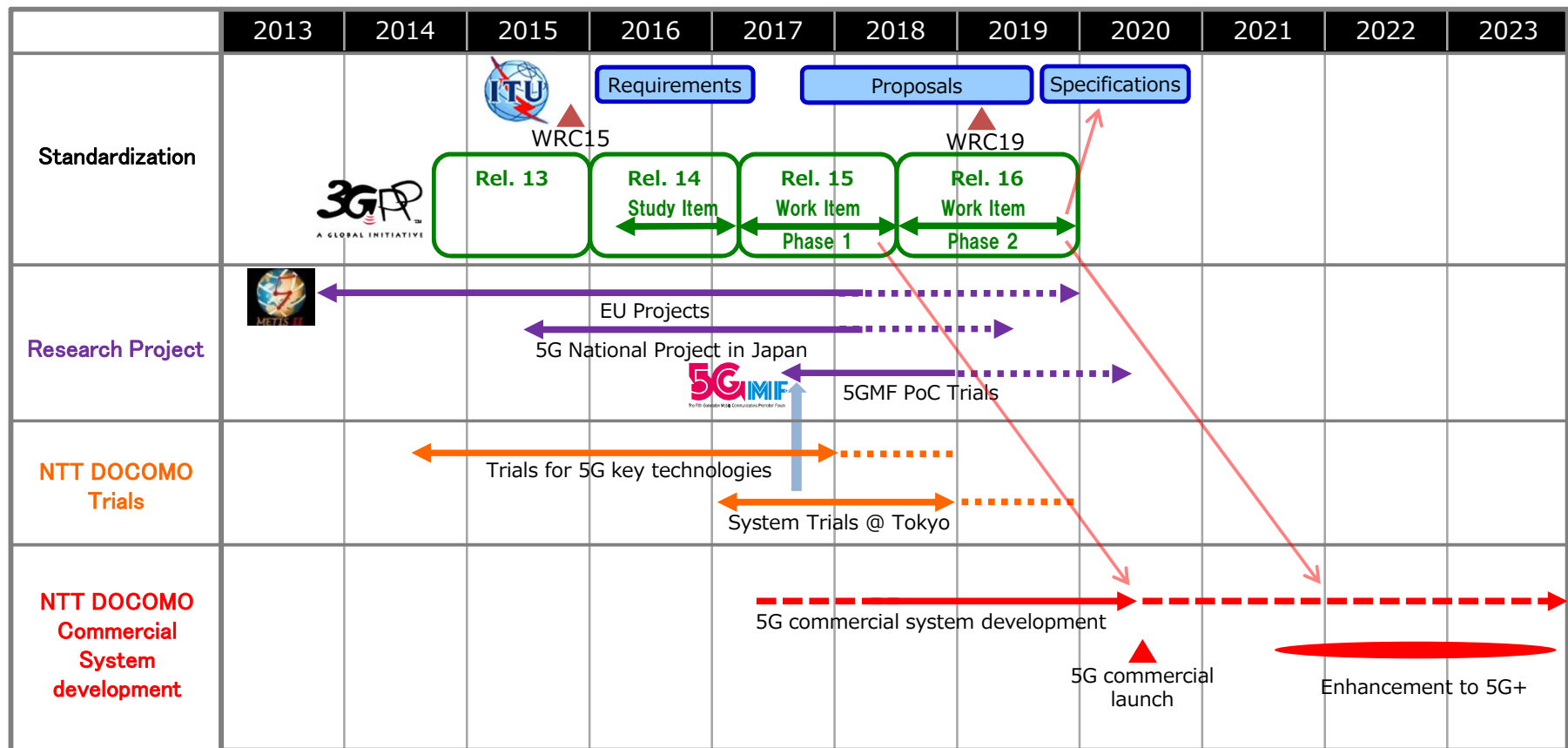


DOCOMO's 5G Trials Using Variety of Spectrum Bands

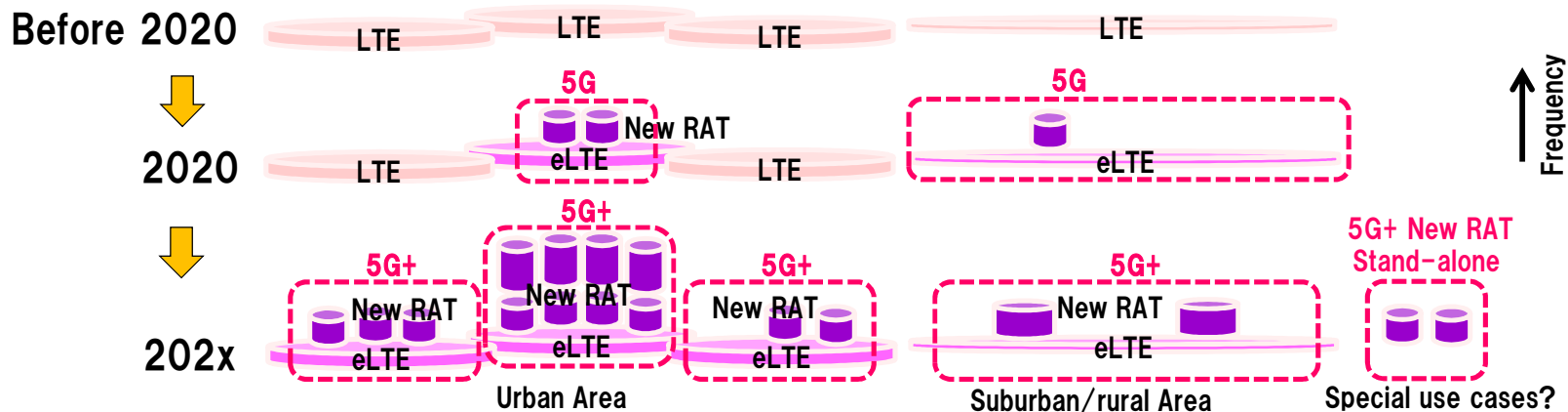
Yoshihisa Kishiyama
NTT DOCOMO, INC.

Time Plan for 5G and 5G+



Deployment/Migration Scenarios

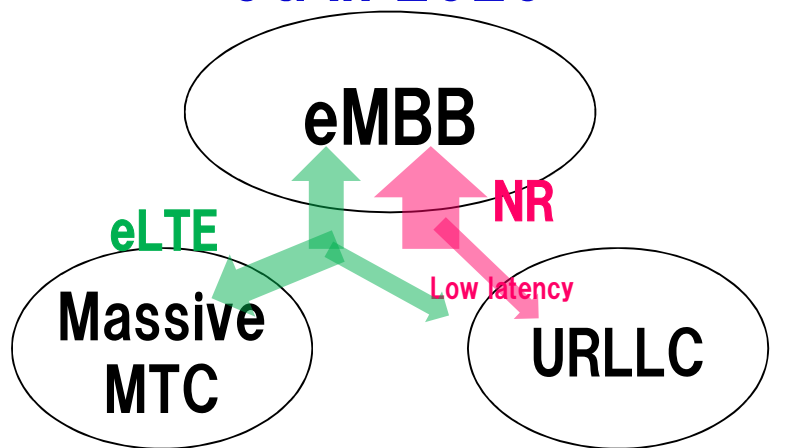
- In 2020, 5G will be deployed initially from areas, where higher performance and necessary features are required
 - Both New RAT (NR) and enhanced LTE (eLTE) introduced to realize tight interworking between lower and higher frequency bands
- In beyond 2020, deployment areas for 5G will be gradually expanded while introducing additional technologies and frequency bands (= 5G+)
 - LTE (or LTE-Advanced) cell can be continuously used as eLTE cell for a long-time
 - Stand-alone NR might be also deployed



eMBB and IoT Use Cases

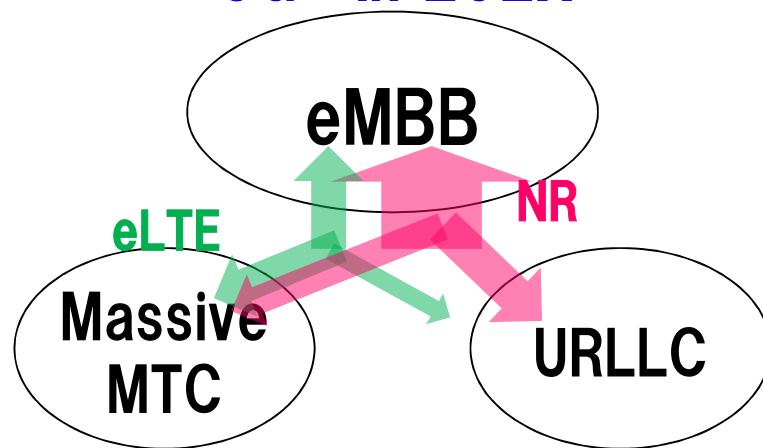
5G will support both eMBB and IoT use cases together with LTE evolution

5G in 2020



New RAT will mainly focus on eMBB

5G+ in 202X



New RAT will be enhanced for all use cases

5G Frequency Band Candidates

Frequency band	Bandwidth	For eMBB	Device availability	Spectrum availability				
				Europe	US	JPN	KOR	CHN
Below 6 GHz								
3.4-3.8GHz	400MHz	😊	😊	😊	😊 3.4-3.7GHz only	😊 for 4G	😊	😊 3.3-3.6GHz only
3.8-4.2GHz	400MHz	😊	😊	😞	😞	😊	?	😞
4.4-4.99GHz	500MHz	😊	😊	😞	😞	😊	😞	😊 4.4-4.5, 4.8-4.99GHz only
5.15-5.35GHz*	200MHz	😊	😊	😊 Indoor only	😊	😊 Indoor only	😊 Indoor only in 5.10-5.25GHz	😊 Indoor only
5.47-5.85GHz*	380MHz	😊	😊	😊 Not available above 5.725GHz	😊	😊 Not available above 5.725GHz	😊	😊 Not available above 5.725GHz
Above 6 GHz								
24.25-27.5GHz	3,250MHz	😊	?	😊?	😊? 24.25-24.45GHz, 25.05-25.25GHz	😊	😊 Unlicensed band >25GHz is used for V2V	😞 FSS
27.5-29.5GHz	2,000MHz	😊	?	😞	😊 27.5-28.35 GHz	😊	😊	😞

*Unlicensed frequency bands, which are mainly used for Wireless LAN now.

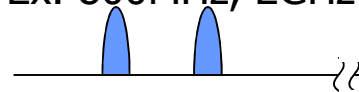
NTT DOCOMO 5G Trials

5G Experimental Trials 【w/ 13 vendors】

5G experimental trials are being started since Q4 of 2014

Existing bands

UHF bands
Ex. 800MHz, 2GHz



Exploitation of higher frequency bands

Low SHF bands
3-6GHz

High SHF bands
6-30GHz

EHF bands
> 30GHz



Frequency



System solution vendor



Key devices/Chip sets vendors

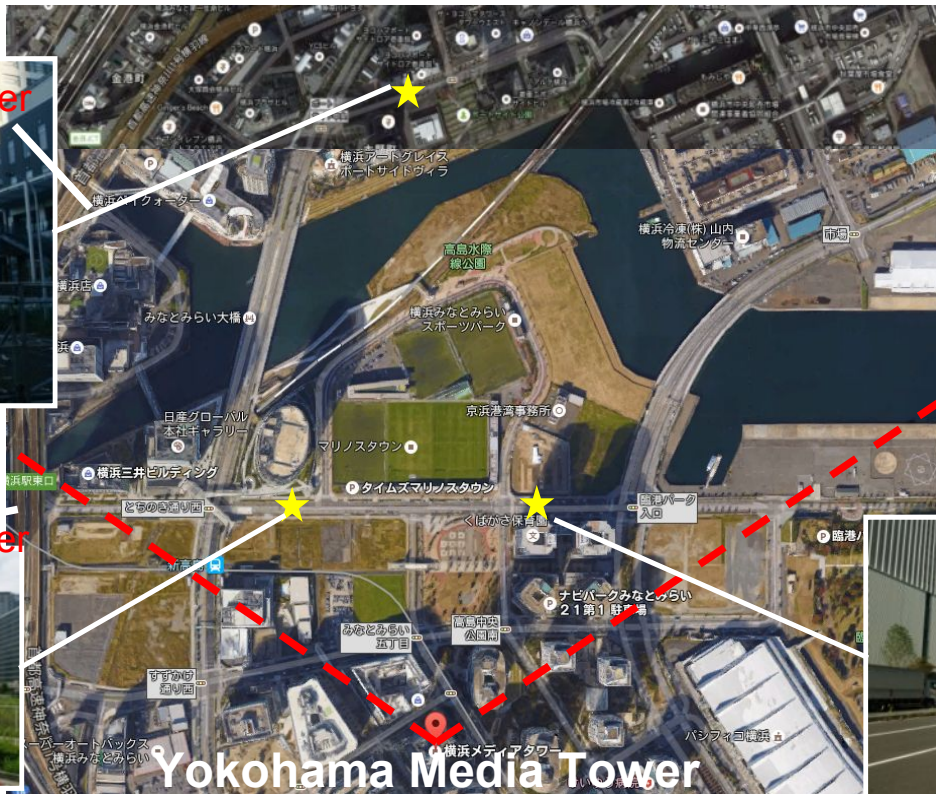


Measuring instruments vendors



5G Capacity Test @ 4.5GHz with Huawei

Trial Environment in Yokohama, Japan



NLOS



5G Capacity Test @ 4.5GHz with Huawei

Experimental Equipment

Base Station (BS)

Number of antennas	BS: 64 TRX UE: 8 TRX
Antenna spacing	BS: 3.72cm x 5.21cm UE : 11cm
Antenna tilting	16.4°
Antenna height	BS: 108m UE: 3.2m
Maximum transmit power	BS: 46dBm UE: 23dBm



Base band unit



Indoor facility

Optical fiber

User Equipment (UE)

E-cart
(including 2 UEs)



RF/BBU



Test vehicle

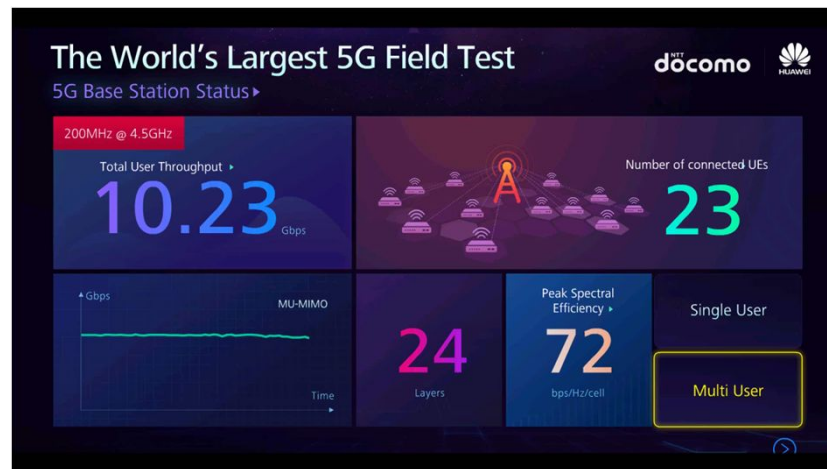


8 TRx

5G Capacity Test @ 4.5GHz with Huawei

Successful large-scale 24-layer MU-MIMO Trial using TDD channel reciprocity

- DL SU-MIMO (1s average) = **1.5 Gbps** (200MHz BW, 3 layers)
- DL total user throughput (1s average) = **11.29 Gbps** (200MHz BW and 23 UEs*)
- DL peak spectral efficiency (1s average) = **79.82 bps/Hz/cell**

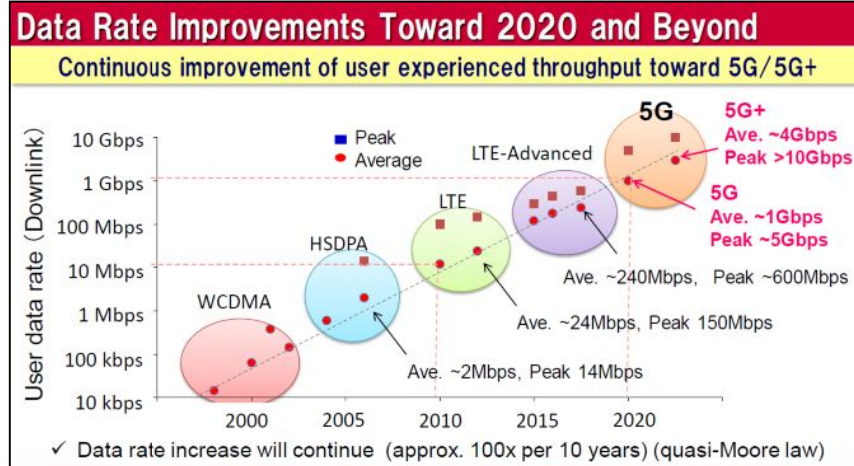
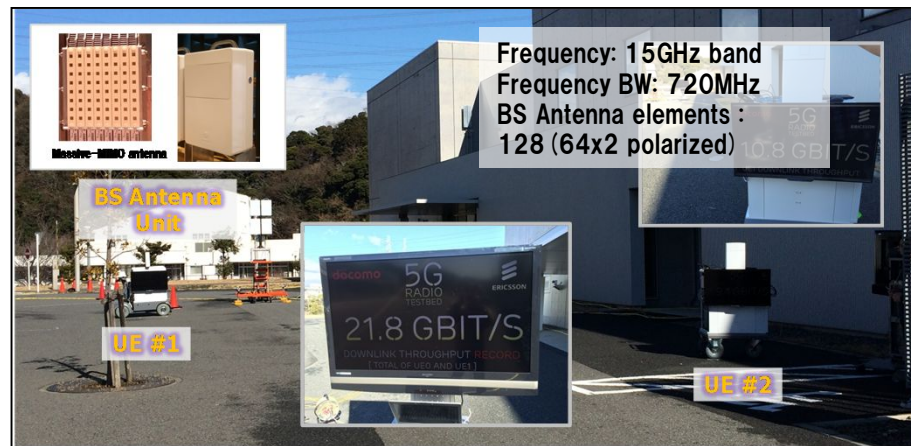


* Number of connected UEs: 23 UEs / 200MHz (11 UEs using lower 100MHz, 11 UEs using upper 100MHz, & 1 UE using 200MHz)

* Number of spatial layers: 24 layers / 100MHz (12 user & 2 layers/user)

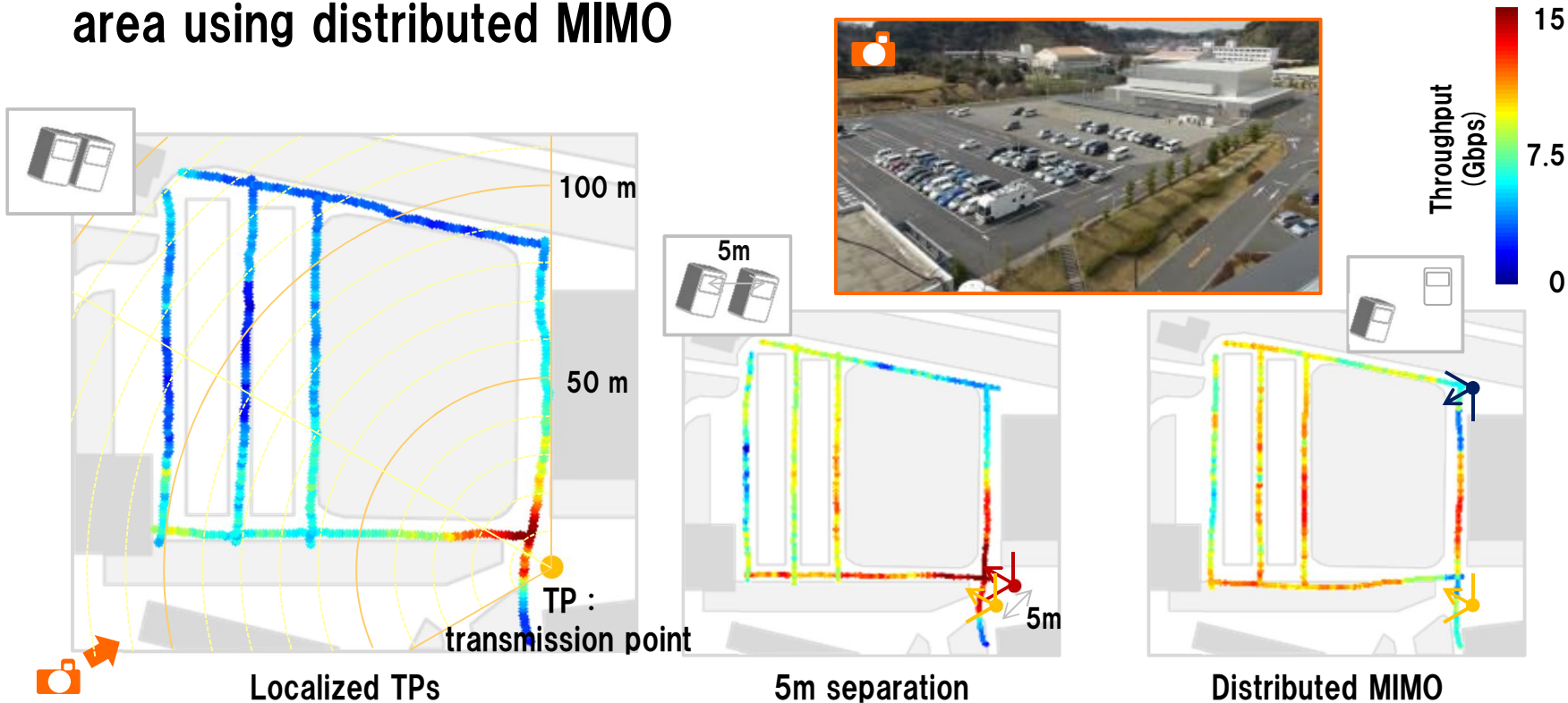
5G Throughput Test @ 15GHz with Ericsson

- Achieved over 15 Gbps per UE and over 25 Gbps per cell (2 UEs) with 800 MHz bandwidth, 256QAM, and 4-layer MIMO per UE
- Based on improvement of UE chip set performance, peak data rate of 5 Gbps (in 2020) and 10 Gbps (in 202x) are expected



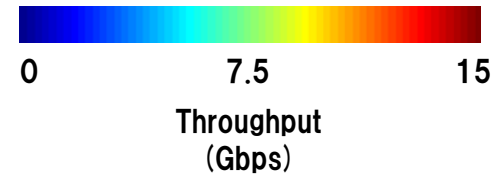
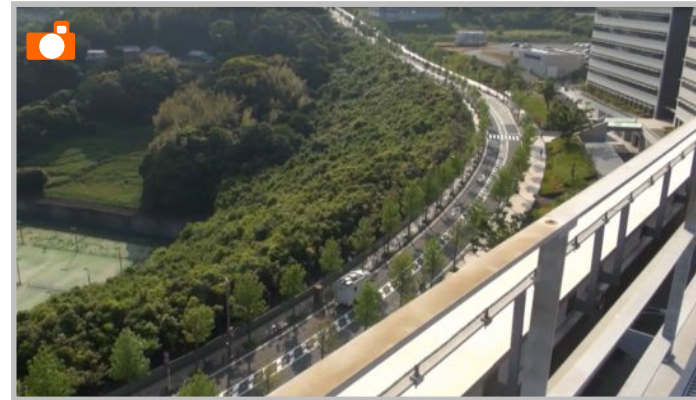
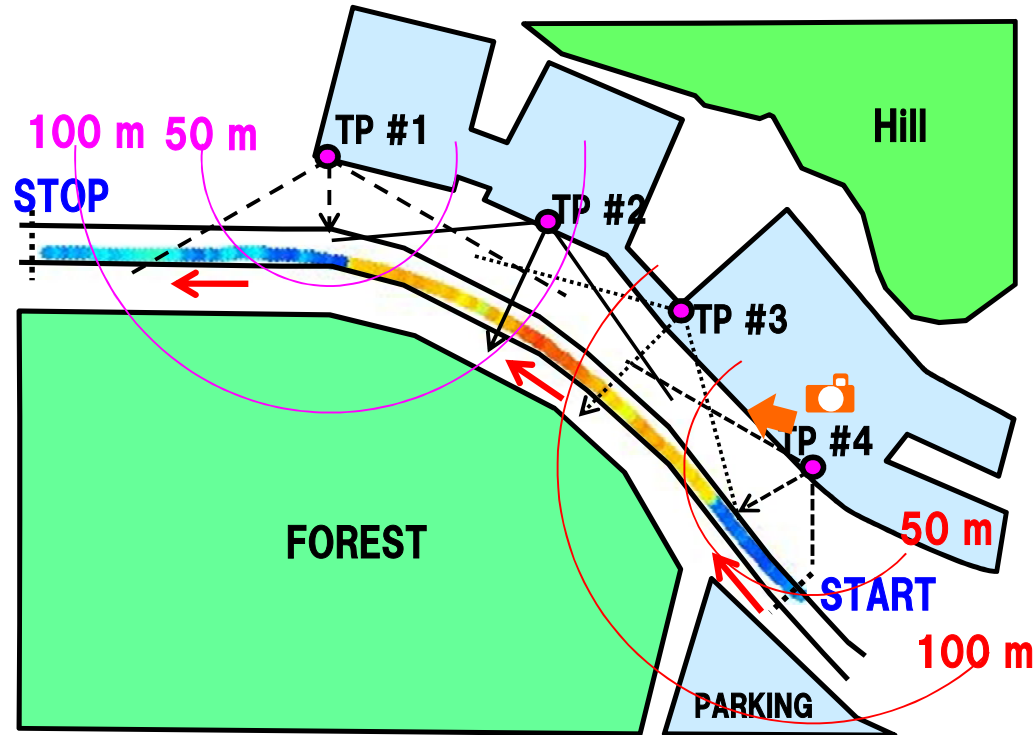
5G Throughput Test @ 15GHz with Ericsson

- Achieved high throughput performance up to 15 Gbps over trial area using distributed MIMO



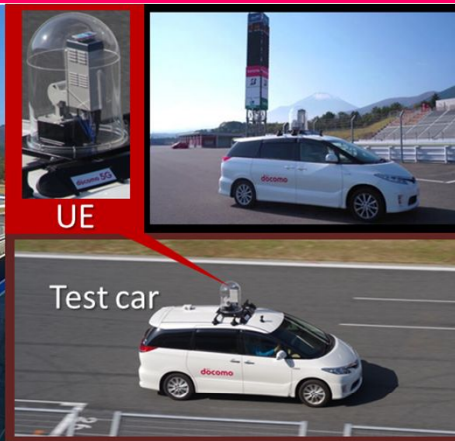
5G Throughput Test @ 15GHz with Ericsson

- Achieved 12 Gbps at mobile speed of 10 km/h with distributed MIMO using 4 TPs mounted on top of building



5G High Mobility Test @ 28GHz with Samsung

We have successfully achieved a data speed of more than 2.5 Gbps on a vehicle travelling at a speed over 150 km/h

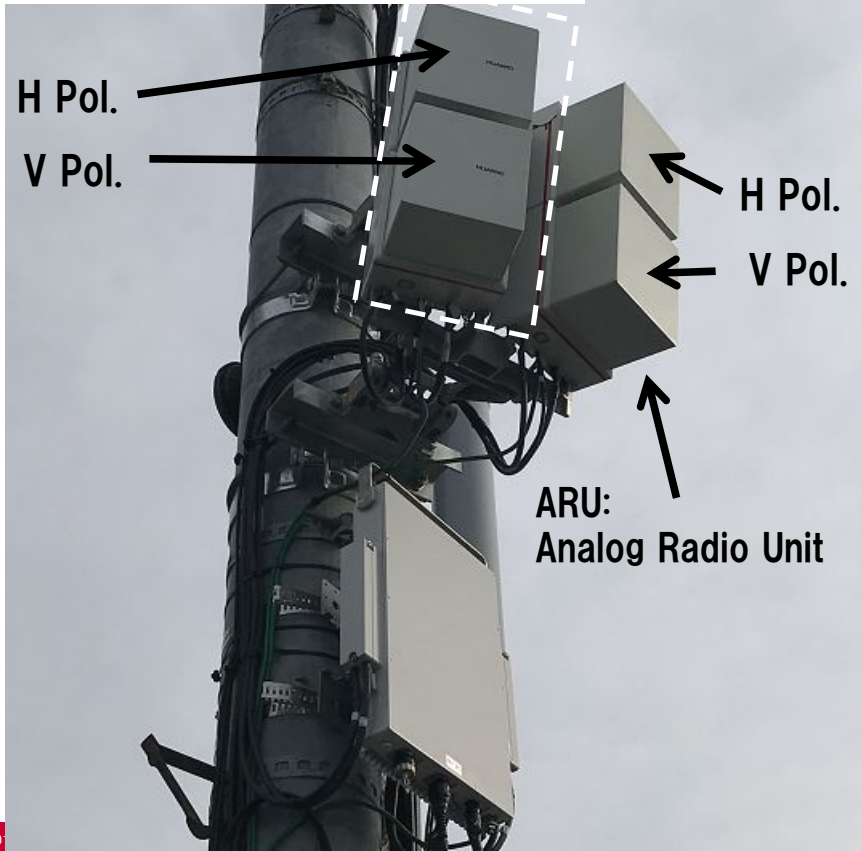


Major specifications

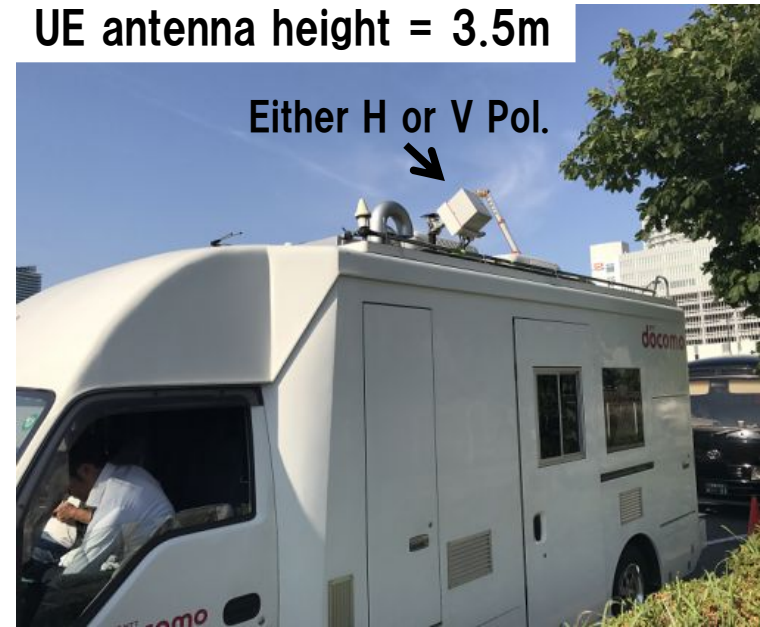
Freq. band	28 GHz band (800 MHz bandwidth)
BS	•96 antenna elements •support up to 2 stream MIMO transmission with 2 beams
UE	•8 antenna elements •2 beams reception

5G Coverage Test @ 39GHz with Huawei

BS antenna height = 108m



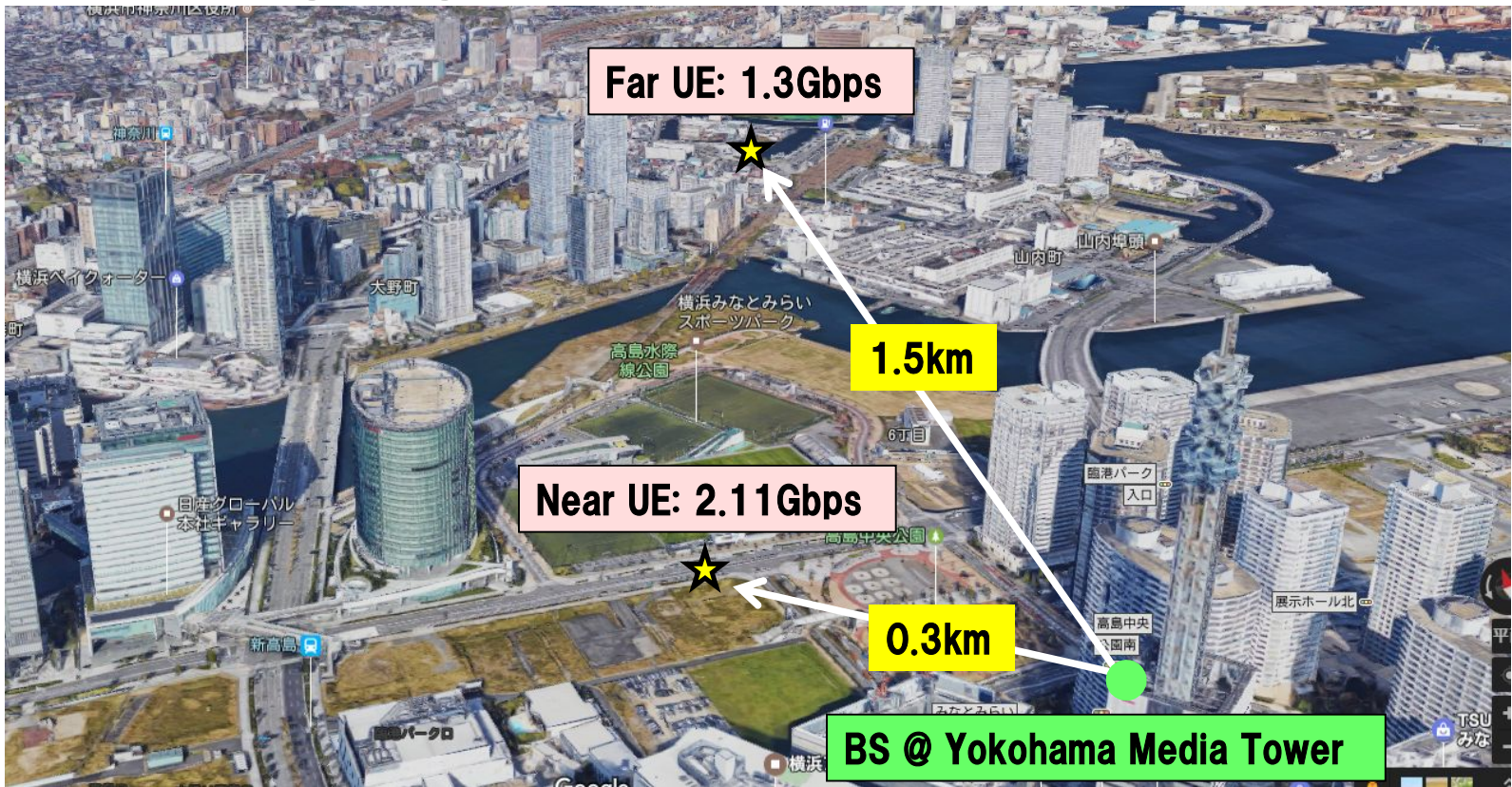
UE antenna height = 3.5m



System bandwidth	1.4 GHz (200MHz/CC)
Tx power per ARU	19 dBm
Antenna gain	31 dBi (Lens antenna)

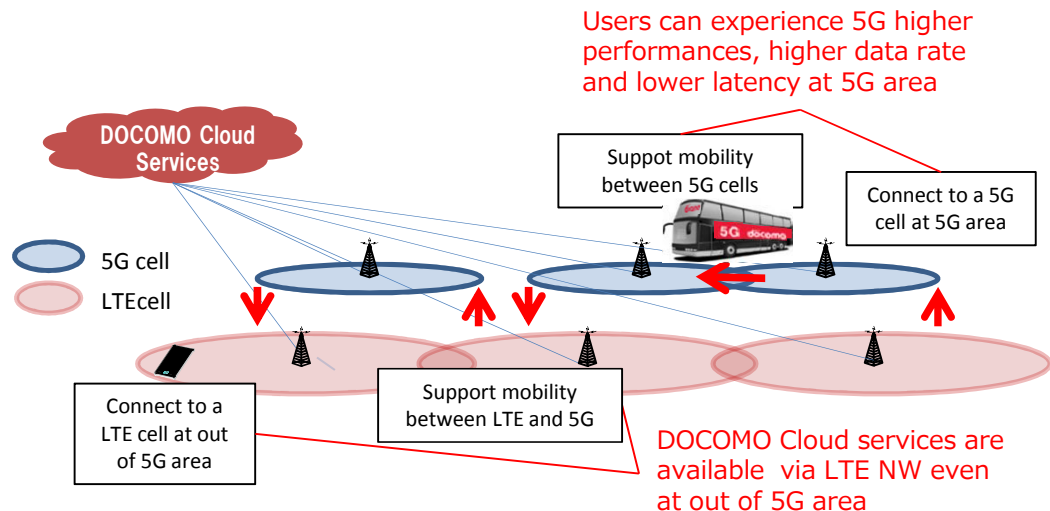
5G Coverage Test @ 39GHz with Huawei

Successful long range 5G transmission (> 1km) even with mmW



NTT DOCOMO 5G Trial Sites

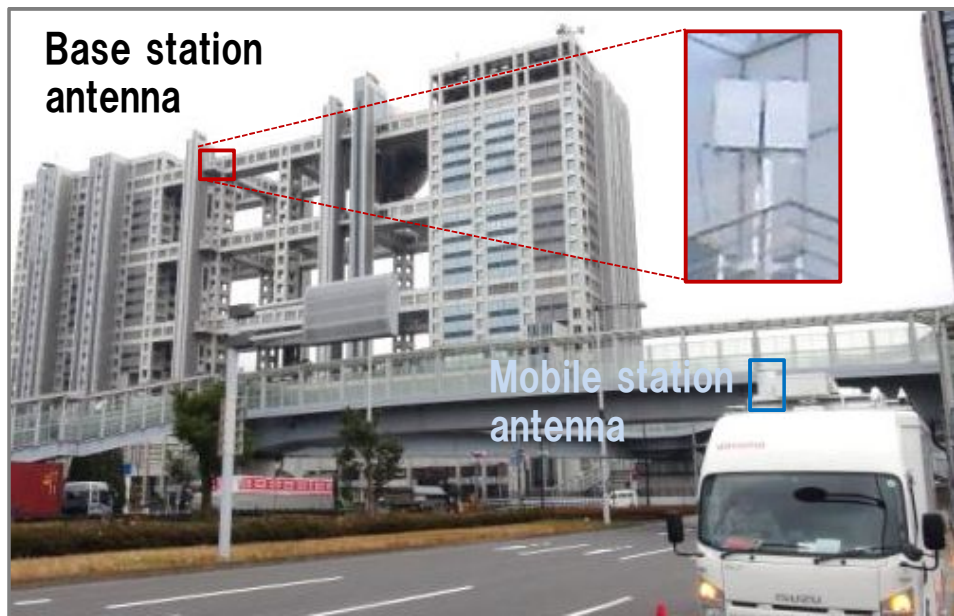
The 5G Trial Sites will be offered mainly in two distinct of Tokyo, the Odaiba waterfront and Tokyo SKYTREE TOWN from May, 2017



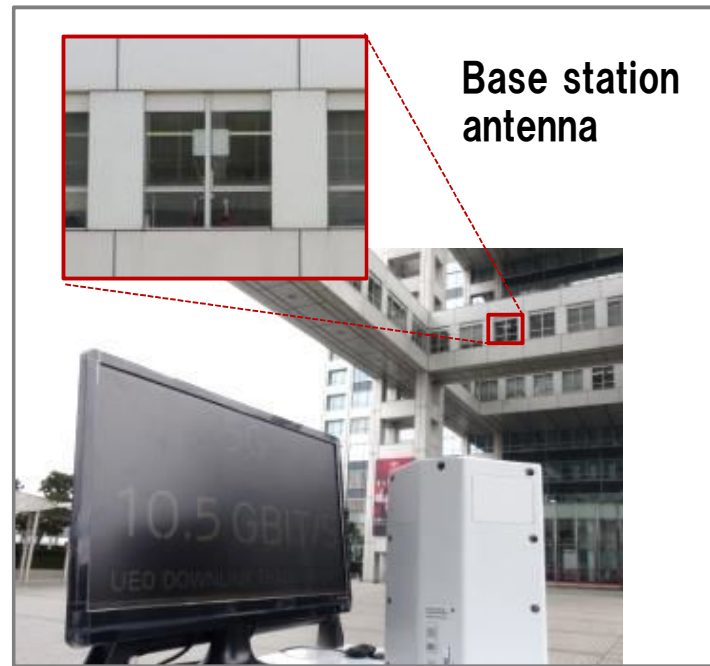
Support mobility between 5G and commercial LTE NW
Utilize 28 GHz and 4.5 GHz frequency bands

5G Experiments @ 28GHz with Ericsson

- DOCOMO x Ericsson 5G trial at 28 GHz for DOCOMO 5G Trial Sites
- Achieved over 10 Gbps in Odaiba



5G trial in Odaiba



5G trial in Fuji TV

NTT
docomo