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Qualcomm

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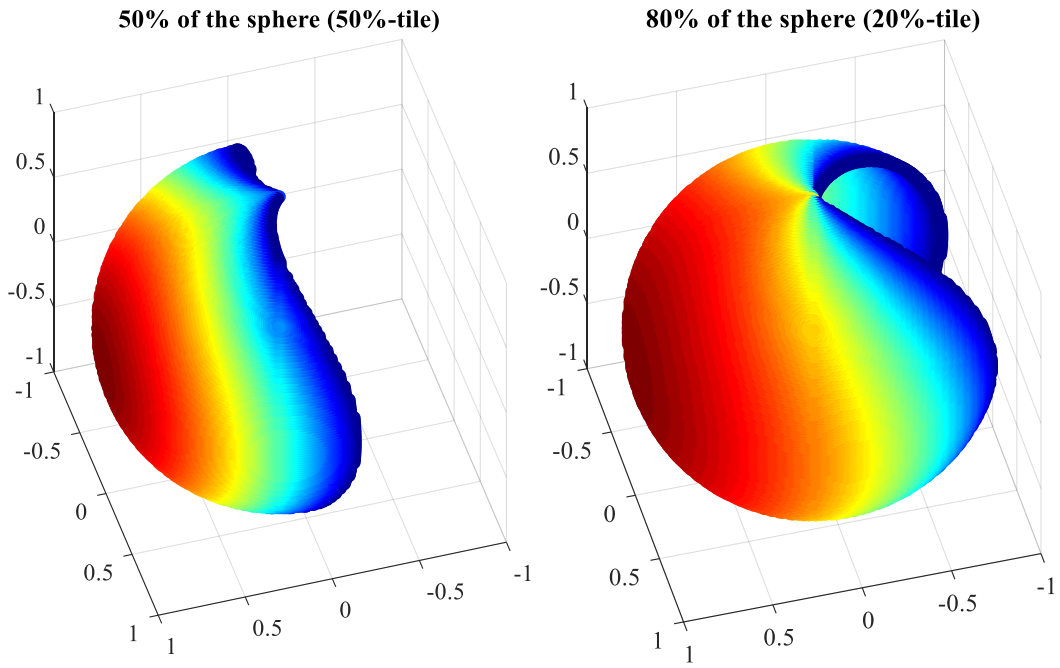
Why spherical coverage matters

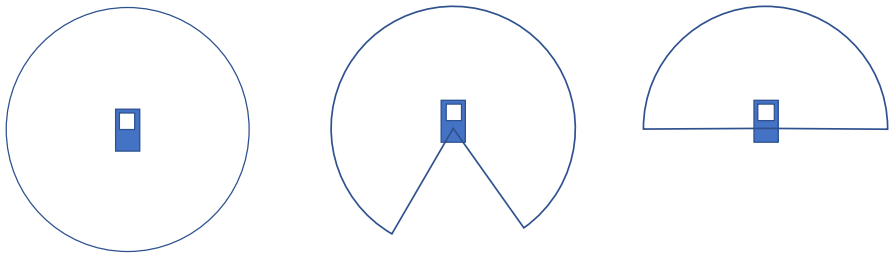
Overview

- In this slide deck we provide a simple link budget analysis considering latest RAN4 agreements on EIRP and EIS
- The goal is to assess how the link budget is statistically affected by the spherical coverage CDF
- The results can be expressed in terms of the maximum allowable UE-BS distance to reach EIS level or, equivalently, in terms of the SNR achievable at a given UE-BS distance
- We also show why lower %-tile is important for RRM testing
- All observations indicate that defining a good spherical coverage requirement is fundamental for NR network deployment

CDF %-tiles and implication on spherical coverage

- With a CDF based only on 50%-tile point, only requirements for half of the points in the sphere will be defined. This means that a single module implementation with very bad coverage in the hemisphere opposite to boresight can pass the requirement (a pictorial representation of an extreme case is shown in the figures below)
- 20%-tile (80% of the sphere) would allow to set a minimum requirement based on at least two modules → much better performance against rotation and hand blockage





100% 80% (20%-tile) 50% (50%-tile)

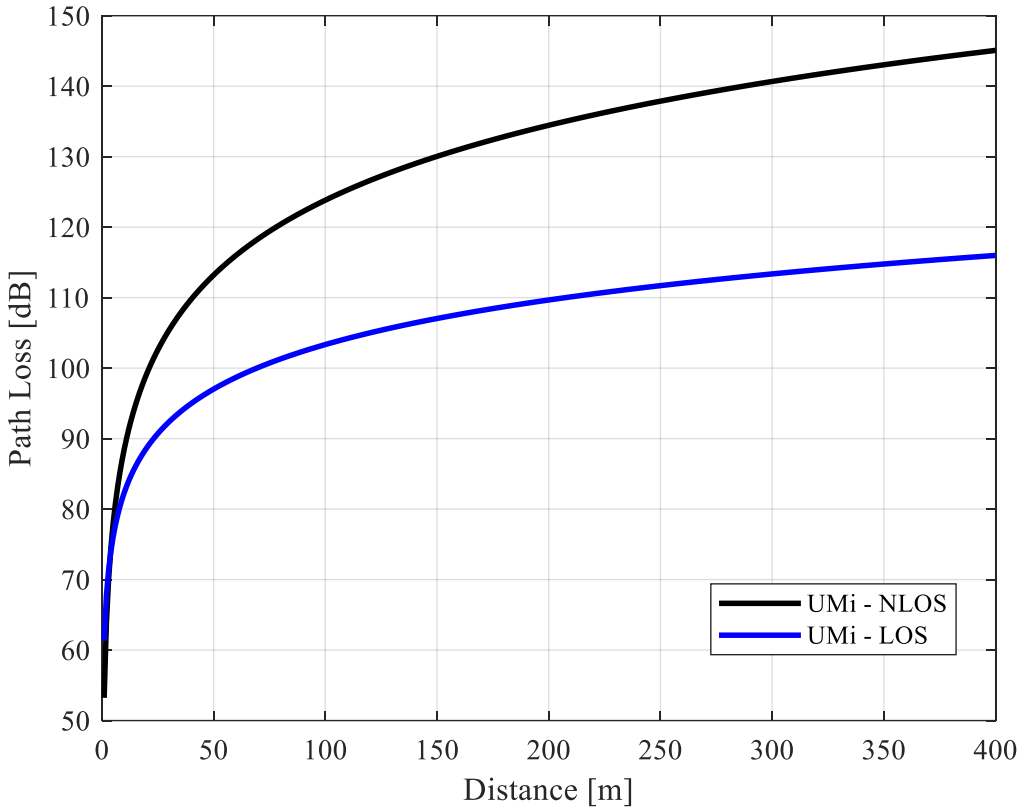
Main assumptions for link budget analysis (1)

Deployments and BS/UE parameters

- Scenario
  - Dense Urban (UMi)
- BS
  - EIRP: 60dBm
  - EIS: -102.5dBm (corresponding to the mid point of the range defined for medium range BS)
- UE
  - EIRP: 22.4dBm
  - EIS: -88.2dBm for 50MHz channel BW following latest RAN4 agreements
- Blockage: no blockage or 15.26dB

Main assumptions for link budget analysis (2)

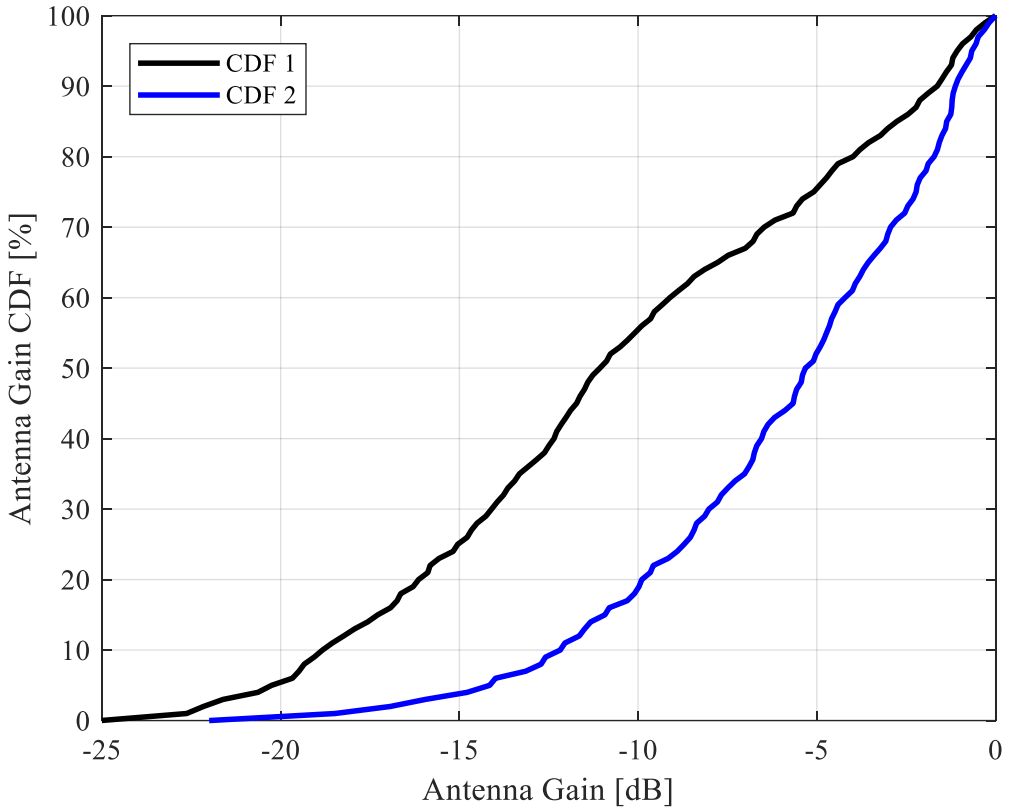
Path loss for UMi LOS vs NLOS



- The figure represents the average path loss for dense urban model, considering both LOS and NLOS conditions

Main assumptions for link budget analysis (3)

Spherical coverage CDFs: single panel vs two panels



- The two CDFs showed in the picture are used in our comparative analysis
- CDF1 (single module/panel):
  - 50%-ile drop = ~11dB
  - 20%-tile drop = ~16.1dB
- CDF2 (two modules/panels):
  - 50%-ile drop = ~5dB
  - 20%-ile drop = ~10dB

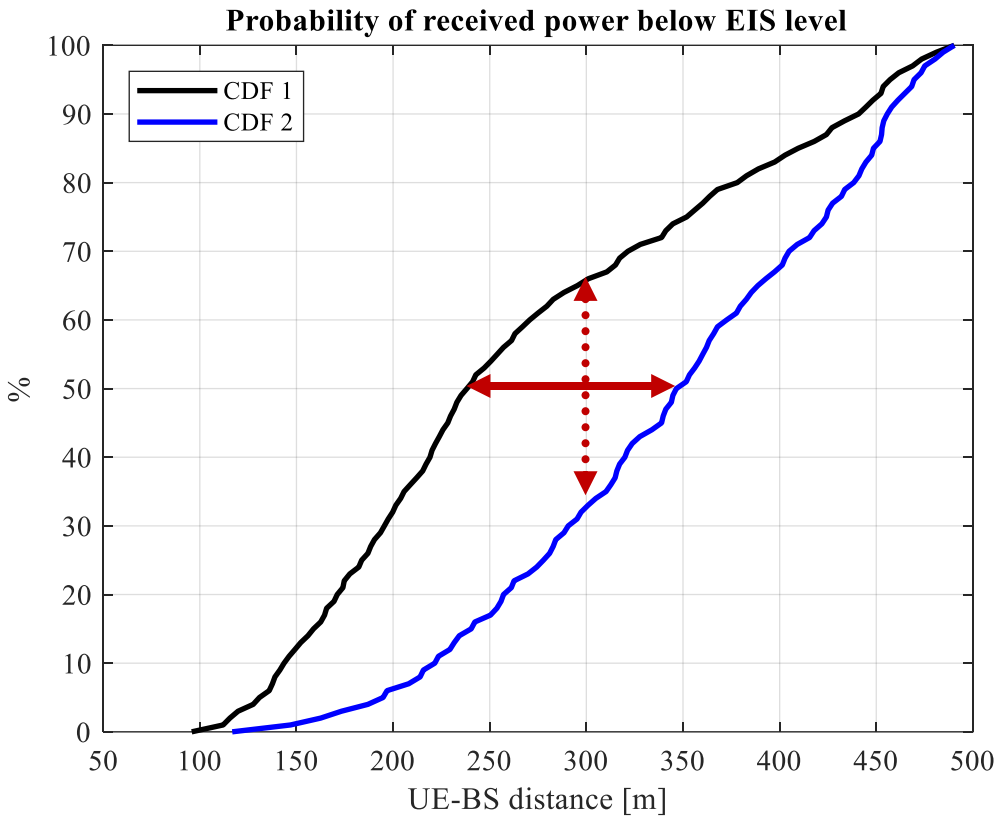
Link budget

Minimum coupling loss to be at EIS level

- The **maximum allowable pathloss** to be at EIS level can be computed as follows for DL and UL, respectively:
  - DL: BS EIRP – UE EIS – Blockage – Shadowing margin
  - UL: UE EIRP – BS EIS – Blockage – Shadowing margin
- The maximum allowed pathloss can be translated into the **cell range** available at EIS level, i.e. the BS-UE distance which would allow to receive a signal at EIS level
- Given the statistical behavior of UE spherical coverage (CDF), the maximum allowable pathloss and cell range can be also represented by probability distributions or CDFs

Probability to receive a signal below EIS level

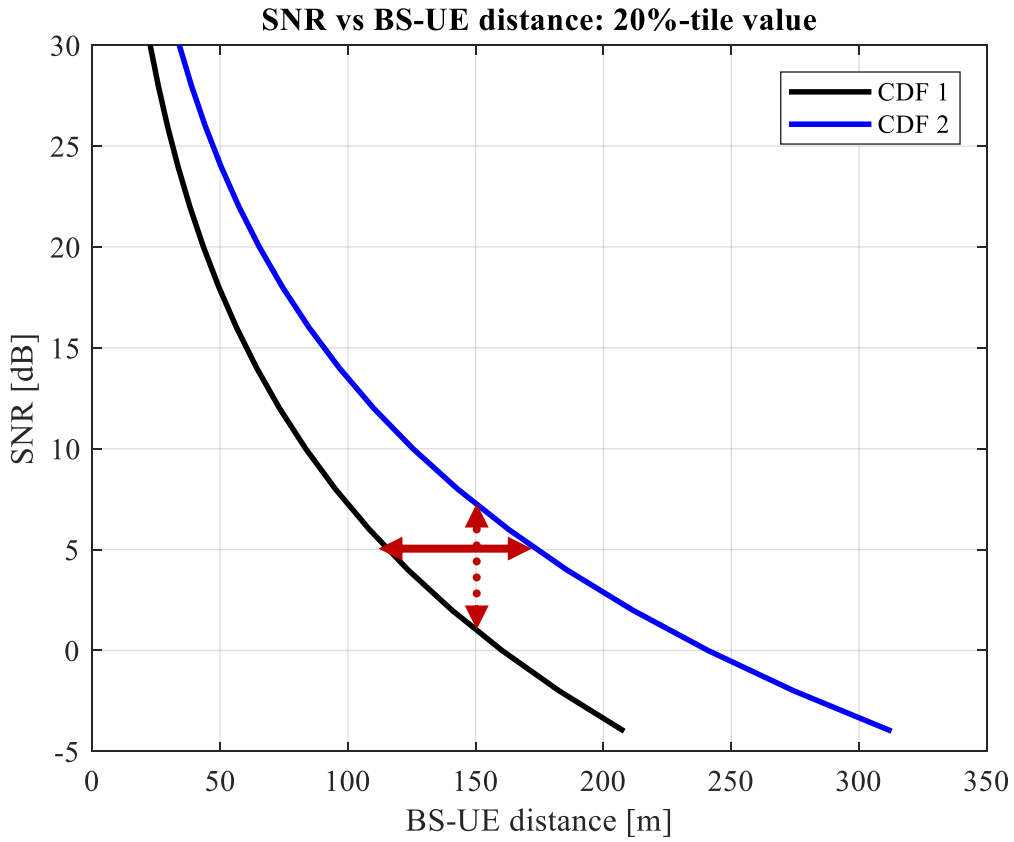
DL – UMi NLOS – No Blockage



- For a given UE-BS distance the probability of receiving a signal below EIS level changes depending on the CDF
  - At 300m ~30% more UEs are at EIS level with two modules
- In the same way, the same reliability (i.e. probability to receive a signal at EIS) can be achieved at larger BS-UE distances in case of better CDF
  - For 50% reliability, 100m better range is achieved with two modules

SNR vs BS-UE distance at a given percentile point

For a given BS-UE distance, better CDF results in better SNR performance



- For a given UE-BS distance a better CDF translate into higher SNR
- In the same way, for the same target SNR, the better CDF allows higher BS-UE distance
- NOTE: no blockage assumed in this picture

Summary of link budget results

UMi path loss model – NLOS conditions

	DL					
	Achievable UE-BS distance [m]					
Probability to receive power below EIS	No Blockage			Blockage		
	CDF1	CDF2	Range Loss for CDF1	CDF1	CDF2	Range Loss for CDF1
20%	171.1	257.1	33%	63.2	95.0	33%
50%	238.2	346.6	31%	88.0	128.1	31%
95%	457.1	469.6	3%	168.9	173.5	3%

	UL					
	Achievable UE-BS distance [m]					
Probability to receive power below EIS	No Blockage			Blockage		
	CDF1	CDF2	Range Loss for CDF1	CDF1	CDF2	Range Loss for CDF1
20%	37.4	56.2	33%	13.8	20.8	33%
50%	52.1	75.8	31%	19.3	28.0	31%
95%	100.0	102.7	3%	37.0	38.0	3%

Cell range degradation vs path loss slope

A simple way to understand the degradation compared to peak EIRP/EIS

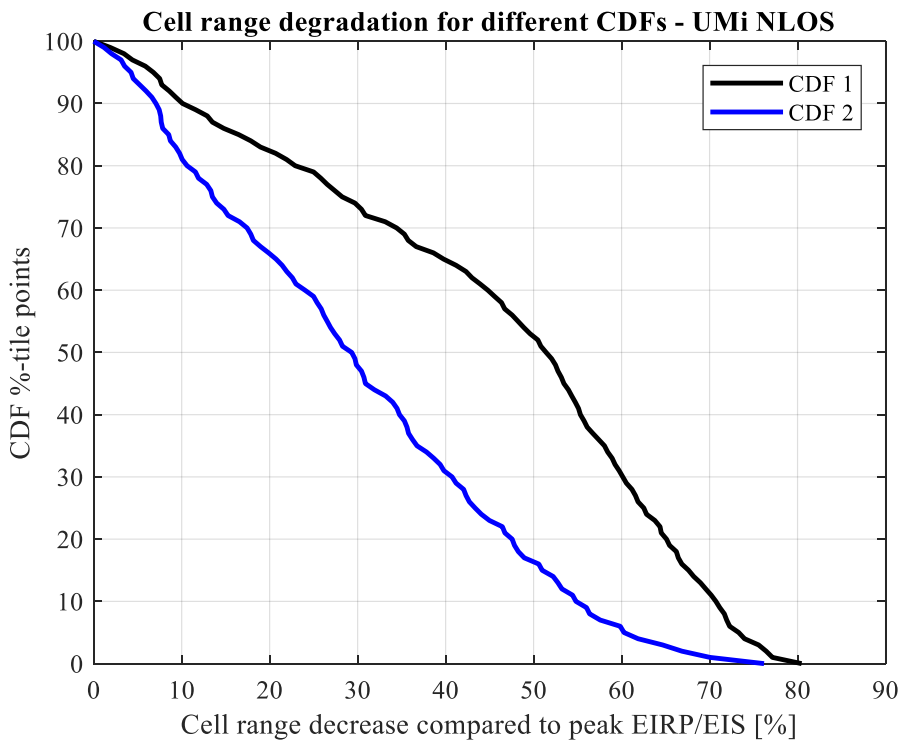
- The cell range degradation compared to the peak EIRP/EIS can be computed as follows:

$$1 - 10^{\left(\frac{-Loss_{Relative}}{PL_{Slope}}\right)}$$

  where $Loss_{Relative}$ is the loss (in dB) relative to the peak EIRP/EIS, while PL_{Slope} is the slope (dB/decade) of the path loss under analysis
- The same degradation can be observed in DL and UL assuming symmetric CDF shapes
- The relative cell range decrease (i.e. the percentage of decrease) does not depend on assumptions about blocking
- Same analysis can be applied to different environments by modifying path loss slope
- This analysis is summarized in the next slide for UMi NLOS

Cell range degradation compared to peak EIRP/EIS

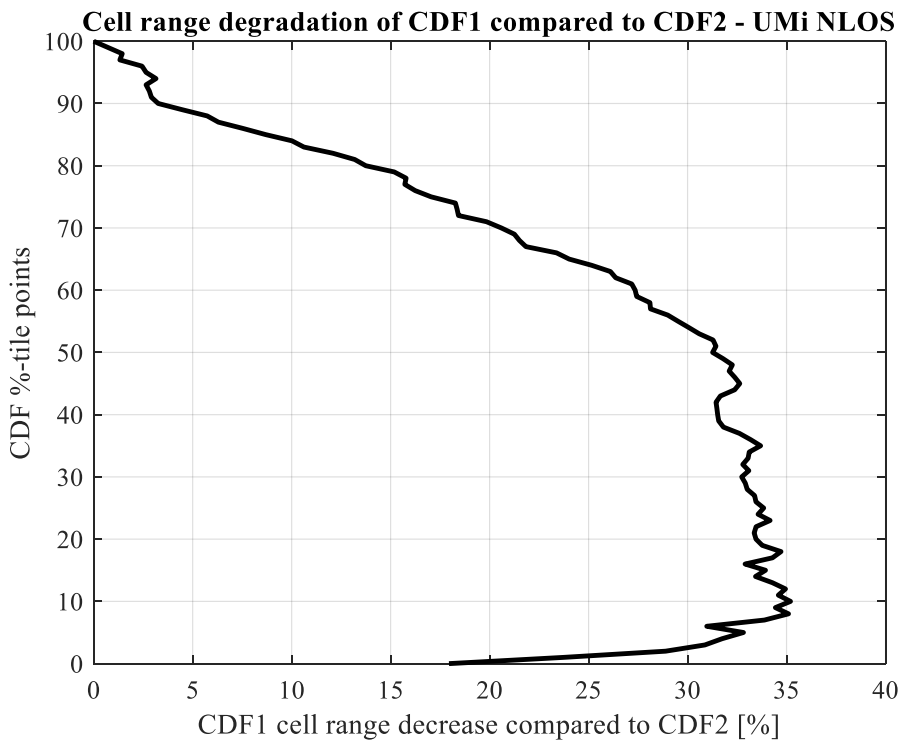
Lower percentile points are important to estimate the real coverage



- It is important to specify a requirement for a low percentile point because lower part of the CDF will be the one affected by larger cell range degradation
- Single module CDF can lead to more then 50% cell range degradation at 50%-tile
- Single module CDF can lead to more then 65% cell range degradation at 20%-tile

CDF1 cell range degradation compared to CDF2

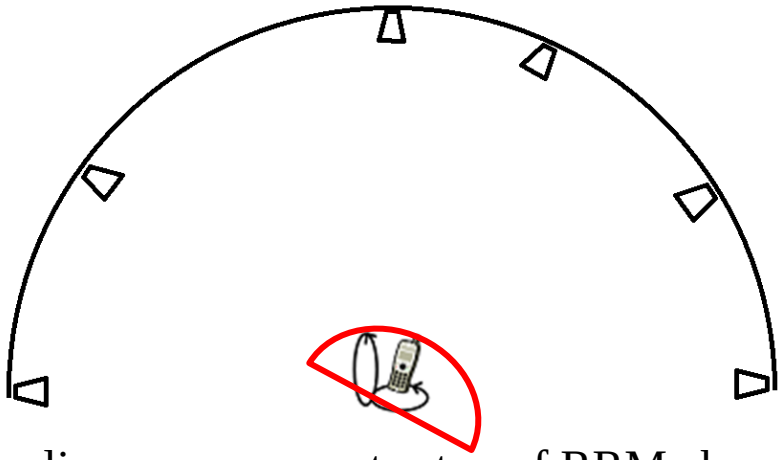
Lower percentile points are important to estimate the real coverage



- The cell range degradation for single module vs dual module CDF is not constant
- It is important to specify a lower percentile point in the CDF to keep cell range degradation under control

RRM testing and spherical coverage

- Figure shows the agreed test setup for RRM (beam tracking)
  - Angle of arrival between different beams varies from 30 to 180 degrees
  - If requirements are defined only for 50%-tile it is very difficult to test for large difference in angle of arrival (e.g. 180 degrees) – single module coverage overlaid on a device shown in red in the figure below
    - ✓ If the UE is rotated compared to a perfect alignment of the semis-phere, UE will not “see” all the probes anymore
- 50%-tile only requirement will make testing very difficult
- RRM will be impacted by a poor spherical coverage requirement (50%-tile only)



Baseline measurement setup of RRM characteristics

Key observations and proposals

Low percentile points matter

- All CDFs points matter to determine overall system performance
- Since the network needs to be designed based on a target cell edge coverage, the low percentile points are more important than the 50%-tile
  - CDF shape has large impact on the reliability achieved at a given distance from BS
  - Low percentile points determine the size of cell edge
- Defining a spherical coverage percentile point below 50% is important for reliability of RRM testing and performance

Proposal 1: to define a spherical coverage requirement corresponding to at least two antenna modules

Proposal 2: to define a CDF percentile point below 50% (e.g. 20%)

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