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Contents

Foreword

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

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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

z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document captures the findings of the study item "Study on 3D-channel model for Elevation Beamforming and FD-MIMO studies for LTE" [2]. The purpose of this TR is to help TSG RAN WG1 to properly model and evaluate the performance of physical layer techniques using 3D channel models.

This document relates to the 3GPP evaluation methodology and covers the modelling of the physical layer of both Mobile Equipment and Access Network of 3GPP systems.

This document is intended to capture the scenarios relevant to 3D channel models and the modifications to the 3GPP evaluation methodology needed to support 3D channel modelling.

This document is a 'living' document, i.e. it is permanently updated and presented to TSG-RAN meetings.

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 TD RP-122034: "Study on 3D-channel model for Elevation Beamforming and FD-MIMO studies for LTE".

[3] 3GPP TR 36.814 (V9.0.0): "Further Advancements for E-UTRA, Physical Layer Aspects".

3 Definitions, symbols and abbreviations

Delete from the above heading those words which are not applicable.

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [x] 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 [x].

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 [x] 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 [x].

FD-MIMO Full Dimension MIMO

4 Introduction

At 3GPP TSG RAN #58 meeting the Study Item Description on "Study on 3D-channel model for Elevation Beamforming and FD-MIMO studies for LTE" was approved [2]. This study item covers the identification of scenarios applicable to 3D beamforming, FD-MIMO and the evaluation methodology needed for modelling and evaluation of such techniques. This technical report documents the modified evaluation methodology including 3D channel models needed for studying the above techniques.

5 General

[NOTE: This section will include general information that is helpful for understanding the TR and for completeness of the TR]

6 Scenarios for UE specific elevation beamforming and FD-MIMO

[NOTE: Intended to identify the typical usage scenarios of UE-specific elevation beamforming and FD- MIMO]

Scenario 3D-UMi: Urban Micro cell with high (outdoor/indoor) UE density

- Base station is below surrounding buildings

Scenario 3D-UMa: Urban Macro cell with high (outdoor/indoor) UE density

- Base station is above surrounding buildings

Table 1: Description of scenarios

		Urban Micro cell with high UE density (3D-UMi)	**Urban Macro cell with high UE density (3D-UMa)**
SECTION-1			
Layout		Hexagonal grid, 19 micro sites,3 sectors per site	Hexagonal grid, 19 macro sites,3 sectors per site
UE mobility (movement in horizontal plane)		3kmph	3kmph
BS antenna height		10m	25m
Total BS Tx Power		41/44 dBm for 10/20MHz	46/49 dBm for 10/20MHz
Carrier frequency		2 GHz	2 GHz
Min. UE-eNB 2D distance[1)]		10m [other values FFS]	35m
UE height (h_{UT}) in meters	general equation	h_{UT}=3(n_{fl} – 1) + 1.5	h_{UT}=3(n_{fl} – 1) + 1.5
	n_{fl} for outdoor UEs	1	1
	n_{fl} for indoor UEs	n_{fl} ~ uniform(1,N_{fl}) where N_{fl} ~ uniform(4,8)	n_{fl} ~ uniform(1,N_{fl}) where N_{fl} ~ uniform(4,8)
Indoor UE fraction		80%	80%
SECTION-2[2)]			
UE distribution (in x-yplane)	Outdoor UEs	uniform in cell	uniform in cell
	Indoor UEs	uniform in cell	uniform in cell
ISD		200m	500m (FFS: 200m)

[1)] Refers to d_{2D} for outdoor UEs and $d_{2D\text{-}out}$ for indoor UEs as defined in Figure 3 and Figure 4 respectively.

[2)]Assumptions in SECTION-2 are for calibration purposes only in this SI. Assumptions in SECTION-2 are to be revisited for evaluating relative performance of proposed solutions in future SIs

Other typical usage scenarios of UE-specific elevation beamforming and FD- MIMO are noted below:

Heterogeneous Networks

- Channel models developed for Urban Micro cell with high UE density and Urban Macro cell with high UE density scenarios shall support heterogeneous deployment scenarios.
    - It is assumed that for heterogeneous deployment scenarios the macro BS height is at 25m and the lower-power node is at 10m height.
    - The carrier frequency(s) for a macro can be 2 or 3.5 GHz or both if multiple carriers are used. The carrier frequency(s) for a low power node can be 2 or 3.5 GHz or both if multiple carriers are used.
    - The transmission power of a low power node can be 30/33 dBm for 10/20 MHz.

Urban micro/macro homogeneous networks with high UE density (similar to 3D-UMi/3D-UMa) using higher than 2 GHz carrier frequency

- The carrier frequency can be 3.5 GHz.

7 3GPP evaluation methodology needed for Elevation Beamforming and FD-MIMO evaluation

[NOTE: The study will consider as a starting point the ITU channel model as described by the combination of A2.1.6 and Annex B in 36.814 [3] and determine the additions that are needed to properly model the elevation dimension of the channel to fit the elevation beamforming and FD-MIMO purposes]

The applicable range of the 3D channel model is at least for 2-3.5 GHz.

7.1 Antenna modelling

- 2D planar antenna array structure is the baseline, i.e., antenna elements are placed in the vertical and horizontal direction as below, where N is the number of columns, M is the number of antenna elements with the same polarization in each column.
- Antenna elements are uniformly spaced in the horizontal direction with a spacing of $d_H \lambda$ and in the vertical direction with a spacing of $d_V \lambda$.

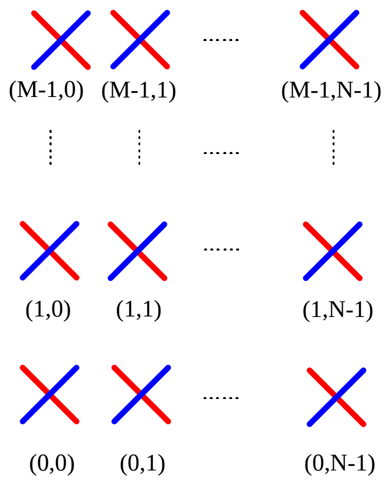

Figure 1: 2D planar antenna structure where each column is a cross-polarized array

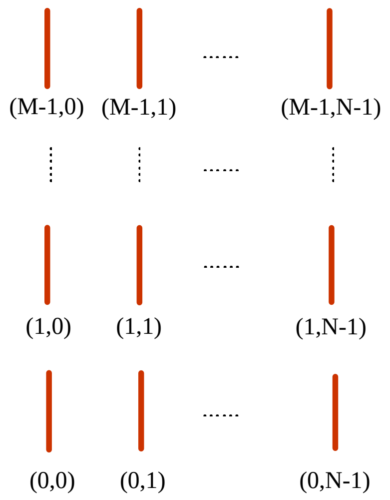

Figure 2: 2D planar antenna structure where each column is a uniform linear array

Table 2: Antenna modelling parameters

Parameter	Applicability	Values
SECTION-1		
Number of horizontal antenna elements	cross-pol	2, 4, 8
	co-pol	1, 2, 4, 8
Polarization slant angle	cross-pol	+/- 45^0
	co-pol	$+90^0$
Horizontal antenna element spacing d_H		0.5λ baseline (other values FFS)
Antenna element vertical radiation pattern (dB)		$A_{E,V}(\theta) = -min\left[12\left(\frac{\theta - 90^0}{\theta_{3dB}}\right)^2, SLA_V\right], \theta_{3dB} = 65^0, SLA_V = 30$
Antenna element horizontal radiation pattern (dB)	3D-UMa, 3D-UMi, LPN deployments	$A_{E,H}(\varphi) = -min\left[12\left(\frac{\varphi}{\varphi_{3dB}}\right)^2, A_m\right], \varphi_{3dB} = 65^0, A_m = 30$
	3D-UMi, LPN deployments	FFS: $A_{E,H}(\varphi) = 0$
Combining method for 3D element antenna pattern (dB)		$A_E(\theta,\varphi) = -min\{-[A_{E,V}(\theta) + A_{E,H}(\varphi)], A_m\}$
Maximum directional gain of an antenna element $G_{E,max}$		8 dBi

SECTION-2[1)]		
Vertical antenna element spacing d_V		0.5λ, 0.8λ
Number of antenna elements with the same polarization in each column M		10 baseline, other values FFS
Complex weight for antenna element *m* in elevation		$w_m = \frac{1}{\sqrt{K}} exp\left(j\frac{2\pi}{\lambda}(m-1)d_V\cos\theta_{etilt}\right)$ where m=1,…,K. θ_{etilt} is the electrical vertical steering angle defined between 0^0 and 180^0 (90^0 represents perpendicular to the array). K = 1, M.

1) Assumptions in SECTION-2 are for calibration of channel modelling

7.2 Pathloss modelling

The pathloss models can be applied in the frequency range of 2 – 6 GHz and for different antenna heights. The pathloss models are summarized in Table 3 and the distance definitions are indicated in Figure 3 and Figure 4.

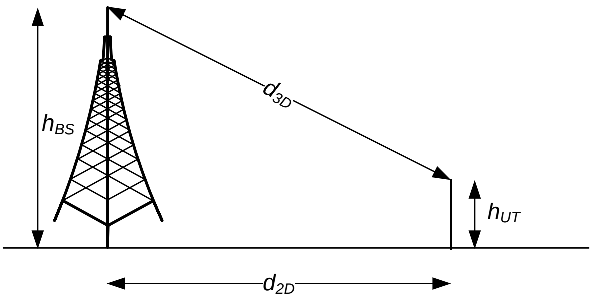

Figure 3: Definition of d_{2D} and d_{3D} for outdoor UEs.

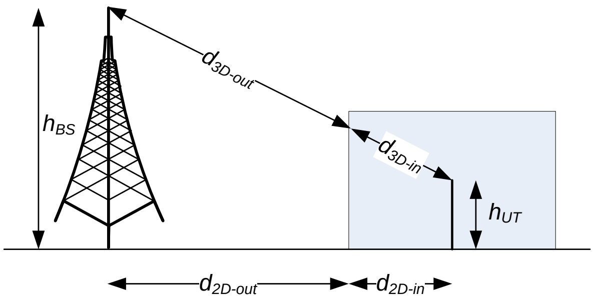

Figure 4: Definition of $d_{2D\text{-}out}$, $d_{2D\text{-}in}$ and $d_{3D\text{-}out}$, $d_{3D\text{-}in}$ for indoor UEs.

Table 3: Pathloss models

Scenario	Pathloss [dB], f_c is in GHz and distance is in meters	Shadow fading std [dB]	Applicability range, antenna height default values
3D-UMi LOS	$PL = 22.0\log_{10}(d_{3D}) + 28.0 + 20\log_{10}(f_c)$ $PL = 40\log_{10}(d_{3D})+28.0+20\log_{10}(f_c) - 9\log_{10}((d'_{BP})^2+(h_{BS} - h_{UT})^2)$		$10\text{m} < d_{2D} < d'_{BP}$ [1)] $d'_{BP} < d_{2D} < 5000\text{m}$ [1)] $h_{BS} = 10\text{m}$ [1)], $1.5\text{m} \leqq h_{UT} \leqq$

			$22.5m^{1)}$
3D-UMi NLOS	**For hexagonal cell layout:** $PL = 36.7\log_{10}(d_{3D}) + 22.7 + 26\log_{10}(f_c)$		$10\ m < d_{2D} < 2000m$ $h_{BS} = 10m$ h_{UT} =1-2.5m
3D-UMi O-to-I	$PL = PL_b + PL_{tw} + PL_{in}$ **For hexagonal cell layout:** $PL_b = PL_{3D\text{-}UMi}(d_{3D\text{-}out} + d_{3D\text{-}in})$ $PL_{tw} = 20$ $PL_{in} = 0.5d_{2D\text{-}in}$		$10m < d_{2D\text{-}out} + d_{2D\text{-}in} < 1000m$ $0m < d_{2D\text{-}in} < 25m$ $h_{BS} = 10m$, $h_{UT}=3(n_{fl} - 1) + 1.5$, n_{fl} = 1, 2, 3, 4, 5, 6, 7, 8. Explanations: see [2)]
3D-UMa LOS	$PL = 22.0\log_{10}(d_{3D}) + 28.0 + 20\log_{10}(f_c)$ $PL = 40\log_{10}(d_{3D})+28.0+20\log_{10}(f_c) - 9\log_{10}((d'_{BP})^2+(h_{BS} - h_{UT})^2)$		$10m < d_{2D} < d'_{BP}$ [3)] $d'_{BP} < d_{2D} < 5000m$ [3)] $h_{BS} = 25m$ [3)], $1.5m \leqq h_{UT} \leqq 22.5m$ [3)]
3D-UMa NLOS	$PL = max(PL_{3D\text{-}UMa\text{-}NLOS}, PL_{3D\text{-}UMa\text{-}LOS})$, $PL_{3D\text{-}UMa\text{-}NLOS} = 161.04 - 7.1 \log_{10}(W) + 7.5 \log_{10}(h) - (24.37 - 3.7(h/h_{BS})^2) \log_{10}(h_{BS}) + (43.42 - 3.1 \log_{10}(h_{BS})) (\log_{10}(d_{3D})-3) + 20 \log_{10}(f_c) - (3.2 (\log_{10}(17.625))^2 - 4.97) - \alpha(h_{UT} - 1.5)$		$10\ m < d_{2D} < 5\,000\ m$ h = avg. building height, W = street width h_{BS} = 25 m, h_{UT} = 1.5m, W = 20m, h = 20 m The applicability ranges: $5\ m < h < 50\ m$ $5\ m < W < 50\ m$ $10\ m < h_{BS} < 150\ m$ $1.5\ m \leqq h_{UT} \leqq 22.5\ m$ Explanations: see [4)]
3D-UMa O-to-I	$PL = PL_b + PL_{tw} + PL_{in}$ **For hexagonal cell layout:** $PL_b = PL_{3D\text{-}UMa}(d_{3D\text{-}out} + d_{3D\text{-}in})$ $PL_{tw} = 20$ $PL_{in} = 0.5d_{2D\text{-}in}$		$10m < d_{2D\text{-}out} + d_{2D\text{-}in} < 1000m$ $0m < d_{2D\text{-}in} < 25m$ $h_{BS} = 25m$, $h_{UT}=3(n_{fl} - 1) + 1.5$, n_{fl} = 1, 2, 3, 4, 5, 6, 7, 8. Explanations: see [5)]

[1)] Break point distance $d'_{BP} = 4\ h'_{BS}\ h'_{UT}\ f_c/c$, where f_c is the centre frequency in Hz, $c = 3.0\times10^8$ m/s is the propagation velocity in free space, and h'_{BS} and h'_{UT} are the effective antenna heights at the BS and the UT, respectively. In 3D-UMi scenario the effective antenna heights h'_{BS} and h'_{UT} are computed as follows: $h'_{BS} = h_{BS} - 1.0$ m, $h'_{UT} = h_{UT} - 1.0$ m, where h_{BS} and h_{UT} are the actual antenna heights, and the effective environment height is assumed to be equal to 1.0m.

[2)] PL_b = basic path-loss, $PL_{3D\text{-}UMi}$ = Loss of 3D-UMi outdoor scenario, PL_{tw} = Loss through wall, PL_{in} = Loss inside, $d_{2D\text{-}in}$ is assumed uniformly distributed between 0 and 25m.

[3)] Break point distance $d'_{BP} = 4\ h'_{BS}\ h'_{UT}\ f_c/c$, where f_c is the centre frequency in Hz, $c = 3.0\times10^8$ m/s is the propagation velocity in free space, and h'_{BS} and h'_{UT} are the effective antenna heights at the BS and the UT, respectively. In 3D-UMa scenario the effective antenna heights h'_{BS} and h'_{UT} are computed as follows: $h'_{BS} = h_{BS} - h_E$, $h'_{UT} = h_{UT} - h_E$, where h_{BS} and h_{UT} are the actual antenna heights, and the effective environment height h_E is a function of the link between a BS and a UT. h_E=1m with a probability equal to $p(d_{2D},h_{UT})$ and TBD otherwise.

4) $PL_{3D\text{-}UMa\text{-}LOS}$ = Pathloss of 3D-UMa LOS outdoor scenario.

5) PL_b = basic path-loss, $PL_{3D\text{-}UMa}$ = Loss of 3D-UMa outdoor scenario, PL_{tw} = Loss through wall, PL_{in} = Loss inside, $d_{2D\text{-}in}$ is assumed uniformly distributed between 0 and 25m.

The line-of-sight (LOS) probabilities are given in

Table 4: LOS probabilities

Scenario	LOS probability, distance is in meters
3D-UMi	$P_{LOS} = \min(18/d_{2D},1)(1-\exp(-d_{2D}/36))+\exp(-d_{2D}/36)$ for outdoor users[1)]
3D-UMa	TBD

1) In O-to-I cases $d_{2D\text{-}out}$ is used to determine P_{LOS}

7.3 Fast fading model

The radio channels are created using the parameters listed in TBD. The channel realizations are obtained by a step-wise procedure illustrated in Figure 5 and described below. It has to be noted that the geometric description covers arrival angles from the last bounce scatterers and respectively departure angles to the first scatterers interacted from the transmitting side. The propagation between the first and the last interaction is not defined. Thus, this approach can model also multiple interactions with the scattering media. This indicates also that e.g., the delay of a multipath component cannot be determined by the geometry. In the following steps, downlink is assumed. For uplink, arrival and departure parameters have to be swapped.

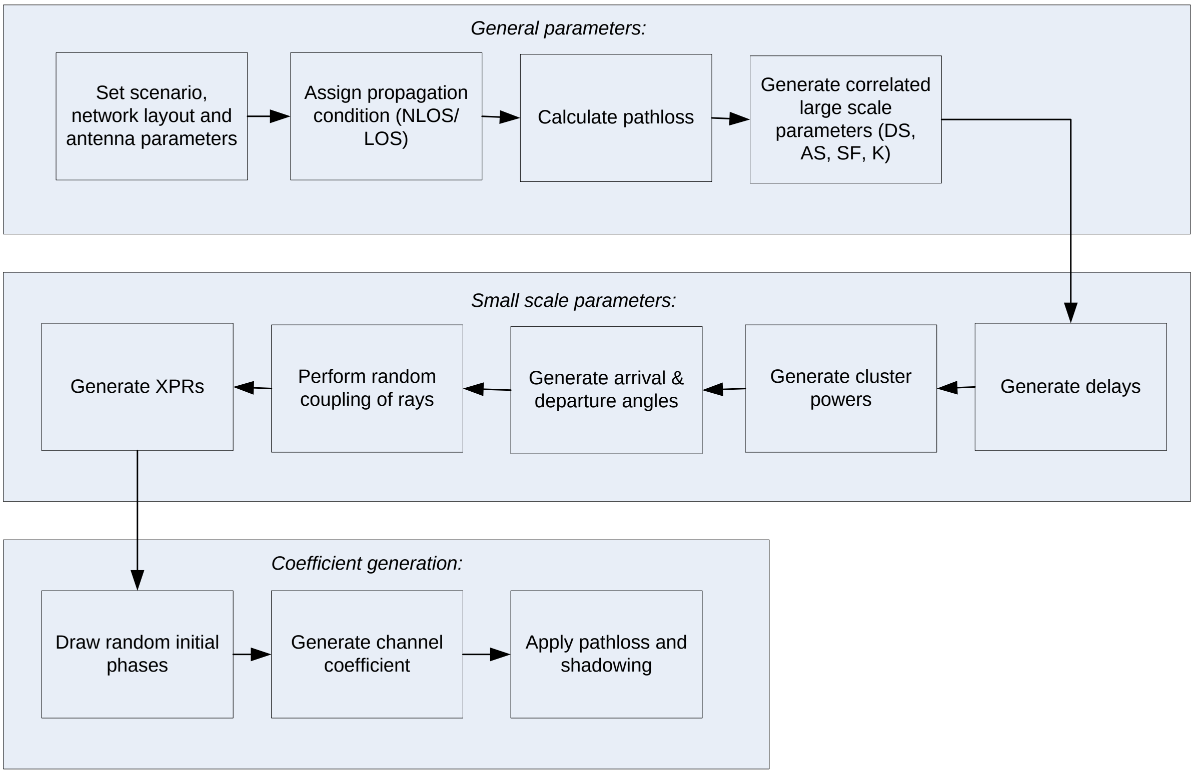

Figure 5: Channel coefficient generation procedure

General parameters:

Step 1: Set environment, network layout, and antenna array parameters

a) Choose one of the scenarios (3D-UMa, 3D-UMi)

Large scale parameters:

Step 2: Assign propagation condition (LOS/NLOS)

Step 3: Calculate pathloss

Step 4: Generate correlated large scale parameters, i.e. delay spread, angular spreads, Ricean K factor and shadow fading term

Small scale parameters:

Step 5: Generate delays

Step 6: Generate cluster powers

Step 7: Generate arrival angles and departure angles for both azimuth and elevation

Step 8: Coupling of rays within clusters for both azimuth and elevation

Step 9: Generate XPRs

Coefficient generation:

Step 10: Draw initial random phases

Step 11: Generate channel coefficients

Step 12: Apply pathloss and shadowing

8 Simulation results

[NOTE: This section will include baseline simulation results (corresponding to a number of antenna ports and transmission scheme supported by Rel-11) with the modified evaluation methodology]

Annex A: (Informative) Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2013-01	*RAN1#72*	*R1-130815*			*Initial draft*		*0.1.0*
2013-04	*RAN1#72bis*	*R1-131244*			*Include agreements in RAN1#72 in section 6*	*0.1.0*	*0.2.0*
2013-05	*RAN1#73*	*R1-132311*			*Include agreements in RAN1#72b in section 6, 7*	*0.2.0*	*0.3.0*
2013-08	*RAN1#74*	*R1-134024*			*Include agreements and working assumptions in RAN1#72b, RAN1#73, RAN1#74 in section 7*	*0.3.0*	*1.1.0*