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EMF mitigation of mobile networks

Introduction to the actual maximum approach specified in IEC 62232 ED3 (FDIS)

Telecom Paris C2M webinar

Christophe Grangeat (EMF Mitigation Lead) et al.
April 26th, 2022

The actual maximum approach specified in IEC 62232 ED3 (FDIS)

Outline

1. IEC 62232 ED3 standard updates
2. Feature validation case study
3. Power reduction factor (F_{PR}) evaluation methods
4. Conclusion

IEC 62232 ED3 standard roadmap

CDV approved (100%, 09.2021) → FDIS developed (04.2022) → publication mid-2022

Jul'17

Publication of IEC 62232:2017 (ED2)

Global standard for RF exposure assessment of base stations

Apr'19

Publication of IEC TR 62669:2019

IEC 62232:2017 implementation guide & introduction of the actual maximum approach rationale and principles

Dec'19

IEC 106/511/CD

Committee Draft → Specification of the actual maximum compliance approach

Jul'21

IEC 106/550/CDV

Committee Draft for Vote → Specification of monitoring counters & control features validation

May'22

IEC FDIS

Final Draft International Standard → Technical freeze

mid-22

Target publication of IEC 62232:2022 (ED3)

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IEC 62232 ED3 standard

FDIS content

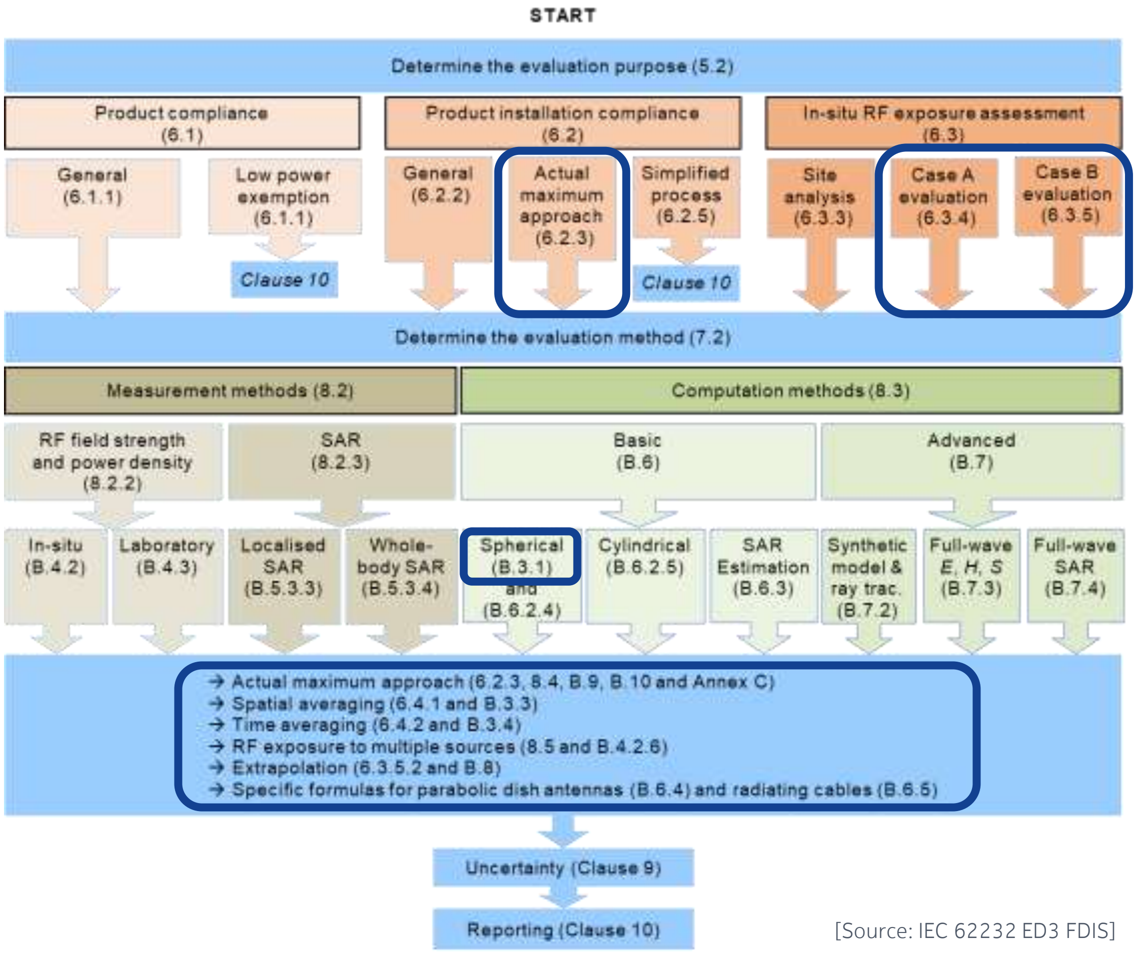
- IEC 62232 ED3 provides a comprehensive set of methods applicable to 5G and beyond
  - Frequency range extended up to 300 GHz
  - ICNIRP-2020 compatible
  - Actual maximum approach specification and validation principles
  - Improvements for beamforming antennas, in-situ measurements, extrapolation
- Actual maximum approach specification
  - Description of the implementation process for product installation compliance
  - Monitoring counters and control feature validation principles have been specified
  - Implementation case studies conducted by vendors, operators and regulators have been included in Annex C

IEC 62232 ED3 standard
Global content

Evaluation purpose

Evaluation methods

Specific technical requirements

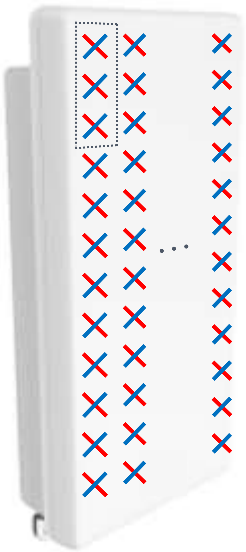


[Source: IEC 62232 ED3 FDIS]

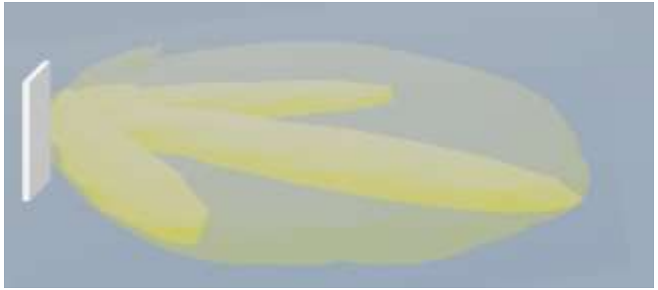
Product compliance

Beamforming and beamsteering antennas

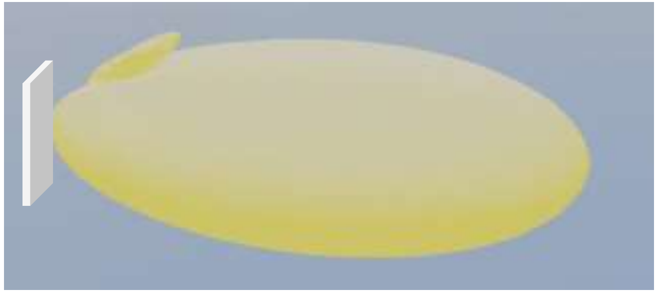
Active antenna array used for beamforming and beamsteering



Typical 3D beam patterns within the envelope



Typical 3D envelope pattern including all possible beams

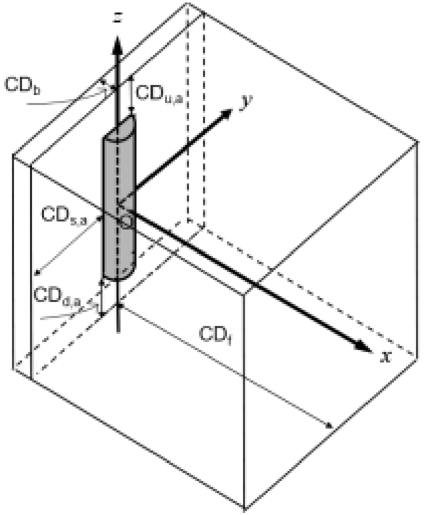


[Source: IEC 62232 ED3 FDIS]

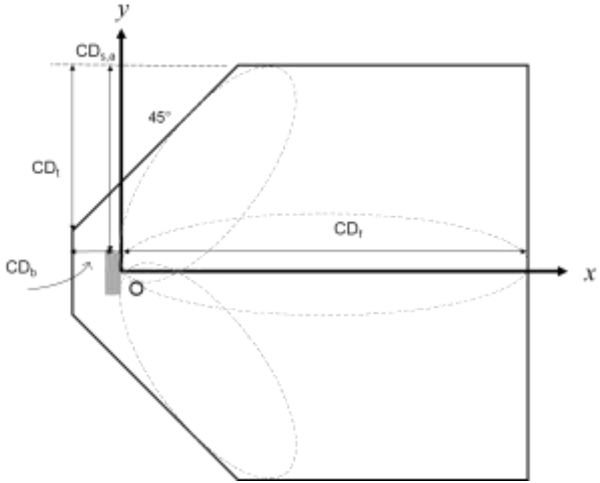
Product compliance

Simplified compliance boundaries

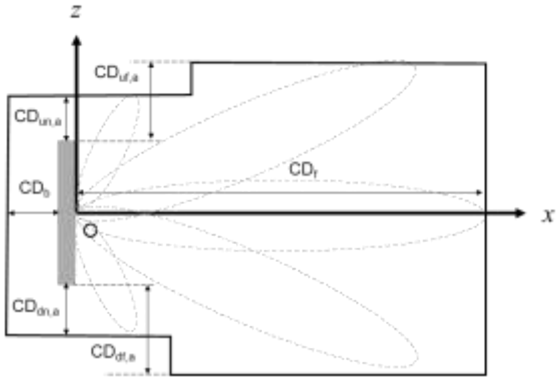
Box shaped (3D view)



Truncated box (top view)



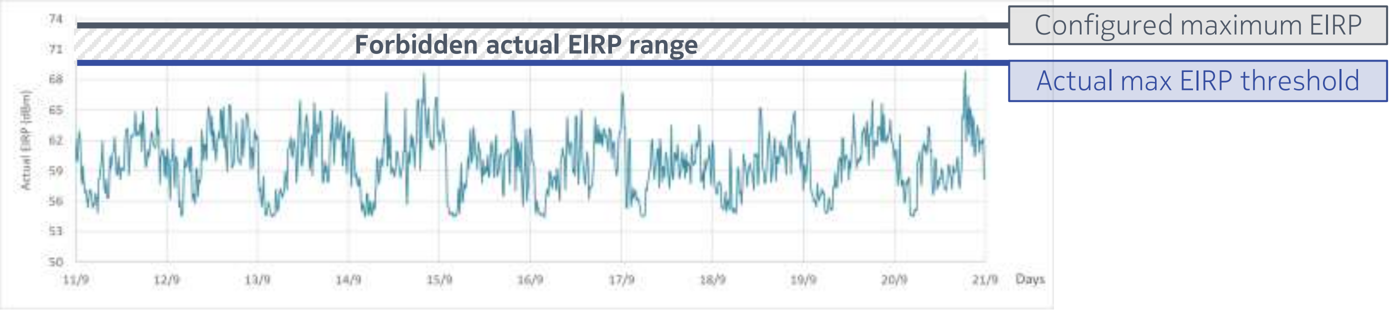
Truncated box for beamsteering (side view)

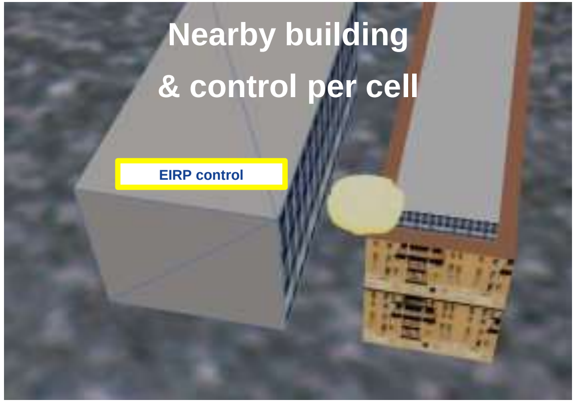


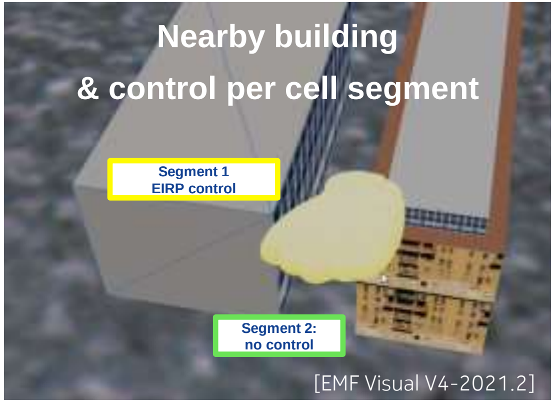
[Source: IEC 62232 ED3 FDIS]

Product installation compliance → The actual maximum approach

To address beam variability (in time and space) and nearby environment constraints







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Actual maximum approach principles

General process

Before putting the BS into operation or when any significant changes are made to the configured parameters of the BS

Step 1: Evaluate the Cumulative Distribution Function

Step 2: Select the percentile applicable to define the actual maximum threshold(s)

Step 3: Determine the actual maximum transmitted power or EIRP threshold(s)

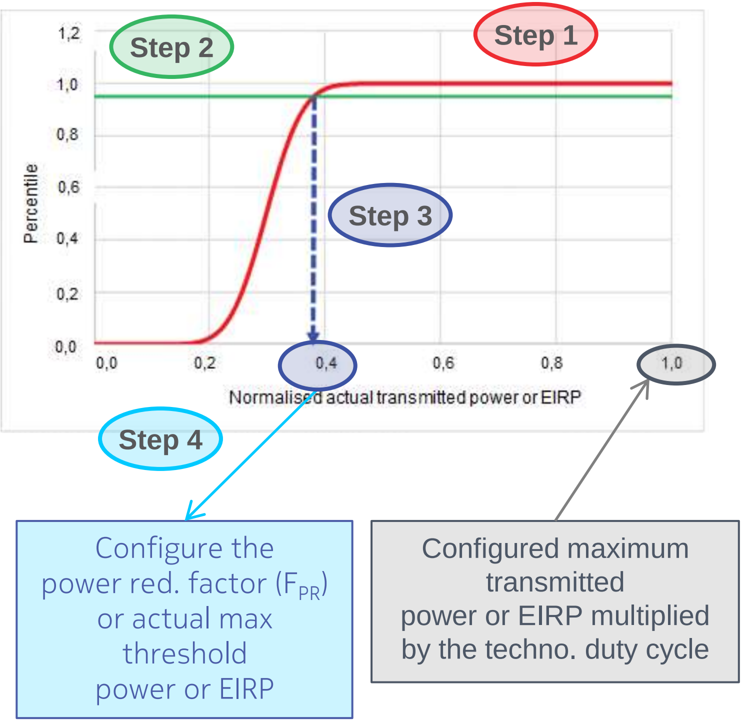
Step 4: Set the BS configured power and power reduction parameters

When the BS is in operation

Step 5: Monitor and/or control the actual transmitted power or EIRP → Reporting (if applicable)

Step 6: Change to BS configured parameters or the actual maximum transmitted power or EIRP threshold(s)

Yes → Step 3

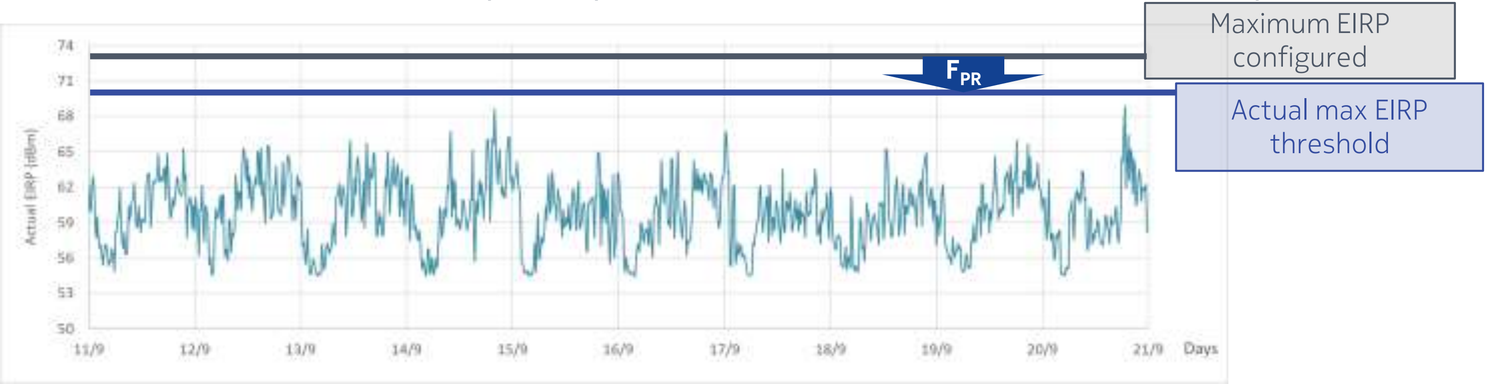


[Source: IEC 62232 ED3 FDIS]

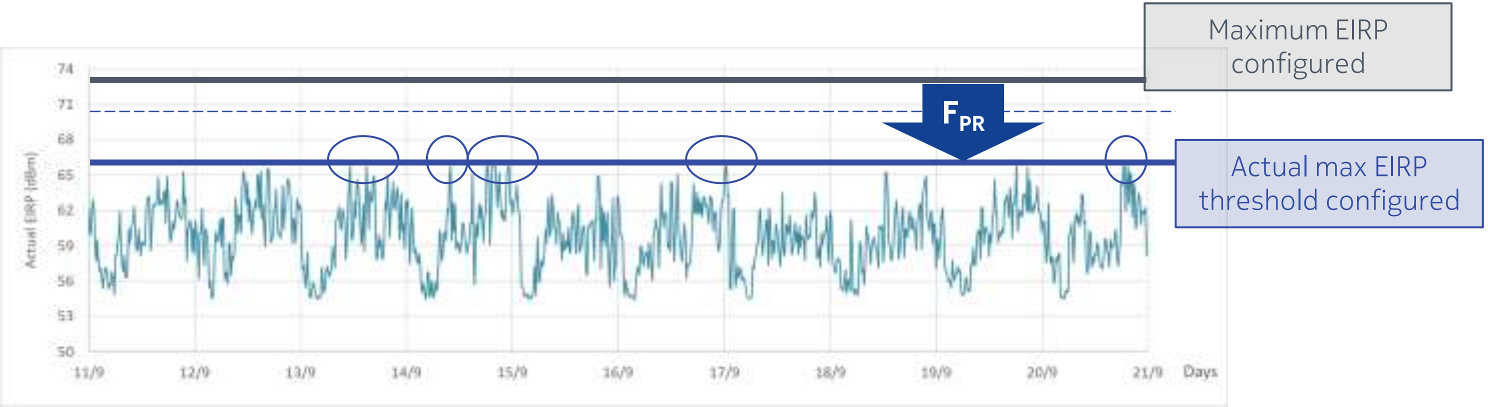
Actual maximum approach principles

Monitoring counters & control features principles when the base station is in operation

Threshold configured **above** the maximum observed power or EIRP



Threshold configured **below** the maximum observed power or EIRP (e.g. 95th percentile)



From monitoring counters recordings using a reporting time of 15 minutes and an averaging time of 6 minutes

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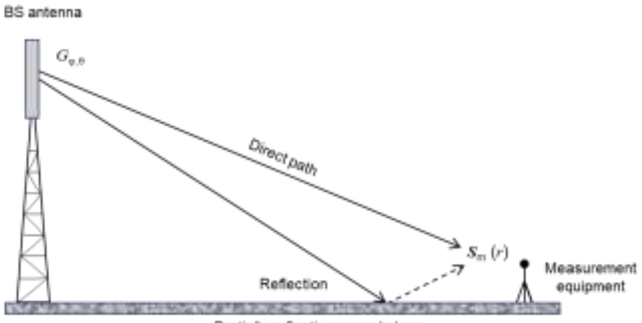
Actual maximum approach principles

Monitoring counters & control features validation

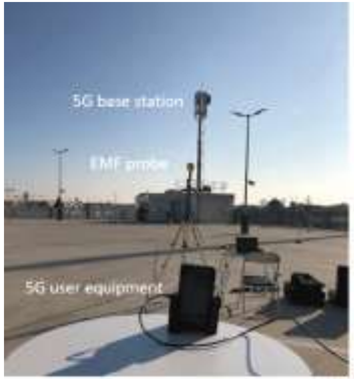
Principles

- Monitoring → validate that power and/or EIRP counters provide values consistent with the measured values of power (in conducted mode) or power density/E-field (for over-the-air testing)
- Control → validate that the configured threshold is not exceeded during operation

Example of validation over-the-air



In an anechoic room



On an operational site

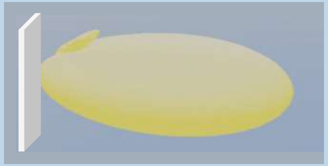
[Source: IEC 62232 ED3 FDIS]

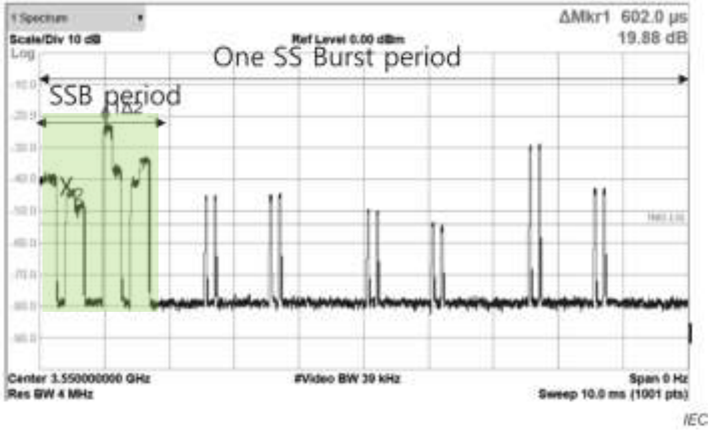
Extrapolation of in-situ measurements

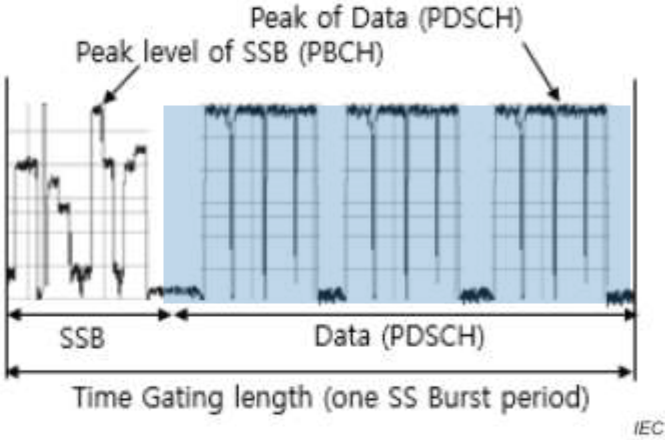
Case of beamforming & beamsteering antennas

1. Measurement of a stable reference signal (power and pattern) leveraging SSB beams

2. Extrapolation of the maximum exposure level at full load







Example of spectrum analyzer views

[Source: IEC 62232 ED3 FDIS]

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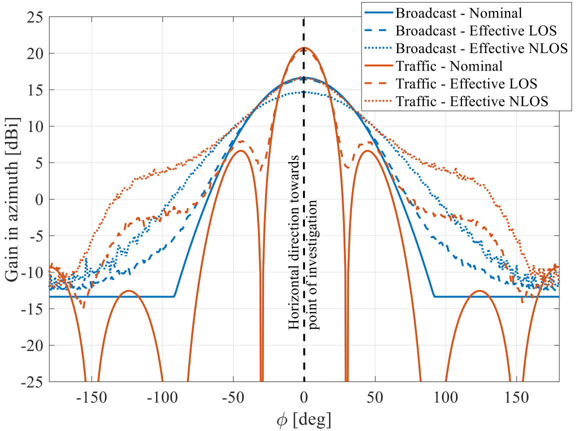
Extrapolation of in-situ measurements

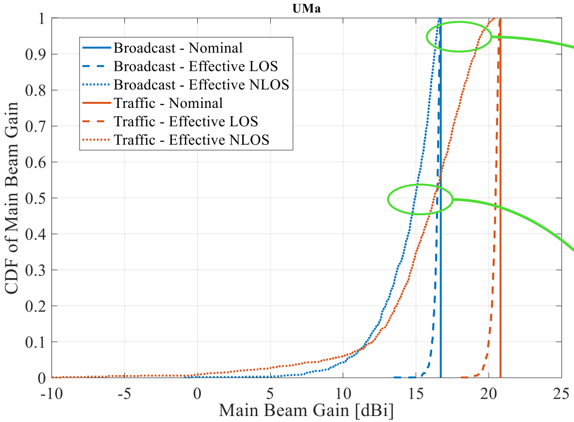
Effective extrapolation – full 3D statistical simulations for 3GPP channel model (TR 38.901)



Nominal and mean effective antenna patterns of broadcast and traffic beams (Commscope RRZZHHTTS4-65B-R7) in 3GPP UMa scenario (boresight direction)

→ Nominal gain of traffic beam = 20.8 dBi

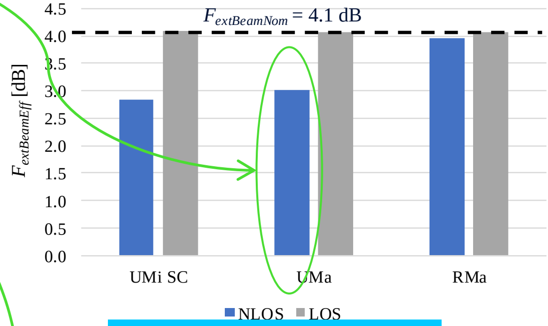
→ Nominal gain of broadcast beam = 16.7 dBi



CDFs of nominal and effective main beam gains for broadcast and traffic patterns of antenna (Commscope RRZZHHTTS4-65B-R7) and 3GPP UMa propagation

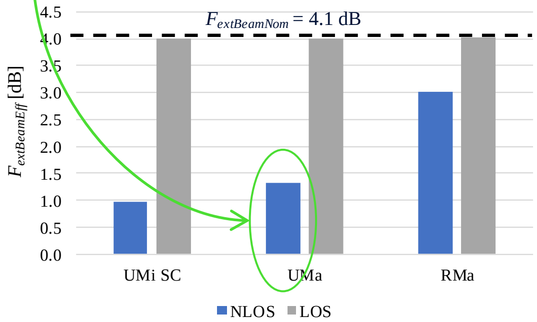
Corresponds to mean AS-2*SD

Based on 95%-tile values of main beams gains



Corresponds to mean AS

Based on median values of main beams gains



From: K. Bechta, C. Grangeat, J. Du and M. Rybakowski, "Analysis of 5G Base Station RF EMF Exposure Evaluation Methods in Scattering Environments", *IEEE Access*, vol. 10, pp. 7196-7206, 2022

The actual maximum approach specified in IEC 62232 ED3 (FDIS)

Outline

1. IEC 62232 ED3 standard updates
2. Feature validation case study
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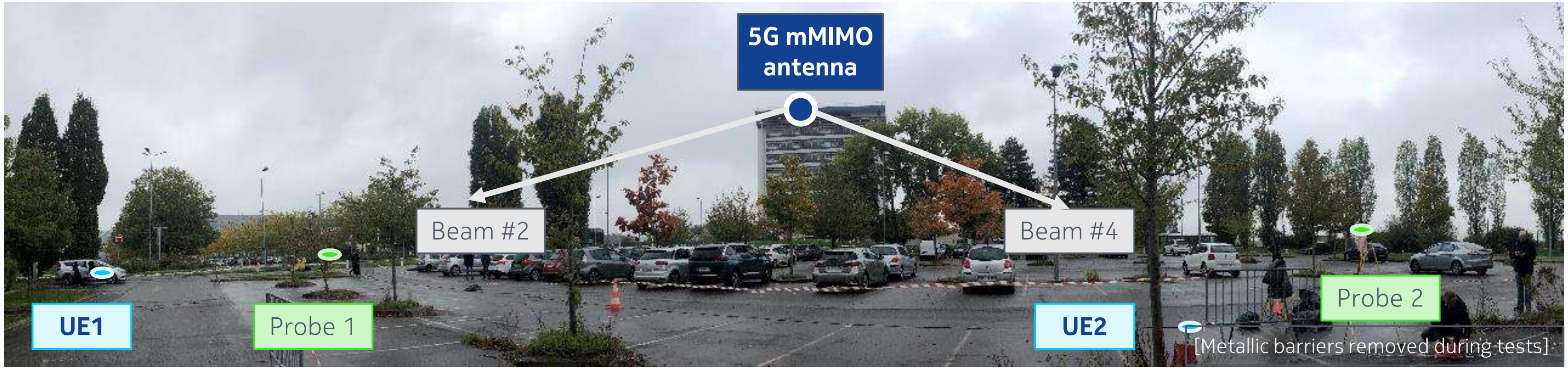
Monitoring counter & control feature validation case study

Test environment

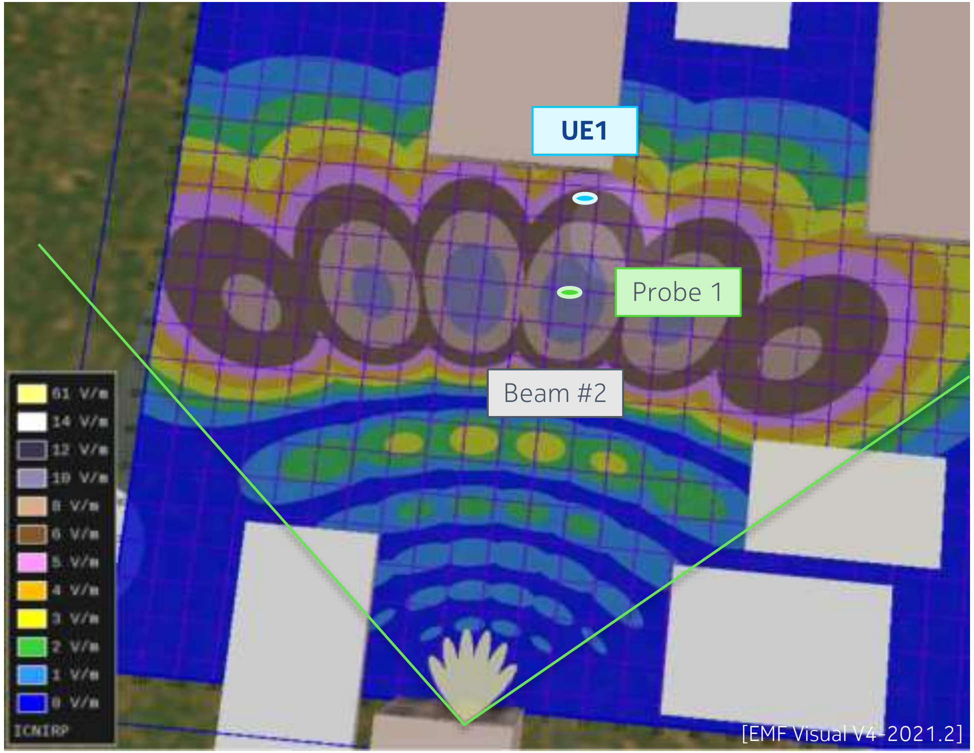
Objective

- Validate monitoring counters
- Validate control feature to ensure the configured threshold is not exceed during operation
- Test results in accordance with IEC 62232 ED3



Monitoring counter & control feature validation case study

Measurement equipment & UE positionning



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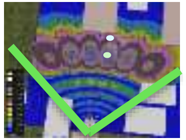
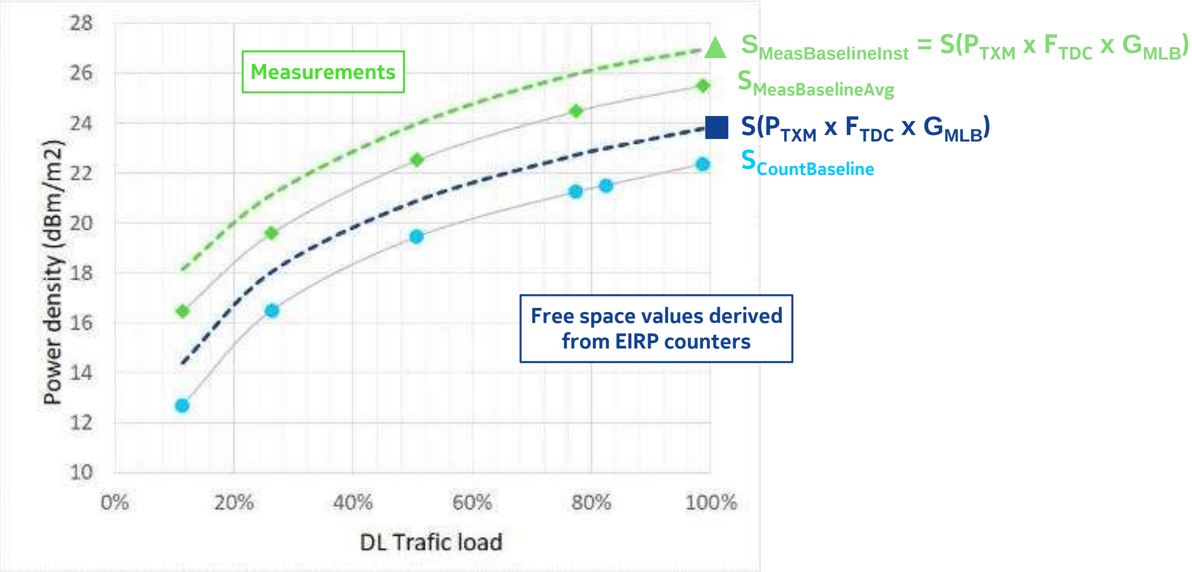
Monitoring counter validation case study

Single UE – single segment





Counters and field measurements follow the same profile with load variations

Measurements are within +/- 4 dB of free space values derived from EIRP counters due to the radio propagation environment (reflexions)

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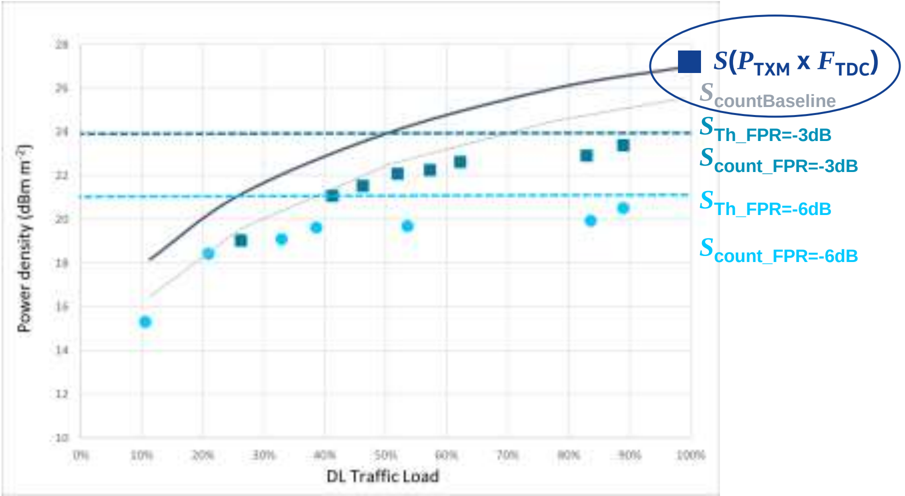
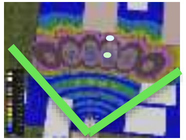
Control feature validation case study

Single UE – single segment

Validation using counters



Vlidation using measurements



NOTE $S_{Th\_FPR=-xdB} = S(P_{TXM} \times F_{TDC} \times F_{PR})$, where F_{PR} = - x dB

Neither measurements nor counters exceed the configured thresholds

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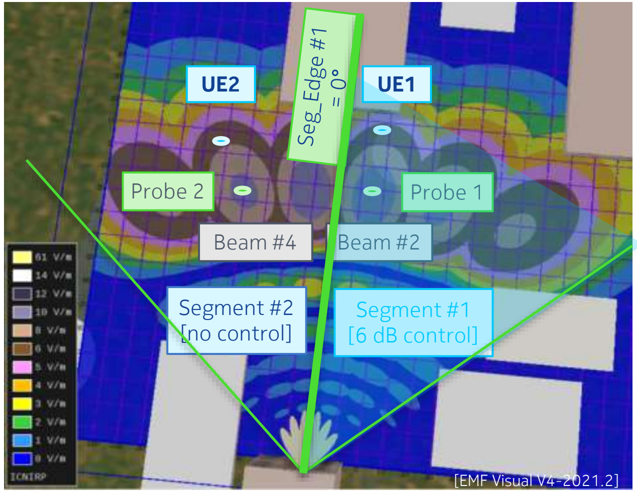
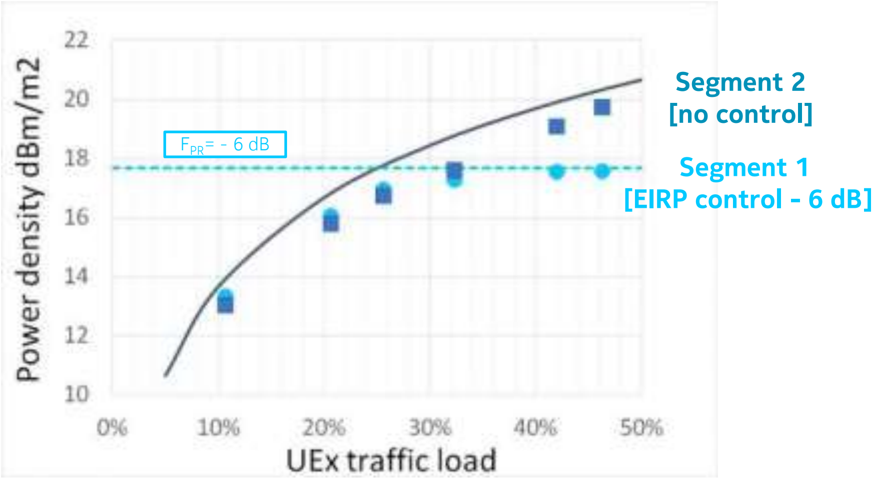
Control feature validation case study

Two UEs – Two segments

Controlled vs uncontrolled segments use case



EIRP counters variations as expected



Monitoring & control features operate as expected
Control feature ensures the configured actual EIRP threshold is not exceed

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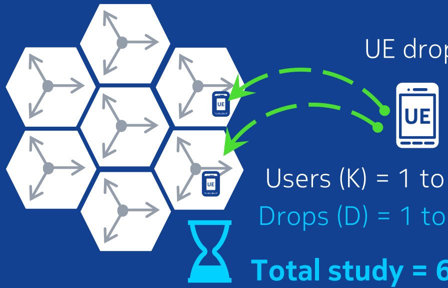
Evaluation of the power reduction factor (F_{PR}) from modelling studies

Outcome of channel modelling studies using 6-min averaging time (ICNIRP-1998)

Model

3GPP TR 36.873
- UMa: 25 m building, 46 dBm
- UMi: 10 m tower, 41 dBm
- Full buffer, 80% indoor, 4 to 8 floors

Test case configuration
- 8x8x1, 2 GHz



Users (K) = 1 to 5/cell

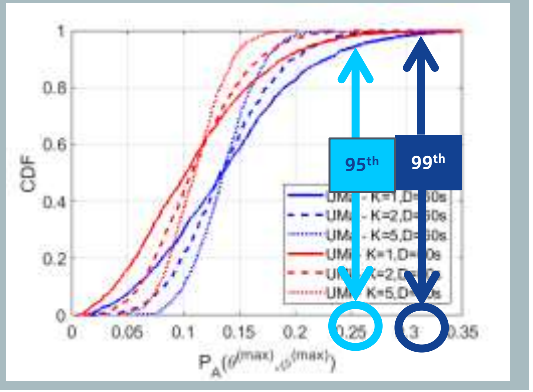
Drops (D) = 1 to 60 s

Total study = 6 min

Tx power statistics

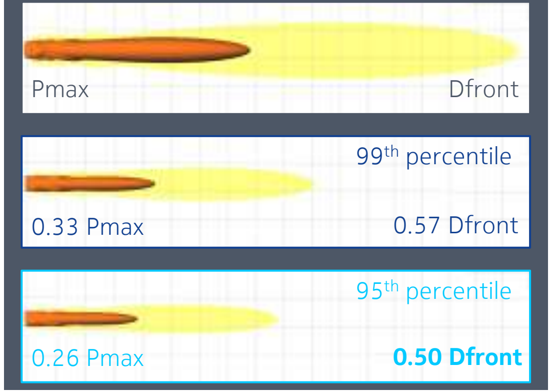
Conservative config
- UMa, K= 1 and D=60s

Actual max power
- 95th percentile = 26% Pmax
- 99th percentile = 33% Pmax



RF compliance

Actual exposure vs. envelope
- Compliance distances divided by a factor 2 using the actual maximum power



[from P. Baracca et al., "A Statistical Approach for RF Exposure Compliance Boundary Assessment in Massive MIMO Systems" https://arxiv.org/abs/1801.08351 & IEC TR62669]

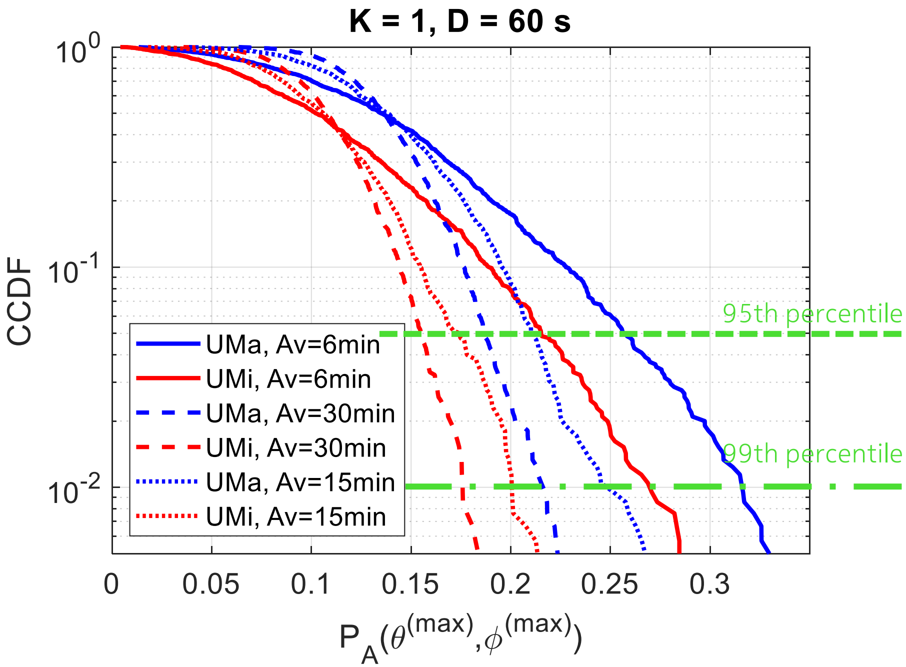
Evaluation of the power reduction factor (F_{PR}) from modelling studies

Impact of the averaging time window: 30-min avg (US & ICNIRP-2020) vs. 6-min avg (ICNIRP-1998)

F_{PR} values with 30-min averaging time are **-1.4 to -1.8 dB below** F_{PR} values using 6-min averaging time

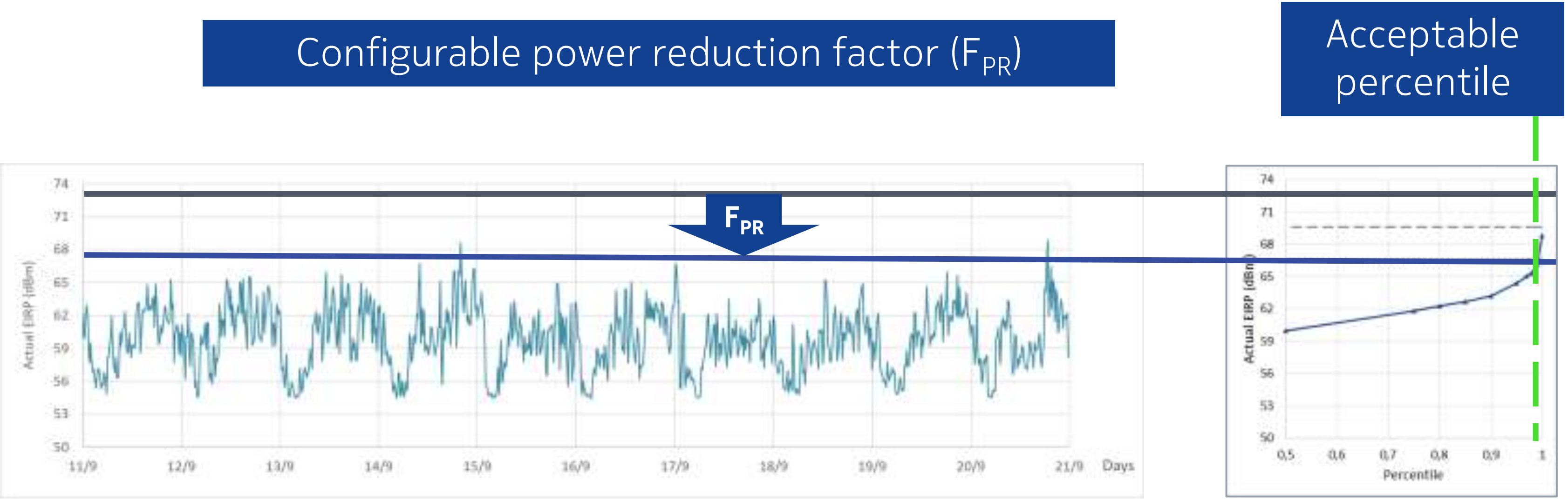
	F_{PR} 6-min	F_{PR} 6-min (dB)	F_{PR} 30-min	F_{PR} 30-min (dB)	Var. (dB)
UMa – p95	0,26	**-5,9**	**0,18**	**-7,4**	**-1.6**
UMi – p95	0,22	-6,6	**0,16**	**-8,0**	**-1.4**
UMa – p99	0,32	-4,9	**0,22**	**-6,6**	**-1.6**
UMi – p99	0,27	-5,7	**0,18**	**-7,4**	**-1.8**

[Presented at BioEM2019 5G workshop in Montpellier]



Evaluation of the power reduction factor (F_{PR})

From operational base station monitoring analytics



Time variation of the actual EIRP

CDF
of the actual EIRP

The actual maximum approach specified in IEC 62232 ED3 (FDIS)

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Introduction to the actual maximum approach specified in IEC 62232 ED3

Conclusion

- IEC 62232 ED3 CDV (Sept'2021) approved by 100% of national committees
  - 18 NCs in favour (Europe, AMEA, APAC, Americas)

- IEC 62232 ED3 FDIS
  - Provides a comprehensive set of methods applicable to 5G and beyond
  - Specifies the actual maximum approach for product installation compliance taking into account the beam variability (in time and space) and nearby environmental constraints
  - Monitoring counters and control features supporting the implementation of the actual maximum approach are specified, operational and validated

- IEC 62232 ED3 publication is expected by mid-2022

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