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Technical Report

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Contents

Foreword

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- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
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1 Scope

The purpose of this TR is to summarize the study of radio requirements for the Base Station (BS) radio transmission and reception as part of the Rel-10 work item on Uplink Multiple Antenna Transmission for LTE (LTE UL MIMO).

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] 3GPP TS 36.104 (9.2.0): "Base Station (BS) radio transmission and reception".

[3] RP-091430: “Work Item Description: multiple antenna transmission or LTE”

3 Definitions, symbols 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 Symbols

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

3.3 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].

UL MIMO Uplink Multiple Antenna Transmission

4 General

No changes for this chapter due to UL MIMO.

5 Operating bands and channel arrangement

No changes for this chapter due to UL MIMO.

6 Transmitter characteristics

No changes for this chapter due to UL MIMO.

7 Receiver characteristics

No changes for this chapter due to UL MIMO.

8 Performance requirement

8.1 General

For Rel-10 BS performance aspects, new performance requirements will be defined for new transmission modes introduced due to UL-MIMO introduction.

As Rel-8 BS performance requirements are based on single uplink transmit antenna port, no additional BS requirements are needed for single antenna port transmission in Rel-10 with the introduction of UL MIMO.

All UL MIMO specific performance requirements will be defined within one component carrier, as UL MIMO will be deployed per CC.

For all BS performance requirements, UE Antenna Gain Imbalance (AGI) will not be taken into account, i.e. UE AGI = 0.

8.2 Performance requirements for PUSCH

8.2.1 Requirements in multipath fading propagation conditions

UL MIMO performance requirements shall cover two and four transmitter antennas ports, where performance requirements for 2Tx antenna configuration at UE will be prioritized in RAN4. Introduction of performance requirements for 4Tx antenna configuration shall follow progress on the core requirements for UL MIMO in RAN4.

For BS performance requirements (Chapter 8 in 36.104), the transmission rank (i.e. number of transmission layers) should be fixed for the PUSCH test cases.

RAN4 concluded that the performance of 2Tx rank 1 with random precoding in comparison with single transmission port mode does not provide justification for 2Tx rank1 performance tests. Based on the conclusion it was decided that no BS performance requirements for 2Tx rank 1 transmission is needed.

Non-contiguous PUSCH RA performance will be covered under CA WI and progress on this topic will be covered in CA BS TR 36.808.

8.2.2 Requirements for UL timing adjustment

No new performance requirements are needed for UL timing adjustment due to introduction of UL MIMO. This requirement will be performed for single antenna port transmission.

8.2.3 Requirements for high speed train

[No additional requirements are needed due to UL MIMO.]

This optional requirement will be performed for single antenna port transmission.

8.2.4 Requirements for HARQ-ACK multiplexed on PUSCH

For the HARQ-ACK multiplexed on PUSCH with MIMO transmission, each layer can be seen as a replication of the Rel-8/9 encoded signal. The requirement of single antenna transmission is sufficient to cover test purpose of this functionality of eNB.

It is thus concluded in RAN4 that no changes are needed for this clause due to the introduction of UL MIMO.

8.3 Performance requirements for PUCCH

For uplink control channels with PUCCH format 1/1a/1b and format 2/2a/2b and format 3, the spatial orthogonal-resource transmit diversity (SORTD) scheme is supported for transmissions with two antenna ports.,

The performance requirements will focus on two antenna port cases. For the UE with four transmit antennas, the 2Tx transmit diversity scheme is applied.

The performance requirements for PUCCH format 1a and format 2 with 2Tx SORTD are agreed to be defined in Rel-10. The same performance measures as for Rel-8 PUCCH performance requirements are reused.

The performance requirements for PUCCH format 3 with 2Tx SORTD are [TBD].

8.3.1 DTX to ACK performance

The DTX to ACK performance is defined for single antenna port transmission in Rel-8. This requirement is extended to cover Rel-10 multiple antenna port transmission schemes.

8.3.2 ACK missed detection requirements for single user PUCCH format 1a

Performance requirements for 2Tx SORTD scheme are agreed to be defined. Detailed simulation assumptions can be found in the Annex[X].

8.3.3 CQI missed detection requirements for PUCCH format 2

Performance requirements for 2Tx SORTD scheme are agreed to be defined. Detailed simulation assumptions can be found in the Annex[X].

8.3.4 ACK missed detection requirements for multi user PUCCH format 1a

RAN4 concluded that no new requirements are needed for multi-user PUCCH format 1a due to the introduction of UL-MIMO.

8.4 Performance requirements for PRACH

The uplink single antenna port transmission is the default transmission scheme before eNodeB is aware of the UE transmit antenna configuration. Therefore, no additional performance requirements are needed due to introduction of UL MIMO.

PRACH requirements will be performed for single antenna port transmission.

Annex A: Measurement channels

Annex B: Propagation conditions

B.1 General

B.2 Propagation channels

B.2.1 Multi-Antenna channel models

B.2.1.1 Definition of MIMO Correlation Matrices

Table B-1 defines the correlation matrix for the eNodeB

Table B-1 eNodeB correlation matrix

	One antenna	Two antennas	Four antennas
eNode B Correlation	$R_{eNB} = 1$	$R_{eNB} = \begin{pmatrix} 1 & \alpha \\ \alpha^* & \mathbf{1} \end{pmatrix}$	$R_{eNB} = \begin{pmatrix} 1 & \alpha^{1/9} & \alpha^{4/9} & \alpha \\ \alpha^{1/9*} & 1 & \alpha^{1/9} & \alpha^{4/9} \\ \alpha^{4/9*} & \alpha^{1/9*} & 1 & \alpha^{1/9} \\ \alpha^* & \alpha^{4/9*} & \alpha^{1/9*} & 1 \end{pmatrix}$

Table B-2 defines the correlation matrix for the UE:

Table B-2 UE correlation matrix

	One antenna	Two antennas	Four antennas
UE Correlation	$R_{UE} = 1$	$R_{UE} = \begin{pmatrix} 1 & \beta \\ \beta^* & \mathbf{1} \end{pmatrix}$	$R_{UE} = \begin{pmatrix} 1 & \beta^{1/9} & \beta^{4/9} & \beta \\ \beta^{1/9*} & 1 & \beta^{1/9} & \beta^{4/9} \\ \beta^{4/9*} & \beta^{1/9*} & 1 & \beta^{1/9} \\ \beta^* & \beta^{4/9*} & \beta^{1/9*} & 1 \end{pmatrix}$

Table B-3 defines the channel spatial correlation matrix R_{spat}. The parameters α and β in Table B-3 defines the spatial correlation between the antennas at the UE and eNB.

Table B-3: R_{spat} correlation matrices

1x2 case	$R_{spat} = R_{eNB} = \begin{pmatrix} 1 & \alpha \\ \alpha^* & 1 \end{pmatrix}$
2x2 case	$R_{spat} = R_{UE} \otimes R_{eNB} = \begin{bmatrix} 1 & \beta \\ \beta^* & 1 \end{bmatrix} \otimes \begin{bmatrix} 1 & \alpha \\ \alpha^* & 1 \end{bmatrix} = \begin{bmatrix} 1 & \alpha & \beta & \beta\alpha \\ \alpha^* & 1 & \beta\alpha^* & \beta \\ \beta^* & \beta^*\alpha & 1 & \alpha \\ \beta^*\alpha^* & \beta^* & \alpha^* & 1 \end{bmatrix}$
2x4 case	$R_{spat} = R_{UE} \otimes R_{eNB} = \begin{bmatrix} 1 & \beta \\ \beta^* & 1 \end{bmatrix} \otimes \begin{bmatrix} 1 & \alpha^{1/9} & \alpha^{4/9} & \alpha \\ \alpha^{1/9*} & 1 & \alpha^{1/9} & \alpha^{4/9} \\ \alpha^{4/9*} & \alpha^{1/9*} & 1 & \alpha^{1/9} \\ \alpha^* & \alpha^{4/9*} & \alpha^{1/9*} & 1 \end{bmatrix}$
4x4 case	$R_{spat} = R_{UE} \otimes R_{eNB} = \begin{pmatrix} 1 & \beta^{1/9} & \beta^{4/9} & \beta \\ \beta^{1/9*} & 1 & \beta^{1/9} & \beta^{4/9} \\ \beta^{4/9*} & \beta^{1/9*} & 1 & \beta^{1/9} \\ \beta^* & \beta^{4/9*} & \beta^{1/9*} & 1 \end{pmatrix} \otimes \begin{bmatrix} 1 & \alpha^{1/9} & \alpha^{4/9} & \alpha \\ \alpha^{1/9*} & 1 & \alpha^{1/9} & \alpha^{4/9} \\ \alpha^{4/9*} & \alpha^{1/9*} & 1 & \alpha^{1/9} \\ \alpha^* & \alpha^{4/9*} & \alpha^{1/9*} & 1 \end{bmatrix}$

For cases with more antennas at either eNodeB or UE or both, the channel spatial correlation matrix can still be expressed as the Kronecker product of R_{UE} and R_{eNB} according to $R_{spat} = R_{UE} \otimes R_{eNB}$.

B.2.1.2 MIMO Correlation Matrices at High, Medium and Low Level

The α and β for different correlation types are given in Table B-4.

Table B-4 Correlation for High Medium and Low Level

Low correlation		Medium Correlation		High Correlation	
α	β	α	β	α	β
[0]	[0]	[0.3]	[0.9]	0.9	0.9

Note: in case the values of α and β for Low correlation and Medium correlation in Table B-4 are changed in future, correlation matrices in Table B-6 and Table B-7 should be changed accordingly.

The correlation matrices for high, medium and low correlation are defined in Table B-5, B-6 and B-7 as below.

The values in Table B-5 have been adjusted for the 2x4 and 4x4 high correlation cases to insure the correlation matrix is positive semi-definite after round-off to 4 digit precision. This is done using the equation:

$$\mathbf{R}_{high} = [\mathbf{R}_{spatial} + aI_n]/(1+a)$$

Where the value "a" is a scaling factor such that the smallest value is used to obtain a positive semi-definite result. For the 2x4 high correlation case, a=0.00010. For the 4x4 high correlation case, a=0.00012.

The same method is used to adjust the 4x4 medium correlation matrix in Table B-6 to insure the correlation matrix is positive semi-definite after round-off to 4 digit precision with a =0.00012.

Table B-5: MIMO correlation matrices for high correlation

1x2 case

$$R_{high} = \begin{pmatrix} 1 & 0.9 \\ 0.9 & 1 \end{pmatrix}$$

2x2 case

$$R_{high} = \begin{pmatrix} 1 & 0.9 & 0.9 & 0.81 \\ 0.9 & 1 & 0.81 & 0.9 \\ 0.9 & 0.81 & 1 & 0.9 \\ 0.81 & 0.9 & 0.9 & 1 \end{pmatrix}$$

2x4 case

$$R_{high} = \begin{bmatrix} 1.0000 & 0.9883 & 0.9542 & 0.8999 & 0.8999 & 0.8894 & 0.8587 & 0.8099 \\ 0.9883 & 1.0000 & 0.9883 & 0.9542 & 0.8894 & 0.8999 & 0.8894 & 0.8587 \\ 0.9542 & 0.9883 & 1.0000 & 0.9883 & 0.8587 & 0.8894 & 0.8999 & 0.8894 \\ 0.8999 & 0.9542 & 0.9883 & 1.0000 & 0.8099 & 0.8587 & 0.8894 & 0.8999 \\ 0.8999 & 0.8894 & 0.8587 & 0.8099 & 1.0000 & 0.9883 & 0.9542 & 0.8999 \\ 0.8894 & 0.8999 & 0.8894 & 0.8587 & 0.9883 & 1.0000 & 0.9883 & 0.9542 \\ 0.8587 & 0.8894 & 0.8999 & 0.8894 & 0.9542 & 0.9883 & 1.0000 & 0.9883 \\ 0.8099 & 0.8587 & 0.8894 & 0.8999 & 0.8999 & 0.9542 & 0.9883 & 1.0000 \end{bmatrix}$$

4x4 case

$$R_{high} = \begin{bmatrix} 1.0000 & 0.9882 & 0.9541 & 0.8999 & 0.9882 & 0.9767 & 0.9430 & 0.8894 & 0.9541 & 0.9430 & 0.9105 & 0.8587 & 0.8999 & 0.8894 & 0.8587 & 0.8099 \\ 0.9882 & 1.0000 & 0.9882 & 0.9541 & 0.9767 & 0.9882 & 0.9767 & 0.9430 & 0.9430 & 0.9541 & 0.9430 & 0.9105 & 0.8894 & 0.8999 & 0.8894 & 0.8587 \\ 0.9541 & 0.9882 & 1.0000 & 0.9882 & 0.9430 & 0.9767 & 0.9882 & 0.9767 & 0.9105 & 0.9430 & 0.9541 & 0.9430 & 0.8587 & 0.8894 & 0.8999 & 0.8894 \\ 0.8999 & 0.9541 & 0.9882 & 1.0000 & 0.8894 & 0.9430 & 0.9767 & 0.9882 & 0.8587 & 0.9105 & 0.9430 & 0.9541 & 0.8099 & 0.8587 & 0.8894 & 0.8999 \\ 0.9882 & 0.9767 & 0.9430 & 0.8894 & 1.0000 & 0.9882 & 0.9541 & 0.8999 & 0.9882 & 0.9767 & 0.9430 & 0.8894 & 0.9541 & 0.9430 & 0.9105 & 0.8587 \\ 0.9767 & 0.9882 & 0.9767 & 0.9430 & 0.9882 & 1.0000 & 0.9882 & 0.9541 & 0.9767 & 0.9882 & 0.9767 & 0.9430 & 0.9430 & 0.9541 & 0.9430 & 0.9105 \\ 0.9430 & 0.9767 & 0.9882 & 0.9767 & 0.9541 & 0.9882 & 1.0000 & 0.9882 & 0.9430 & 0.9767 & 0.9882 & 0.9767 & 0.9105 & 0.9430 & 0.9541 & 0.9430 \\ 0.8894 & 0.9430 & 0.9767 & 0.9882 & 0.8999 & 0.9541 & 0.9882 & 1.0000 & 0.8894 & 0.9430 & 0.9767 & 0.9882 & 0.8587 & 0.9105 & 0.9430 & 0.9541 \\ 0.9541 & 0.9430 & 0.9105 & 0.8587 & 0.9882 & 0.9767 & 0.9430 & 0.8894 & 1.0000 & 0.9882 & 0.9541 & 0.8999 & 0.9882 & 0.9767 & 0.9430 & 0.8894 \\ 0.9430 & 0.9541 & 0.9430 & 0.9105 & 0.9767 & 0.9882 & 0.9767 & 0.9430 & 0.9882 & 1.0000 & 0.9882 & 0.9541 & 0.9767 & 0.9882 & 0.9767 & 0.9430 \\ 0.9105 & 0.9430 & 0.9541 & 0.9430 & 0.9430 & 0.9767 & 0.9882 & 0.9767 & 0.9541 & 0.9882 & 1.0000 & 0.9882 & 0.9430 & 0.9767 & 0.9882 & 0.9767 \\ 0.8587 & 0.9105 & 0.9430 & 0.9541 & 0.8894 & 0.9430 & 0.9767 & 0.9882 & 0.8999 & 0.9541 & 0.9882 & 1.0000 & 0.8894 & 0.9430 & 0.9767 & 0.9882 \\ 0.8999 & 0.8894 & 0.8587 & 0.8099 & 0.9541 & 0.9430 & 0.9105 & 0.8587 & 0.9882 & 0.9767 & 0.9430 & 0.8894 & 1.0000 & 0.9882 & 0.9541 & 0.8999 \\ 0.8894 & 0.8999 & 0.8894 & 0.8587 & 0.9430 & 0.9541 & 0.9430 & 0.9105 & 0.9767 & 0.9882 & 0.9767 & 0.9430 & 0.9882 & 1.0000 & 0.9882 & 0.9541 \\ 0.8587 & 0.8894 & 0.8999 & 0.8894 & 0.9105 & 0.9430 & 0.9541 & 0.9430 & 0.9430 & 0.9767 & 0.9882 & 0.9767 & 0.9541 & 0.9882 & 1.0000 & 0.9882 \\ 0.8099 & 0.8587 & 0.8894 & 0.8999 & 0.8587 & 0.9105 & 0.9430 & 0.9541 & 0.8894 & 0.9430 & 0.9767 & 0.9882 & 0.8999 & 0.9541 & 0.9882 & 1.0000 \end{bmatrix}$$

Table B-6: MIMO correlation matrices for medium correlation

1x2 case

$$[R_{medium} = \begin{pmatrix} 1 & 0.3 \\ 0.3 & 1 \end{pmatrix}]$$

2x2 case

$$R_{medium} = \begin{pmatrix} 1.0000 & 0.3000 & 0.9000 & 0.2700 \\ 0.3000 & 1.0000 & 0.2700 & 0.9000 \\ 0.9000 & 0.2700 & 1.0000 & 0.3000 \\ 0.2700 & 0.9000 & 0.3000 & 1.0000 \end{pmatrix}$$

2x4 case

$$R_{medium} = \begin{pmatrix} 1.0000 & 0.8748 & 0.5856 & 0.3000 & 0.9000 & 0.7873 & 0.5271 & 0.2700 \\ 0.8748 & 1.0000 & 0.8748 & 0.5856 & 0.7873 & 0.9000 & 0.7873 & 0.5271 \\ 0.5856 & 0.8748 & 1.0000 & 0.8748 & 0.5271 & 0.7873 & 0.9000 & 0.7873 \\ 0.3000 & 0.5856 & 0.8748 & 1.0000 & 0.2700 & 0.5271 & 0.7873 & 0.9000 \\ 0.9000 & 0.7873 & 0.5271 & 0.2700 & 1.0000 & 0.8748 & 0.5856 & 0.3000 \\ 0.7873 & 0.9000 & 0.7873 & 0.5271 & 0.8748 & 1.0000 & 0.8748 & 0.5856 \\ 0.5271 & 0.7873 & 0.9000 & 0.7873 & 0.5856 & 0.8748 & 1.0000 & 0.8748 \\ 0.2700 & 0.5271 & 0.7873 & 0.9000 & 0.3000 & 0.5856 & 0.8748 & 1.0000 \end{pmatrix}$$

4x4 case

$$R_{medium} = \begin{pmatrix} 1.0000 & 0.8747 & 0.5855 & 0.3000 & 0.9882 & 0.8645 & 0.5787 & 0.2965 & 0.9541 & 0.8347 & 0.5588 & 0.2862 & 0.8999 & 0.7872 & 0.5270 & 0.2700 \\ 0.8747 & 1.0000 & 0.8747 & 0.5855 & 0.8645 & 0.9882 & 0.8645 & 0.5787 & 0.8347 & 0.9541 & 0.8347 & 0.5588 & 0.7872 & 0.8999 & 0.7872 & 0.5270 \\ 0.5855 & 0.8747 & 1.0000 & 0.8747 & 0.5787 & 0.8645 & 0.9882 & 0.8645 & 0.5588 & 0.8347 & 0.9541 & 0.8347 & 0.5270 & 0.7872 & 0.8999 & 0.7872 \\ 0.3000 & 0.5855 & 0.8747 & 1.0000 & 0.2965 & 0.5787 & 0.8645 & 0.9882 & 0.2862 & 0.5588 & 0.8347 & 0.9541 & 0.2700 & 0.5270 & 0.7872 & 0.8999 \\ 0.9882 & 0.8645 & 0.5787 & 0.2965 & 1.0000 & 0.8747 & 0.5855 & 0.3000 & 0.9882 & 0.8645 & 0.5787 & 0.2965 & 0.9541 & 0.8347 & 0.5588 & 0.2862 \\ 0.8645 & 0.9882 & 0.8645 & 0.5787 & 0.8747 & 1.0000 & 0.8747 & 0.5855 & 0.8645 & 0.9882 & 0.8645 & 0.5787 & 0.8347 & 0.9541 & 0.8347 & 0.5588 \\ 0.5787 & 0.8645 & 0.9882 & 0.8645 & 0.5855 & 0.8747 & 1.0000 & 0.8747 & 0.5787 & 0.8645 & 0.9882 & 0.8645 & 0.5588 & 0.8347 & 0.9541 & 0.8347 \\ 0.2965 & 0.5787 & 0.8645 & 0.9882 & 0.3000 & 0.5855 & 0.8747 & 1.0000 & 0.2965 & 0.5787 & 0.8645 & 0.9882 & 0.2862 & 0.5588 & 0.8347 & 0.9541 \\ 0.9541 & 0.8347 & 0.5588 & 0.2862 & 0.9882 & 0.8645 & 0.5787 & 0.2965 & 1.0000 & 0.8747 & 0.5855 & 0.3000 & 0.9882 & 0.8645 & 0.5787 & 0.2965 \\ 0.8347 & 0.9541 & 0.8347 & 0.5588 & 0.8645 & 0.9882 & 0.8645 & 0.5787 & 0.8747 & 1.0000 & 0.8747 & 0.5855 & 0.8645 & 0.9882 & 0.8645 & 0.5787 \\ 0.5588 & 0.8347 & 0.9541 & 0.8347 & 0.5787 & 0.8645 & 0.9882 & 0.8645 & 0.5855 & 0.8747 & 1.0000 & 0.8747 & 0.5787 & 0.8645 & 0.9882 & 0.8645 \\ 0.2862 & 0.5588 & 0.8347 & 0.9541 & 0.2965 & 0.5787 & 0.8645 & 0.9882 & 0.3000 & 0.5855 & 0.8747 & 1.0000 & 0.2965 & 0.5787 & 0.8645 & 0.9882 \\ 0.8999 & 0.7872 & 0.5270 & 0.2700 & 0.9541 & 0.8347 & 0.5588 & 0.2862 & 0.9882 & 0.8645 & 0.5787 & 0.2965 & 1.0000 & 0.8747 & 0.5855 & 0.3000 \\ 0.7872 & 0.8999 & 0.7872 & 0.5270 & 0.8347 & 0.9541 & 0.8347 & 0.5588 & 0.8645 & 0.9882 & 0.8645 & 0.5787 & 0.8747 & 1.0000 & 0.8747 & 0.5855 \\ 0.5270 & 0.7872 & 0.8999 & 0.7872 & 0.5588 & 0.8347 & 0.9541 & 0.8347 & 0.5787 & 0.8645 & 0.9882 & 0.8645 & 0.5855 & 0.8747 & 1.0000 & 0.8747 \\ 0.2700 & 0.5270 & 0.7872 & 0.8999 & 0.2862 & 0.5588 & 0.8347 & 0.9541 & 0.2965 & 0.5787 & 0.8645 & 0.9882 & 0.3000 & 0.5855 & 0.8747 & 1.0000 \end{pmatrix}$$

Table B-7: MIMO correlation matrices for low correlation

1x2 case	$R_{low} = \mathbf{I}_2$
1x4 case	$R_{low} = \mathbf{I}_4$
2x2 case	$R_{low} = \mathbf{I}_4$
2x4 case	$R_{low} = \mathbf{I}_8$
4x4 case	$R_{low} = \mathbf{I}_{16}$

In Table B-7, $\mathbf{I}_d$ is a $d \times d$ identity matrix.

Annex C: Simulation assumptions for Rel-10 PUSCH performance requirements

Simulation assumptions for UL MIMO PUSCH performance requirements are captured in the Table below

Table C-1: Simulation assumptions for Rel-10 PUSCH

Common parameters	Value
Number of TX antennas	2
Number of RX antennas	2, 4
Channel Model	EVA, EPA
Noise Model	AWGN
Power imbalance between antennas	0 dB
Channel Bandwidth	1.4MHZ, 3MHz, 5MHz, 10 MHz, 15 MHz, 20 MHz,
Channel estimation	Practical and realizable channel and noise estimates
Cyclic prefix	Normal
Precoding method	Rank1: random precoding Rank2: fixed precoding
Resource allocation	Full RB allocation
Modulation scheme and code rate	QPSK 1/3, 16QAM 3/4
Number of HARQ processes	8 HARQ processes for FDD
Maximum number of HARQ transmissions	4
Redundancy version sequence	0, 2, 3, 1, 0, 2, 3, 1
HARQ combining	Incremental redundancy
Number of retransmission layers	Rank2: 2
Simulation length	10000 subframes at minimum

Annex D: Simulation assumptions for Rel-10 PUCCH performance requirements

Simulation assumptions for UL-MIMO PUCCH performance requirements are captured in the Tables below.

Table D-1: Common simulation assumptions

Parameters	Value
Channel bandwidth	1.4MHz/3MHz/5MHz/10MHz/15MHz/20MHz
Noise model	AWGN
Cyclic prefix	Normal
DMRS sequence group hopping	Disabled
Channel estimation	ML channel estimator with real noise estimation
Timing estimation	Perfect
Frequency domain equalizer	MMSE

Table D-2: Simulation assumptions for PUCCH format 1a

Parameters	Value
Antenna configuration/ correlation matrix	2x2 Low, 2x4 Low
Propagation conditions	EPA 5Hz, EVA 70Hz
resource index for SORTD	Two adjacent resources in the same PRB with the same orthogonal sequence.
$\Delta_{\text{shift}}^{\text{PUCCH}}$	2
Number of users	1

Table D-3: Simulation assumptions for PUCCH format 2

Parameters	Value
Antenna configuration/ correlation matrix	2x2 Low
Propagation conditions	EVA 5Hz
resource index for SORTD	Two adjacent resources in the same PRB
Number of CQI bits	4 bit

Annex E: Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2010-05	R4#55	R4-101805			Report skeleton		0.0.1
2010-08	R4#56	R4-103429			Agreed Text Proposals in RAN4#55: **R4-102346**, "TP for UL MIMO TR: Clause 8.1 (Performance requirement: General)" Agreed Text Proposals in RAN4 ad hoc#3: **R4-102710**, "TP for UL MIMO TR: Annex B (channel model)"	0.0.1	0.1.0
2010-10	R4 Ad Hoc#4	R4-103574			Specification updated with TR number: 36.817 Agreed Text Proposals in RAN4#56: **R4-103428**, "TP for UL MIMO TR: Annex B (channel model)"	0.1.0	0.2.0
2010-11	R4#57	R4-104541			Agreed Text Proposals in RAN4 ad hoc#3: **R4-103904**, "TP for UL MIMO TR 36.817: Chapter 4: General" **R4-103905**, "TP for UL MIMO TR 36.817: Chapter 5: Operating bands and channel arrangement" **R4-103906**, "TP for UL MIMO TR 36.817: Chapter 6: Transmitter characteristics"	0.2.0	0.3.0
2011-01	R4#57AH	R4-110191			Agreed Text Proposals in RAN4#57: **R4-104997**, "TP for UL MIMO TR 36.817: Clause 8.3 (Performance requirements for PUCCH) and Clause 8.4 (Performance requirements for PRACH)" **R4-104998**, "TP for UL MIMO TR 36.817: Clause 8.1 (General) and clause 8.2 (Performance requirements for PUSCH)"	0.3.0	0.4.0
2011-04	R4#58AH	R4-112223			Agreed Text Proposals in RAN4#58: **R4-111625**, "TP for UL MIMO TR 36.817: Clause 8.2 (Performance requirements for PUSCH) on rank1 performance requirements"	0.4.0	0.5.1
2011-05	RAN4#59	R4-112853			Agreed Text Proposals in RAN4#58AH: **R4-112276**, "TP for UL-MIMO TR 36.817: Clause 8.3 (Performance requirements for PUCCH)" **R4-112277**, "TP for UL-MIMO TR 36.817: Clause 8.2 (Performance requirements for PUSCH)"	0.5.1	0.6.0
2011-05	RAN#52	RP-110731			Submission to RAN#52	0.6.0	1.0.0
2011_05	RAN#52	RP-110754			Agreed TP in RAN4#59: **R4-112586**, "TP for UL-MIMO TR 36.817: Clause 8.2 (Performance requirements for PUSCH)"	1.0.0	1.1.0
2011-05	RAN#52	RP-110731			V1.1.0 approved by TAS RAN	1.1.0	10.0.0