



**LTE;  
5G;**

**Study on channel model for frequency spectrum above 6 GHz  
(3GPP TR 38.900 version 14.2.0 Release 14)**



---

Reference

DTR/TSGR-0138900ve20

---

Keywords

LTE,NR

**ETSI**

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

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

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

---

**Important notice**

The present document can be downloaded from:

<http://www.etsi.org/standards-search>

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the only prevailing document is the print of the Portable Document Format (PDF) version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at

<https://portal.etsi.org/TB/ETSI/DeliverableStatus.aspx>

If you find errors in the present document, please send your comment to one of the following services:

<https://portal.etsi.org/People/CommitteeSupportStaff.aspx>

---

**Copyright Notification**

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.

The content of the PDF version shall not be modified without the written authorization of ETSI.

The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2017.  
All rights reserved.

DECT™, PLUGTESTS™, UMTS™ and the ETSI logo are Trade Marks of ETSI registered for the benefit of its Members.  
3GPP™ and LTE™ are Trade Marks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.

oneM2M logo is protected for the benefit of its Members  
GSM® and the GSM logo are Trade Marks registered and owned by the GSM Association.

---

## Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: "*Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards*", which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (<https://ipr.etsi.org>).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

---

## Foreword

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

The present document may refer to technical specifications or reports using their 3GPP identities, UMTS identities or GSM identities. These should be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between GSM, UMTS, 3GPP and ETSI identities can be found under <http://webapp.etsi.org/key/queryform.asp>.

---

## Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

# Contents

Intellectual Property Rights .....	2
Foreword.....	2
Modal verbs terminology.....	2
Foreword.....	5
1 Scope .....	6
2 References .....	6
3 Definitions, symbols and abbreviations .....	7
3.1 Definitions .....	7
3.2 Symbols.....	7
3.3 Abbreviations .....	8
4 Introduction .....	9
5 General .....	9
6 Status/Expectation of existing information on high frequencies.....	9
6.1 Channel modelling works outside of 3GPP.....	9
6.2 Scenarios of interest .....	11
6.3 Channel measurement capabilities .....	12
6.4 Modelling objectives .....	13
7 Channel model(s) for >6GHz.....	14
7.1 Coordinate system .....	14
7.1.1 Definition.....	14
7.1.2 Local and global coordinate systems .....	15
7.1.3 Transformation from a LCS to a GCS .....	15
7.1.4 Transformation from an LCS to a GCS for downtilt angle only.....	18
7.2 Scenarios .....	20
7.3 Antenna modelling .....	22
7.4 Pathloss, LOS probability and penetration modelling .....	24
7.4.1 Pathloss .....	24
7.4.2 LOS probability .....	27
7.4.3 O2I penetration loss .....	28
7.4.4 Autocorrelation of shadow fading .....	30
7.5 Fast fading model .....	30
7.6 Additional modelling components .....	45
7.6.1 Oxygen absorption.....	46
7.6.2 Large bandwidth and large antenna array .....	47
7.6.2.1 Modelling of the propagation delay .....	47
7.6.2.2 Modelling of intra-cluster angular and delay spreads .....	47
7.6.3 Spatial consistency.....	48
7.6.3.1 Spatial consistency procedure .....	48
7.6.3.2 Spatially-consistent UT mobility modelling .....	49
7.6.3.3 LOS/NLOS, indoor states and O2I parameters .....	51
7.6.4 Blockage .....	52
7.6.4.1 Blockage model A.....	53
7.6.4.2 Blockage model B.....	55
7.6.5 Correlation modelling for multi-frequency simulations.....	57
7.6.6 Time-varying Doppler shift .....	58
7.6.7 UT rotation.....	58
7.7 Channel models for link-level evaluations .....	58
7.7.1 Clustered Delay Line (CDL) models .....	58
7.7.2 Tapped Delay Line (TDL) models.....	63
7.7.3 Scaling of delays.....	66
7.7.4 Spatial filter for generating TDL channel model .....	68
7.7.4.1 Exemplary filters/antenna patterns.....	68

7.7.4.2	Generation procedure .....	69
7.7.5	Extension for MIMO simulations .....	69
7.7.5.1	CDL extension: Scaling of angles .....	69
7.7.5.2	TDL extension: Applying a correlation matrix .....	70
7.7.6	K-factor for LOS channel models.....	70
7.8	Channel model calibration.....	71
7.8.1	Large scale calibration .....	71
7.8.2	Full calibration.....	71
7.8.3	Calibration of additional features.....	72
8	Map-based hybrid channel model (Alternative channel model methodology) .....	75
8.1	Coordinate system .....	75
8.2	Scenarios .....	75
8.3	Antenna modelling .....	75
8.4	Channel generation.....	75
<b>Annex A:</b>	<b>Calculation of angular spread.....</b>	<b>86</b>
<b>Annex B:</b>	<b>Change history .....</b>	<b>87</b>
History .....		88

---

# Foreword

This Technical Report has been produced by the 3<sup>rd</sup> 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:

Version x.y.z

where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- 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 channel model for frequency spectrum above 6 GHz” [2]. The purpose of this TR is to help TSG RAN WG1 to properly model and evaluate the performance of physical layer techniques using the above-6GHz channel model(s).

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 channel model(s) for frequencies above 6 GHz up to 100GHz.

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-151606: "Study on channel model for frequency spectrum above 6 GHz".
- [3] 3GPP TR 36.873 (V12.2.0): "Study on 3D channel model for LTE".
- [4] 3GPP RP-151847: “Report of RAN email discussion about >6GHz channel modelling”, Samsung
- [5] 3GPP R1-163408: “Additional Considerations on Building Penetration Loss Modeling for 5G System Performance Evaluation,” Straight Path Communications
- [6] METIS channel model, METIS 2020,ICT-317667-METIS/D1.4, Feb, 2015
- [7] A S. Glassner, An introduction to ray tracing. Elsevier, 1989
- [8] J. W. McKown, R. L. Hamilton. “Ray tracing as a design tool for radio networks,” Network, IEEE, 1991(6): 27-30.
- [9] T. Kurner, D. J. Cichon, W. Wiesbeck, “Concepts and results for 3D digital terrain-based wave propagation models: An overview,” IEEE J.Select. Areas Commun., vol. 11, pp. 1002–1012, 1993.
- [10] M. Born, E. Wolf, Principles of optics: electromagnetic theory of propagation, interference and diffraction of light. CUP Archive, 2000
- [11] H. Friis, “A note on a simple transmission formula,” proc. IRE, vol. 34, no. 5, pp. 254–256, 1946
- [12] R. G. Kouyoumjian and P. H. Pathak, “A uniform geometrical theory of diffraction for an edge in a perfectly conducting surface,” Proc. IEEE, vol. 62, pp. 1448–1461, Nov. 1974.
- [13] P. Pathak, W. Burnside, and R. Marhefka, “A Uniform GTD Analysis of the Diffraction of Electromagnetic Waves by a Smooth Convex Surface,” IEEE Transactions on Antennas and Propagation, vol. 28, no. 5, pp. 631–642, 1980
- [14] IST-WINNER II Deliverable 1.1.2 v.1.2, “WINNER II Channel Models”, IST-WINNER2, Tech. Rep., 2007 (<http://www.ist-winner.org/deliverables.html>).