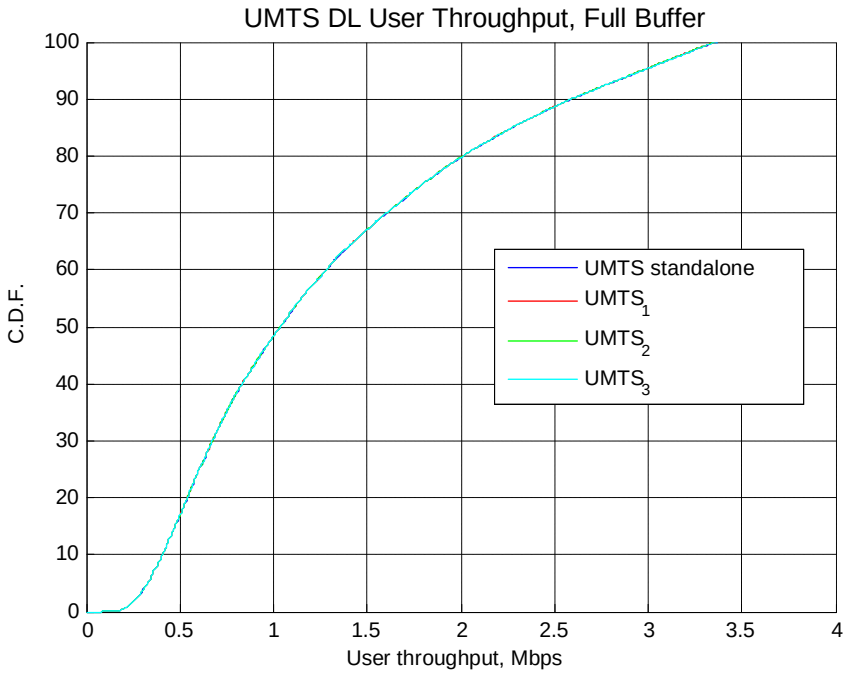


Figure 6.10.3-2: UMTS DL user throughput, full buffer

The system simulation results for multiple-carrier scenario of 3xUMTS + 1.25 MHz time-dilated UMTS in 15 MHz show that the impact on the UMTS carriers is negligible when using extremely good radio models.

7 Conclusions

This study proposes solutions for transmitting in smaller bandwidths as one possible technology for replacement for GSM/GPRS/EDGE in these bandwidths.

NOTE: Other technologies, e.g. LTE, are not covered by this study.

The study on Scalable UMTS FDD bandwidth focused on the following deployment scenarios:

- Standalone
  - Bandwidths with scale factors N=2 (2.5 MHz) and 4 (1.25 MHz) were considered with the N=4 case being considered only for HS data traffic.
- Multi-carrier
  - Carrier Aggregation with an UMTS carrier was also considered where the secondary carrier was either N=2 or N=4; i.e. a total of 7.5 MHz or 6 MHz of bandwidth

The scenarios above have been studied in Bands VIII and I.
A more detailed description of the deployment scenarios is provided in clause 6.2 of the present document.

The following solutions for Scalable UMTS were proposed during the study:

Time Dilation

- In this solution, the UMTS chip rate is scaled by a factor of N which results in a smaller bandwidth. The TTI length increases by a factor of N as a result while other aspects such as number of HARQ processes, retransmissions, coding, etc. are unchanged.
  More details on time-dilated UMTS can be found in subclause 6.1.
  In the present document, this solution is referred to as time-dilated UMTS.
  Time dilated UMTS aims to improve performance by increasing latency.

Scalable UMTS by Filtering (FUMTS)

- This solution achieves a lower bandwidth by modifying the RRC filter to match the target bandwidth. All other aspects of the UMTS transmit and receive chains were unchanged.
  Additional details can be found in subclause 6.2.
  Scalable UMTS by filtering experiences larger Inter Symbol Interference than normal UMTS.

Scalable UMTS by filtering and chip zeroing/spreading factor dilation (CZ-UMTS)

- This solution mitigates the inter symbol interference experienced with filtered UMTS, by zeroing all chips except every Nth chip of the 3.84 Mcps UMTS signal.
  Thus, the solution reduces the size of the OVSF code tree by a factor N.

In the standalone case, if an operator has a 5 MHz UMTS carrier available that is not fully loaded, it is better to map users to the 5 MHz carrier, since the users will experience better throughput on 5 MHz than 2.5 MHz.
In the multicarrier case, multicarrier users can benefit from increased throughput; the extent of the benefit depends on the bandwidth and the penetration level of multicarrier users. Strategies (e.g. incentives) need to be developed and executed by an operator that will ensure a good penetration of time-dilated UMTS capable UEs.

7.1 Conclusions for Time-Dilated UMTS

Downlink link level simulations have indicated that, for standalone (depending on channel conditions):

- At a cell edge geometry (-5 dB), time-dilated UMTS throughput is around 33-48% of normal UMTS throughput;
- At a median geometry (5 dB), time-dilated UMTS throughput is around 37-48% of normal UMTS throughput;
- At a high geometry, near the cell centre, time-dilated UMTS throughput is around 44-50% of normal UMTS throughput.

However, when using a normalized throughput which corresponds to spectral efficiency, the performance of time-dilated UMTS was between 75% to 100% of the spectral efficiency of UMTS .

Uplink link level simulations were performed, for one Rx EbNo value for each of the HARQ operating points of 1% BLER after 4 transmissions and 10% BLER after 1 transmission.

When DCH traffic was considered on the downlink, N=2 standalone time-dilated UMTS provides equivalent spectral efficiency as normal UMTS system (i.e. time-dilated UMTS requires approximately 3 dB higher Ec/Ior for the same data rate). The solution for DCH traffic is described in Clause 6.1.1.3.
It is ensured that the latency requirements for DCH transmission in time-dilated UMTS match that of normal UMTS.

Downlink system level modelling indicates that in bursty traffic in low load scenarios, the downlink burst rate of time-dilated UMTS N=2 is in the range 4-10% less than half that of UMTS. For the case when N=4, the burst rate is in the range 4-7% less than a quarter of that for UMTS at low loads. The simulation results in Pedestrian A indicated that an additional 2.5 MHz may provide up to 25% extra capacity in Band VIII or 15% in Band I, assuming a minimum user burst rate of 1 Mbps. Full buffer simulation results comparing time-dilated UMTS and UMTS spectral efficiencies are in subclause 6.9.2.
The receivers assumed for the simulations performed were optimized for the UMTS carrier.
Further receiver optimizations for time-dilated and filtered UMTS are possible.

Uplink system level evaluations were not performed, and therefore no conclusions can be drawn on this aspect.

In Carrier Aggregation scenarios, where there are no legacy users (i.e. all users are capable of carrier aggregation, including between carriers of unequal bandwidths) the performance can improve by around 50% as expected for bursty traffic assuming that the available bandwidth is 7.5 MHz. The performance gains with no legacy users when a UMTS carrier is aggregated with a time-dilated UMTS N=4 carrier are around 25% for bursty traffic models if the available bandwidth is 6 MHz or more. The simulations assumed that all the UEs were capable of carrier aggregation.
Due to the HARQ RTT differences between the two carriers, a latency difference by a factor of N (resulting in a difference of up to tens of msec when considering HARQ retransmissions) in MAC PDU delivery with carrier aggregation should be taken into account.

Unlike other DC schemes, with less than 100% penetration, legacy users can only be mapped to one of the carriers; system simulations with intermediate penetration levels were not conducted.

Maximum HARQ RTT, considering a usual operating point of 3 maximum retransmissions in the worst case is increased to 72-96 ms for N=2 and 144-192 ms for N=4. For practical web browsing tests conducted in a lab, the download times for time-dilated UMTS were comparable to UMTS at high geometries but increased as the geometry decreased until it was approximately twice at low geometry conditions. This can be considered to be representative of user experience. For example, the Amazon Web page download time for time-dilated UMTS N=2 is approximately double that for normal UMTS (i.e. 4 s for UMTS to 8 s for time-dilated UMTS) at very low geometries whereas at medium to high geometry conditions, the Amazon Web page download times for both systems are the same. For very large web pages, the latency increases were estimated to be several tens of seconds for low/medium geometries (i.e. a higher number of MAC PDUs per IP packet). Additional details are provided in subclause 6.1.7.1.
The user plane latency on the uplink can be mitigated by utilizing the excess power available on the uplink as long as the system not interference limited; i.e. power may be applied within the UL RoT budget. However, such mitigating techniques may have a corresponding impact on capacity.

The UE complexity for the time-dilation solution was shown to be lower than normal UMTS for a low capability UE supporting only time-dilated UMTS and not normal UMTS. However, it may be justifiable to assume that time-dilated UMTS UE would need to also support normal UMTS, in which case there would be no complexity reduction. Since the chip rate is a very fundamental parameter in any CDMA system, it is not unlikely that the hardware impact can be very large for certain implementations. It is also possible that other implementations offer the possibility to change the chip rate quite flexibly.

In CELL_FACH, the amount of UE on time required per UL or DL event increases with time-dilated UMTS by a factor of around 2, and the efficiency of DTX/DRX for reducing modem power consumption is reduced. Further, due to the lower burst rate of a time-dilated carrier, the total time the UE spends in CELL_DCH to transfer a certain amount of bits will be higher with time-dilated UMTS than normal UMTS depending on the relative loading of UMTS and time-dilated UMTS which may also have a negative impact on modem power consumption. However, the overall UE battery life impact is determined by the ratio of the time spent in CELL_DCH state to the time spent in non CELL_DCH states including Idle mode.

The signalling latency was analyzed in subclause 6.5 and it was shown that the call setup delay would not increase significantly if mitigating factors were taken into account (e.g., scaling SF by 1/N in order to maintain the same bitrate

as normal UMTS). However, if no changes are made, the delay increases for time-dilated UMTS N=2 and N=4 by a factor of 2 and 4, respectively over the air-interface and the feasibility of this approach depends on implementation. The backhaul and network delays remain the same for both time-dilated UMTS and normal UMTS.

Analysis of control plane latency assumed that the P-CCPCH is scaled such that access latency is not impacted, at the cost of increased control overhead.

Coverage was compared between time-dilated UMTS and UMTS by evaluating the Maximum Allowed Path Loss (MAPL) for a particular effective data rate in both networks.

The analysis for voice indicated that time-dilated UMTS will have around 1dB lower coverage than normal UMTS if the same carrier power is assumed. For E-DCH, time-dilated UMTS provides similar coverage to normal UMTS if same PSD is assumed, and a 3 dB higher coverage when same carrier power is assumed.

When CPC is considered, the link efficiency for time-dilated UMTS was shown to be comparable to UMTS (i.e. throughput is scaled down by 1/N). Additional details on the simulation assumptions and the results are provided in subclause 6.1.4.5.1. The impact to UE battery life was evaluated by analyzing the on-time percentage of the UE when CPC is enabled.

When in CPC DTX/DRX, it was found that for single TTI packet sizes and when the UE is transmitting/receiving continuously (e.g. streaming), there was no increase in on-time percentage at the UE. However, in web browsing scenarios when the UE transmits bursts of several TTIs, an increase in the on-time percentage of around 9% on the DL and 6% on the UL per event (corresponding to a scale factor of 1.5 for N=2) was observed.

An analysis on impact and workload in RAN1, 3, 4 and RAN5 is provided in subclause 6.1.5.
In particular, many aspects of RAN1 and most core and performance requirements, and potentially RRM impacts, need to be revisited in RAN4, and RAN5 will need to address corresponding test cases as well as revisit the SRBs.
Depending upon the signalling mechanism used to differentiate time-dilated UMTS from normal UMTS, the RAN2 specification impact could be medium/high. However, an efficient signalling mechanism to communicate time-dilated UMTS functionality as a new band would minimize RAN2 specification impact. A coexistence study was also performed for the UE and Node B Tx/Rx characteristics against the existing requirements in the specifications and the findings are summarized in subclause 6.1.6. Due to coexistence aspects, the specification impact may not be limited to UMTS FDD, and support for inter-RAT mobility may need specification support in that RAT.

When deploying time-dilated UMTS, tuning of some network and UE parameters will be required to ensure that target KPIs can be met. Accordingly, the impacts on MAC, RLC and RRC performance, including impact on timers and procedures are captured in subclause 6.6. New RRM procedures may be required in the network for managing user experience with carriers having different capabilities.

For Scalable UMTS by filtering, link level simulations of scalable UMTS by filtering showed link level spectral efficiency losses of 20% to 66% at high C/I levels and zero-to-little losses at low C/I levels in downlink compared to UMTS. Similarly, in uplink, a small loss was seen at low data rates and the loss increases as a function of data rate.
A potential solution shown to largely mitigate these losses by setting every second chip to zero in the transmitter was briefly discussed. The performance for 1.25 MHz Scalable Bandwidth UMTS with filtering and without any loss-mitigating techniques was significantly worse than UMTS in terms of spectral efficiency.
System level simulations of scalable UMTS by filtering were not conducted.
The study did not have time to analyze many of the aspects of the proposed filtered UMTS scheme to the same level of detail done for the time-dilated UMTS scheme. Thus Scalable UMTS by filtering may have the potential to overcome some of the issues (e.g. latency) for time-dilated UMTS, but may have drawbacks (e.g. spectral efficiency) of its own.

7.2 Conclusions for Scalable UMTS by filtering

Downlink link level simulation results, which are indicative of the performance of CZ-FUMTS, imply that the spectral efficiency is likely to be within 10-15% below that of UMTS for N=2 depending on the overhead scaling factors. The loss is due to the reduced code utilization for CZ-UMTS and also due to increased overhead channel powers. These simulations show trends but not exact throughput levels since the assumptions for the overhead channels have not been finalized. Therefore, these results should not be compared with time-dilated UMTS.

For FUMTS, the indicative downlink simulations imply that the performance loss is likely to be around 50-70% at medium to high geometries for N=2. At low geometries the spectral efficiency of FUMTS is likely to be comparable to UMTS.

For N=4, conclusions could not be drawn at this stage due to uncertainty in the overhead assumptions.

When DCH traffic was considered, CZ-UMTS and FUMTS have comparable spectral efficiency as UMTS. When compared with each other, the two schemes FUMTS and CZ-UMTS have similar performance on the uplink since voice traffic is operated in the low SNR region. However, the downlink performance of FUMTS is slightly worse than CZ-UMTS.

It is not yet possible to identify which filtering scheme for the uplink would be preferable from the results obtained, since the results and any conclusions that might be drawn from them have sensitivities to different assumptions, and these sensitivities need to be evaluated for different assumptions that are identified to be relevant.

It is considered that the operation of PRACH with and without chip zeroing is possible. Performance of PRACH with and without chip zeroing is comparable to that of UMTS in AWGN conditions; preamble detection in the presence of other preambles, and impact on Enhanced Cell_FACH in case of chip-zeroing, have not been studied. It is noted that the number of PRACH signatures for PRACH without chip zeroing would be the same as normal UMTS while scaled down to 1/N for PRACH with chip zeroing. The impact of filtering and chip zeroing on PAPR and CM in the uplink has not been concluded.

Downlink system level modelling indicates that in bursty traffic in low load scenarios, the downlink burst rate of CZ-UMTS is in the range of 4-10% less than half that of UMTS.

In carrier aggregation scenarios, the gains for CZ-UMTS are around 10-20% when a UMTS carrier is aggregated with an N=4 Scalable UMTS carrier if the available bandwidth is 6 MHz or more. The gains for CZ-UMTS are around 40-45% when a UMTS carrier is aggregated with N=2 Scalable UMTS carrier in 7.5MHz.

When cross-carrier scheduling is considered, the gains for CZ-UMTS are up to 25% for carrier aggregation in 6MHz with N=4 and up to 50% for carrier aggregation in 7.5MHz with N=2. It should be noted that the simulations assumed that all the UEs were capable of carrier aggregation and the gains are all relative to a 5Mhz UMTS carrier. The gains with carrier aggregation with lower user penetration levels have not been studied.

The benefits of cross carrier scheduling includes: increasing the available power in the secondary cell and helps to balance the control channel overhead, potential for reducing the total number of HS-SCCH monitored by UE, and giving a UE battery life saving compared to the degraded UE battery life of multi-carrier operation.

Assuming that standalone operation is not supported and there is therefore only one uplink available, the impact on uplink performance of signalling to support multi-carrier operation, and lack of ability to balance between uplink carriers, has not been studied.

The operation of SCH with chip zeroing was shown to be feasible for N=2, with boosting to compensate the loss in autocorrelation peak (around 3dB). For N=4, around 6-10dB of boosting is required for the SCH channel. Possible methods for detecting system bandwidth have also been identified.

An analysis on impact and workload in RAN1 is provided in subclause 6.8A.6 and it was shown that there was minimal impact to the RAN1 specifications for filtering based solutions. Differences in RAN2/RAN4 impact compared to time-dilated Scalable UMTS have not been studied, and thus conclusions cannot be drawn on the RAN2/RAN4 specification impacts. An analysis of the implementation impact is provided in section 6.8.3 and 6.8A.4 and showed acceptable complexity at least for some implementations. Complexity of FUMTS and CZ-UMTS can be different for different implementations.

In summary, it is considered that there is the potential for gains in carrier aggregation scenarios (over a 5Mhz UMTS carrier) when a UMTS carrier is aggregated with a Scalable UMTS carrier (N=2 or 4) and a CZ-UMTS filtering solution is used; the ability to realize these gains will depend on the spectrum scenario and the scalable UMTS penetration level. For standalone Scalable UMTS carrier deployment, adequate downlink throughputs can be achieved, at least for N=2 with CZ-UMTS. The choice of the exact solution (FUMTS or CZ-UMTS) for the uplink can be based on further study.

If FUMTS or CZ-FUMTS is specified, some flexibility in bandwidth may be possible, e.g. the exact carrier bandwidth need not be exactly 2.5 MHz.

Initial observations have been made, that the following aspects have not been considered in any detail by RAN1:

- The degree to which scalable UMTS and UMTS features should be tied
- How capability signaling should be managed, considering signaling and test overhead
- Impacts on the overall benefit of scalable UMTS and carrier management of not supporting all UMTS features

Specification complexity and management

Annex A:
Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2013-01	R1#72	R1-130821			Initial Draft		0.1.0
2013-08	R1#74	R1-133869			Added text in subclauses 5, 7.1.1, 7.1.2, 7.1.6.4, and 7.1.6.5 based on approved TPs	0.1.0	0.2.0
2013-08	R1#74	R1-133951			Incorporated agreed text proposals at RAN1#74, RAN2#83 and RAN4#68 and from email approval	0.2.0	0.2.1
2013-08	R1#74	R1-133955			Endorsed by RAN1	0.2.1	0.3.0
2013-09	RP#61	RP-131261			Rapporteur's draft, not agreed by RAN1 - only noted for information - Note RP-131261 shows v0.3.0 on cover and no update to history table	0.3.0	1.0.0
2013-11	R1#74b	R1-134837			Incorporated agreed text proposals at RAN1#74bis	1.0.0	1.0.1
2013-11	R1#75	R1-135969			MCC clean-up and incorporated text proposals approved by email discussion after RAN1#74bis	1.0.1	1.0.2
2013-11	R1#75	R1-135916			Editorial changes	1.0.2	1.0.3
2013-11	R1#75	R1-136041			Agreed version in RAN1	1.0.3	1.1.0
2013-11	R1#75	R1-136044			Incorporated text proposals approved at RAN1#75 and by email discussion	1.1.0	1.2.0
2013-11	R1#75	R1-136046			Endorsed version in RAN1	1.2.0	2.0.0
2013-12	RP_62	RP-131759			Approved and placed under change control	2.0.0	2.0.1
2013-12	-	-			MCC clean-up	2.0.1	12.0.0
2014-03	RP_63	RP-140292	007		Inclusion of Scalable Bandwidth UMTS by filtering and by chip-zeroing	12.0.0	12.1.0
2014-06	RP_64	RP-140863	008		Update of the TR based on agreements done on RAN1#77 meeting	12.1.0	12.2.0