

IMT Backhaul

(Including High Altitude Platform Stations)

ITU/SPBPU Seminar for CIS and Europe

St. Petersburg
June 7th 2018

Pietro Nava
Chairman ITU-R WP5C



1 Introduction: 5G Requirements

2 Panorama of Microwave and Millimeter-wave Usage

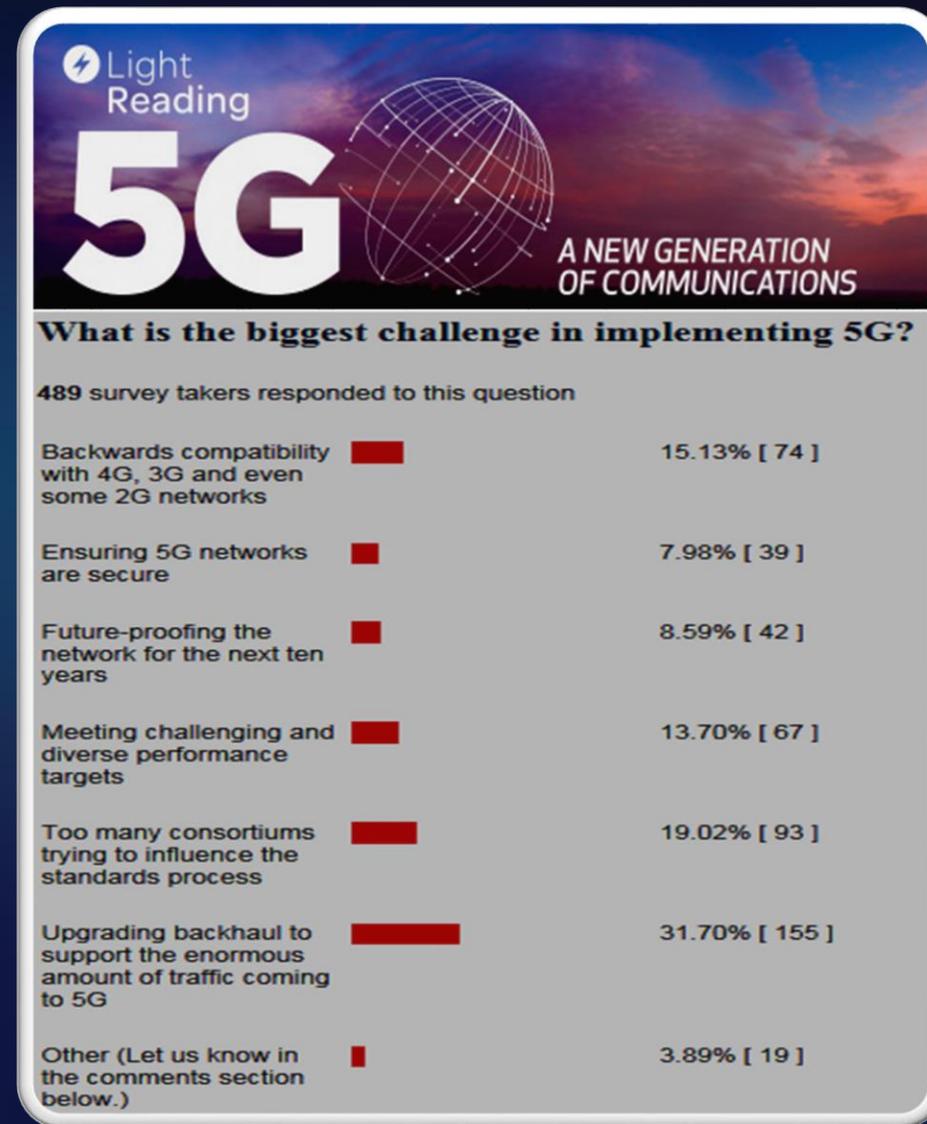
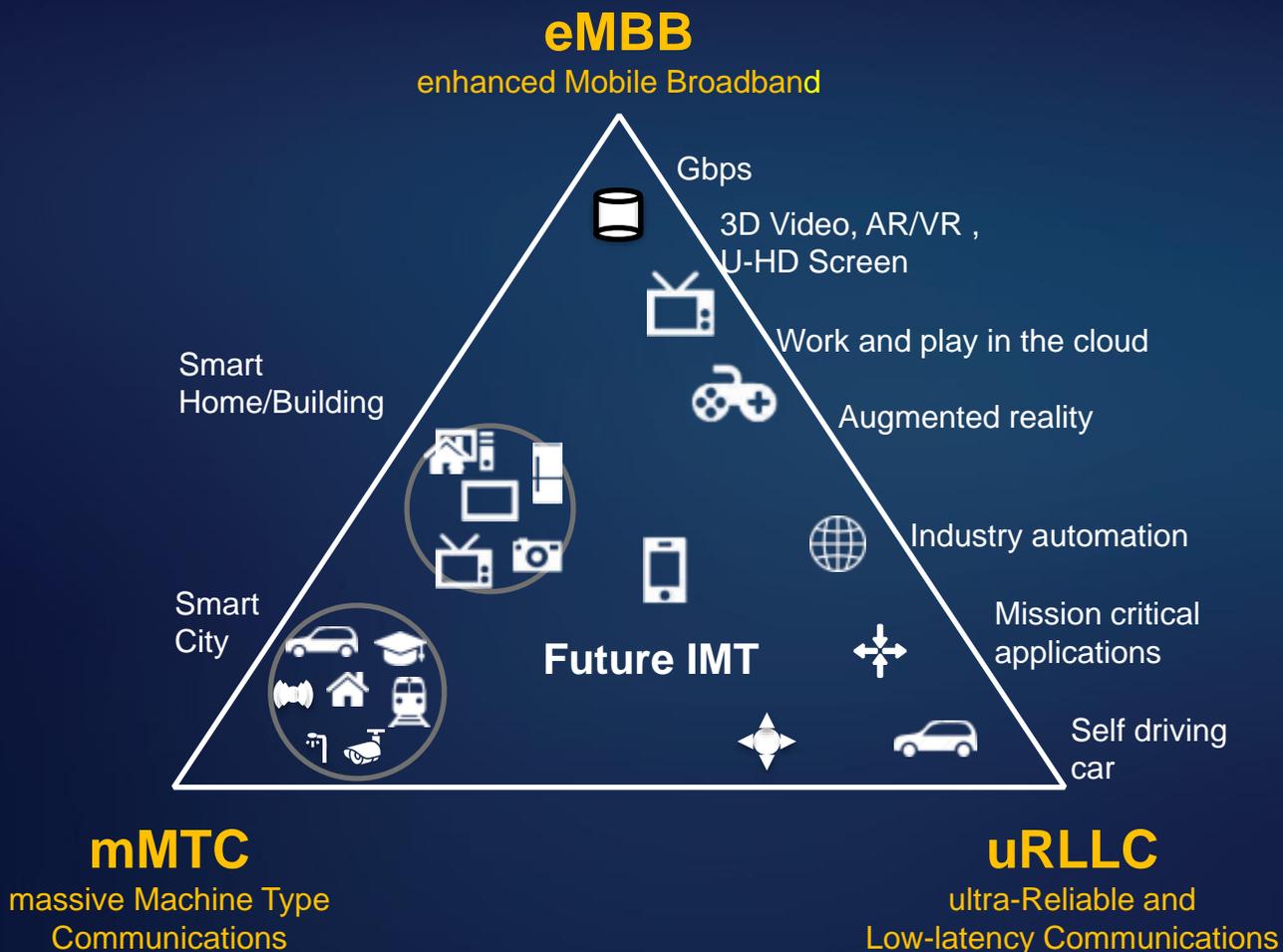
3 Technology Evolution Trends

4 Spectrum Evolution Trends

5 High Altitude Platform Stations

6 Summary

New Services, New Challenges...



5G

Throughput

10Gbps
/ connection



Area Traffic Capacity

10 Mbps/m²
Ultra Dense
Tera Cell



Latency

1 ms
E2E
Latency



Network Architecture

Slicing
Ability
required



Connections

1,000K
Connections
/ Km²



Mobility

500km/h
High-speed
railway



100x

Densification

30~50x

Hard SLA
SDN/NFV

100x

1.5x

100 Mbps

Small Cells

30~50ms

Inflexible

10K

350Km/h

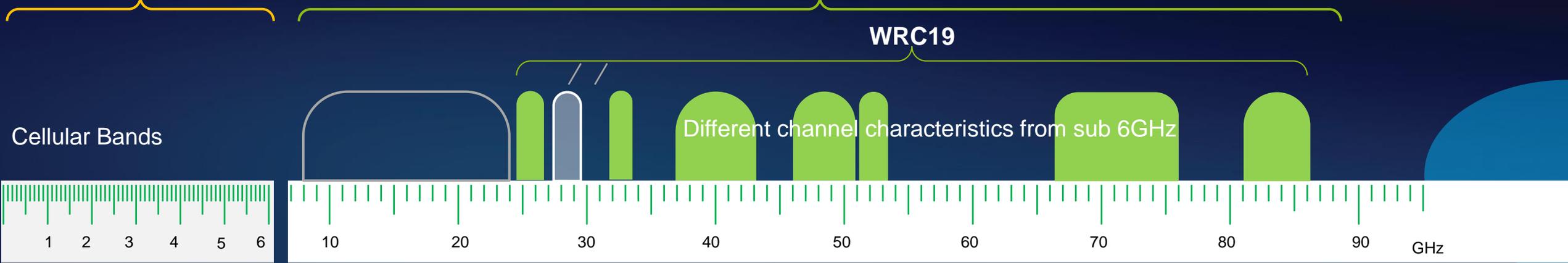
LTE

Complementary Bands for 5G



Primary bands

Complementary bands for additional capacity



Group 30	Group 40	Group 50	Group 80
<ul style="list-style-type: none"> •24.25 - 27.5 GHz •31.8 - 33.4 GHz 	<ul style="list-style-type: none"> •37.0 - 40.5 GHz •40.5 - 42.5 GHz •42.5 - 43.5 GHz 	<ul style="list-style-type: none"> •45.5 - 47 GHz •47.0 - 47.2 GHz •47.2 - 50.2 GHz •50.4 - 52.6 GHz 	<ul style="list-style-type: none"> •66 - 76 GHz •81 - 86 GHz

The allocation of spectrum for 5G/IMT-2020 is including bands traditionally used by Fixed Service and this might have big impact on operators

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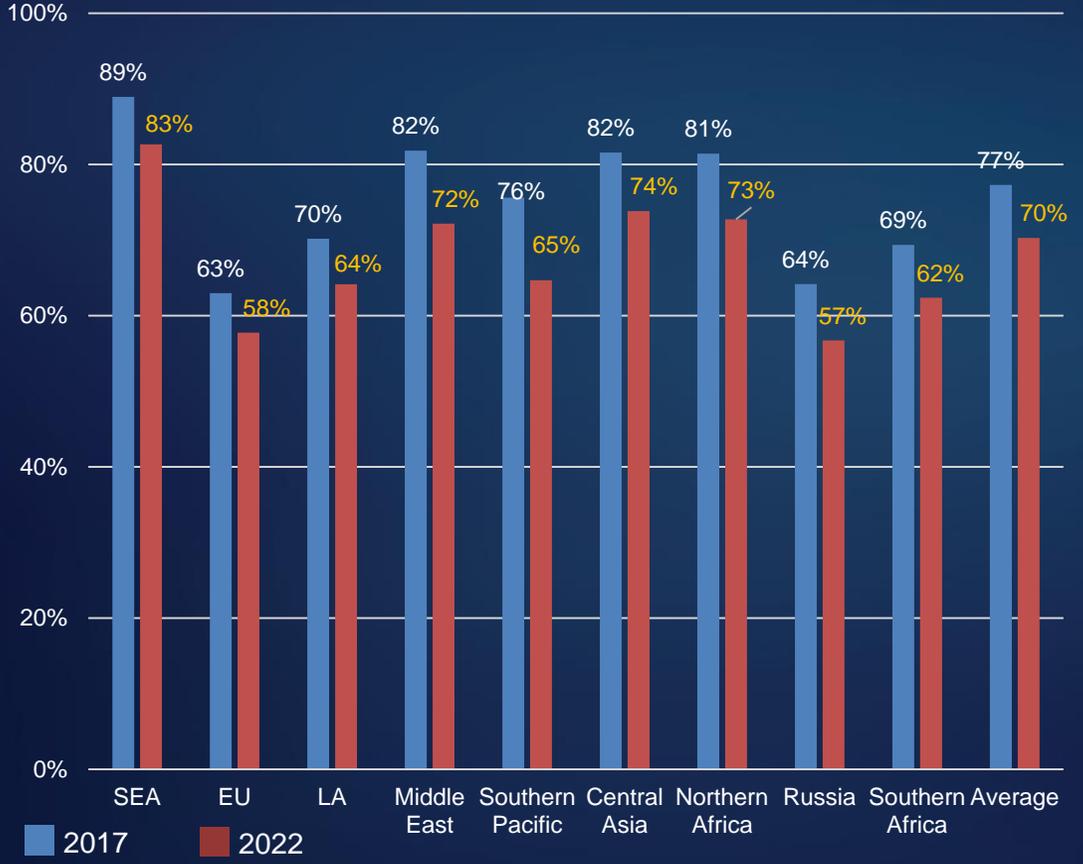
6 Summary

70% of Macro Sites Backhauled by MW in 2022

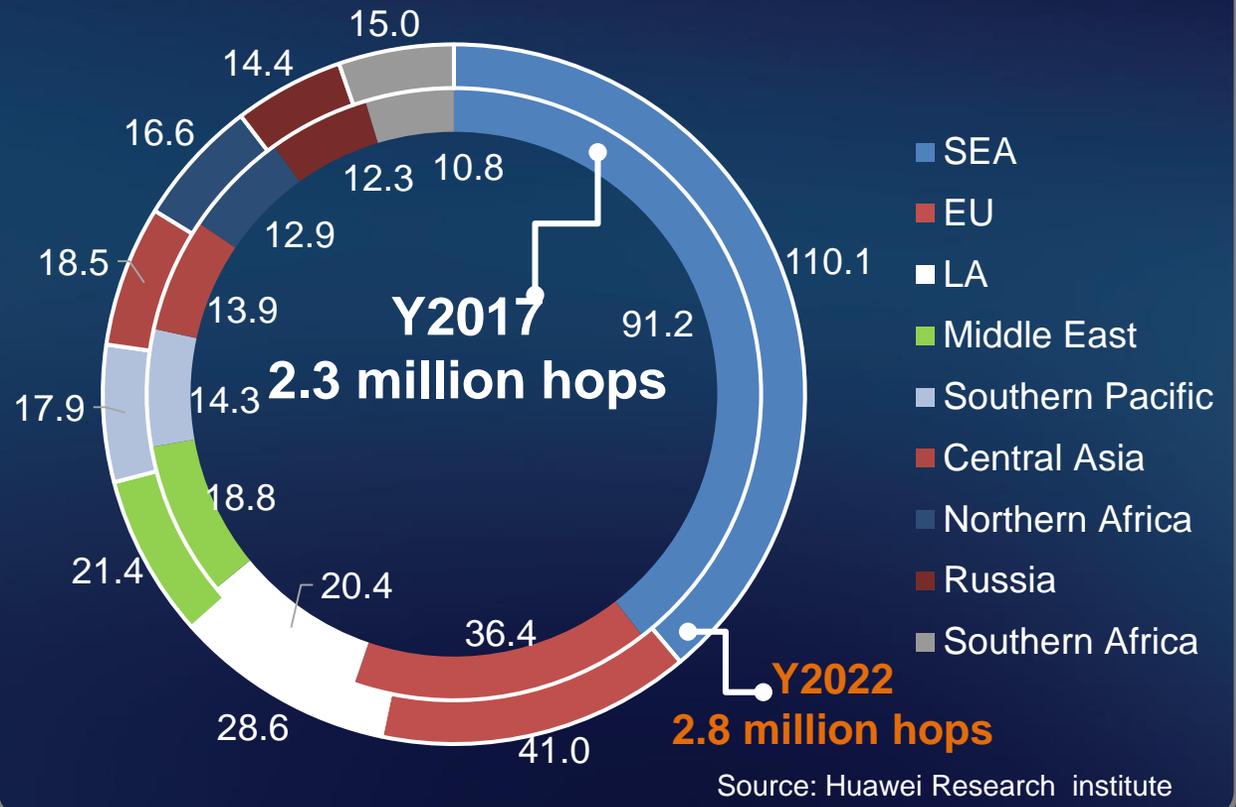


2017: **77%** base stations* backhauled by MW
 2022: still **70%** base stations choose MW

Source: Huawei Research Institute



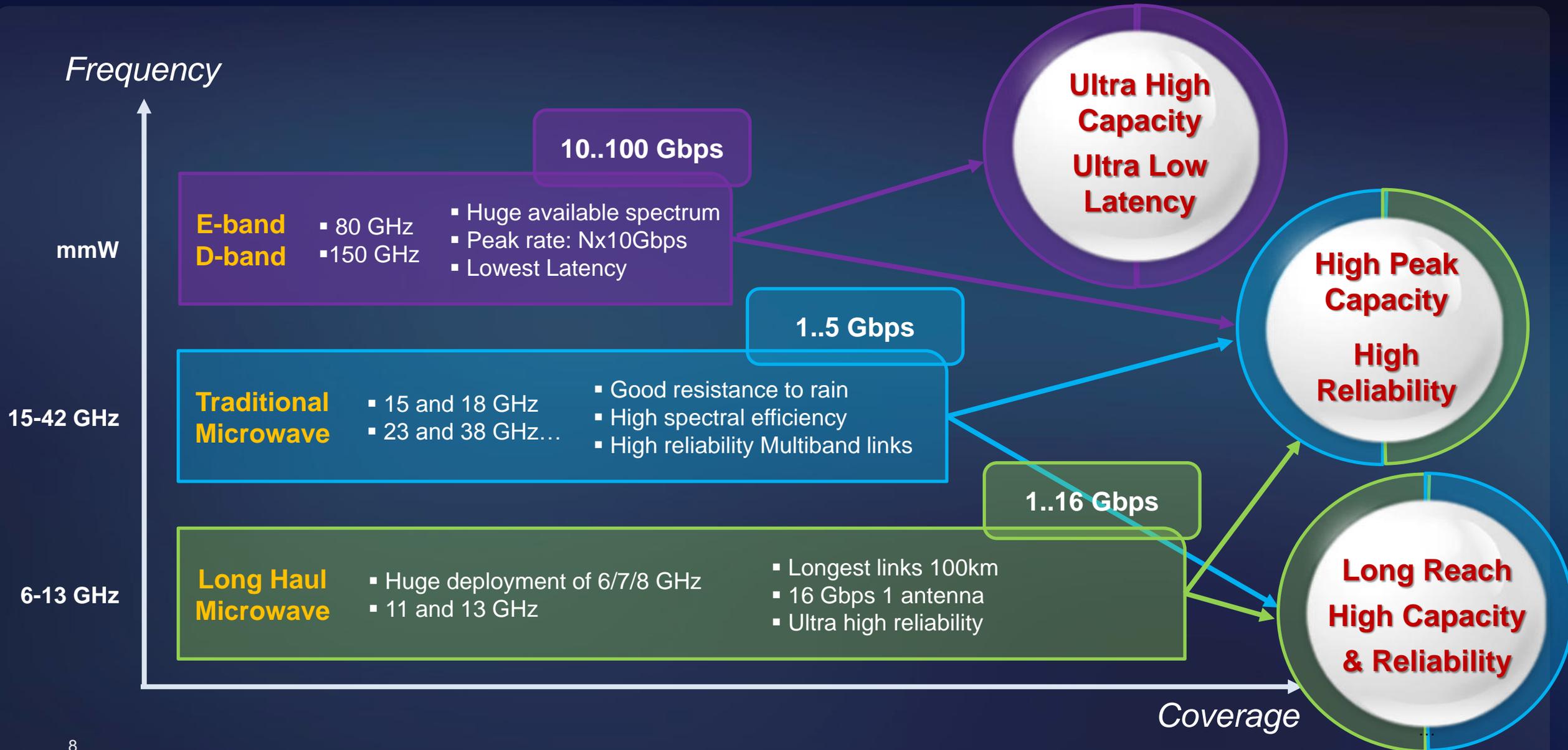
Number of MW hops **keep increasing**, predicted to reach **2.8 million** hops in Y2022



Microwave will remain the main backhaul solution for 5G in the mid-term

(*) excluding China, Japan, Korea

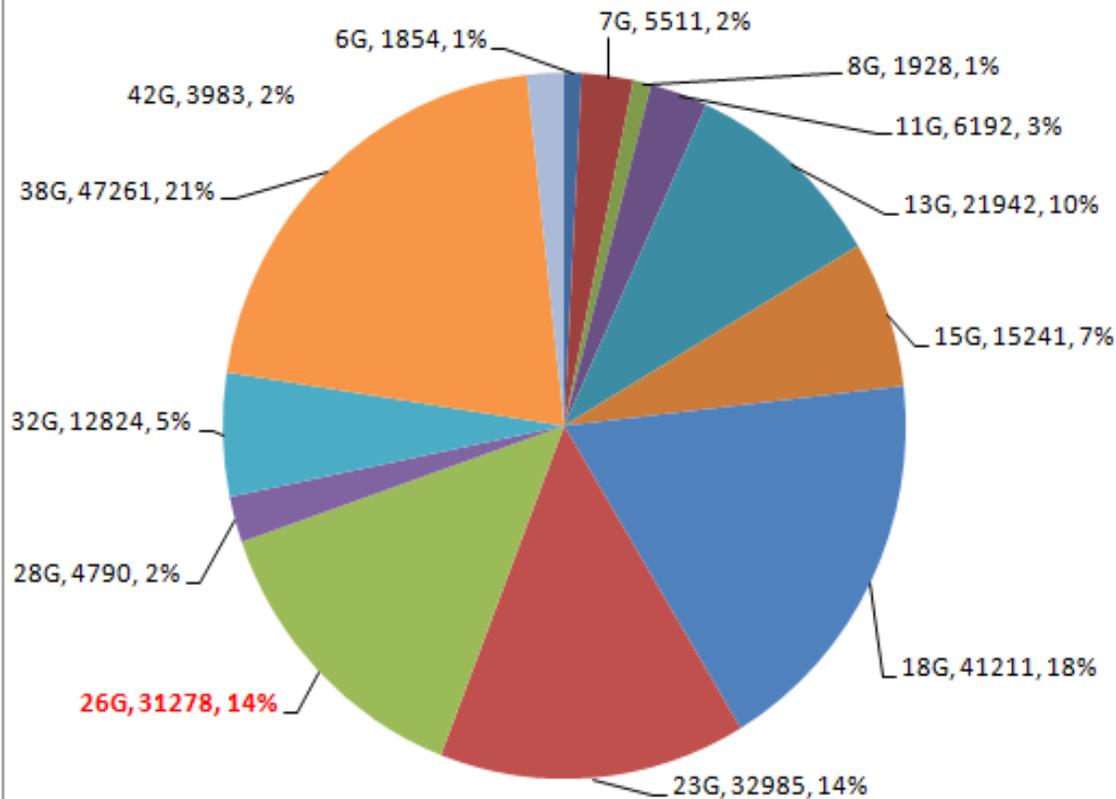
Spectrum vs. Capacity vs. Distance



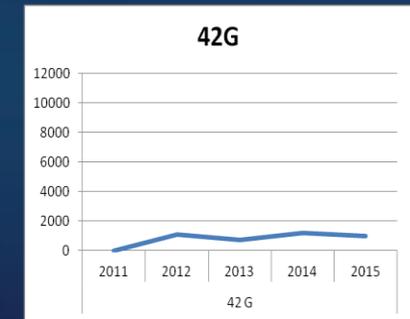
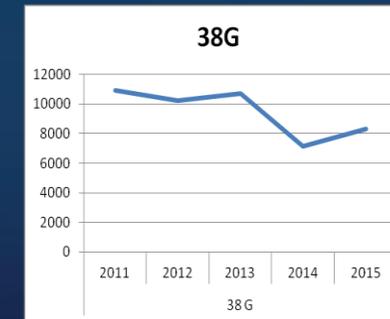
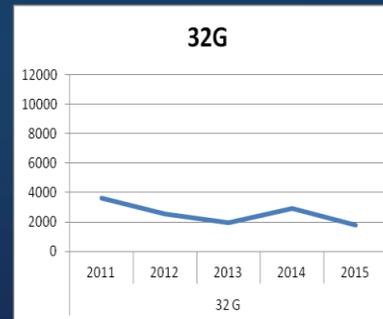
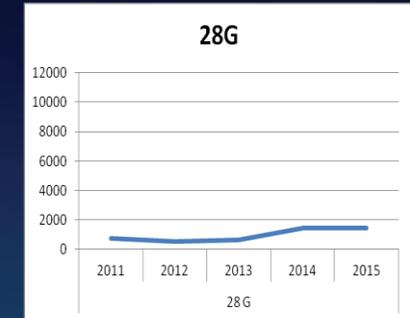
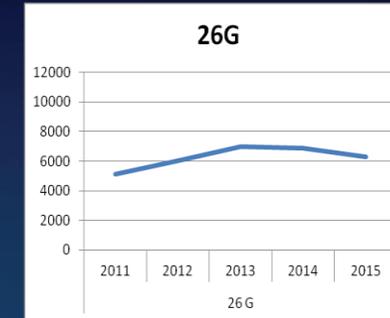
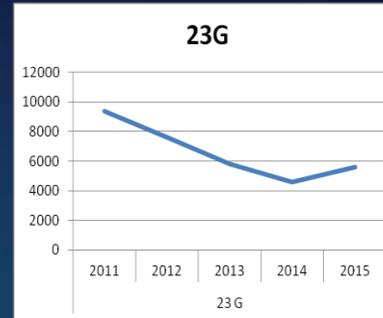
Backhaul - Frequency Bands Use in Region 1



MW deliveries by Frequency Band



Huawei internal analysis



- **26 GHz:** migration to 23 GHz or 32 GHz
- **38 GHz:** possible replacement by E-band
- **42 GHz:** possible replacement by E-band
- **mmW:** enabler of spectrum decongestion and higher throughput

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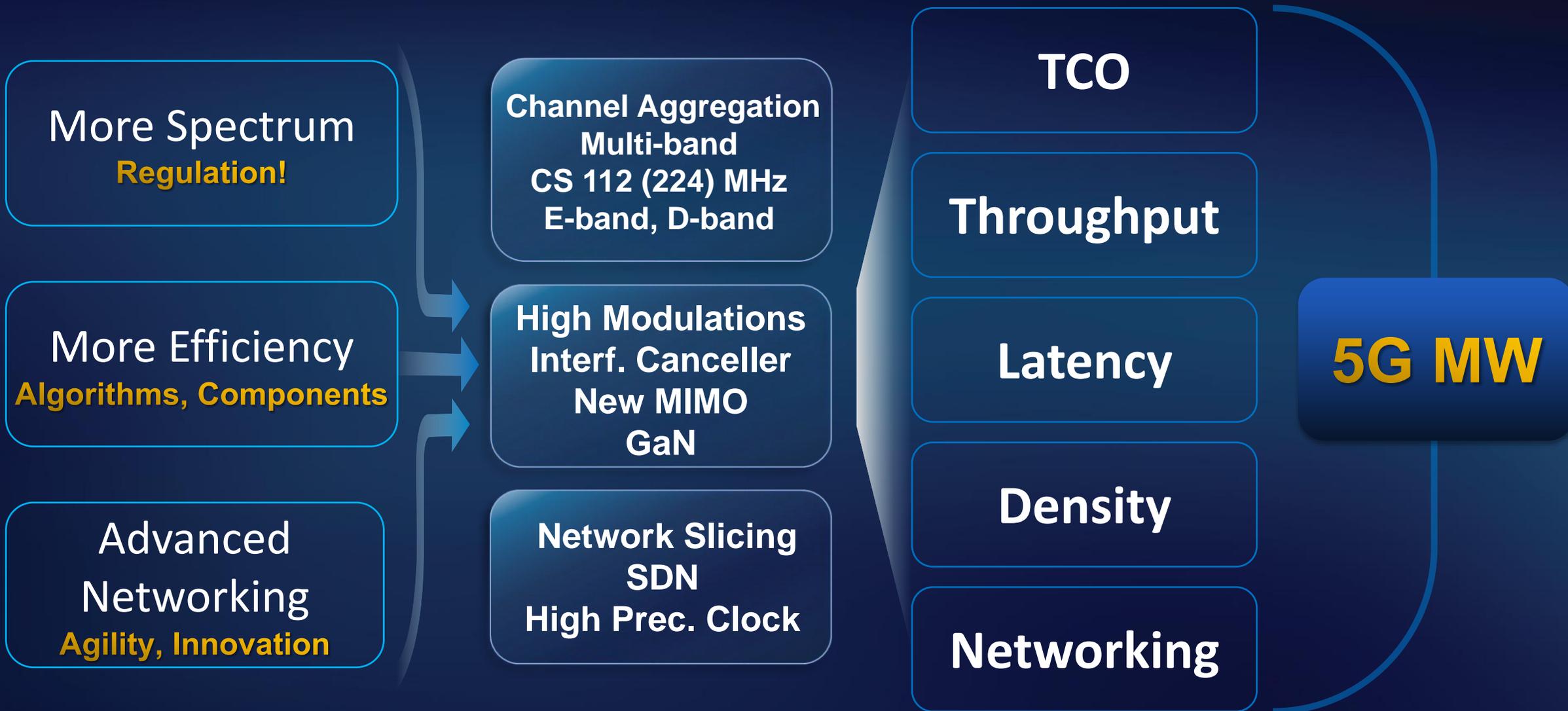
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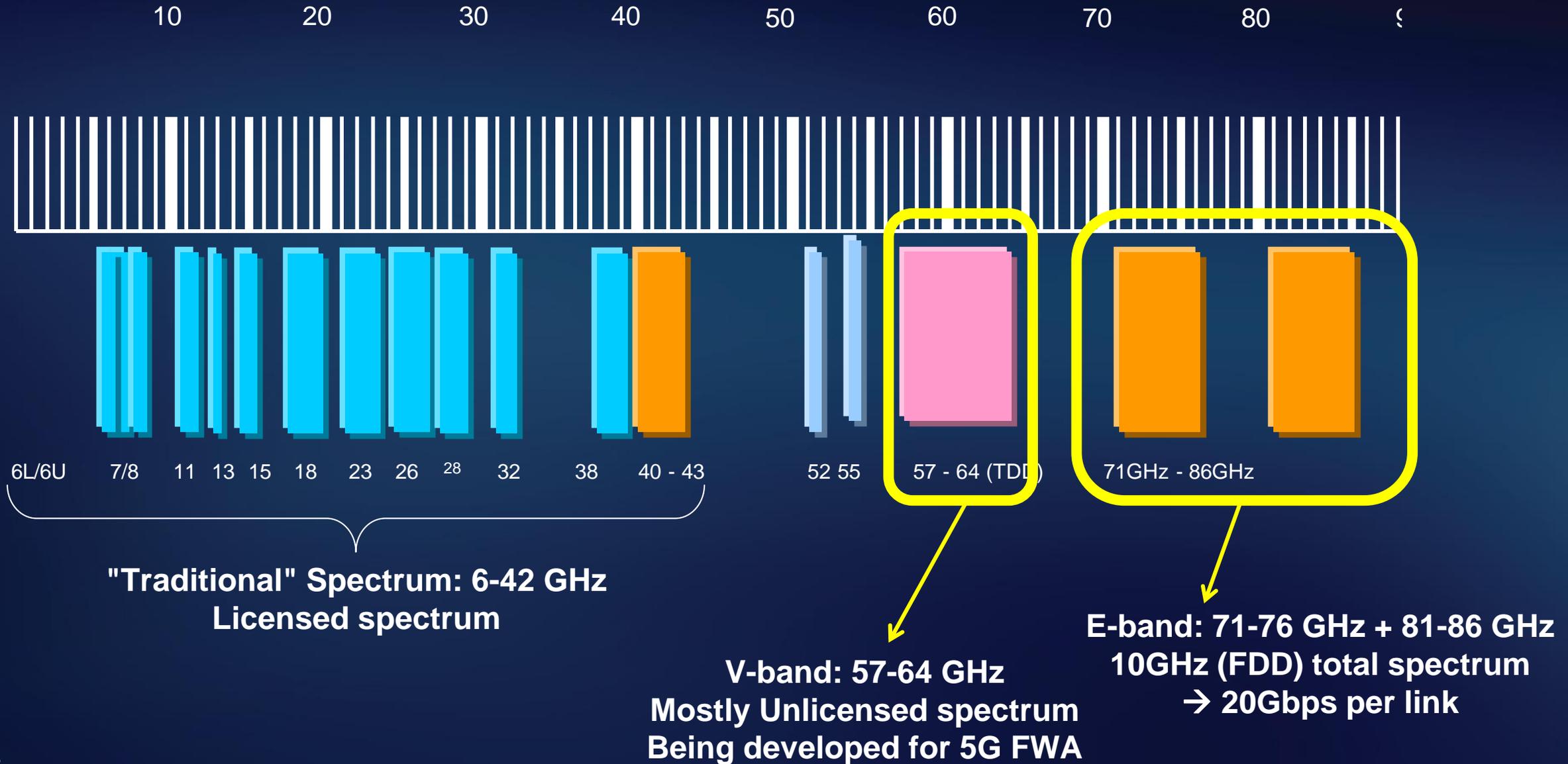
The MW Technology Map



Technology, Standards and Regulation Status

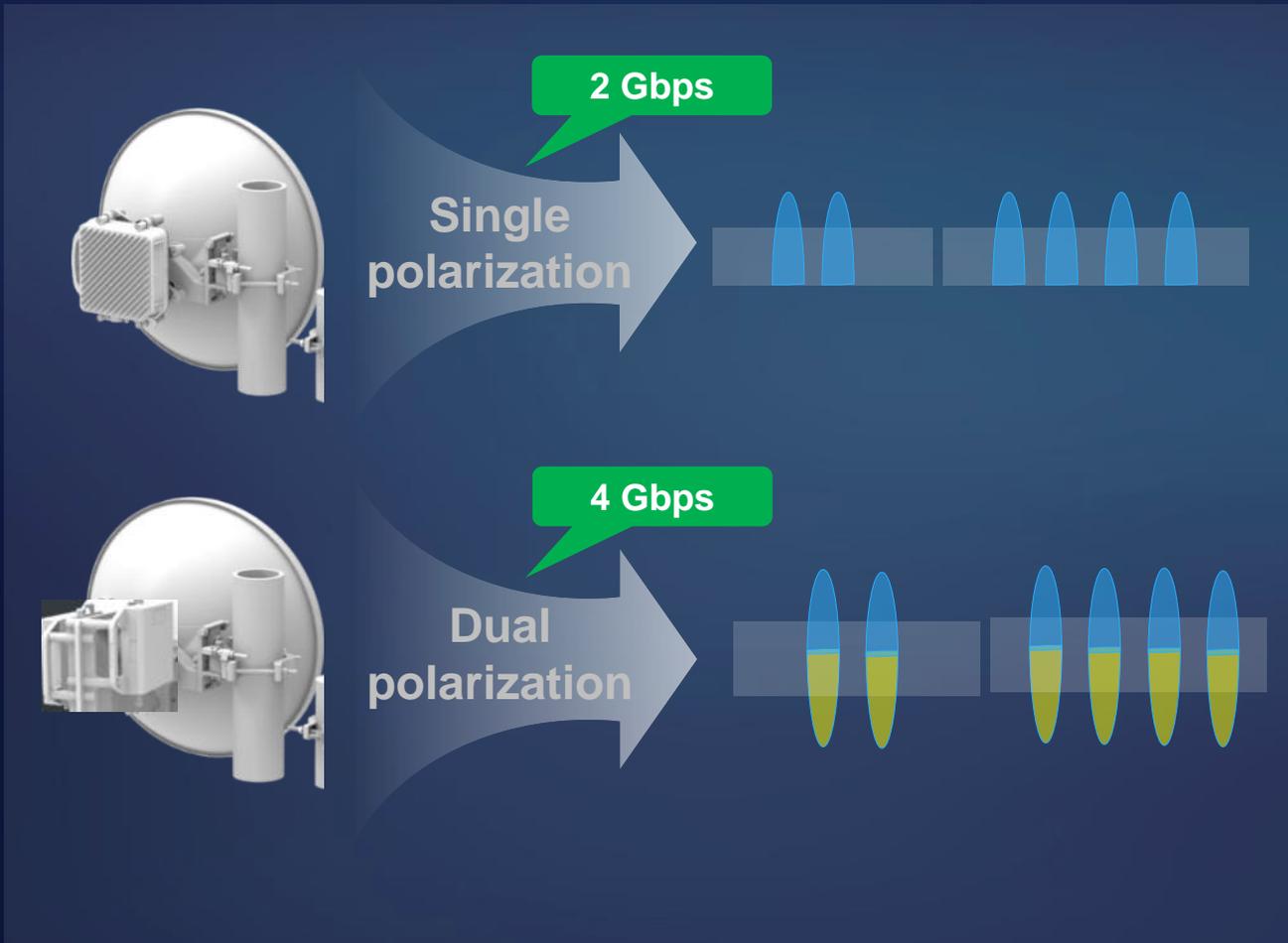
Item	Status and Current Issues
Channel Aggregation	<ul style="list-style-type: none"> • Licensing fees to be clarified
Multi-band	<ul style="list-style-type: none"> • Licensing fees to be clarified
112 (224) MHz channel size	<ul style="list-style-type: none"> • 112 MHz channels available in some bands (typically >23GHz) • Standardization ongoing where needed (CEPT, ITU-R)
E-band	<ul style="list-style-type: none"> • Available in many countries, use expected exponential increase
D-band	<ul style="list-style-type: none"> • Standardization ongoing where needed (CEPT, ITU-R)
Higher modulations	<ul style="list-style-type: none"> • Available
Interference canceler	<ul style="list-style-type: none"> • Technology under development • Planning tools and link licensing to be adapted
Line of sight MIMO	<ul style="list-style-type: none"> • Available, regulatory framework to be further clarified
Energy efficiency (GaN)	<ul style="list-style-type: none"> • Technology available
Advanced networking	<ul style="list-style-type: none"> • Standardization ongoing (IEEE, IETF, ETSI, ITU-T)

Millimeter Wave Spectrum



Channel Aggregation

Use of two or more RF channels by same equipment, to obtain a «virtual» wide capacity channel». RF channels may be not contiguous.



- **Increase Throughput** while reducing CAPEX (up to **75%** less Hardware).
- **Max Flexibility** with Software-Defined Multichannel Radio (non-contiguous channels).
- **OPEX Reduction** increasing channel size and number “as-you-grow”.

Multi-Band Radio Solutions

Traditional Band

Current Solution
600 Mbps



Traditional Band + E-band

>10 Gbps

E-band: High Peak Capacity

Traditional MW Long Distance

Multiband Solution with E-band
Single Antenna, 10Gbps Peak

2.7 Gbps	99.95%	4.4 h
Sum of IP MW & E-Band		
1.5 Gbps	99.979%	1.8 h
Sum of IP MW & E-Band		
220 Mbps	99.995%	16m
IP MW Capacity		

2.5 Gbps	99.762%	20h
Sum of IP MW & E-Band		
1 Gbps	99.942%	5h
Sum of IP MW & E-Band		
330 Mbps	99.995%	26m
IP MW Capacity		

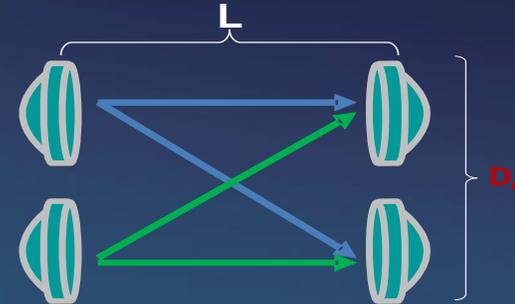
Spectrum Efficiency improvement

XPIC 2x Spectrum Efficiency



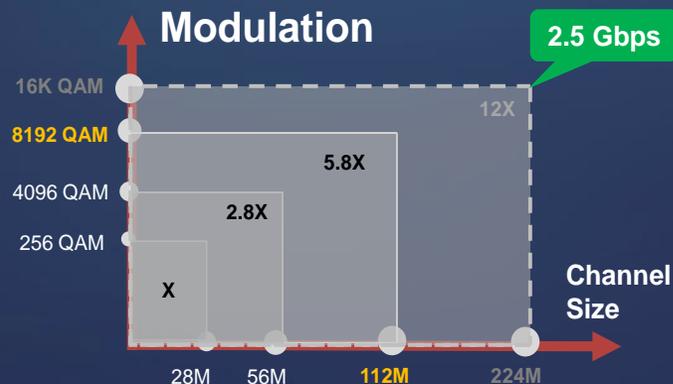
Industry 1st 20Gbps Microwave link

MIMO 4x Spectrum Efficiency



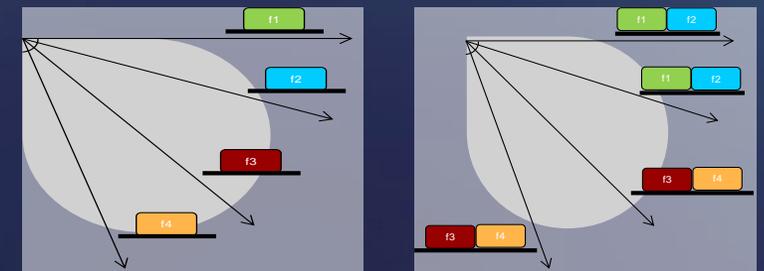
MIMO 2.0: down to 60% of D_0
MIMO 3.0: down to 20% of D_0

5x .. 12x Throughput Increase



4x Geographical Spectrum Efficiency

Co-Channel Interference Cancellation Reuse Frequencies



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Global 112MHz CS Releasing Profile

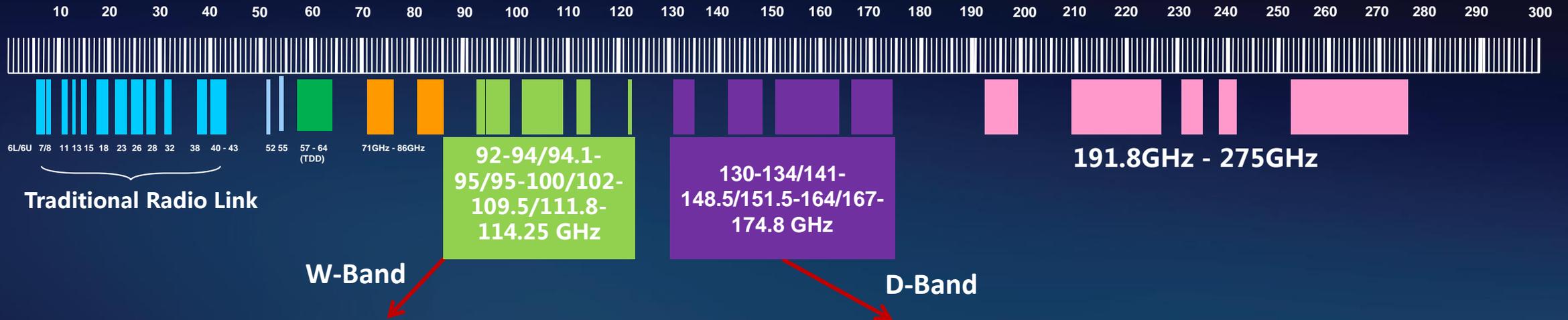
Frequency

● Released ● To be released or not official released



Malaysia Indonesia Iraq Norway Germany Finland France Peru Australia Italy Myanmar Spain UK

Above 90 GHz Frequencies Profile



W-band make CEPT ECC SE19 release regulations to secure spectrum for fixed services without pushing industry further

D-band make CEPT ECC SE19 release regulations & ETSI TM4 harmonized standards with active push of industry according to ISG mWT application scenarios. *The draft recommendation on D band channelization has been approved in CEPT SE 19 in Dec 2017*

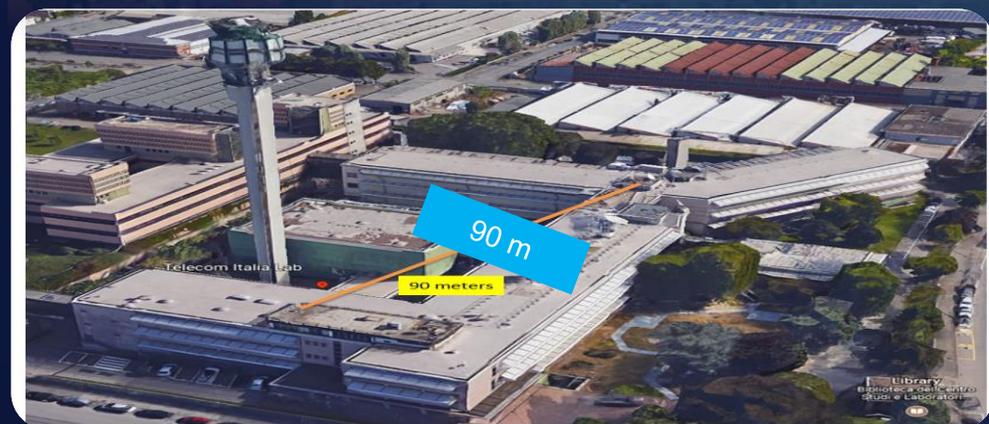
W/D spectrum allocation almost stable and RF related deliverables will be published in 2018

Long-Term D-band Trial, Validation of ITU-R Model

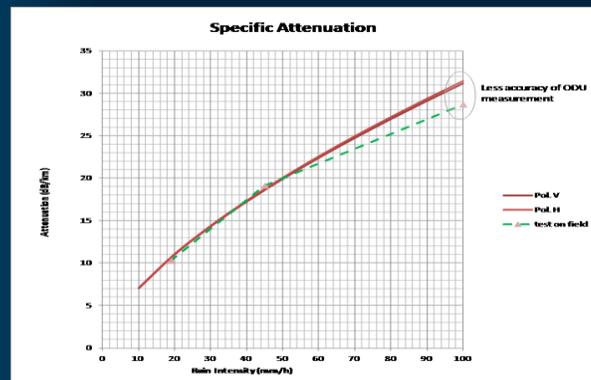
1st Trial in Milan since November 2016



2nd trial in Turin since July 2017

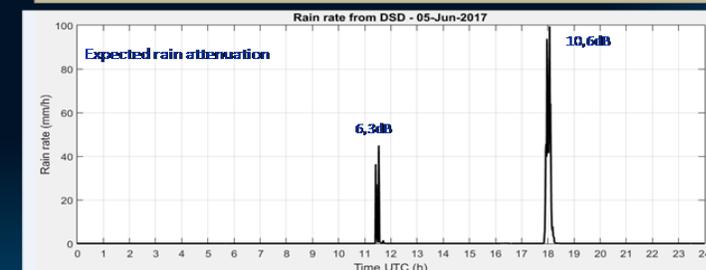
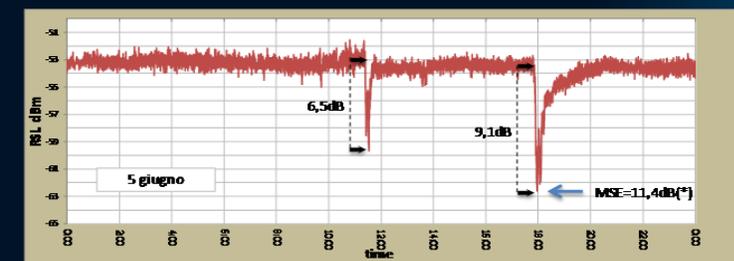


Rain attenuation is quite close to ITU-R P.530-16 model



- Need of much more statistical data collection in order to validate ITU-R P.530-16 model
- One year of measurements under the coordination of **Prof. Carlo Riva** (Chairman of ITU R WP 3J – propagation fundamentals)

- Even up to **100 mm/h** rain rate, system is not under threshold
- One outage due to rain fading till now (rain intensity up to **230 mm/h**)



(*)Receiver Threshold (QPSK): MSE=7dB

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High Altitude Platform Stations (HAPS)

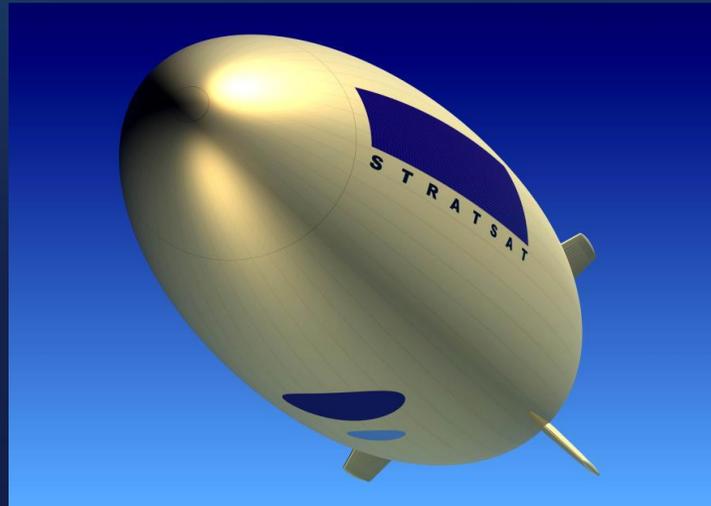


Item	Current Status
Spectrum allocation	<ul style="list-style-type: none"> Existing bands: 6 440-6 520 MHz(D), 6 560-6 640 MHz(U), 27.9-28.2 GHz(D), 31.0-31.3 GHz(U) outside Region 2, 47.2-47.5 GHz and 47.9-48.2 GHz , New bands under study: 21.4-22 GHz and 24.25-27.5 (region 2), 38-39.5 on a glob
Coverage	<ul style="list-style-type: none"> Typical coverage radius 50km (HAPS height : 20 km)
Application to backhaul	<ul style="list-style-type: none"> Network availability and performance concept needs analysis
Platforms availability	<ul style="list-style-type: none"> Lighter than Air (LTA): fixed-position balloons Heavier than Air (HTA): long-term high altitude “drones” flying in patterns
Standardization status	<ul style="list-style-type: none"> Under study by ITU-R under AI 1.14
Examples	<ul style="list-style-type: none"> Airbus... Boeing... Google:...

HAPS Example



HTA



LTA

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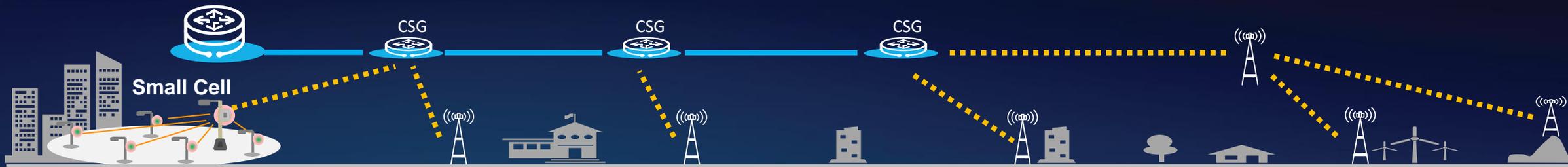
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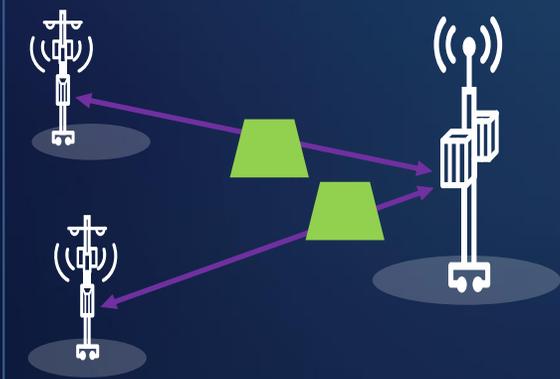
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Microwave Solutions for all Scenarios



Dense Urban

- Small Cell on Pole
- Link Distance: <1Km
- Capacity : Up to 10Gbps



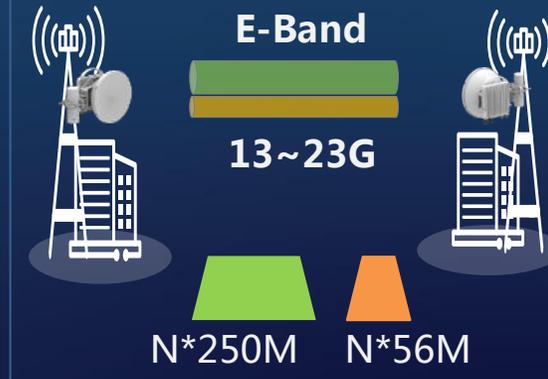
Urban

- Macro on Rooftop
- Link Distance: <2Km
- Capacity : Up to 10Gbps



Suburban

- Macro on Tower
- Link Distance: 2~7Km
- Capacity : Up to 4Gbps



Rural

- Macro on Tower
- Link Distance: >10Km
- Capacity : Up to 2Gbps



Now

PtP V-Band

E-Band, 20G/XPIC

Super Dual Band

112M , XPIC

Future

PtMP D-Band/V-Band

Long Range E-Band

Integrated Dual Band,
Long Range Eband

CA/MIMO/CCIC

Summary



Capacity
Nx10
Gbps
Per channel

*E-band, D-band,
Super Dual Band*

Latency
50 μ s
Per Microwave
Link

*New modem technology,
low latency packet queues*

Density
100s
Links
Per km²

*E-band, D-band
Interference reduction*

Efficiency
4x
b/s/Hz
LoS MIMO

*MIMO 2.0
MIMO 3.0*

[ETSI ISG mWT Whitepaper on Microwave and Millimetre-wave for 5G \(pdf, link\)](#)

Thank You.

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