5G mmWave Discussion with VNICTP

October 8, 2020

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Solution Sales | Czech

Security Level:

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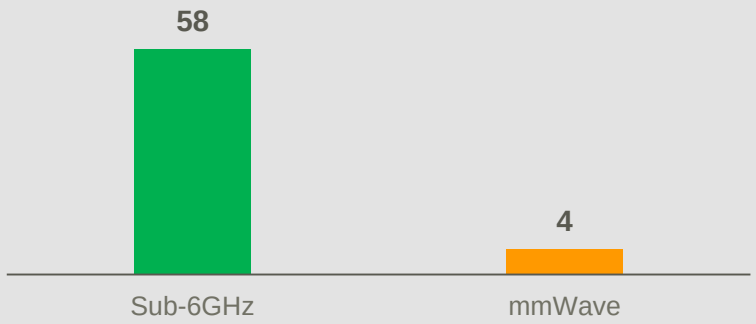
1. mmWave Industry Updates
2. mmWave Application Scenario
3. Huawei Technical Analysis
4. Huawei mmWave Roadmap

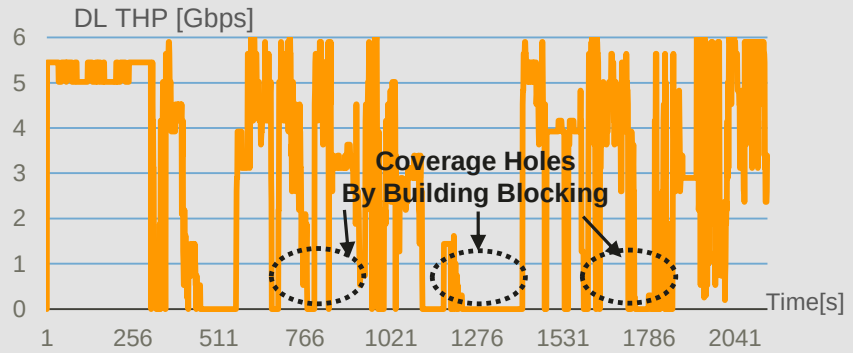
All Bands to 5G: Sub-6G as Mainstream Investment, mmWave is Currently Limited in Coverage

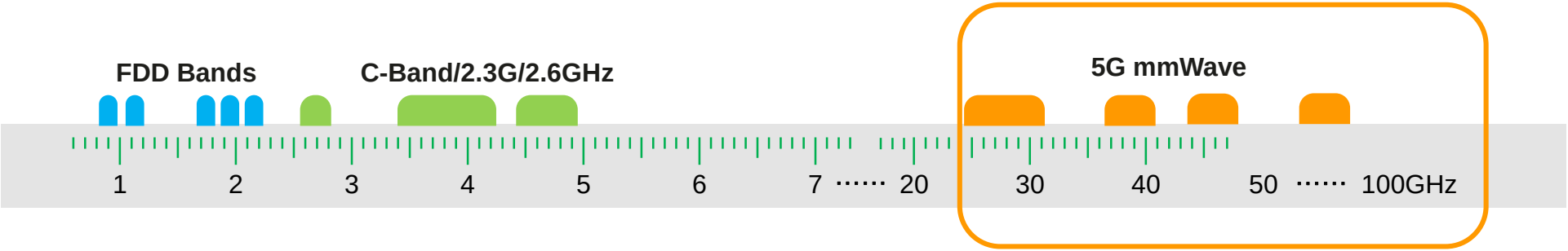
58 of 62 Operators Launched 5G at Sub-6GHz for Best Investment Efficiency



Source: GSA Report, Feb, 2020

mmWave Boosts User Experience but Coverage Blind Spots Exist due to Higher Loss than Sub-6G





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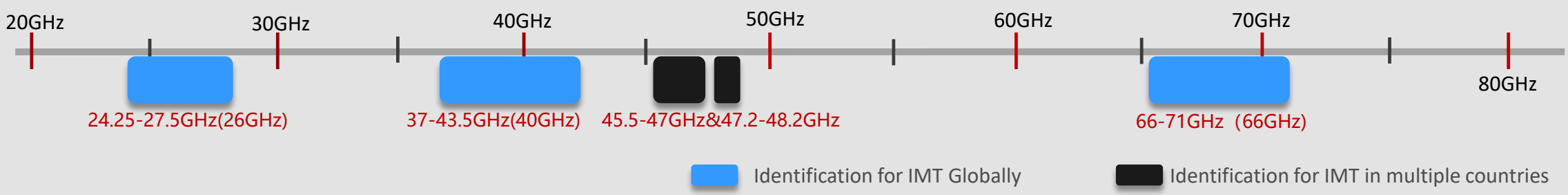
More mmWave Spectrum Identified as IMT, Global Industry due to Mature

WRC-19 in **Oct/2019** defined: 17.25GHz of mmWave Identified for IMT



5G mmWave **Mainstream Band**: **26GHz, 28GHz & 39GHz**

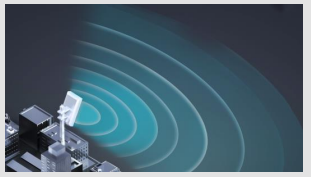
mmWave@Countries	26GHz	28GHz	39GHz
China	24.75-27.5 GHz		37-42.5GHz
Europe	24.25-27.5 GHz		
USA		27.5-28.35 GHz	37-40GHz
Japan		27.5-29.5 GHz	
South Korea		26.5-29.5 GHz	
Hong Kong	24.25-28.35 GHz	24.25-28.35 GHz	

5G mmWave **Industry Needs Time to Go Mature**

9 countries have available mmWave , Only **1** Commercialized.

Best Scenarios: FWA, Hotspot and Indoor 2B

LOS (Line of Sight)



Multi-paths reflections

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Before Global Application, mmWave Spectrums Remain Cost Effective

Korea 5G bands auctioned in June / 2018:

C-Band	mmWave
$ 0.95/Hz/Y	**€ 0.05/Hz/Y**
	5% of C-Band

- Total mmWave Bandwidth: **2.4GHz @28G**
- Unit price is **5%** of C-band

Italy 5G bands auctioned in Sept / 2018

700M	C-Band	mmWave
€ 1.7/Hz/Y	€ 1.09/Hz/Y	**€ 0.008/Hz/Y**
	64% of 700M	**0.7%** of C-Band

- Total mmWave Bandwidth: **1GHz @26G**
- Unit price is **0.7%** of C-band

Hongkong 5G bands auctioned in Oct / 2019

C-Band	4.9G	mmWave
$ 0.043/Hz/Y	$ 0.026/Hz/Y	**0**
	60% of C-Band	

- Total mmWave Bandwidth: **1.2GHz @28G**
- mmWave is **free of charge**

Thailand 5G bands auctioned in Feb / 2020

700M	2.6G TDD	mmWave
$ 3.66/Hz/Y	$ 0.42/Hz/Y	**€ 0.009/Hz/Y**
	11% of 700M	**2%** of 2.6GHz

- Total mmWave Bandwidth: **2.6GHz @26G and 28G**
- mmWave is **2%** of 2.6G

Spectrum cost of mmWave are only *1% - 5%* of 5G Sub6G TDD bands

mmWave Global Industry progress

2018 → 2019-2021 → 2022~

Frequency Readiness

1st Wave

- Italy 26G
- Japan 28G
- HK 26/28G
- Korea 28G
- USA 28/39G
- Thailand 26/28G

2nd Wave

Europe
Asia Pacific
Canada …

Ecosystem Readiness

Network

Oct/2018
3GPP-mmWave
Commercial First Call

Terminals

CPE

CPE

Smart Phone

Chips

Balong

Kirin

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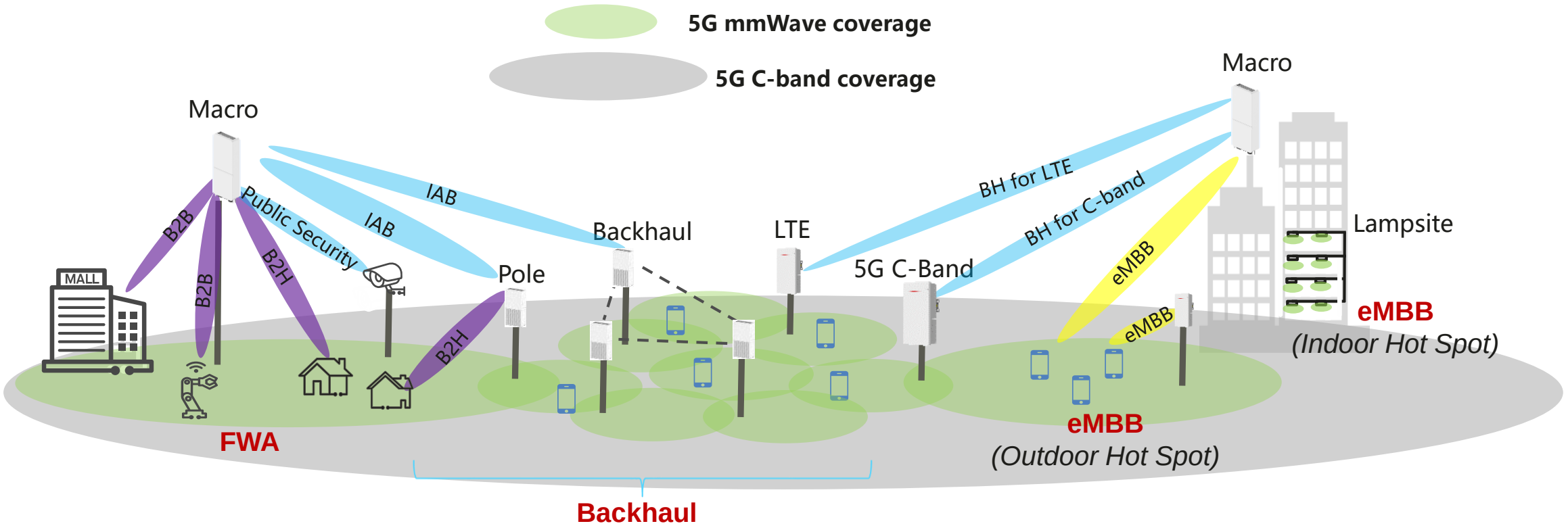
mmWave Typical Scenarios: FWA, Hot Spots and Backhaul



1. **FWA** *(Fixed Wireless Access)*: B2H, B2B
2. **Backhaul:** Backhaul for other RAT, IAB (Integrated access backhaul)
3. **Outdoor hot spot:** CBD, dense street etc.
4. **Indoor hot spot:** Stadium, airport etc., with lampsites.

**IAB to be defined from 3GPP R16 and R17*

mmWave Commercialization Today: Limited Coverage and Revenue

- 5G mmWave Commercialized only in USA in 2019, due to limited commercialization.
- C-band for eMBB is re-considered in 2020, mmWave will be mainly for FWA.

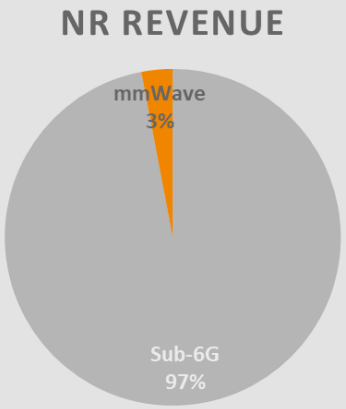
mmWave 28GHz Deployment in Verizon, USA

End of 2018
4 cities

Q3/2019
10 cities for only hotspot like parks, monuments, museums, college campuses and stadiums

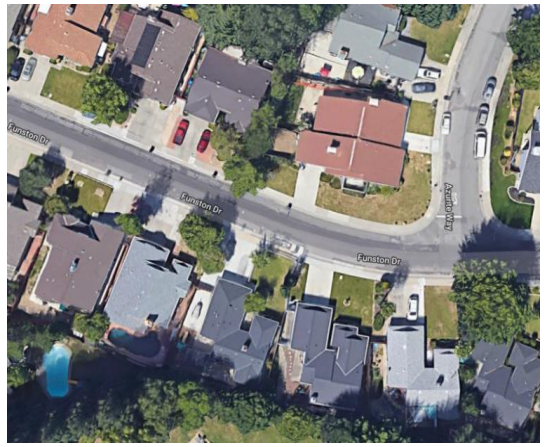
By 2020
C-Band due to release

Sub 6 GHz 5G NR, accounted for 97% of the 2019 5G NR revenues, with mmWave comprising the remaining **3%**.



Source: Dell'Oro Mobile RAN Quarterly Report 2019

A Verizon 5G TF network site. (Image: Emil Olbrich/SRG)



Typical FWA Target Area – Dense houses Sacramento, CA

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FWA is the Key mmWave Application, eMBB and B2V due to be Explored

Fix Service for Houses

- **Now:**

Cell throughput **>8Gbps@800MHz**.

Single User throughput **>4Gbps@800MHz**.

- **Future**

Low latency and large uplink, IAB

Regional uRLLC

HD (above 8K) Transmission

Fix Service for Buildings

Mobile Service for Hotspot Square

Mobile Service for Hotspot Street

Integrated Access Backhaul

Indoor Accurate Positioning

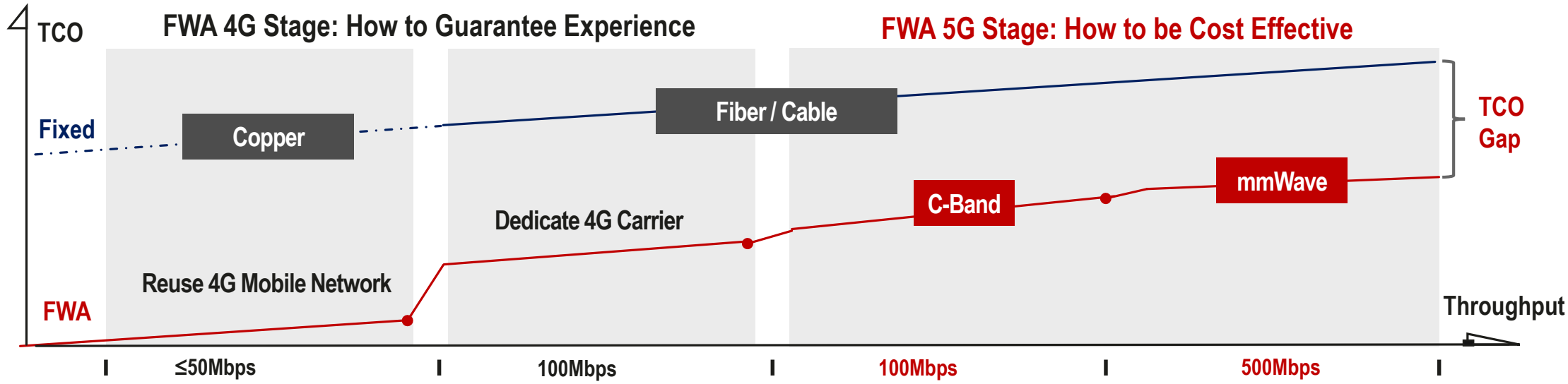
...

FWA **eMBB** **B2V**

2019-2021 **2022~** **2023~**

mmWave is Highest Stage of FWA: Same User Experience but Lower TCO than FTTx

FWA Development History and Comparison with Fixed Network



4G and C-Band for Suburban and Rural

mmWave for Urban and Dense Urban

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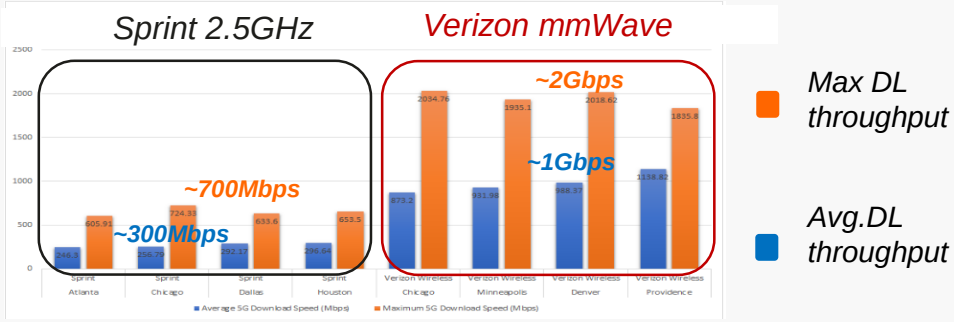
Future mmWave eMBB and Vertical Applications: under Evolution and Exploration

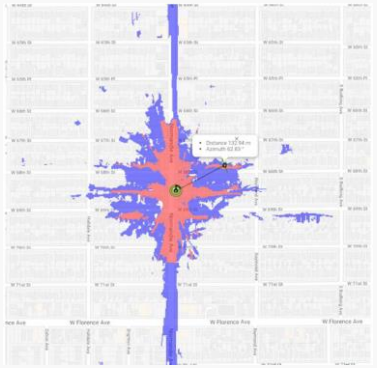
eMBB in USA: *Needs Improvement*

Benefits: Higher user experience in hot spot

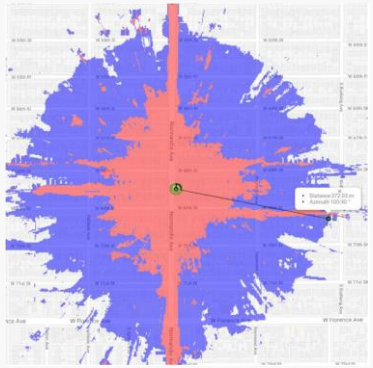


Weakness: needs much denser sites

mmWave Simulation



C-Band Simulation



1Gbps throughput

100Mbps throughput

Source: 5G report from Defense Innovation Board ,USA

mmWave 2B: *Under Exploration*

Technical advantages
need more commercial exploration

- Lower latency:

Short TTI, ¼ of C-Band

- UL improvement:

More flexible DL/UL ratio

- High accuracy:

Indoor positioning

- High penetration loss:

Outdoor-indoor interference free

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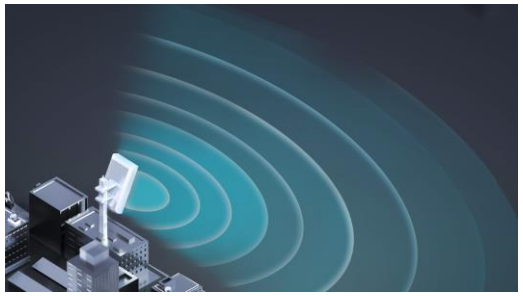
mmWave Coverage Tranches: LOS and Reflections are Best Cases

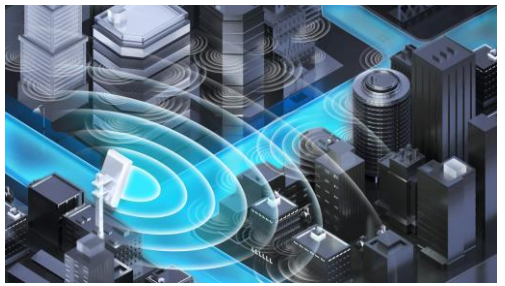
I. Best Scenarios:

1. **LOS (Line of Sight): Ideal scenario for mmWave**
2. **Rich reflections:** Using reflections to enhance the outdoor signals. Hotspot outdoor streets and squares are typical cases.

LOS (Line of Sight)



Multi-paths reflections



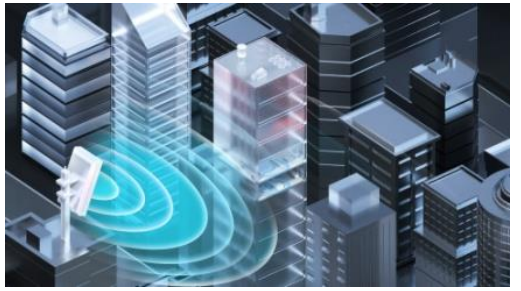
II. Acceptable Scenarios *(near LOS):*

Low penetrations like:

1. **Foliage penetrations:** Averagely 8dB loss per tree, 1 or 2 trees foliage penetration is acceptable. Some times pole site is needed.
2. **Glass penetrations:** Near glass shallow O2I (outdoor to indoor) coverage is acceptable. Deep indoor needs indoor solutions.

Foliage Penetrations

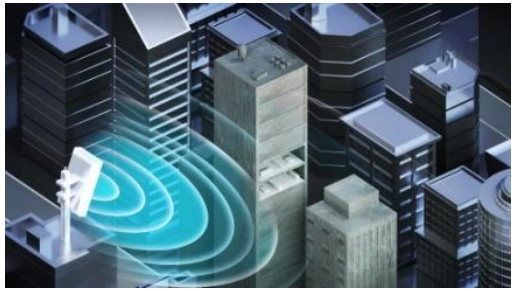
Glass Penetrations



III. Difficult Scenarios:

1. **High penetrations:** Such as concrete wall (>60dB loss), very difficult for O2I coverage. Indoor solution is needed.
2. **Diffractions:** >18dB loss. Pole site is needed for coverage compensation.

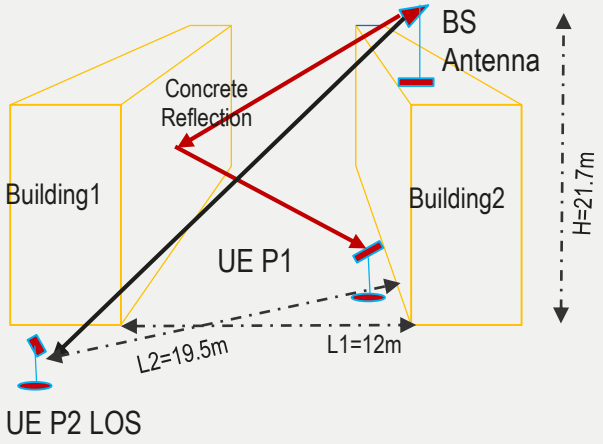
Concrete Penetrations

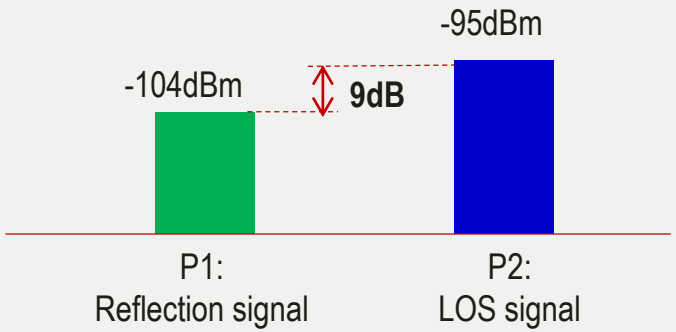


Diffractions

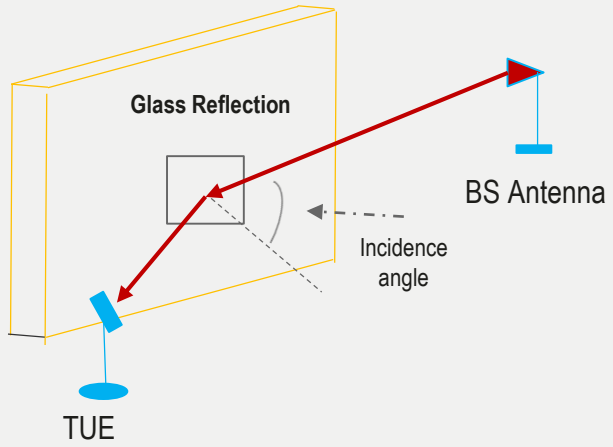
Reflections and Diffraction Losses Modeling: mmWave Reflections are Acceptable

Concrete Reflection Loss ~10dB



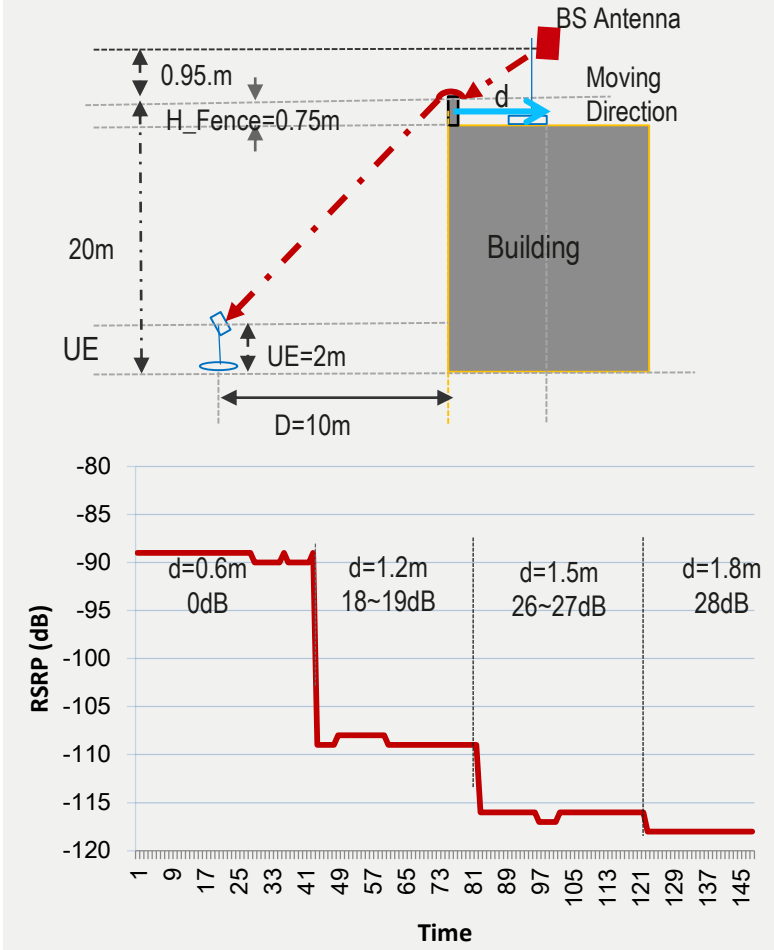


Glass Reflection Loss ~6dB



Reflection loss of different incidence angle into glass (dB)			
Incidence angle	Ordinary glass 8mm 28G	Metal coated glass 8mm 28G	Low-e metal glass 6mm 28G
10	5.0	8.4	4.9
20	4.8	6.7	5.1
30	4.1	5.3	5.3
40	2.3	4.3	5.8
50	2.0	3.5	5.5
60	1.1	2.3	5.8

Diffraction Loss >18dB



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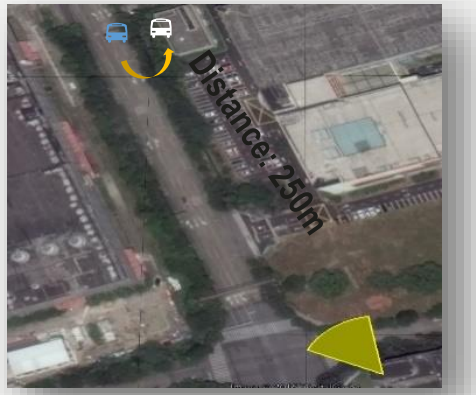
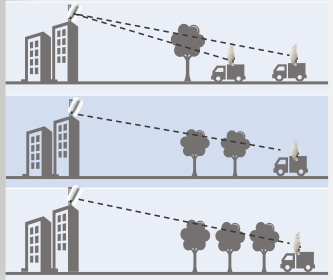
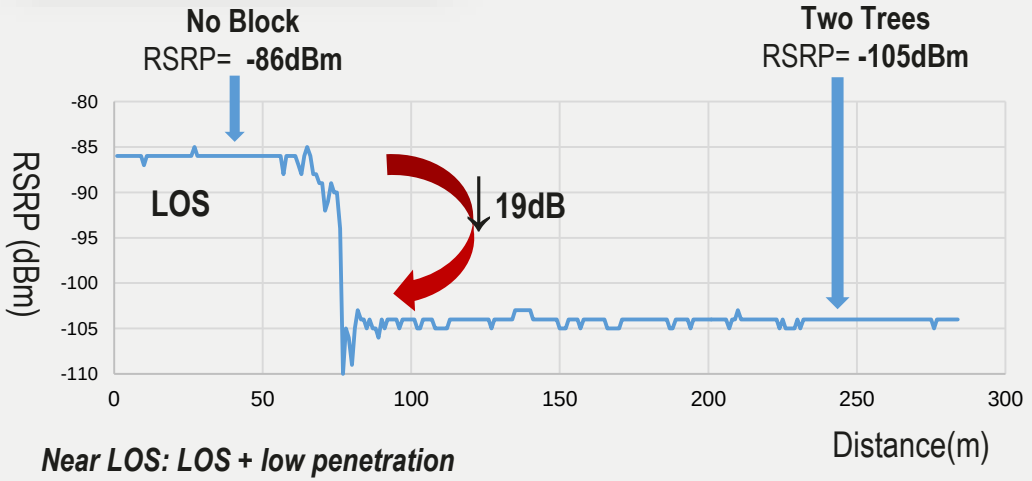
Near LOS Cases: mmWave is Acceptable in Low Penetration Scenarios

1~2 foliage penetration is acceptable



Scenarios	Results
	11~17dB
	19dB
	24dB

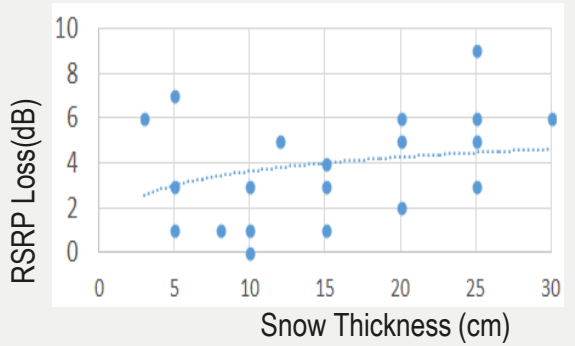


Near LOS: LOS + low penetration

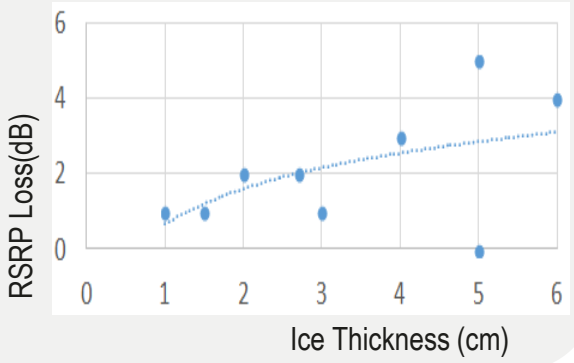
Snow & ice penetration is acceptable

~4dB loss with snow block

@Test in Canada



~2dB loss with ice block



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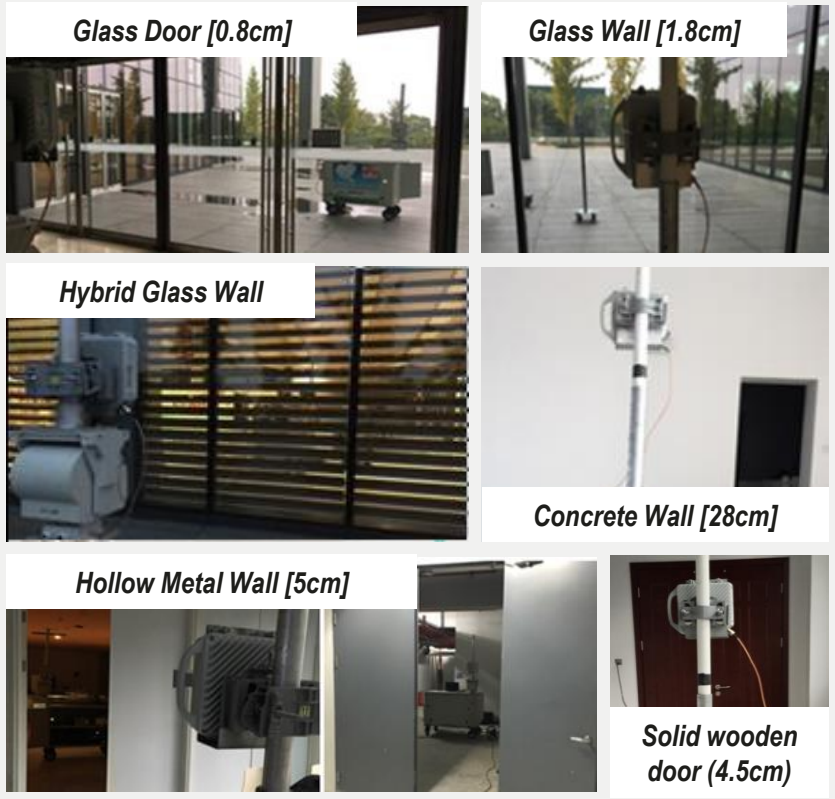
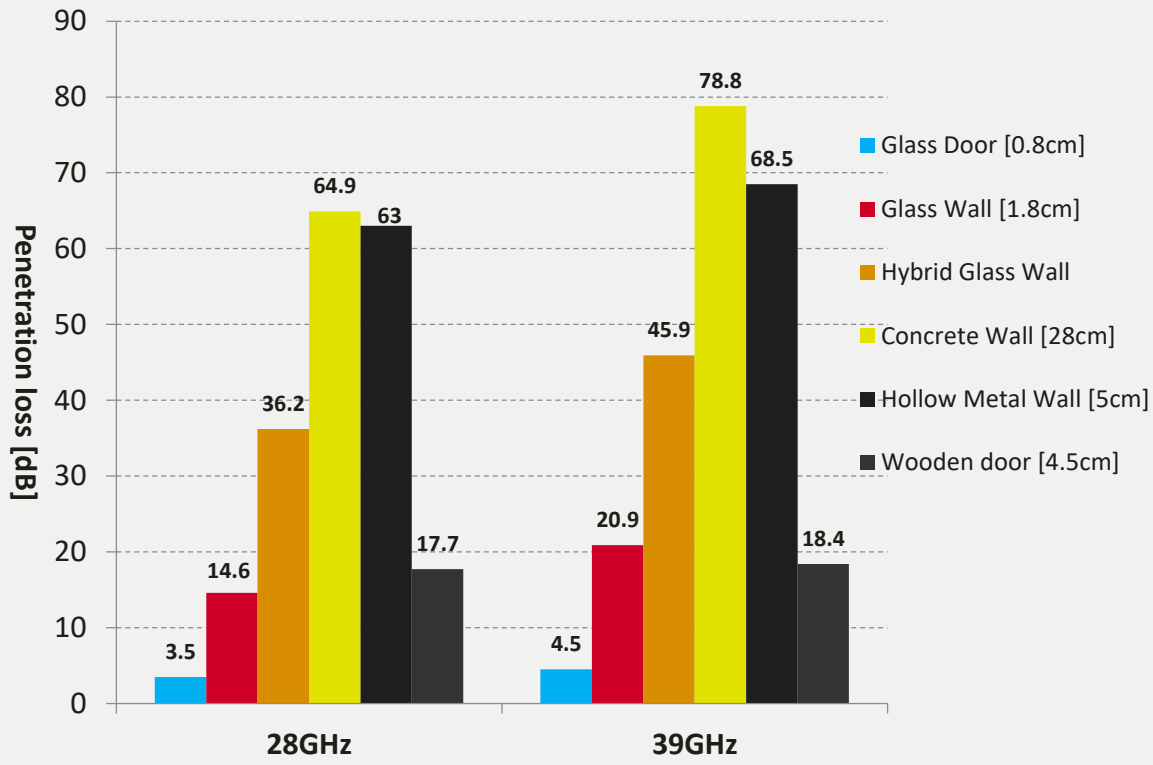
NLOS and Near LOS Cases: Penetration Scenarios under Different Materials

Glass door / wall and wooden door can be considered as 'Near LOS' for Indoor Coverage





Note: Hybrid Glass wall: Window-shades + 2 layer glass (5cm+1.8cm)

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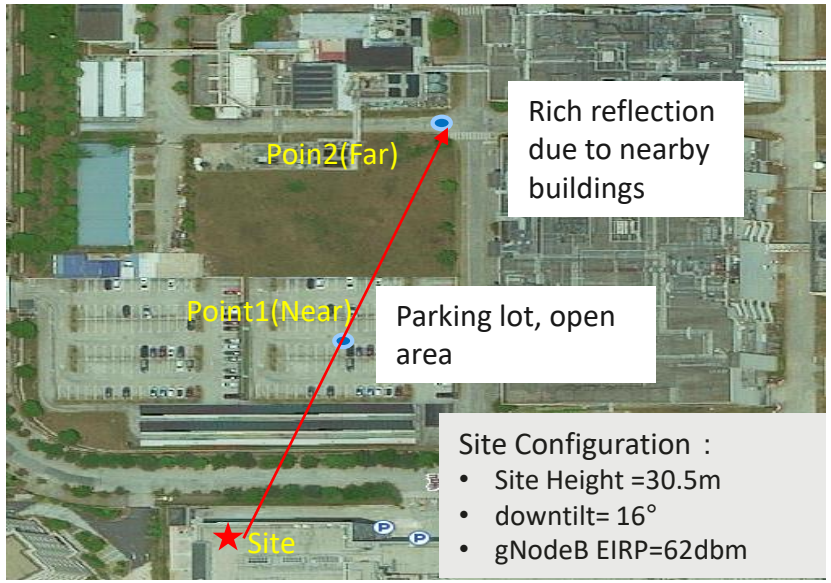
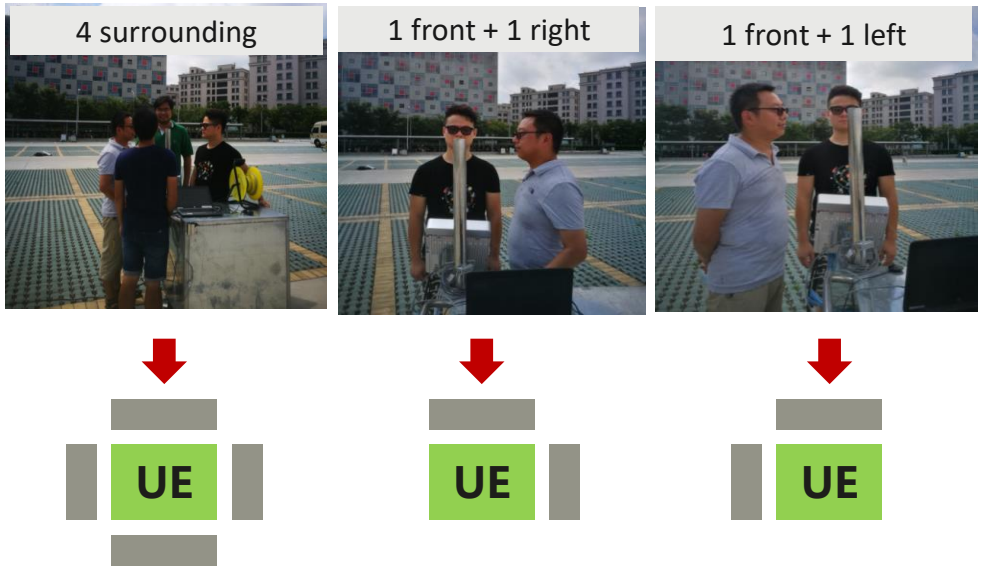
NLOS and Near LOS Cases: 9~13dB Human Body Blocking Loss under 28GHz



Site Configuration：
- Site Height =30.5m
- downtilt= 16°
- gNodeB EIRP=62dbm

UE Position：
- Point 1 Distance =85m
- Point 2 Distance =180m



Position	Scenario	RSRP (dBm)	Body block loss (dB)
Distance=85m （LOS + open area）	Basic test (No block)	-84	Baseline
	4 persons block (Surrounding)	-96	12
	2 persons block (1 front + 1 right)	-96	12
	2 persons block (1 front + 1 left)	-97	13
Distance=180m （LOS + building nearby）	Basic test (No block)	-92	Baseline
	4 persons block (Surrounding)	-105	13
	2 persons block (1 front + 1 right)	-102	**10**
	2 persons block (1 front + 1 left)	-101	**9**

Reflection helps to reduce body blocking loss

mmWave NLOS Summary: Near LOS and Rich Reflections are Preferred

Scenarios	Material	Loss (dB)	Conclusion
Wall Penetration	Cement (28cm)	64.9	NLOS: Difficult
	Hollow metal (5cm)	63	NLOS: Difficult
	Wood (4.5cm)	17.7	NLOS: Possible
Glass Penetration	Normal glass (3~8mm)	1.9~3.8	Near LOS: OK
	2-layer reinforced glass (6~13mm)	1.6~4.1	Near LOS: OK
	Coated glass (~6mm)	11.7	Near LOS: OK
	2-layer insulating glass	16.0	NLOS: Possible
	Glass door (0.8cm)	3.5	Near LOS: OK
	Glass wall (1.8cm)	14.6	NLOS: Possible
Train Penetration		~50	NLOS: Difficult
Human Body Penetration and Reflection		9~13	Near LOS: OK
Foliage Penetration		~8 / tree	Near LOS: OK
Cement Wall Reflection		~10	Near LOS: OK
Glass Reflection		~6	Near LOS: OK
Diffraction		~18	NLOS: Possible

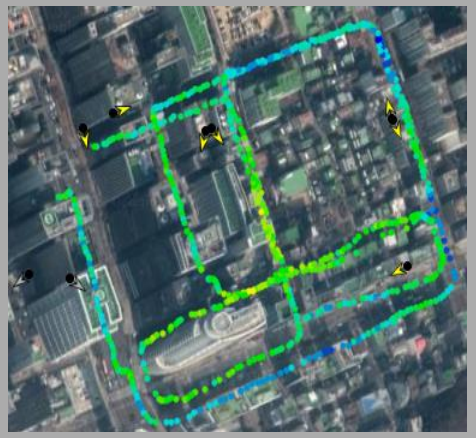
Good mmWave O2O Coverage, Meeting 95% Coverage Requirement Despite 6 dB Vehicle Body Loss

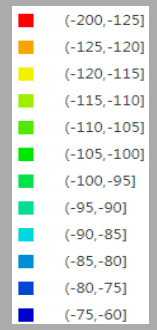
Test Line and Scenario

Number of sites: 4
Number of AAUs: 7 (10 for LTE)
ISD: ~212 m
Area: 0.08058km²
Average site height: ~47 m
Bandwidth; 800 MHz
Frequency band: 28 GHz
Module type: HAAU5213

Test of Coverage Inside and Outside the Vehicle

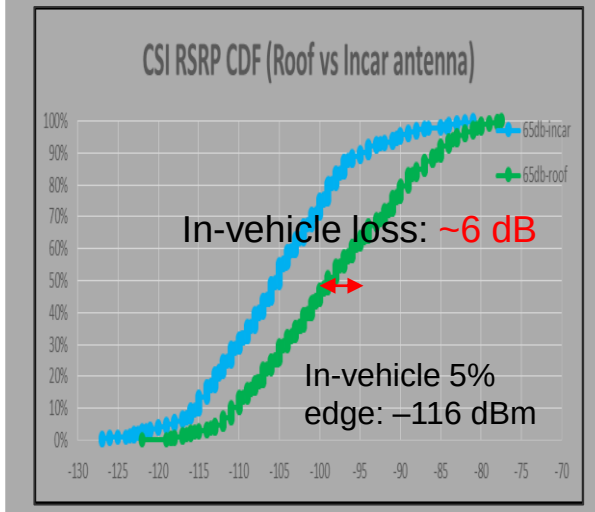
Outside a vehicle



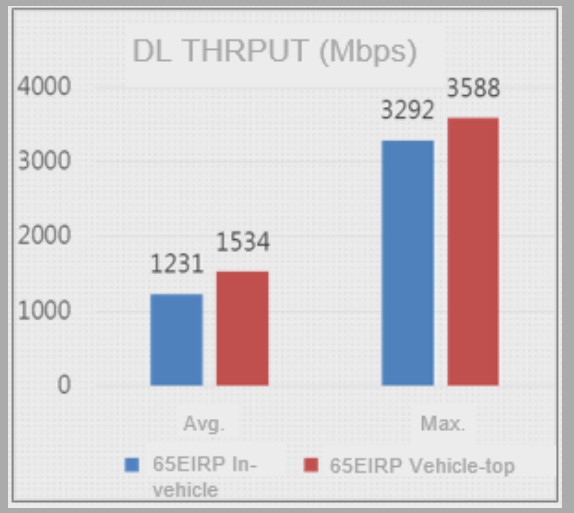


Inside a vehicle

In-vehicle: –116 dBm@95%



In-vehicle average: 1.2 Gbps



Test date: Sep., 2019

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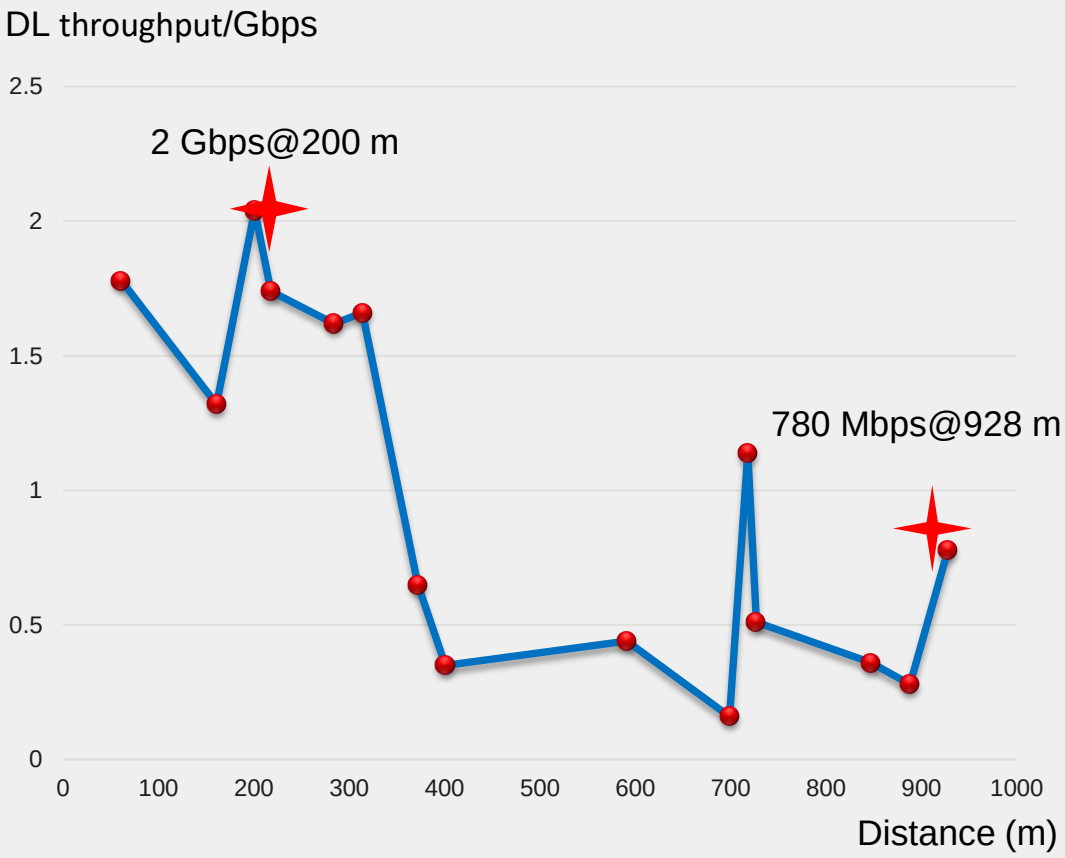
FWA Scenario: mmWave Peak Downlink Rate@400 MHz BW and 780 Mbps@1 km

Single house B2H field test

Site height: 15.5 m
Tree height:18 m

Gbps experience via 5G FWA @ 400MHz



Test date: H1, 2018

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mmWave Roadmap

Released
Ready for Contract
Planned
Planning

Characteristic	HAAU5213				HAAU5323
Freq. Band- GHz	26.5~29.5		24.25~27.5		26.5~29.5
TRx Num.	4TRx				8TRx
IBW-MHz	800	1000	800	1000	8TRx: 800 4TRx: 3GHz
Max EIRP-dBm	65	62	62	59	70
Size -mm	H: 585,W:300,D: 152				H: 585,W: 300,D: 115
Weight- Kg	20				18
Cooling Method	Natural				

HAAU5213
24.25-27.5G
4T4R
eCPRI
5G NR Support

HAAU5213
26.5-29.5G
4T4R
eCPRI
5G NR Support

****HAAU5323**
26.5-29.5G
4T4R/8T8R
eCPRI
5G NR Support

****HAAU5323**
24.25-27.5G
4T4R/8T8R
eCPRI
5G NR Support

***: The Status is TR5.*

18Q4 **20Q1** **20Q4**

HAAU5213 Macro Site AAU Specification

Frequency Band (GHZ)	26G: 24.25-27.5 28G: 26.5-29.5	**Interface**	2*SFP(eCPRI)
IBW	800MHz	**Power Supply**	-48V DC
OBW	800MHz	**Power Consumption**	Typical ~465W(DL:UL=3:1)
TRX	4	**Volume**	~26L
EIRP	65dBm@800M	**Weight**	~20kg
Antenna Element	768	**Sweep Range**	H:120°, V:30°
Polarization	+45° , -45°	**Cooling**	Nature Cooling

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Frequency Band (GHZ)	26G：24.25-27.5 28G: 26.5-29.5	**Interface**	2*SFP(eCPRI)
IBW	3.25GHz	**Power Supply**	-48V DC
OBW	800MHz	**Power Consumption**	Typical ~325W(DL:UL=3:1)
TRX	4T4R@800M 8T8R@400M	**Volume**	~20L
EIRP	*70dBm	**Weight**	~16kg
Antenna Element	1024	**Sweep Range**	H:120°, V:30°
Polarization	+45° , -45°	**Cooling**	Nature Cooling

*: Max 70dBm@400MHZ

Thank you.

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