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Report to analyse the possibilities to develop reference documents for methods of measurements for radio standards in ETSI

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

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.

Introduction

ETSI TR 100 027 [i.1] written in the early days of ETSI, provides a set of methods of measurement for private mobile radio equipment to be used as draft material in ETSI standards written at a later stage. The original intention was to keep it up to date but that work was never done. Later on other documents addressing methods of measurements were developed (ETSI TR 102 273 [i.2] to [i.9], ETSI TS 103 052 [i.11]). Some ERM WGs have in addition developed their own documents (e.g. ETSI EN 300 220-1 [i.29] in TG28, ETSI EN 303 883 parts 1 [i.30] and 2 [i.31] in TGUWB). There is not one clear reference measurement procedures available for rapporteurs of radio standards with the risk that radio standards in ETSI will diverge in different directions.

The present document aims to analyse the ways in which a set of reference documents (e.g. a set of technical specifications) could be written including text for methods of measurement to be used as reference material in future ETSI standards. The present document analyses if there is a clear benefit of developing and maintaining such reference documents, for which areas reference documents should be developed at a central place in ETSI (e.g. at WGRM), for which areas the expert WG should be responsible, and if there would be other options (e.g. refer to existing documents from other organizations.). Pros and cons of different options are analysed. Such reference documents would provide a clear guidance on common information and methods in harmonised standards and it would be a huge help for rapporteurs of new harmonised standards. The aim of the present document is to describe the various possibilities and find out their different merits.

The present document is structured as follows:

- Clause 1 provides the scope
- Clause 2 provides a list of used normative and informative references
- Clause 3 provides the definition of terms, symbols and abbreviations used in the present document
- Clause 4 provides an overview of available ETSI guidance for rapporteurs of harmonised standards
- Clause 5 provides related information on requirements and definitions
- Clause 6 provides a discussion on the need of a method of measurement
- Clause 7 provides a discussion of the pros and cons of the different options
- Clause 8 provides a conclusion

1 Scope

The present document contains an analysis of the possibilities to develop reference documents for methods of measurements for radio standards in ETSI.

The present document is limited to harmonised standards according to Article 3.2 of Directive 2014/53/EU [i.16].

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TR 100 027 (V1.2.1) (12-1999): "ElectroMagnetic Compatibility and Radio Spectrum Matters (ERM); Methods of measurement for private mobile radio equipment".

[i.2] ETSI TR 102 273-1-1 (V1.2.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties Part 1: Uncertainties in the measurement of mobile radio equipment characteristics; Sub-part 1: Introduction".

[i.3] ETSI TR 102 273-1-2 (V1.2.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 1: Uncertainties in the measurement of mobile radio equipment characteristics; Sub-part 2: Examples and annexes".

[i.4] ETSI TR 102 273-2 (V1.2.1) (2001-12): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 2: Anechoic chamber".

[i.5] ETSI TR 102 273-3 (V1.2.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 3: Anechoic chamber with a ground plane".

[i.6] ETSI TR 102 273-4 (V1.2.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 4: Open area test site".

[i.7] ETSI TR 102 273-5 (V1.2.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 5: Striplines".

[i.8] ETSI TR 102 273-6 (V1.2.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties Part 6: Test fixtures".

[i.9] ETSI TR 102 273-7 (V1.2.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 7: Artificial human beings".

[i.10] ETSI TS 103 051 (V1.1.1) (08-2011): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Expanded measurement uncertainty for the measurement of radiated electromagnetic fields".

[i.11] ETSI TS 103 052 (V1.1.1) (03-2011): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Radiated measurement methods and general arrangements for test sites up to 100 GHz".

[i.12] ETSI TR 103 581 (V1.1.1) (11-2019): "Use of measurement detectors in radio measurement methods".

[i.13] ETSI TS 102 321 (V1.1.1) (05-2004): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Normalized Site Attenuation (NSA) and validation of a fully lined anechoic chamber up to 40 GHz".

[i.14] ETSI TR 102 215 (V1.3.1) (11-2004): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Recommended approach, and possible limits for measurement uncertainty for the measurement of radiated electromagnetic fields above 1 GHz".

[i.15] Regulation (EU) No 1025/2012 of the European Parliament and of the Council of 25 October 2012 on European standardisation.

[i.16] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC Text with EEA relevance.

[i.17] ETSI Directives Version 42r1 from 30 November 2020.

NOTE: Available at https://docbox.etsi.org/Board/ETSI_Directives/42r1_directives_nov_2020.pdf.

[i.18] ETSI EG 203 336 (V1.2.1) (05-2020): "Guide for the selection of technical parameters for the production of Harmonised Standards covering article 3.1(b) and article 3.2 of Directive 2014/53/EU".

[i.19] IEC 60050: "IEC International Electrotechnical Vocabulary".

NOTE: Available at http://www.electropedia.org/.

[i.20] TErms and Definitions Database Interactive (TEDDI).

NOTE: Available at https://webapp.etsi.org/Teddi/.

[i.21] ETSI TR 103 265 (V1.4.1) (12-2019): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Definition of radio parameters".

[i.22] ETSI skeleton of harmonised standards under directives; version from 7 July 2020.

NOTE: Available at https://portal.etsi.org/Services/editHelp/Standards-development/Drafting/Skeletons.

[i.23] A guidance for users of the CISPR standards.

NOTE: Available at https://assets.iec.ch/further_informations/1298/CISPR%20Guide%202021.pdf?0107T10.

[i.24] ANSI C63.10-2013: "American National Standard for Testing Unlicensed Wireless Devices".

[i.25] ETSI TS 138 521-2 (V16.6.0) (02-2021): "5G; NR; User Equipment (UE) conformance specification; Radio transmission and reception; Part 2: Range 2 standalone (3GPP TS 38.521-2 version 16.6.0 Release 16)".

[i.26] ETSI Harmonised Standard check list; approved at OCG RED EMCD meeting#74 (16 March 2020).

[i.27] ETSI TR 100 028-1 (V1.4.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 1".

[i.28] ETSI TR 100 028-2 (V1.4.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 2".

[i.29] ETSI EN 300 220-1 (V3.1.1) (02-2017): "Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz; Part 1: Technical characteristics and methods of measurement".

[i.30] ETSI EN 303 883-1 (V1.2.1) (02-2021): "Short Range Devices (SRD) and Ultra Wide Band (UWB); Part 1: Measurement techniques for transmitter requirements".

[i.31] ETSI EN 303 883-2 (V1.2.1) (02-2021): "Short Range Devices (SRD) and Ultra Wide Band (UWB); Part 2: Measurement techniques for receiver requirements".

[i.32] CEPT Recommendation T/R 24-01 (Copenhagen 1987): "Specifications of equipment for use in the land mobile service".

[i.33] CEPT Recommendation T/R 34-01 (Copenhagen 1987): "Specifications for maritime mobile radio equipment".

[i.34] ETSI ETR 027 (09-1991): "Radio Equipment and Systems (RES); Methods of measurement for private mobile radio equipment".

[i.35] ETSI ETR 273-1-1 (1998): "ElectroMagnetic Compatibility and Radio Spectrum Matters (ERM); Improvement of radiated methods of measurement (using test sites) and evaluation of the corresponding measurement uncertainties; Part 1: Uncertainties in the measuremement of mobile radio equipment characteristics; Sub-part 1: Introduction".

[i.36] ETSI ETR 273-1-2 (1998): "ElectroMagnetic Compatibility and Radio Spectrum Matters (ERM); Improvement of radiated methods of measurement (using test sites) and evaluation of the corresponding measurement uncertainties; Part 1: Uncertainties in the measuremement of mobile radio equipment characteristics; Sub-part 2: Examples and annexes".

[i.37] ETSI ETR 273-2 (1998): "ElectroMagnetic Compatibility and Radio Spectrum Matters (ERM); Improvement of radiated methods of measurement (using test sites) and evaluation of the corresponding measurement uncertainties; Part 2: Anechoic chamber".

[i.38] ETSI ETR 273-3 (1998): "ElectroMagnetic Compatibility and Radio Spectrum Matters (ERM); Improvement of radiated methods of measurement (using test sites) and evaluation of the corresponding measurement uncertainties; Part 3: Anechoic chamber with a ground plane".

[i.39] ETSI ETR 273-4 (1998): "ElectroMagnetic Compatibility and Radio Spectrum Matters (ERM); Improvement of radiated methods of measurement (using test sites) and evaluation of the corresponding measurement uncertainties; Part 4: Open area test site".

[i.40] ETSI ETR 273-5 (1998): "ElectroMagnetic Compatibility and Radio Spectrum Matters (ERM); Improvement of radiated methods of measurement (using test sites) and evaluation of the corresponding measurement uncertainties; Part 5: Striplines".

[i.41] ETSI ETR 273-6 (1998): "ElectroMagnetic Compatibility and Radio Spectrum Matters (ERM); Improvement of radiated methods of measurement (using test sites) and evaluation of the corresponding measurement uncertainties; Part 6: Test fixtures".

[i.42] ETSI ETR 273-7 (1998): "ElectroMagnetic Compatibility and Radio Spectrum Matters (ERM); Improvement of radiated methods of measurement (using test sites) and evaluation of the corresponding measurement uncertainties; Part 7: Artificial human beings".

[i.43] ETSI EG 202 373 (V1.1.1) (08-2005): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Guide to the methods of measurement of Radio Frequency (RF) fields".

[i.44] ETSI EN 302 065-4 (V1.1.1) (11-2016): "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 4: Material Sensing devices using UWB technology below 10,6 GHz".

[i.45] ETSI EN 303 447 (V1.1.1) (09-2017): "Short Range Devices (SRD); Inductive loop systems for robotic mowers in the frequency range 0 Hz to 148,5 kHz; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU".

[i.46] ETSI TR 137 941 (V16.2.0) (01-2021): "Universal Mobile Telecommunications System (UMTS); LTE; 5G; Radio Frequency (RF) conformance testing background for radiated Base Station (BS) requirements (3GPP TR 37.941 version 16.2.0 Release 16)".

[i.47] ETSI TS 138 141-1 (V.16.8.0) (09-2021): "5G; NR; Base Station (BS) conformance testing Part 1: conducted conformance testing (3GPP TS 38.141-1 version 16.8.0 Release 16)".

[i.48] ETSI TS 138 141-2 (V.16.8.0) (09-2021): "5G; NR; Base Station (BS) conformance testing Part 2: radiated conformance testing (3GPP TS 38.141-2 version 16.8.0 Release 16)".

[i.49] ETSI ETR 028 (03-1994): "Radio Equipment and Systems (RES); Uncertainties in the measurement of mobile radio equipment characteristics".

3 Definition of terms, symbols and abbreviations

3.1 Terms

Void.

3.2 Symbols

Void.

3.3 Abbreviations

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

3GPP	3rd Generation Partnership Project
ANSI	American national standards institute
CEPT	Commission Européenne des Postes et Télécommunications - European Conference of Postal and Telecommunications Administrations
CISPR	Comité International Spécial des Perturbations Radioélectriques - International Special Committee on Radio Interference
EA	European co-operation for Accreditation
EC	European Commission
ECC	Electronic Communications Committee of CEPT
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
EN	European standard
ENAP	EN Approval Procedure
ERM	EMC and Radio Spectrum Matters
ETR	ETSI Technical Report
ETSI	European Telecommunications Standards Institute
EU	European Union
EUT	Equipment Under Test

FCC	Federal Communications Commission
HS	Harmonised Standard
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMT	International Mobile Telecommunications
ITU-R	International Telecommunication Union - Radiocommunication
ITU	International Telecommunication Union
KDB	Knowledge DataBase
LNA	Low Noise Amplifier
MSG	Mobile Standards Group of ETSI
RAN	Radio Access Network

NOTE: Technical specification group of 3GPP.

REC	RECommendation
RED	Radio Equipment Directive
RES	Radio Equipment and Systems
RF	Radio frequency
SC	SubCommittee
TB	Technical Body
TC	Technical Committee
TEDDI	Terms and Definitions Database Interactive
TEM	Transverse ElectroMagnetic
TFES	ETSI Task Force TC ERM and TC MSG for the production of Harmonised Standards under the Radio Equipment Directive for the IMT family
TGUWB	ETSI ERM Task Group of for Ultra-WideBand applications
TR	Technical Report
TS	Technical Specification
WGRM	ETSI ERM Working Group on Radio Matters

4 Available ETSI guidance for rapporteurs of harmonised standards

Before starting with the analysis on how to develop reference documents for methods of measurements for radio standards in ETSI, the document does first provide an overview of the status quo.

Harmonised standards are developed within the relevant ERM working group under the leadership of the rapporteur of the standard.

The rapporteurs are guided by the ETSI Drafting Rules, which is provided in the ETSI Directives [i.17].

The ETSI Drafting Rules do first refer to a pre-structured deliverable skeleton [i.22] which is used as a basis for drafting. The skeleton for harmonised standard is maintained by the ETSI secretariat and provides partly technical guidance relevant for measurements procedures, e.g.:

- example text for the environmental profile clause(s) of harmonised standards;
- example text on measurement uncertainty.

The ETSI drafting rules do also define the objective of an ETSI deliverable as "*to define clear and unambiguous provisions in order to facilitate international and European trade and communication*". To achieve this objective, an ETSI deliverable should:

- "*be as complete as necessary within the limits specified by its scope;*
- *be consistent, clear and accurate;*
- *provide a framework for future technological development;*
- *be comprehensible to qualified persons who have not participated in its preparation; and*

- *respect the rules for the drafting of ETSI deliverables.*"

The ETSI Drafting Rules [i.17] has in clause 8.1 the following general guidance on conformance tests for harmonised standards:

- *"the HS shall include all technical specifications necessary for demonstrating presumption of conformity of the products and phenomena within its scope;"*

Further general guidance on conformance tests in harmonised standards is provided in clause 7.2 of ETSI EG 203 336 [i.18]:

- *"Where technical parameters are specified, these should be accompanied by a test/assessment method, related to the required limits and pass/fail criteria. The shared risk approach, which aims to equally share the risks of allowing equipment failing a limit and rejecting equipment that complies with a limit, is standard practice in ETSI HSs. Where the TB decides to include measurement uncertainty in an HS it should not be within a normative part of the HS."*

In addition the ETSI harmonised standard checklist [i.26] provides the following guidance:

- *"Harmonised standards should report precise, complete, well defined and clear performance criteria, technical specifications and test methods to provide presumption of conformity. If deemed appropriate, the harmonised standard can define different precise performance criteria, technical specifications and test methods for different (sub)categories or (sub)classes of radio equipment."*

In addition to the above generic guidance, the common technical content of harmonised standards (e.g. methods of measurements) has been standardized in several generic documents to support the rapporteurs (see Table 1). Table 1 provides a non-exhaustive list of published ETSI reference documents.

Table 1: Reference documents from ETSI

Document	Version, Group, Rapporteur	Title	Comments
ETSI ETR 027 [i.34]	Edition 1 (09-1991), 111 pages ETSI RES 02, Land Mobile Rapporteur: Georges de Brito	Radio Equipment and Systems (RES); Methods of measurement for private mobile radio equipment	Based on CEPT T/R 24-01 [i.32] and T/R 34-01 [i.33]; ETSI ETR 027 [i.34] was adopted in the early days of ETSI with the aim of highlighting the commonalties between the methods of measurement in a variety of ETSI standards; No consideration of measurement uncertainties.
ETSI ETR 028 [i.49]	Edition 2 (03-1994) ETSI RES 02, Land Mobile Rapporteur: Gerald Chambers	Radio Equipment and Systems (RES); Uncertainties in the measurement of mobile radio equipment characteristics	
ETSI ETR 273-1-1 [i.35]	Edition 1, 1998, 199 pages ERM RP01 on Maritime Radio Rapporteur: Gerald Chambers	Improvement of radiated methods of measurement (using test sites) and evaluation of the corresponding measurement uncertainties; Part 1: Uncertainties in the measurement of mobile radio equipment characteristics; Sub-part 1: Introduction	The attached documentation is the outcome of the project team's investigation into the uncertainties involved in radiated measurements.
ETSI ETR 273-1-2 [i.36]	Edition 1, 1998, 197 pages Edition 1, 1998 ERM RP01 on Maritime Radio Rapporteur: Gerald Chambers	Part 1: Uncertainties in the measurement of mobile radio equipment characteristics; Sub-part 2: Examples and annexes	

Document	Version, Group, Rapporteur	Title	Comments
ETSI ETR 273-2 [i.37]	Edition 1, 1998 ERM RP01 on Maritime Radio Rapporteur: Gerald Chambers	Part 2: Anechoic chamber	
ETSI ETR 273-3 [i.38]	Edition 1, 1998 ERM RP01 on Maritime Radio Rapporteur: Gerald Chambers	Part 3: Anechoic chamber with a ground plane	
ETSI ETR 273-4 [i.39]	Edition 1, 1998 ERM RP01 on Maritime Radio Rapporteur: Gerald Chambers	Part 4: Open area test site	
ETSI ETR 273-5 [i.40]	Edition 1, 1998 ERM RP01 on Maritime Radio Rapporteur: Gerald Chambers	Part 5: Striplines	
ETSI ETR 273-6 [i.41]	Edition 1, 1998 ERM RP01 on Maritime Radio Rapporteur: Gerald Chambers	Part 6: Test fixtures	
ETSI ETR 273-7 [i.42]	Edition 1, 1998 ERM RP01 on Maritime Radio Rapporteur: Gerald Chambers	Part 7: Artificial human beings	
ETSI TR 100 027 [i.1]	(V1.2.1) (12-1999), 246 pages ERM RP02 on Land Mobile Radio Rapporteur: Gerald Chambers	Methods of measurement for private mobile radio equipment	Based on ETSI ETR 027 [i.34] and ETSI ETR 273 series [i.35] to [i.42]; includes a number of enhancements, as a result of work done in the preparation of ETSI ETR 273 series [i.35] to [i.42] (which covers radiated measurements).
ETSI TR 100 028-1 [i.27]	(V1.4.1) (12-2001), 241 pages ERM RP02 on Land Mobile Radio Rapporteur: Georges de Brito	Uncertainties in the measurement of mobile radio equipment characteristics; Part 1	Method of calculating the total measurement uncertainty for procedures in ETSI TR 100 027 [i.1].
ETSI TR 100 028-2 [i.28]	(V1.4.1) (12-2001), 285 pages ERM RP02 on Land Mobile Radio Rapporteur: Georges de Brito	Uncertainties in the measurement of mobile radio equipment characteristics; Part 2	
ETSI TR 102 273-1-1 [i.2]	(V1.2.1) (12-2001), 230 pages ERM RP02 on Land Mobile Radio Rapporteur: Hugh Shapter	Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 1: Uncertainties in the measurement of mobile radio equipment characteristics; Sub-part 1: Introduction	Focus on measurement uncertainties for radiated measurements.
ETSI TR 102 273-1-2 [i.3]	(V1.2.1) (12-2001), 185 pages ERM RP02 on Land Mobile Radio Rapporteur: Hugh Shapter	Sub-part 2: Examples and annexes	
ETSI TR 102 273-2 [i.4]	(V1.2.1) (12-2001), 107 pages ERM RP02 on Land Mobile Radio Rapporteur: Hugh Shapter	Part 2: Anechoic chamber	

Document	Version, Group, Rapporteur	Title	Comments
ETSI TR 102 273-3 [i.5]	(V1.2.1) (12-2001), 115 pages ERM RP02 on Land Mobile Radio Rapporteur: Hugh Shapter	Part 3: Anechoic chamber with a ground plane	
ETSI TR 102 273-4 [i.6]	(V1.2.1) (12-2001), 105 pages ERM RP02 on Land Mobile Radio Rapporteur: Hugh Shapter	Part 4: Open area test site	
ETSI TR 102 273-5 [i.7]	(V1.2.1) (12-2001), 47 pages ERM RP02 on Land Mobile Radio Rapporteur: Hugh Shapter	Part 5: Striplines	
ETSI TR 102 273-6 [i.8]	(V1.2.1) (12-2001), 89 pages ERM RP02 on Land Mobile Radio Rapporteur: Hugh Shapter	Part 6: Test fixtures	
ETSI TR 102 273-7 [i.9]	(V1.2.1) (12-2001), 69 pages ERM RP02 on Land Mobile Radio Rapporteur: Hugh Shapter	Part 7: Artificial human beings	
ETSI TS 102 321 [i.13]	(V1.1.1) (05-2004) ERM TG33: Measurement Methods and their Uncertainty Rapporteur: Alan Dearlove	Electromagnetic compatibility and Radio spectrum Matters (ERM); Normalized Site Attenuation (NSA) and validation of a fully lined anechoic chamber up to 40 GHz	
ETSI TR 102 215 [i.14]	(V1.3.1) (11-2004) ERM TG33: Measurement Methods and their Uncertainty Rapporteur: Brian Copsey	Electromagnetic compatibility and Radio spectrum Matters (ERM); Recommended approach, and possible limits for measurement uncertainty for the measurement of radiated electromagnetic fields above 1 GHz	
ETSI EG 202 373 [i.43]	(V1.1.1) (08-2005) ERM TG27: Radio site engineering Rapporteur: Norman Lightfoot	Electromagnetic compatibility and Radio spectrum Matters (ERM); Guide to the methods of measurement of Radio Frequency (RF) fields	
ETSI TS 103 051 [i.10]	(V1.1.1) (08-2011), 75 pages ERM TG27: Radio site engineering Rapporteur: Manfred Dudde	Expanded measurement uncertainty for the measurement of radiated electromagnetic fields	
ETSI TS 103 052 [i.11]	(V1.1.1) (03-2011), 44 pages ERM TG27: Radio site engineering Rapporteur: Manfred Dudde	Radiated measurement methods and general arrangements for test sites up to 100 GHz	
ETSI EN 300 220-1 [i.29]	(V3.1.1) (02-2017) Technical Body: ERM TG28 Rapporteur: Philippe Magneron	Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz; Part 1: Technical characteristics and methods of measurement	

Document	Version, Group, Rapporteur	Title	Comments
ETSI TR 103 265 [i.21]	(V1.4.1) (12-2019) ERM WGRM Rapporteur: Sjoert Fleurke	Electromagnetic compatibility and Radio spectrum Matters (ERM); Definition of radio parameters	
ETSI TR 103 581 [i.12]	(V1.1.1) (11-2019) ERM WGRM Rapporteur: Ralf Kallenborn	Use of measurement detectors in radio measurement methods	
ETSI EN 303 883-1 [i.30]	(V1.2.1) (02-2021) ERM TGUWB Rapporteur: Michael Mahler	Measurement methods for transmitters	
ETSI EN 303 883-2 [i.31]	(V1.2.1) (02-2021) ERM TGUWB Rapporteur: Michael Mahler	Measurement methods for receivers	
ETSI TR 137 941 [i.46]	(V16.2.0) (02-2021) 3GPP RAN 4, ETSI ERM TFES Rapporteur: Michal Szydelko	Radio Frequency (RF) conformance testing background for radiated Base Station (BS) requirements	
ETSI TS 138 141-1 [i.47]	(V16.8.0) (09-2021) 3GPP RAN 4, ETSI ERM TFES Rapporteur: Ye Liu	Base Station (BS) conformance testing Part 1: conducted conformance testing	
ETSI TS 138 141-2 [i.48]	(V16.8.0) (09-2021) 3GPP RAN 4, ETSI ERM TFES Rapporteur: Ye Liu	Base Station (BS) conformance testing Part 2: radiated conformance testing	

5 Requirements and definition of terms

Connected to each method of measurement is a requirements, which is ideally defined at a central place. The definition of terms used in ETSI standards are summarized in ETSI TR 103 265 [i.21] and in the TEDDI database [i.20]. At the time of writing the present document the definition of terms in published ETSI standards were not aligned between all ETSI standards.

To improve the situation, a new work is planned to develop preferred and common definition of terms for harmonised standards. The aim is to align the definition of terms in ETSI standards.

Generally a harmonised standard should not create its own terms if the parameters are already defined at a higher level, e.g. in the EC Directives, EC Decisions, CEPT/ECC documents, ITU-R documents, Radio Regulations. Another useful source for definitions is the IEC International Electrotechnical Vocabulary [i.19].

6 The need of a method of measurement

Is a method of measurement needed as a normative part in a harmonised standard to proof the compliance against a requirement or is method of measurement redundant? Three theoretical cases are possible:

- Case A: A standard says nothing and everything is left to the interpretation of the manufacturer (risk assessment)
- Case B: A standard provides a common method of measurement which ensures a common quality (state of the art)
- Case C: A standard provides every detail

As a first step the value of a harmonised standard only with requirements but without measurement procedures is discussed in the following (Case A):

- such a standard would not provide a standardized methods of measurement;
- the manufacturer would need to proof in its technical documentation and risk assessment how the equipment complies with the requirements without a standardized guidance;
- in absence of a harmonised method of measurement, the quality of the assessment of the manufacturers (with and without measurements) would very likely be very different; and
- the quality of the assessment would also depend on the quality of the definition of the requirements (e.g. in the regulation), and in many cases the regulation is not absolutely clear; for this reason one main objective of standardization is to support/complement the regulation);
- national frequency assignments do usually refer to a harmonised standards, to clarify how a limit should be measured; without a method of measurement such a reference would be not present.

In addition, the ETSI drafting rules [i.17] and the ETSI EG 203 336 [i.18] do ask for a method of measurement to be used (see more details in clause 4).

As a consequence a harmonised standard should, if possible, contain guidance on how to perform a measurement to test compliance towards parameters given in regulation and mutual agreements achieved in ETSI (not being regulation).

However, it is important to note that for some parts of a method of measurement it is more important to provide a detailed description than for others; test hardware and test setup description may require more details than the description of the test process (e.g. test frequencies, angular resolution of antenna measurements). Further information on the detail degree of a method of measurement is provided in Annex A. It should also be noted that standardization is an iterative process, where shortcomings in a published standard are reported to ETSI which triggers a new work item to improve the standard.

Also the RED [i.16] foresees a procedure for market surveillance authorities for radio equipment presenting a risk at national level (Directive 2014/53/EU [i.16] article 40 and 41), which can lead to the withdrawal of the references to the harmonised standard concerned from the Official Journal of the European Union (Regulation (EU) No 1025/2012 [i.15] article 11 on "Formal objections to harmonised standards").

The above conclusion that a method of measurement should (if possible) be part of a harmonised standard, is drawn under the assumption that the method of measurement is feasible. They apply to typical regulatory requirements like radiated power, unwanted emissions, receiver requirements. But there are (regulatory) requirements where a method of measurement procedure is not possible or is meaningless:

- Duty cycle limit in regulation for equipment where the duty cycle of the equipment is dependent on the use (e.g. garage door opener).
- Push-button, Wall contact (ETSI EN 302 065-4-1 [i.44]).
- Dimension of boundary wire of a lawn mower (ETSI EN 303 447 [i.45]).
- Applying requirements over temperature range.

Such requirements do typically apply to the user of the equipment or to the installer of a network and they cannot be tested when putting the device to the market. One approach could be to outlaw such requirements in the scope clause but this requires the manufacturer to declare the applicability of this.

7 Discussion

7.1 Summary previous clauses

Guidance for rapporteurs of harmonised standard is available in a huge number of ETSI documents (see clauses 4 and 5). However due to the huge number of documents, the variety of possible methods of measurement is also huge and there is a diverse use of terms and definitions.

The need of a method of measurement was discussed in clause 6 and it was concluded that in most cases it is needed. But there are cases where a method of measurement is not possible or meaningless.

7.2 Options to proceed

Are the documents from ETSI now sufficient to support the work of rapporteurs or should ETSI start developing and maintaining reference documents?

Numerous ETSI reference documents are available but they are not maintained at a central place. A clear reference document would be better which should be maintained by ETSI. There is agreement to as much as possible use standardized methods of measurement (including test equipment) and definitions. Requirements for measurements should be equal for all and they do not need to be developed uniquely for each harmonised standard; ETSI should not reinvent the wheel in every standard.

There are basically three different possibilities on how to proceed:

- Option 1: No change
- Option 2: Development of one document with references to existing documents
- Option 3: Development of an "ETSI radio bible"

Table 2: Pros and cons of the options

	Option 1: no change	**Option 2: Document with links to existing documents**	**Option 3: "ETSI radio bible"**
Pros	No effort needed at a central place.	guidance for rapporteurs on which of the many measurement procedures to use	Rapporteurs could profit well from it while developing a new harmonised standard.
	Liberal approach with full flexibility for rapporteur.	Improves quality of harmonised standards	Improves quality of harmonised standards.
			It would also facilitate the manufacturer, economic operators, market surveillance authorities and notified bodies.
			Clear reference for manufacturer, economic operators, market surveillance authorities and notified bodies.
			Less misunderstanding in the interpretation of new harmonised standard.
			Less effort for rapporteurs if the radio bible will be available.

	Option 1: no change	Option 2: Document with links to existing documents	Option 3: "ETSI radio bible"
Cons	The variety of possible measurement procedure is huge, it is not clear which is "the best".	Not clear if the references do work with each other in a harmonised standard	Huge effort to develop the "radio bible".
	Diverse use of terms and definitions, which causes misunderstandings.	Not easy to correct errors in the reference documents	This could put finalized and listed standards under pressure to apply the methods from the "radio bible".
	Huge effort to follow and contribute to standardization as administration.		If all possible/available equipment and methods needs to be reflected in the radio bible, then it is getting a real huge document (e.g. with several methods for each requirement).
	Great effort for rapporteur to develop a new harmonised standard.		Difficulties for harmonized standards based on international standards (e.g. from 3GPP). Those standards refer to measurements methods which are already worldwide approved, ETSI radio bible would have to mention or describe all of them to not create any confusion.
	Challenge for the manufacturer, economic operators, market surveillance authorities and notified bodies to interpret the harmonised standard correctly.		
	Quality of harmonized standards depends on involved people.		

Taking into account the pros and cons listed in Table 2, one can see a tendency towards Option 3. Closer inspection of the listed entries demonstrates gains in regards of quality and reduced time-consuming discussions during the writing of the procedures as dominant factors here.
The major drawbacks in the development of such a document is the large effort in regard to time and resources and the overlap with other existing reference documents (e.g. 3GPP as in [i.46], [i.47] and [i.48]).

Care could be taken that the 'ETSI radio bible' keeps a voluntary status, i.e. a technical report. Otherwise it has to be used in all subsequent and currently existing harmonised standards, hence all changes in the bible are automatically applied to the coupled standards, which is far too much for a measurement guidance to handle. Nonetheless, the radio bible as a voluntary document has anyhow the potential to grow into a document that set a quasi-state-of-the-art, given enough support and appreciation from the ETSI members. Even then this does not mean that different measurement techniques and procedures can be applied in standardization work. However, the disadvantage of a report (and also of an ETSI Guide) would be that a normative reference to it would not be possible and the content would needs to be copied to the harmonised standard. Normative references are only possible to an EN and TS.

Clear is that the "radio bible" cannot be developed with a single new work item or in a single work package; ETSI has only limited resources and thus the development needs to be piecewise.

To the possible content of the "radio bible": The target could be to develop methods of measurement for the requirements from clause 5 of ETSI EG 203 336 [i.18]. A detailed reference description of the following aspects could be offered in the radio bible:

- test sites
- test equipment (e.g. antennas, spectrum analysers)
- procedures
- measurement uncertainty
- environmental conditions

How could this be work be arranged? A potential multipart technical report on "Methods of measurement for radio standards" might consist of the following subparts:

- Part 1-1: Measurement instruments and ancillary equipment:
  - Part 1-1-1: Measurement instruments, e.g. EMI receiver, spectrum analyser, frequency counter
  - Part 1-1-2: Signal generators
  - Part 1-1-3: Antennas
  - Part 1-1-4: Test fixture, test jigs
  - Part 1-1-5: Cables
- Part 1-2: Measurement environments and test sites:
  - Part 1-2-1: Open area test site
  - Part 1-2-2: Semi anechoic chamber
  - Part 1-2-3: Fully anechoic chamber
  - Part 1-2-4: TEM-cell
- Part 2-1: Methods of measurement for transmitter parameters:
  - Part 2-1-1: Radiated power and magnetic field measurements
  - Part 2-1-2: Transmitter frequency stability
  - Part 2-1-3: Transmitter time domain measurements
- Part 2-2: Methods of measurement for receiver parameters:
  - Part 2-2-1: Receiver sensitivity
- Part 3-1: Measurement uncertainties
- Part 3-2: Environmental conditions

The above structure is to be seen as an incomplete initial idea and the final structure/content needs to be decided at a later stage.

ETSI ERM could schedule a remote consensus for discussion to ask ERM working groups for potential work items to find out which aspect to start with; or the work could be contribution driven.

This work could be supported in addition by a service of WGRM to ERM Working Groups and rapporteurs to develop on request specific reference documents (e.g. a sub-part of a technical report).

All this could lead over the years to an "ETSI radio bible".

An excellent idea would be to foresee in addition a document for errata and interpretations like ANSI is doing (see http://www.c63.org/explanations_interpretations_request.htm).

8 Conclusion

The present document has analysed the possibilities and chances given by the development of reference methods of measurements for radio standards in ETSI. Currently, ETSI has a liberal approach that leads to a certain spread in the use of methods of measurement. With the existence of a single reference document which is maintained by ETSI, following opportunities arise for the standardization process:

- higher quality by clear reference texts for the standardization groups;
- starting point and shortcut for discussions during the writing of a standard;

- less effort for rapporteurs and faster production times for a standard.

One major drawback in the development of such a document is the large initial effort in regard to time and resources. Even after the publication, a regular effort of all chapters is needed to keep the document up-to-date. However this could be manageable by a relative small group of radio experts, if the work would be arranged piecewise as described in clause 7.2.

Another drawback is the overlap with other existing reference documents for example at 3GPP. Those standards refer to measurement methods which are already worldwide approved. To avoid this overlap and any potential confusion on the applicability, the "radio bible" could either need to include all possible methods of measurement (which would result in a huge document) or the scope of the "radio bible" could be limited.

ETSI might also consider the establishment of a technical review process to check the methods of measurement of new or updated standards in an advisory nature. A potential candidate for that is WGRM. However, to ensure an objective and reproducible review process it would be sensible to base such a review on written references.

Related to the setting of procedures are terms and definitions, which are not aligned between harmonised standards. It is evident that standardizing methods also calls for stable terms and definitions. Currently, a work item addressing that topic is underway in WGRM, which should be developed in close cooperation with a potential development of reference methods of measurement.

Annex A:
The detail degree auf a method of measurement

A.1 General

Clause 6 has concluded that a method of measurement should be part of a harmonised standard, if possible. The detail degree of a method of measurement depends from many aspects.

Figure A.1 shows an indicative curve of the benefit of a harmonised standard as a function of the detail degree of the method of measurement.

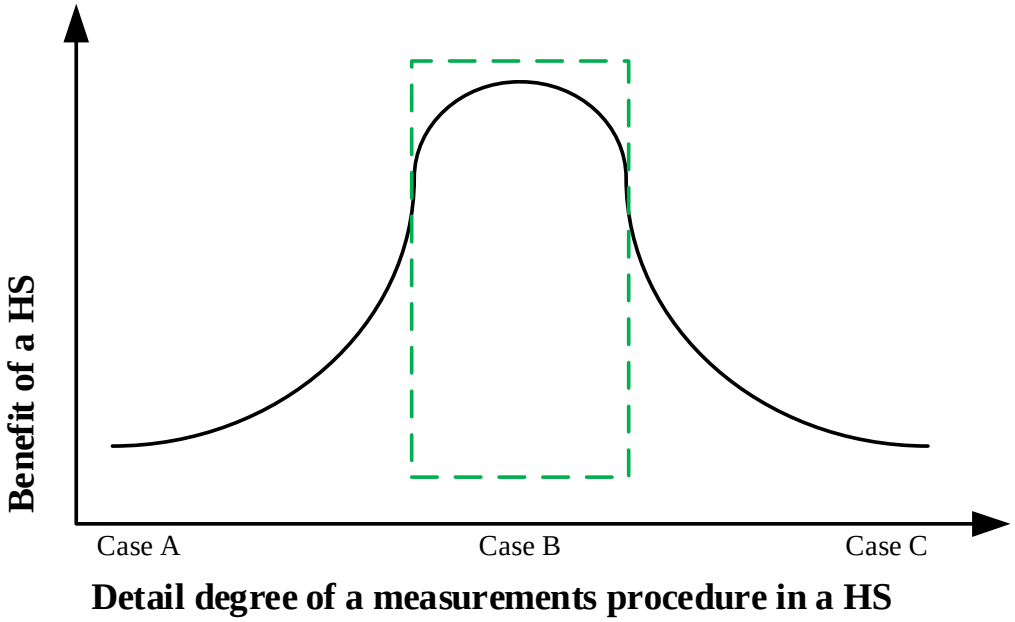

Figure A.1: Benefit vs detail degree

"Benefit" means the advantages a harmonised standard brings to the involved parties (manufacturers, notified bodies, authorities, etc.) in terms of time, costs, measurement errors, misunderstandings etc.

Case C, which requires all details, might be seen as the optimum, but this would require the standardization of each and every detail of the EUT, of the test equipment and of the test procedure. This goal would require a huge effort for all involved parties and it is not clear if this can ever be achieved.

Case B is seen as an optimal detail degree of a measurements procedure and it should be aimed to ensure a common quality of conformance assessments and also assist people who want to carry out the measurements correctly. Only parts of the measurement should be considered which has an impact on the measurement result (e.g. absorbers not relevant for conducted measurements). Such a "state of the art" measurement procedure would be the outcome of a standardization procedure with the involvement of manufacturers, consumer association, test labs and administrations (e.g. the ETSI EN Approval Procedure ENAP).

Why does "Benefit" decrease with increasing level of detail? An over- specification could lead to unnecessary confusions and discussions. A specification consists of measurement setup (hardware), instrument settings, description of the measurement process and limits. Over- specification means many unnecessary information, which have no influence on the measurement. For example, if an LNA is introduced in a normative method of measurement of a harmonised standard, then the manufacturer has the obligation to purchase the specified LNA, even if the measurement instrument has enough dynamics without the LNA. This is a pity, because it generates many unnecessary costs. Besides, the used LNA could lead to measurement errors if it is not used properly.

A.2 Test hardware: Test equipment, test sites, test setup

A common description of the test-setup should be provided in a harmonised standard (Case B or C), a harmonised standard without a description of the test setup (case A) is not a viable solution. Table A.1 provides an indicative description of case B and C for radiated power measurements, just to visualize the difference between case B and C.

Table A.1: Example description of Case B and C for radiated power measurements

	Case B / low detail	Transition area	Case C / High detail
Measurement instrument	Measurement instrument able to measure the limit form the regulation over the required frequency range.		Measurement receiver/analyser with clear specifications compliant with a specific standard or (ITU) recommendation (e.g. as EMI receiver in CISPR 16-1-1)
Settings of measurement instrument	Basic instrument capabilities and measurement parameters and settings are specified for example: Instrument should be able to measure RF power using the following settings: • measurement bandwidth • dynamic range • measurement detectors • measurement time • trace mode • see also ETSI TR 103 581 [i.12]		Instrument should contain a specific measurement mode setting all the parameters described for a particular measurement; this is part of the specification (e.g. as EMI receiver in CISPR 16-1-1, or ANSI C63.2)
Measurement antenna	The used antenna needs a calibration for the required frequency range and parameter to be measured.		A specific antenna (such as a logperiodic) with specific calibration (with given dimensions and number of elements should be used (e.g. EN 55016-1-4 and ANSI C63.5).
Measurement Distance EUT-Test antenna	For the case of radiated power: A far field condition should be achieved for all measured frequencies and the dimensions of the antenna and EUT. Measurement distance to be chosen that limit can be measured given the limited sensitivity of the measurement instrument.		Antenna and EUT is positioned at xx m (fixed distance for each measurement).
Cabling	Cabling providing at least x dB shielding and connectors providing a high repeatability.		Clearly specified cable (e.g. minimum shielding attenuation, connector N).

A.3 Test process, EUT configuration and modes

Not only description of hardware is part of a method of measurement but also the description of the measurement process (how to perform the measurement, how to use the hardware). Such examples are given below:

- How many of the 500 channels to be measured?
- How many points of temperature/humidity on environmental profile to be tested?
- What is the angular resolution of radiated power measurements of a EUT with integral antenna (spherical measurement)?

- How many of the x EUT modulation-stages/ modes?
- Pointing direction of adaptive/scanning antennas during the tests?
- How to find the spurious responses of a receiver?
- Combination of above points leads to a multiplication of the test cases

The goal is that the equipment complies with all the technical requirements under all intended operating conditions (Article 17.1 of RED [i.16]).

But the above examples show the challenge that the consideration of every possible configuration/condition (like a cookbook) can lead to a huge amount of time (and costs). The question is, what the standardization can offer here. Would it partly be acceptable to not provide any guidance in these cases?

Example of the frequency channels: a harmonised standard may not provide any guidance on which channels to be tested and with this it would be left to the manufacturer. This approach is chosen by many standards, because the justification for a limited number of channels cannot easily be done for a wide range of applications in the scope of a standard. But also here the disadvantages of this case A without a standardized solution do apply (the quality of the assessment would depend on the manufacturer). If the aim is to ensure by the harmonised standards a common quality of radio equipment, then a common procedure would be needed, which means to standardize a common procedure, e.g. measurement on the lowest, highest, middle channel. But this may be in contradiction with some legal constrains, because it is not easy to technically justify why three channels are sufficient to proof compliance against a requirement. However, overall it would be better to provide a common procedure. Clause C.1 provides examples how this is dealt with in some standards.

Another example is the spherical measurement of a radiated power. Most standards do provide a detailed description on how to do the scan in frequency, time and space (azimuth/elevation) in order to find the maxima of the emission. Clause C.2 provides examples how this is dealt with in some standards.

The way the environmental profile should be considered in a measurement procedure is already standardized in the ETSI skeleton for harmonised standards [i.22], see Annex B. Two different options are offered:

- whenever an environmental profile is not normatively specified
- whenever an environmental profile is normatively specified

The approach for the environmental profile could possibly also be used in a broader meaning to consider the all possible settings, configurations of the EUT by such a general description.

Annex B:
ETSI skeleton on environmental profile

The ETSI skeleton for harmonised standard under directive [i.22] does provide the following guidance for the environmental conditions for testing:

"Harmonised Standards for equipment whenever an environmental profile is not normatively specified in the present document should use the following text:

Tests defined in the present document shall be carried out at representative points within the boundary limits of the operational environmental profile defined by its intended use.

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions (within the boundary limits of the operational environmental profile defined by its intended use) to give confidence of compliance for the affected technical requirements.

Harmonised Standards for equipment whenever an environmental profile is normatively specified in the present document should use the following alternative text:

Tests defined in the present document shall be carried out at representative points within the boundary limits of the operational environmental profile defined by its intended use, which, as a minimum, shall be that specified in the test conditions contained in the present document.

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions as specified in the present document to give confidence of compliance for the affected technical requirements.

If a clause concerning measurement uncertainties is included in the document, then the text shall be moved to an informative annex (see annexes). Measurement Uncertainty shall not be included in the normative part of a Harmonised Standard."

Annex C:
Examples from standards

C.1 Modes and test channels

ANSI C63.10 [i.24] provides in clause 5.6 guidance on the number of test frequencies in each band of operation (see Table C.1).

Table C.1: Number of frequencies to be tested

Frequency range in which device operates	Location in frequency range of operation
1 MHz or less	Middle
1 MHz to 10 MHz	1 near top and 1 near bottom
More than 10 MHz	1 near top, 1 near middle, and 1 near bottom

Some guidance is also provided by ANSI C63.10 [i.24] on how to find the "worst case mode" to be selected for measurements, e.g. to use for Spurious emissions the mode with the highest output power.

C.2 Spherical measurements

ANSI C63.10 [i.24] provides guidance on measurements around the EUT with the following main elements:

- Test site with turntable allowing EUT azimuth rotation of 0° through 360°: Continuous azimuth searches to identify the direction and field strength of the maximum radiation for each EUT emission frequency.
- Test site without turntable (e.g. If EUT is so large that a turntable is not available): frequency scans of the EUT field strength with both polarizations of the measuring antenna at a minimum of 16 azimuth angles around the EUT, nominally spaced by 22,5°. Smaller azimuth angles are given for directional EUT radiation patterns

See ANSI C63.4 for details of the test site, turntable, and antenna positioner.

ETSI TS 138 521-2 [i.25] provides in clause M.1 a detailed description of the measurement grit points.

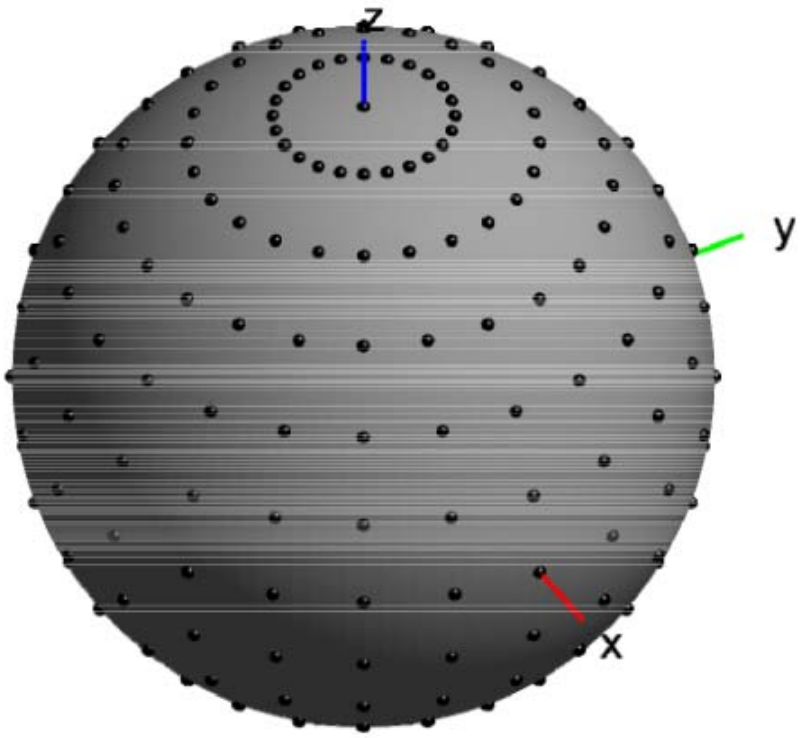

Figure C.1: Distribution of measurement grid points in ETSI TS 138 521-2 [i.25]

Annex D:
Available non-ETSI documents for basic methods of measurement and measurement equipment

D.1 ITU-R, CEPT

- CEPT T/R 24-01 [i.32] (Latest version from 1987): "Specifications of equipment for use in the land mobile service".
- ITU-R Handbook of spectrum monitoring, Edition 2011.
- Recommendation ITU-R V.431-8: "Nomenclature of the frequency and wavelength bands used in telecommunications".
- Recommendation ITU-R V.573-6 (08/2015): "Radiocommunication vocabulary".
- Recommendation ITU-R SM.1045-1 (07/1997): "Frequency tolerance of transmitters".
- ECC/REC(12)03 of 18 February 2013 on determination of the radiated power through field strength measurements in the frequency range from 30 MHz to 6000 MHz, amended 8 February 2019.
- ECC/REC(17)01 of 3 February 2017 on measurement uncertainty assessment for field measurements.
- ECC/REC(07)01 of 31 May 2007 on frequency measurements using Fast Fourier Transform (FFT) techniques.
- ECC/REC(06)01 on Bandwidth measurements using FFT techniques.

D.2 CISPR

CISPR 16-1: this consists of five parts which specify voltage, current and field measuring apparatus:

- Part 1-1 Measuring apparatus
- Part 1-2 Ancillary equipment - Conducted disturbances
- Part 1-3 Ancillary equipment - Disturbance power
- Part 1-4 Ancillary equipment - Radiated disturbances
- Part 1-5 Antenna calibration test sites for 30 MHz to 1 000 MHz

CISPR 16-2: consists of five parts which specify the methods for measuring high-frequency EMC phenomena. It addresses both EMC disturbances and immunity:

- Part 2-1 Conducted disturbance measurements
- Part 2-2 Measurement of disturbance power
- Part 2-3 Radiated disturbance measurements
- Part 2-4 Immunity measurements
- Part 2-5 In situ measurements for disturbing emissions produced by physically large equipment

CISPR 16-3: is basically a technical report rather than a standard and it contains specific technical reports and information on the history of CISPR.

CISPR 16-4: consists of five parts and contains information related to uncertainties, statistics and limit modelling:

- Part 4-1 Uncertainties in standardized EMC tests
- Part 4-2 Uncertainty in EMC measurements
- Part 4-3 Statistical considerations in the determination of EMC compliance of mass-produced products
- Part 4-4 Statistics of complaints and a model for the calculation of limits
- Part 4-5 Conditions for the use of alternative test methods

A guidance for users of the CISPR standards is offered by CISPR in [i.23].

D.3 IEC, ISO

- IEC 60489 (1988): "Methods of measurement for radio equipment used in the mobile services".
- TC 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories:
  - SC 46A: Coaxial cables
  - SC 46F: RF and microwave passive components
- TC 51: Magnetic components, ferrite and magnetic powder materials.
- TC 85: Measuring equipment for electrical and electromagnetic quantities.

D.4 FCC/ANSI

- Electronic Code of Federal Regulations from 14 May 2021: Title 47, Chapter I, Subchapter A, Part 15, §15.31: Measurement standards
- The FCC Knowledge Database (KDB) provides additional guidance on testing devices subject to the FCC rules.

  "The Measurement of Radiated Emissions on Frequencies below 30 MHz":
  https://www.c63.org/documents/c63/ANSI_NIST_Below%2030%20MHz.pdf
- ANSI C63.2-2009: "American National Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz Specifications".
- ANSI C63.4-2014: "American National Standard for Methods of Measurement of Radio- Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz".
- ANSI C63.5 Corrigendum 1-2018: "Electromagnetic Compatibility - Radiated Emission Measurements in Electromagnetic Interference (EMI) Control - Calibration and Qualification of Antennas (9 kHz to 40 GHz) Corrigendum".
- ANSI C63.6-1996: "American National Standard Guide for the Computation of Errors in Open-Area Test Site Measurements".
- ANSI C63.7-2005: "American National Standard Guide for Construction of Open-Area Test Sites for Performing Radiated Emission Measurements".
- ANSI C63.8-draft: "American National Standard for Guidance on specifying requirements for the calibration and verification of EMC test equipment".
- ANSI C63.10-2013 [i.24]: "American National Standard for Testing Unlicensed Wireless Devices".

- ANSI C63.12-2015: "American National Standard for Electromagnetic Compatibility Limits-- Recommended Practice".
- ANSI C63.18-2014: "On-site, Ad-Hoc Test Method for Estimating Radiated Electromagnetic Immunity of Medical Devices to Specific Radio Frequency Transmitters".
- ANSI C63.19-2011: "American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids".
- ANSI C63.23-2012: "Guide for Computations and Treatment of Measurement Uncertainty".
- ANSI C63.25-draft: "Test Site validation time domain".
- ANSI C63-26: "Compliance testing of transmitters used in licensed radio services".
- ANSI C63.27-draft: "American National Standard for Evaluation of Wireless Coexistence".
- ANSI C63.30-draft: "American National Standard of procedures for compliance testing of Wireless Power Transfer products".
- ANSI C63.31-draft: "American National Standard for compliance testing of Industrial, Scientific and Medical (ISM) Equipment".

D.5 IEEE

- IEEE 145-2013™: "IEEE Standard for Definitions of Terms for Antennas".
- IEEE 149-1977™ "IEEE Standard Test Procedures for Antennas".

D.6 Others

- EA-4/02: "Evaluation of the Uncertainty of Measurement in Calibration", www.european-accreditation.org.

History

Document history		
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