5G Reality with mmWave

Joseph Jeon

28 September 2018

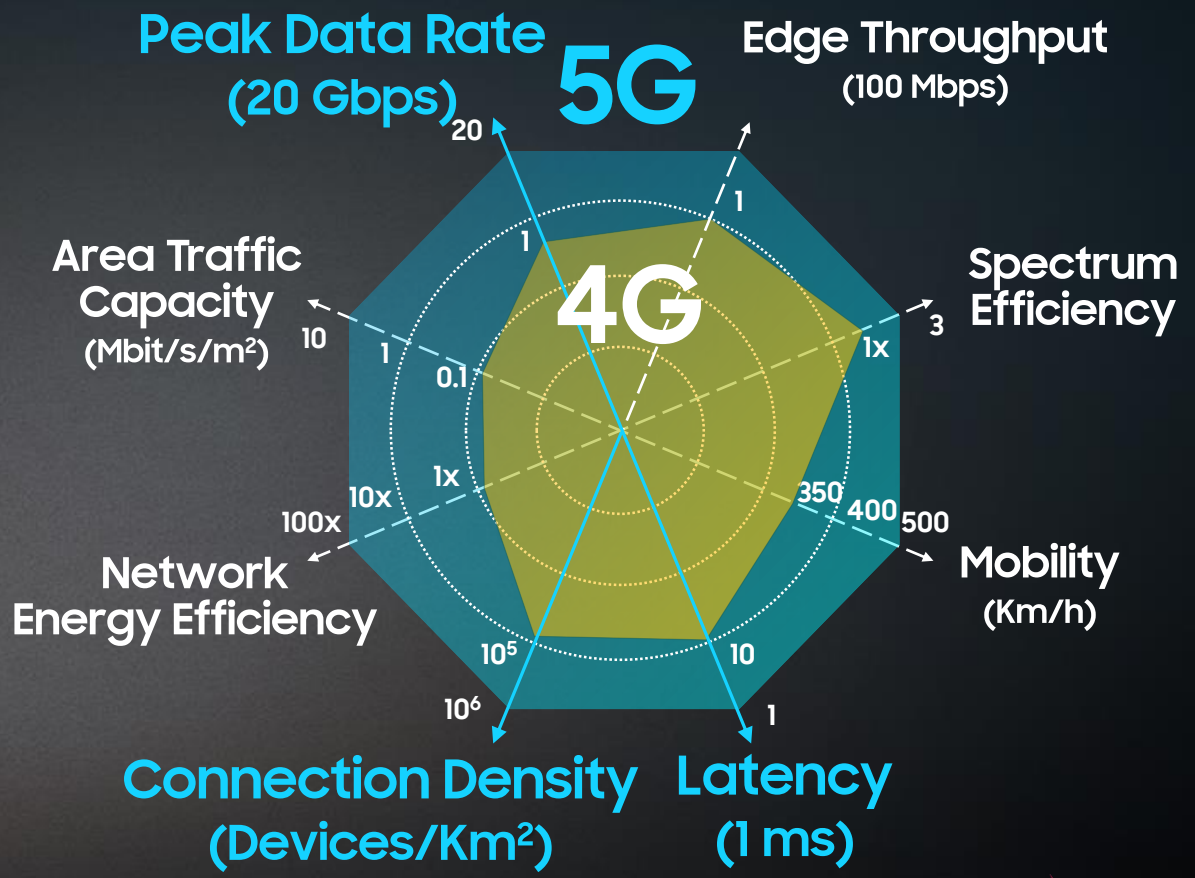
Samsung Electronics

5G Technology Vision

Ultra-Fast
20Gbps (LTE x20) Peak Throughput

Instantaneous
1 ms (LTE x 1/10) Latency

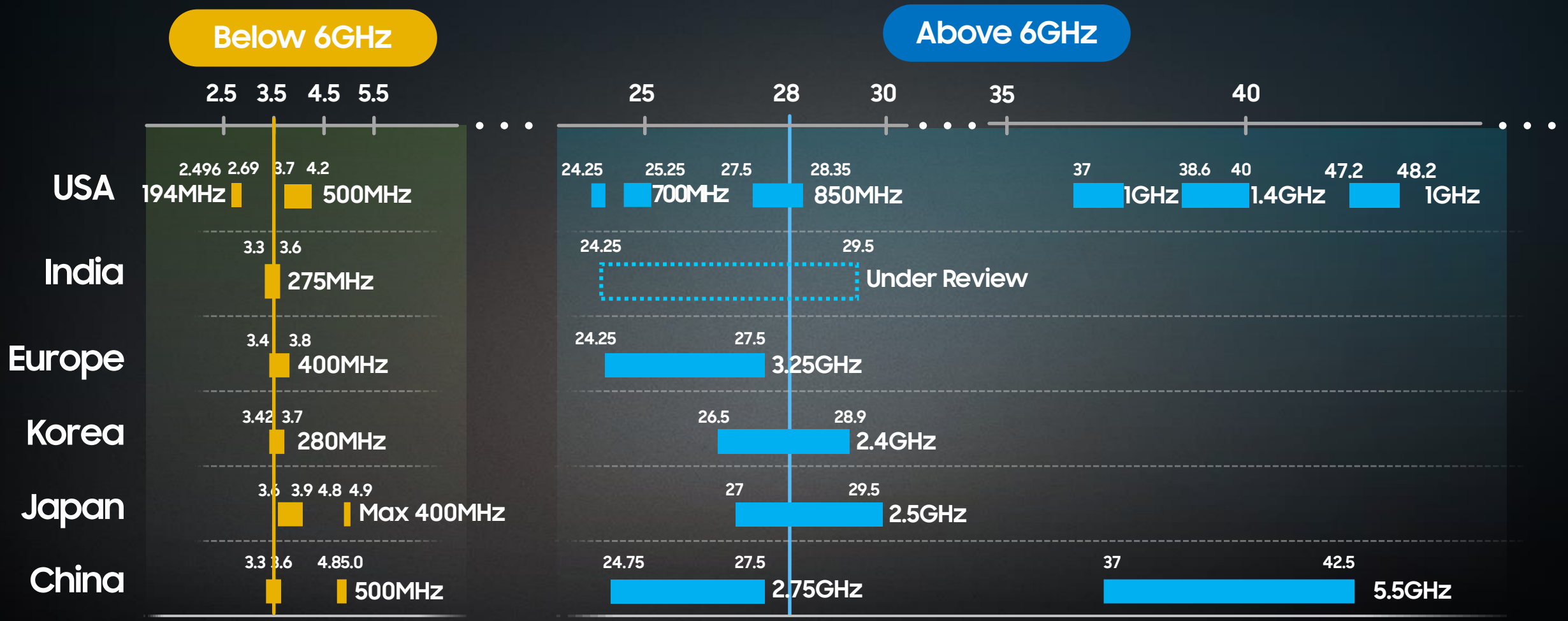
Massive Connectivity
1 Million (LTE x10) Devices/Km²



[Reference] Rec. ITU-R M.2083 - IMT Vision

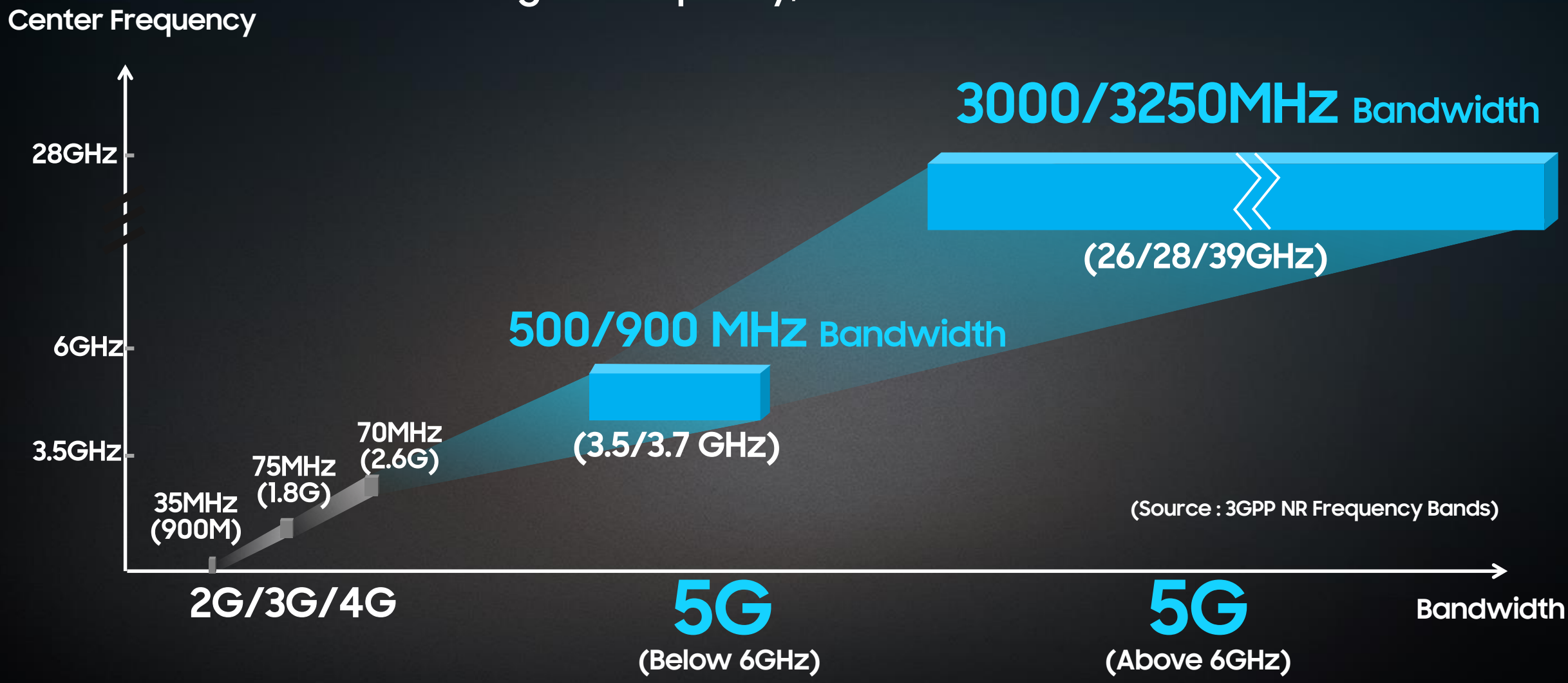
5G Candidate Frequencies

3.5GHz & 28GHz are Leading Candidates



5G, the New Frontier

Higher Frequency, Wider Bandwidth



Break prejudice about mmWave

Coverage ?

Penetration ?

Mobility ?

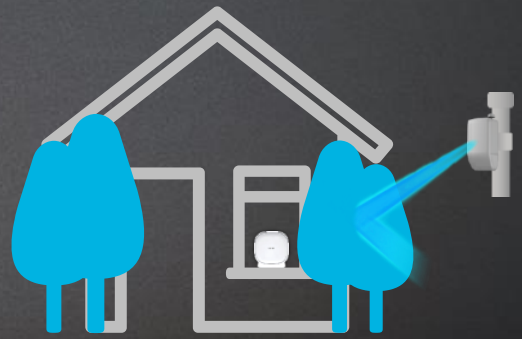
Lessons Learned about mmWave (1/3)

Coverage ?

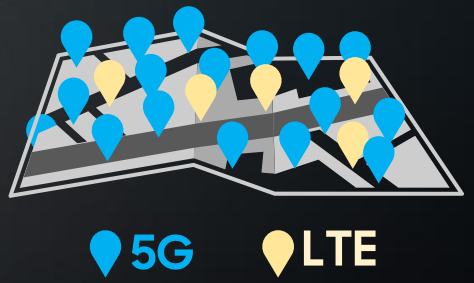
Short Coverage

NLOS Condition

Foliage



Number of Sites



Short Coverage ?

Larger than 1km Coverage in Line-of-Sight

Concern

... 50m ?

Actual Results

800m

(Residential area, LOS, 2m Height)

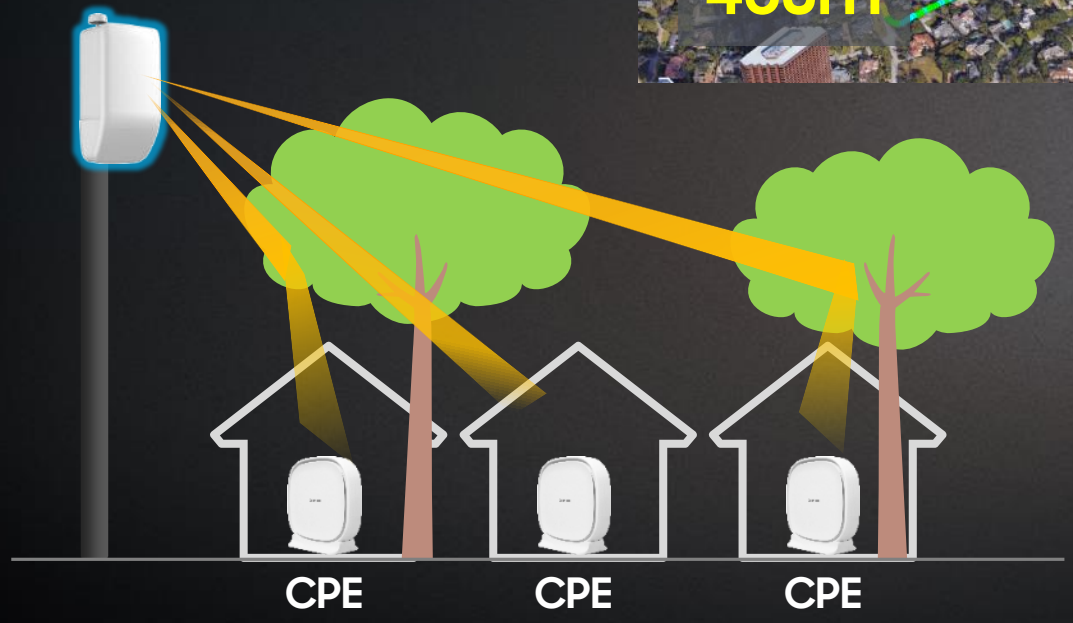
1.2km

(Residential area, LOS, 40m Height)

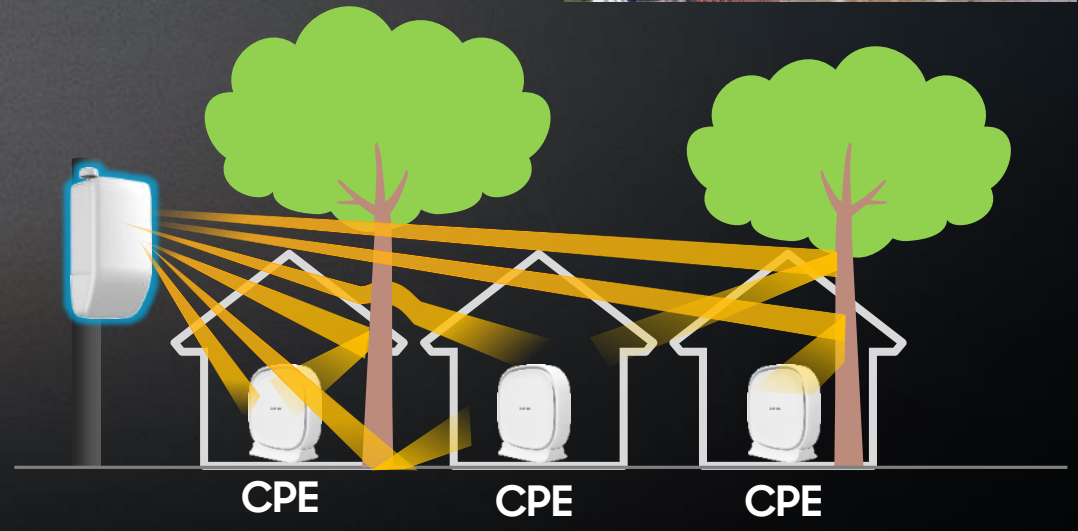
NLOS Condition & Foliage ?

Overcome NLOS with Reflected & Trunk-Diffracted Paths

AU Height : 7m



AU Height : 2m



Number of Sites ?

Similar Outdoor Coverage from Co-Sites with LTE in Dense Urban

19 5G & LTE
1:1 Co-Location
(Inter Site Distance : 120m)

Dense Urban
(Seoul, May 2018)

LTE Coverage : DL ≥ 10 Mbps, UL ≥ 1 Mbps
5G Coverage : DL ≥ 1 Gbps, UL ≥ 40 Mbps

Outdoor Main Road Coverage

-70 ≥ RSRP
-80 ≤ RSRP < -70
-90 ≤ RSRP < -80
-100 ≤ RSRP < -90
-110 ≤ RSRP < -100
RSRP < -110

>99% (DL)
28GHz CPE on the car

>94% (DL)
28GHz Tablet at sidewalk

RF Planning

Provides Accurate Coverage & Throughput Analysis

Step 1

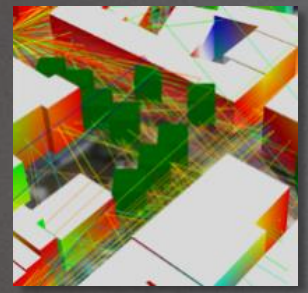
Semantic 3D Map Generation

Foliage/Materials from Real Images

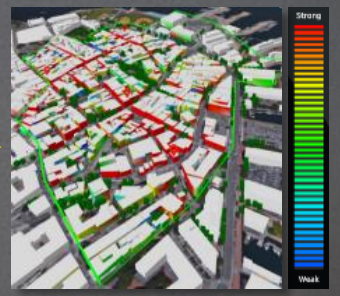
Semantic 3D Map

Step 2

mmWave Analysis by Ray-tracing



Ray & Foliage Effect Analysis

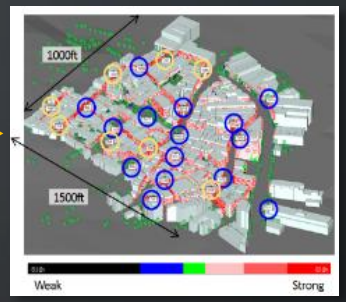


Radio Map Analysis

Step 3

RF Planning & Site Optimization

Coverage & Throughput Simulation

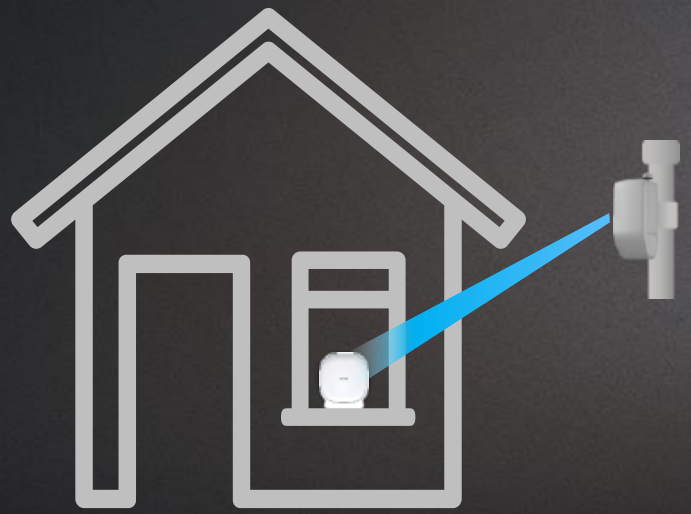


AU Location Optimization

Lessons Learned about mmWave (2/3)

Outdoor to Indoor Penetration ?

Walls & Window



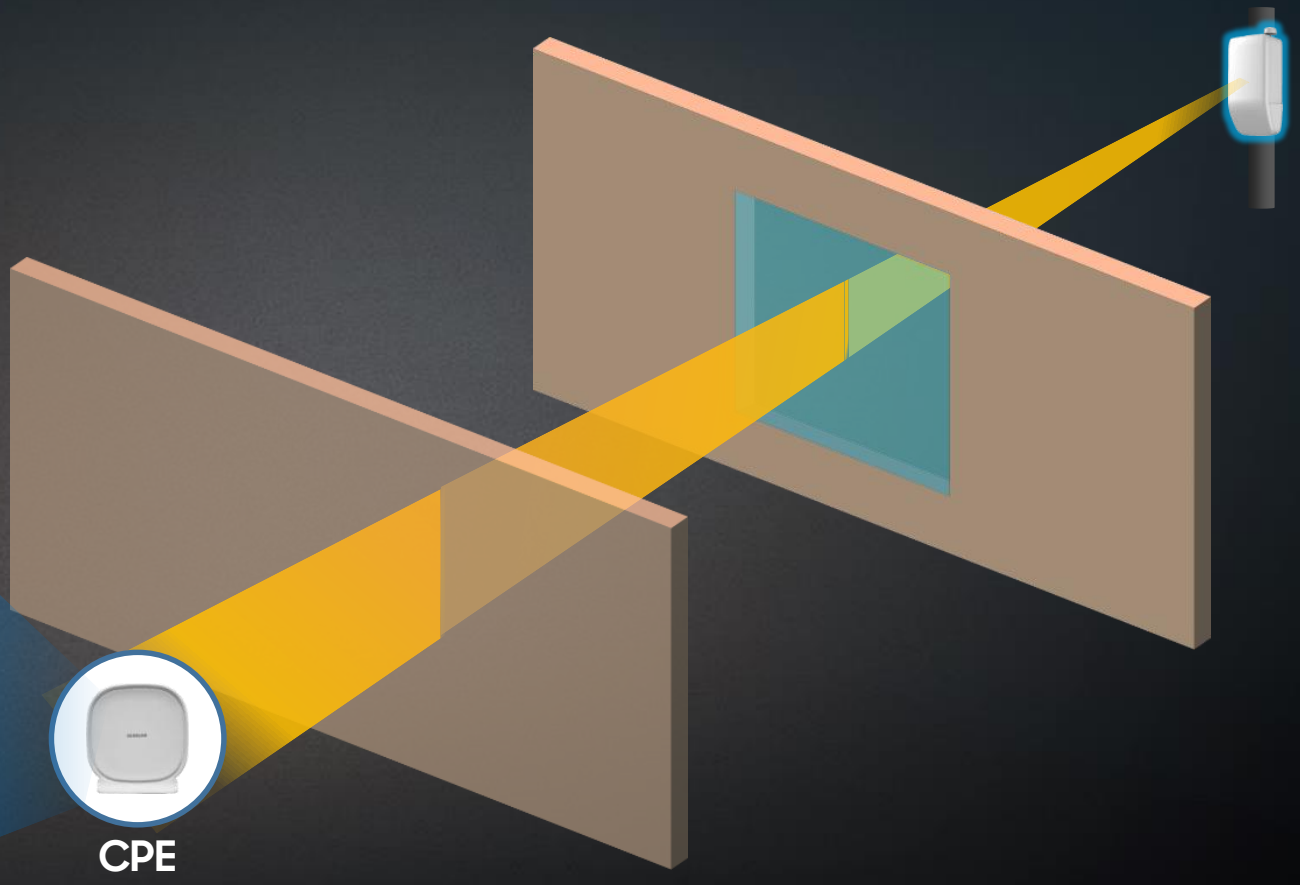
Low-E* Glass

(* Low-Emissivity)

Indoor Penetration : Walls & Window

Indoor Penetration is Better than Expected

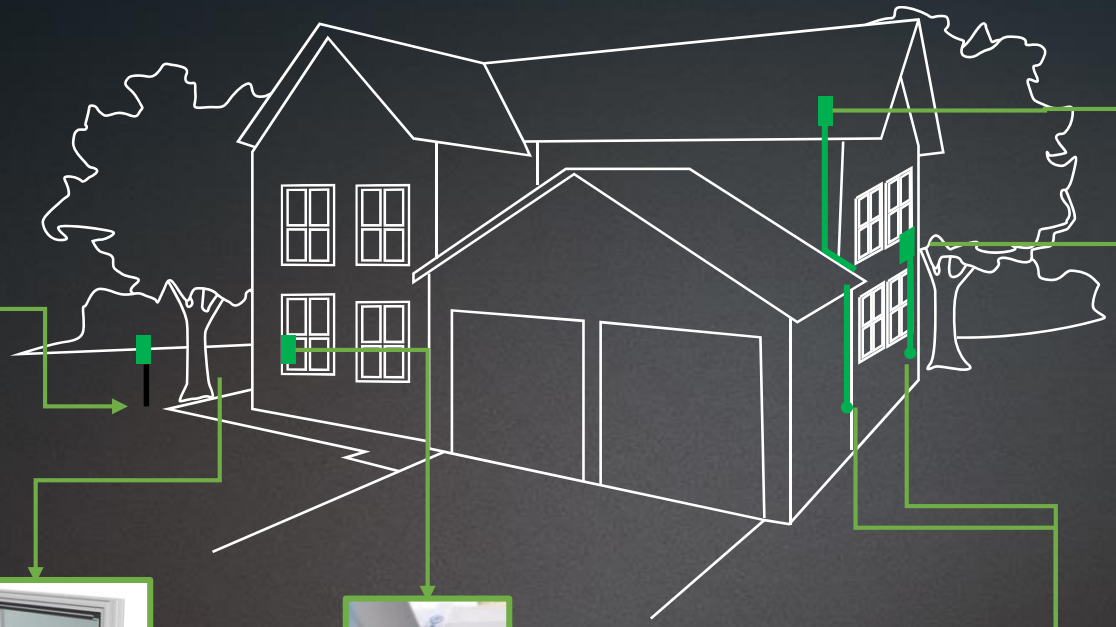
2017, US Operator's Trial Result



Indoor Penetration : Low-E Glass

Outdoor CPE can be Alternative Solution to Overcome Excessive Penetration Loss

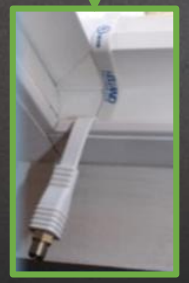
Pole Installation



Rooftop Installation

Wall Installation

Window Installation

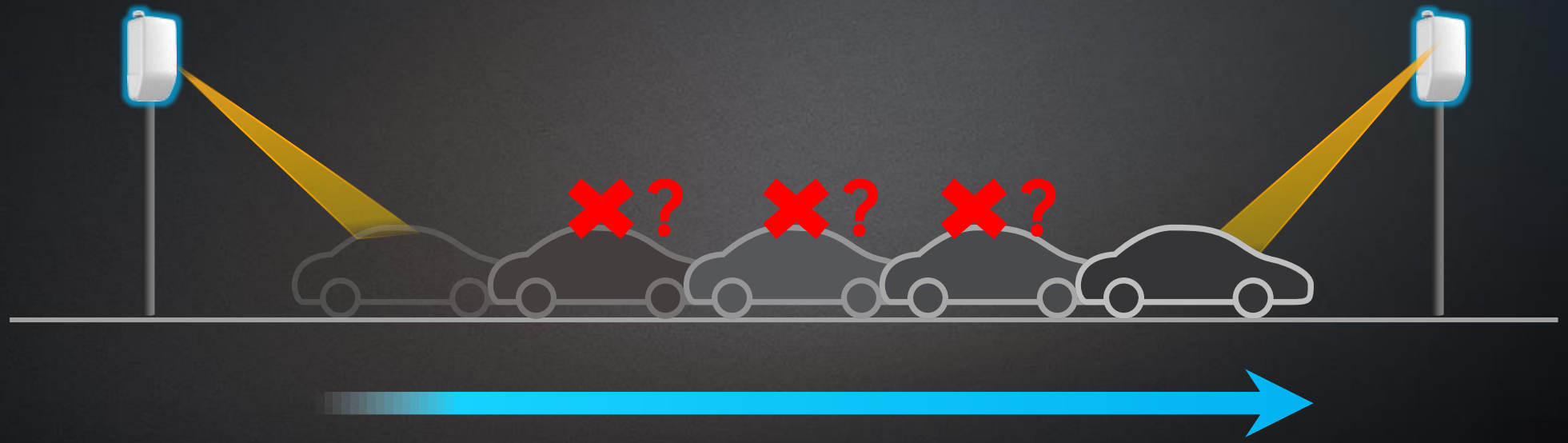


Flat Cable

Cable Wall Penetration

Lessons Learned about mmWave (3/3)

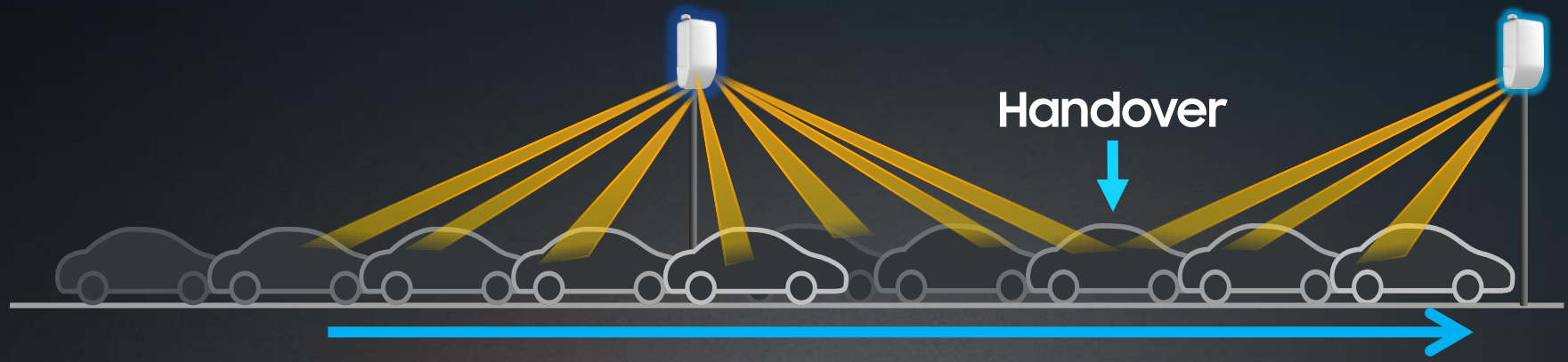
Mobility ?
Handover ?



World's Fastest Multi-cell Handover

(Korea, 2017)

5G mmWave Handover at 192 km/h



Stable 5G Service at Over 200 km/h

mmWave in commercial network

5G Commercial Service in 2018

28GHz

5G FWA Commercial

USA

2H 2018

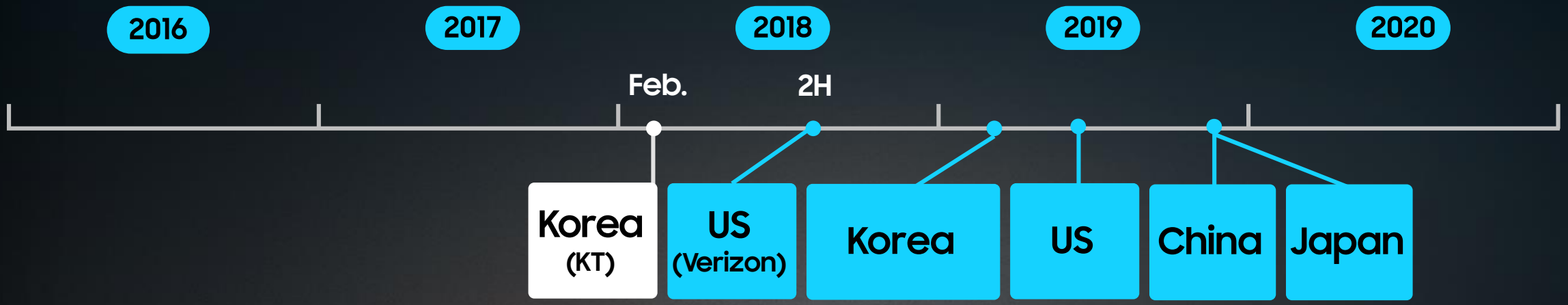
3.5GHz, 28GHz

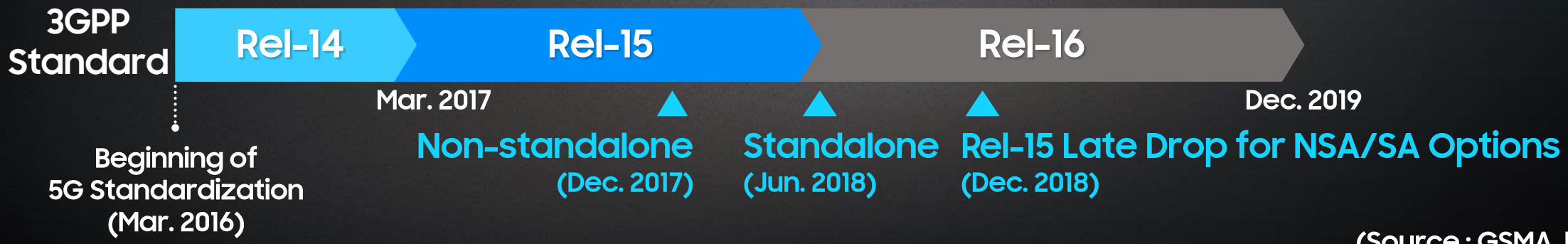
5G NR Mobile Commercial

KOREA

Q1 2019

5G Commercial Timelines





(Source : GSMA, Mar.2018)

Above 6GHz 5G FWA Trial in UK

arqiva

Offered New and Compelling Connected Service Opportunities in London, UK

(Jul. 2017)

5G NRU
on the Rooftop of Operator A's Office

5G CPE
Inside Operator A's Nearby Headquarters

28GHz (400MHz Bandwidth)

Below 6GHz 5G Mobile Trials in Korea

World's 1st LTE/3.5GHz/28GHz Interworking Trial in Downtown Seoul

SK telecom

1 Gbps @ 3.5GHz

(Jun. 2017)

NR Key Features

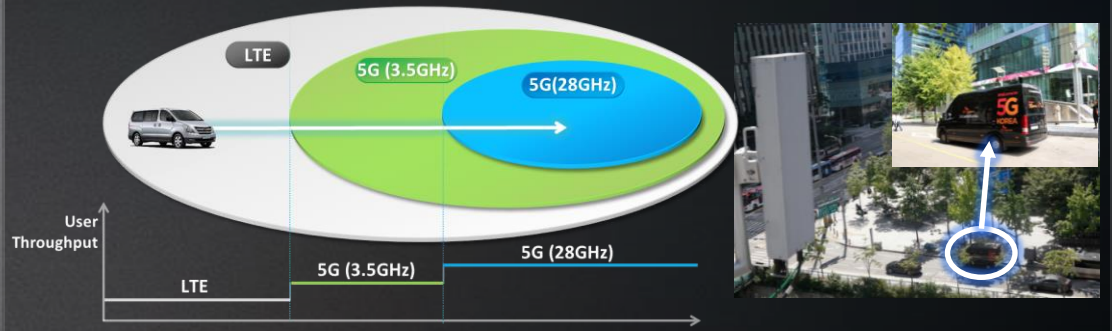
- 60kHz Subcarrier Spacing,
- LDPC & Self-contained Subframe

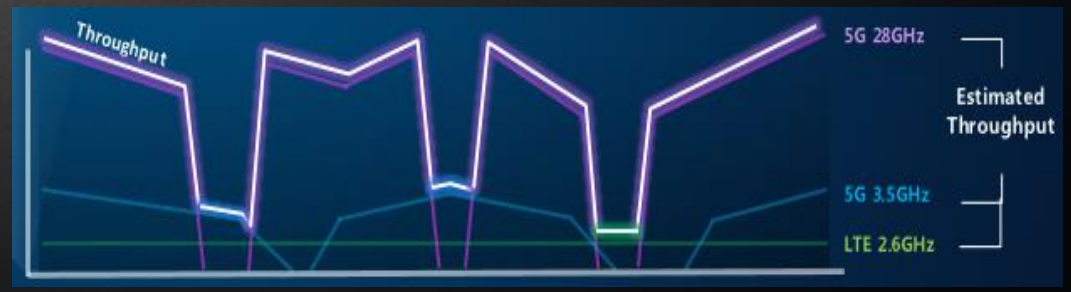
4G-5G (3.5GHz, 28GHz) Interworking

(Sep. 2017)

Selecting a Better RAT among Connected RANs

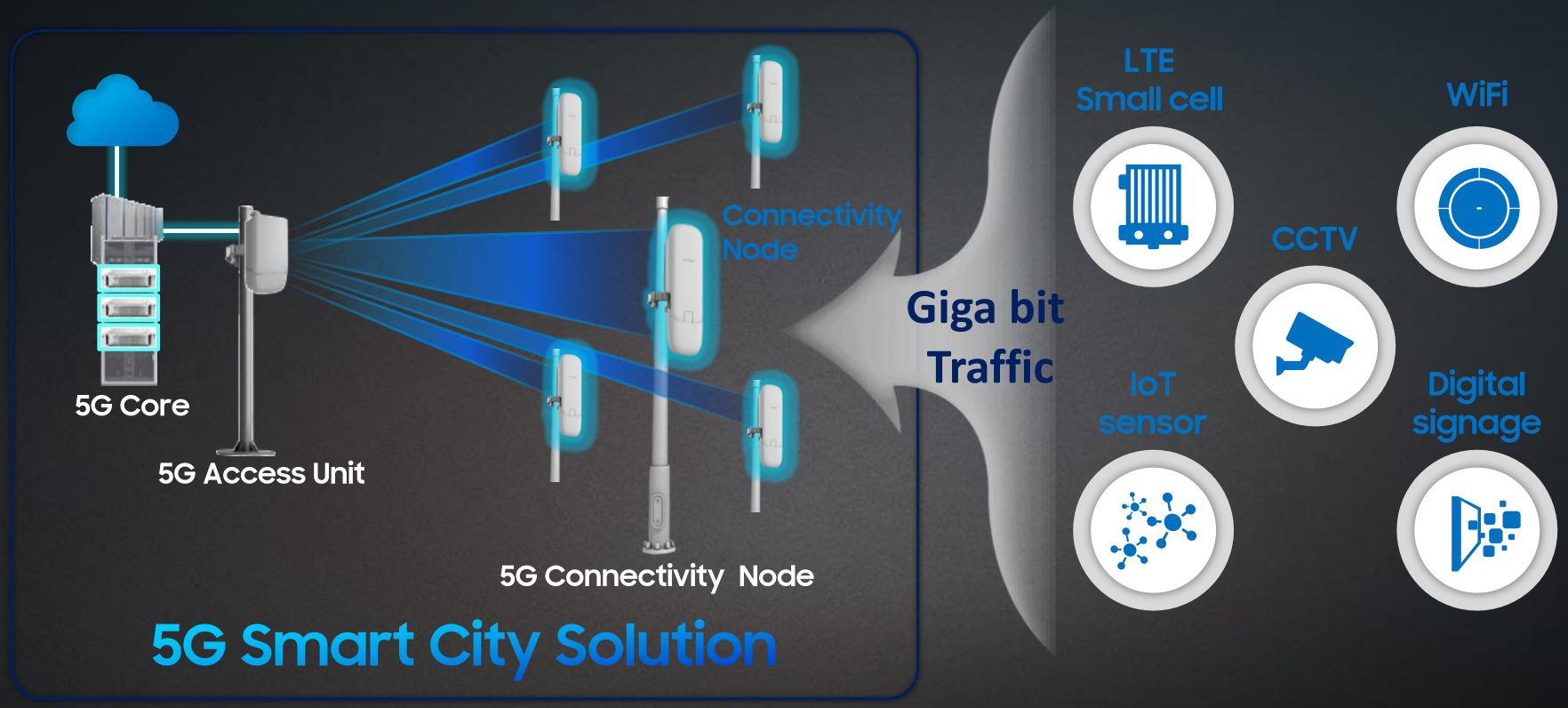
※ Radio Access Technology





5G Connectivity Node for Smart City

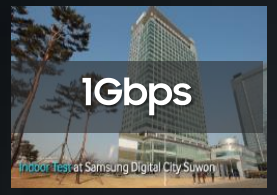
5G Connectivity Node Provides Gigabit Connectivity for Smart City



Samsung 5G Technology Leadership

2013 — 2014 — 2015 — 2017 — 2018

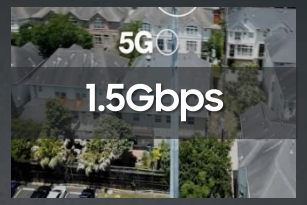
Fixed



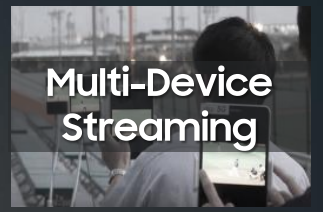
mmWave Testbed

mmWave High Speed

4K Video Streaming (UK)



Fixed Wireless Access Field Trial (US)

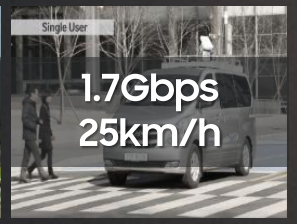


Stadium (JP) : 50 5G Tablets

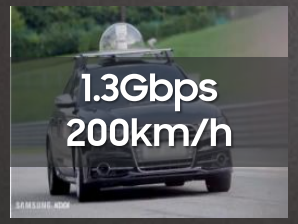
Home Broadband Field Trial (Romania)

Mobile

mmWave High Speed



Multi-Cell Handover (mmWave)



Fastest Handover (mmWave)

LTE/3.5/28GHz Interworking

5G Train (JP) : 8K UL, 4K DL (100km/h)

Autonomous Driving

Cooperative Platooning

Unveiled 5G Base Stations

World's First/Best

Thank You