

Reliability: 5x9s vs 6x9s

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(99.999 vs 99.9999)



# NTT Docomo: 3GPP Release 15 Overview

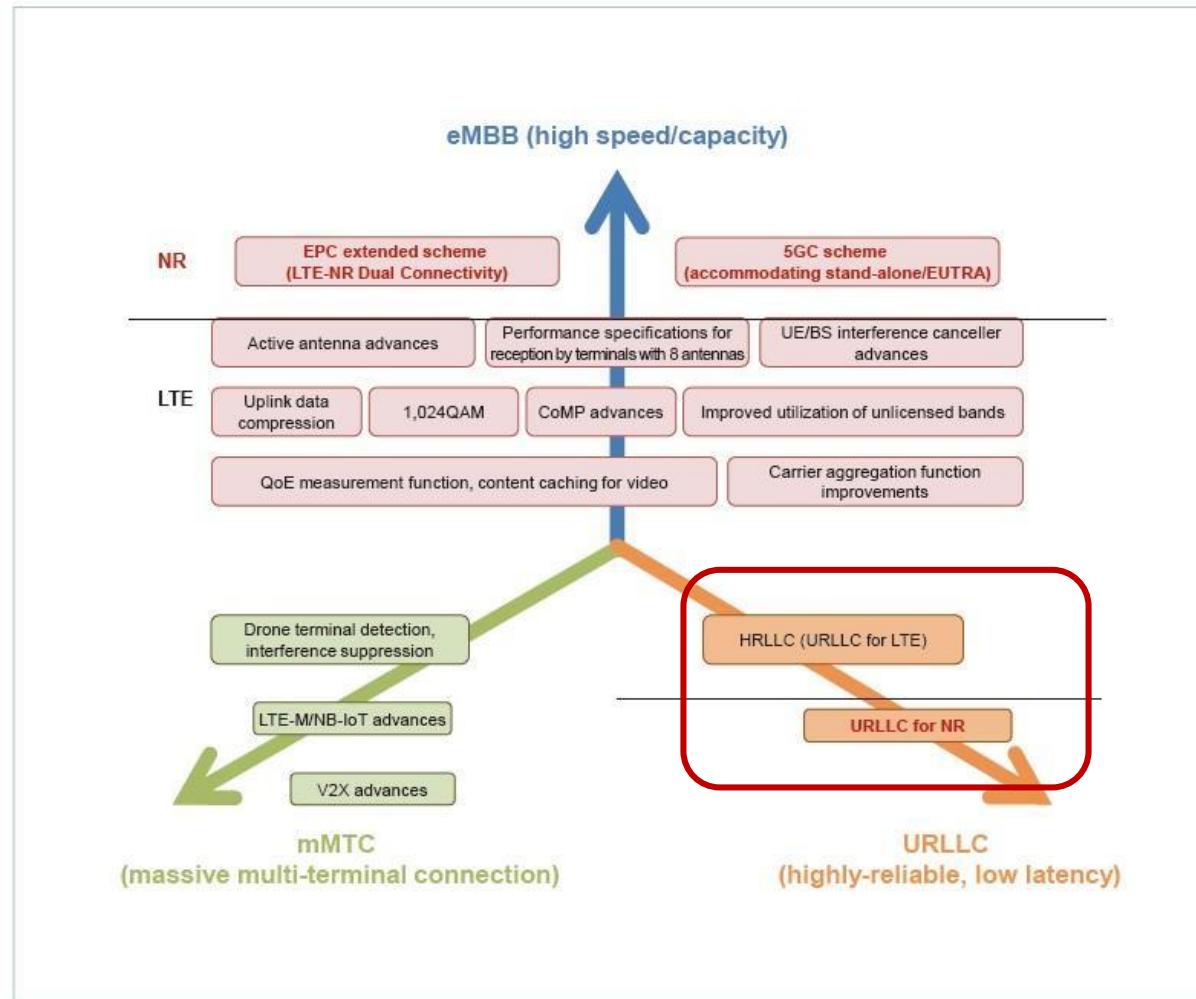
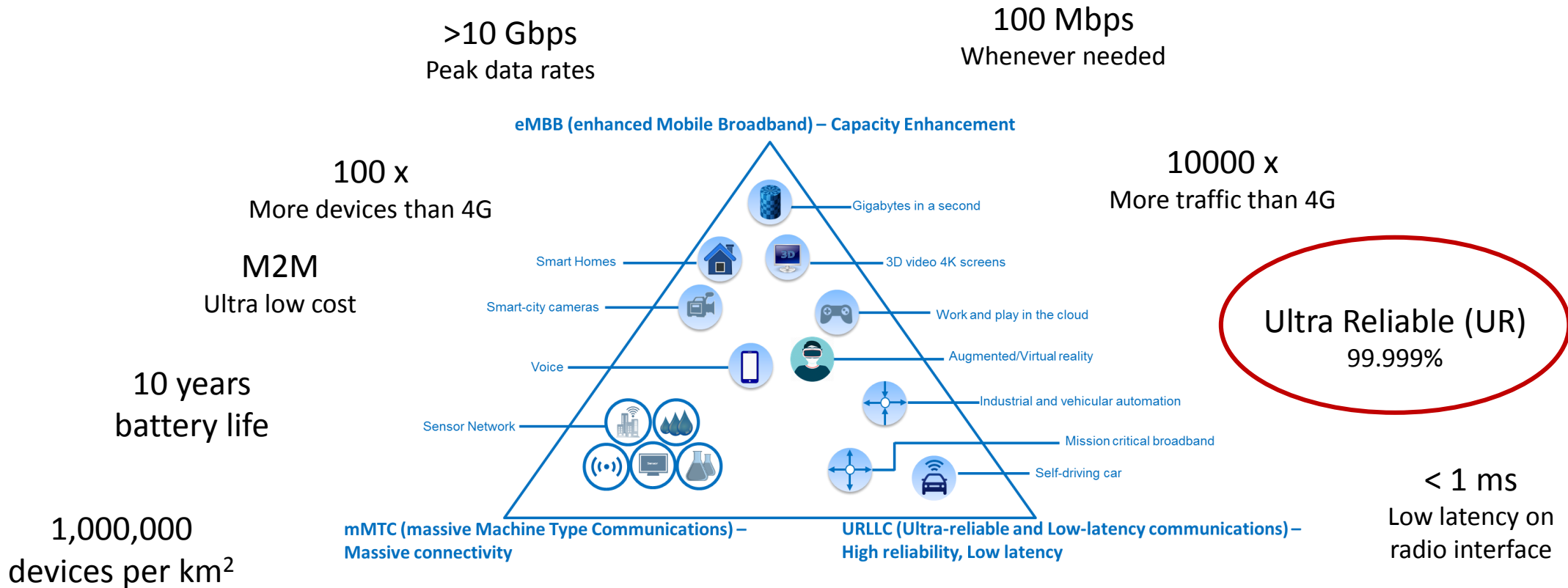


Figure 1 Main functions specified in Release 15 for NR, 5GC, and LTE/LTE-Advanced

[Source](#)

# 5G High Level Requirements and Wish List

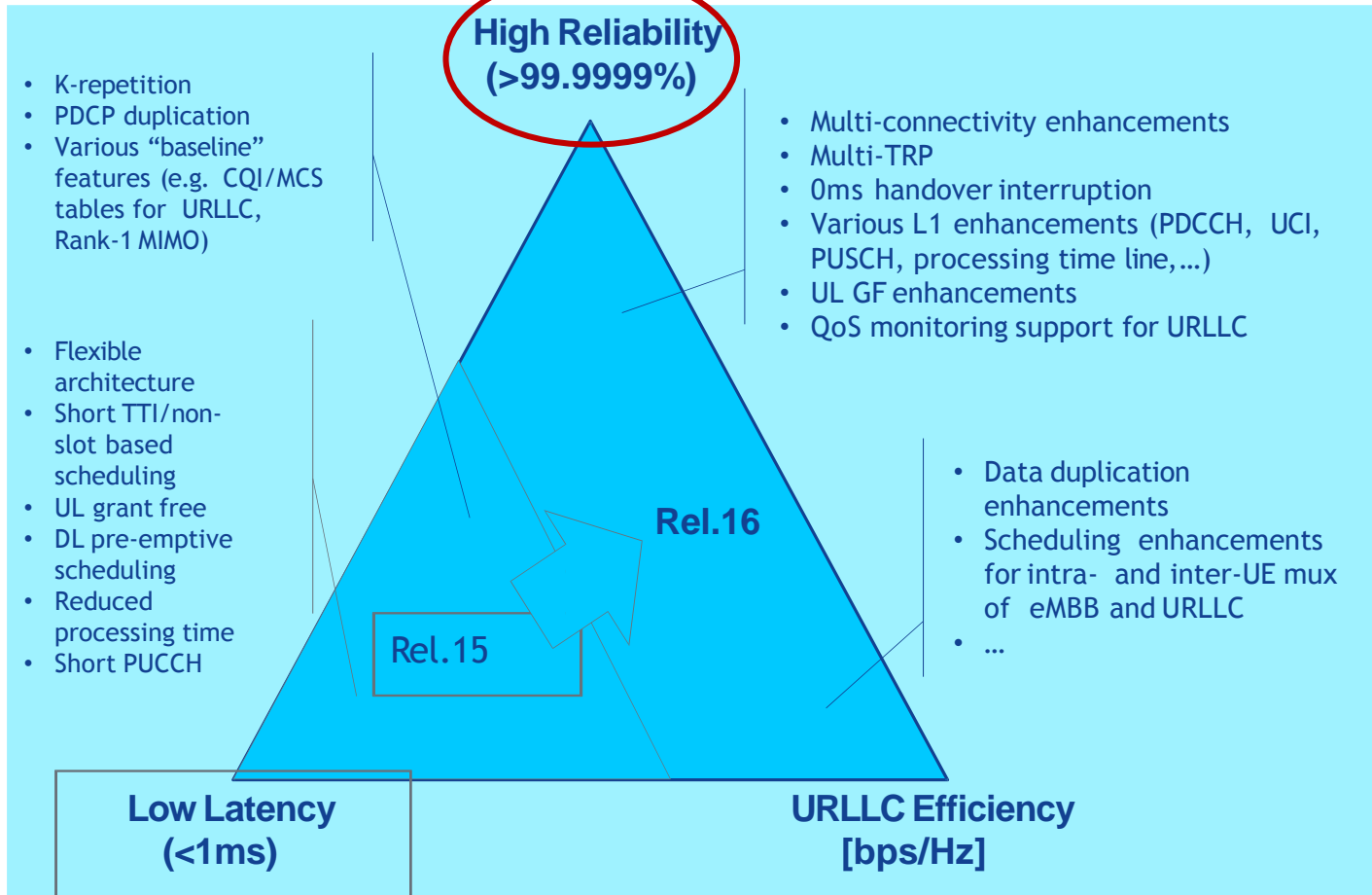
ITU-R IMT-2020 requirements



# Rel.16 URLLC Enhancements

## Enhancements for latency and reliability in Radio and E2E

Rel.16 URLLC aims for higher reliability and better efficiency



- R15 use case improvements (e.g. AR/VR)
- New use cases with higher requirements (e.g. factory automation, transport industry, electrical power distribution)



| Key Rel.16 SI/WIs        | Primary WG |
|--------------------------|------------|
| FS_5G_URLLC (SP-180118)  | SA2        |
| NR IIoT (RP-181479)      | RAN2       |
| NR_Mob_enh (RP-181433)   | RAN2       |
| NR_eURLLC_L1 (RP-181477) | RAN1       |
| NR_eMIMO (RP-181453)     | RAN1       |

# URLLC Use Cases and Requirements (TS 22.261)

Table 7.2.2-1 Performance requirements for low-latency and high-reliability scenarios.

| Scenario  | End-to-end latency | Communication service availability | Reliability | User experienced data rate | Payload size   | Traffic density          | Connection density      | Service area dimension  |
|---|--------------------|------------------------------------|-------------|----------------------------|----------------|--------------------------|-------------------------|-------------------------|
| Discrete automation – motion control                    | 1 ms               | 99.9999%                           | 99.9999%    | 1 Mbps up to 10 Mbps       | Small          | 1 Tbps/km <sup>2</sup>   | 100 000/km <sup>2</sup> | 100 x 100 x 30 m        |
| Discrete automation                                     | 10 ms              | 99.99%                             | 99.99%      | 10 Mbps                    | Small to big   | 1 Tbps/km <sup>2</sup>   | 100 000/km <sup>2</sup> | 1000 x 1000 x 30 m      |
| Process automation – remote control                     | 50 ms              | 99.9999%                           | 99.9999%    | 1 Mbps up to 100 Mbps      | Small to big   | 100 Gbps/km <sup>2</sup> | 1 000/km <sup>2</sup>   | 300 x 300 x 50 m        |
| Process automation – monitoring                         | 50 ms              | 99.9%                              | 99.9%       | 1 Mbps                     | Small          | 10 Gbps/km <sup>2</sup>  | 10 000/km <sup>2</sup>  | 300 x 300 x 50          |
| Electricity distribution – medium voltage               | 25 ms              | 99.9%                              | 99.9%       | 10 Mbps                    | Small to big   | 10 Gbps/km <sup>2</sup>  | 1 000/km <sup>2</sup>   | 100 km along power line |
| Electricity distribution – high voltage                 | 5 ms               | 99.9999%                           | 99.9999%    | 10 Mbps                    | Small          | 100 Gbps/km <sup>2</sup> | 1 000/km <sup>2</sup>   | 200 km along power line |
| Intelligent transport systems – infrastructure backhaul | 10 ms              | 99.9999%                           | 99.9999%    | 10 Mbps                    | Small to big   | 10 Gbps/km <sup>2</sup>  | 1 000/km <sup>2</sup>   | 2 km along a road       |
| Tactile interaction                                     | 0,5 ms             | [99.999%]                          | [99.999%]   | [Low]                      | [Small]        | [Low]                    | [Low]                   | TBC                     |
| Remote control  | [5 ms]             | [99.999%]                          | [99.999%]   | [From low to 10 Mbps]      | [Small to big] | [Low]                    | [Low]                   | TBC                     |

Various requirements from different URLLC services

# What is 5x9s or 99.999% Reliability

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- There are  $24 \times 60 = 1440$  minutes per day
- For a 365 day year, its  $365 \times 1440 = 525,600$  minutes per year
- 99.999% reliability =  $525,600 - 525,600 \times 0.99999 = 5.256$  minutes down time per year
- Total down time allowed = 5.256 minutes per year = 315.36 seconds per year

# What is 6x9s or 99.9999% Reliability

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- There are  $24 \times 60 = 1440$  minutes per day
- For a 365 day year, its  $365 \times 1440 = 525,600$  minutes per year
- $99.9999\%$  reliability =  $525,600 - 525,600 \times 0.999999 = .5256$  minutes down time per year
- Total down time allowed =  $.5256$  minutes per year =  $31.536$  seconds per year

# High Availability Chart ([Wikipedia](#))

| Availability %                    | Downtime per year   | Downtime per month  | Downtime per week   | Downtime per day    |
|-----------------------------------|---------------------|---------------------|---------------------|---------------------|
| 55.5555555% ("nine fives")        | 162.33 days         | 13.53 days          | 74.92 hours         | 10.67 hours         |
| 90% ("one nine")                  | 36.53 days          | 73.05 hours         | 16.80 hours         | 2.40 hours          |
| 95% ("one and a half nines")      | 18.26 days          | 36.53 hours         | 8.40 hours          | 1.20 hours          |
| 97%                               | 10.96 days          | 21.92 hours         | 5.04 hours          | 43.20 minutes       |
| 98%                               | 7.31 days           | 14.61 hours         | 3.36 hours          | 28.80 minutes       |
| <b>99% ("two nines")</b>          | 3.65 days           | 7.31 hours          | 1.68 hours          | 14.40 minutes       |
| 99.5% ("two and a half nines")    | 1.83 days           | 3.65 hours          | 50.40 minutes       | 7.20 minutes        |
| 99.8%                             | 17.53 hours         | 87.66 minutes       | 20.16 minutes       | 2.88 minutes        |
| <b>99.9% ("three nines")</b>      | 8.77 hours          | 43.83 minutes       | 10.08 minutes       | 1.44 minutes        |
| 99.95% ("three and a half nines") | 4.38 hours          | 21.92 minutes       | 5.04 minutes        | 43.20 seconds       |
| <b>99.99% ("four nines")</b>      | 52.60 minutes       | 4.38 minutes        | 1.01 minutes        | 8.64 seconds        |
| 99.995% ("four and a half nines") | 26.30 minutes       | 2.19 minutes        | 30.24 seconds       | 4.32 seconds        |
| <b>99.999% ("five nines")</b>     | 5.26 minutes        | 26.30 seconds       | 6.05 seconds        | 864.00 milliseconds |
| <b>99.9999% ("six nines")</b>     | 31.56 seconds       | 2.63 seconds        | 604.80 milliseconds | 86.40 milliseconds  |
| <b>99.99999% ("seven nines")</b>  | 3.16 seconds        | 262.98 milliseconds | 60.48 milliseconds  | 8.64 milliseconds   |
| <b>99.999999% ("eight nines")</b> | 315.58 milliseconds | 26.30 milliseconds  | 6.05 milliseconds   | 864.00 microseconds |



# Thank You

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