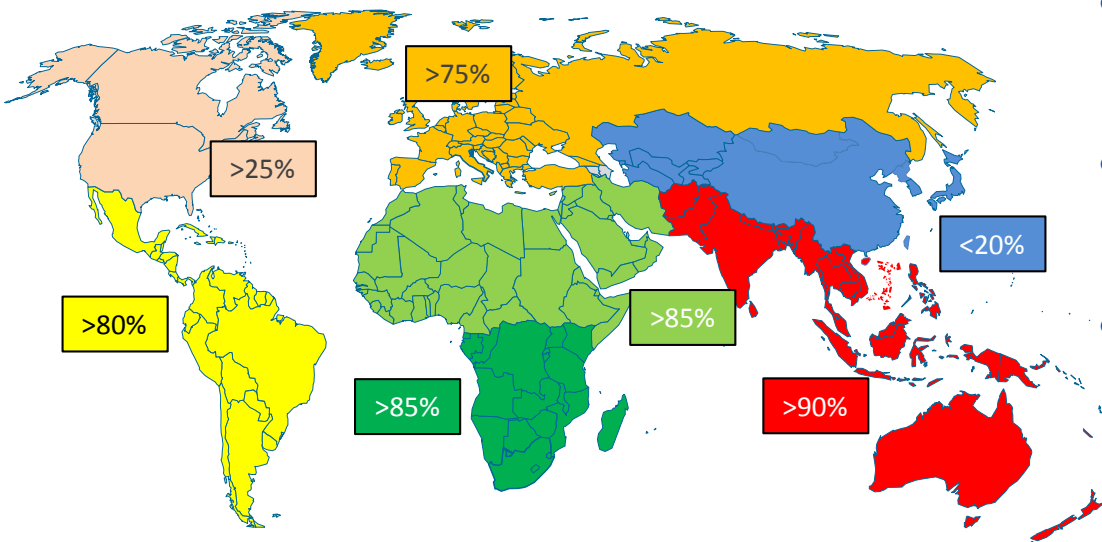
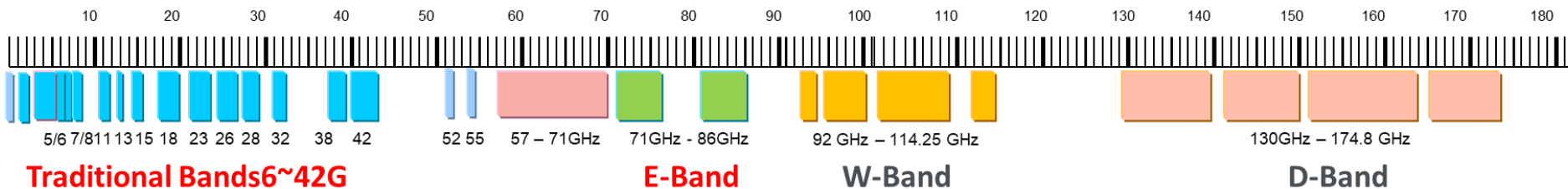


Evolution of Fixed Services for wireless backhaul of IMT 2020 / 5G

- **Wireless Backhaul for IMT 2020 / 5G - Overview and introduction**
by Renato Lombardi, Huawei
- **Wireless X-Haul Requirements**
by Nader Zein, NEC
- **Microwave and millimeter-wave technology overview and evolution**
by Mario Frecassetti, Nokia
- **Operator's view on frequency use related challenges for microwave and millimeter-wave in IMT 2020/ 5G backhaul/X-Haul**
by Paolo Agabio, Vodafone
- **Panel discussion:**
Economics on deployment and operational aspects of microwave and millimeter-wave technology in IMT 2020 / 5G mobile backhaul/X-Haul network



Role of wireless backhaul in Mobile Networks

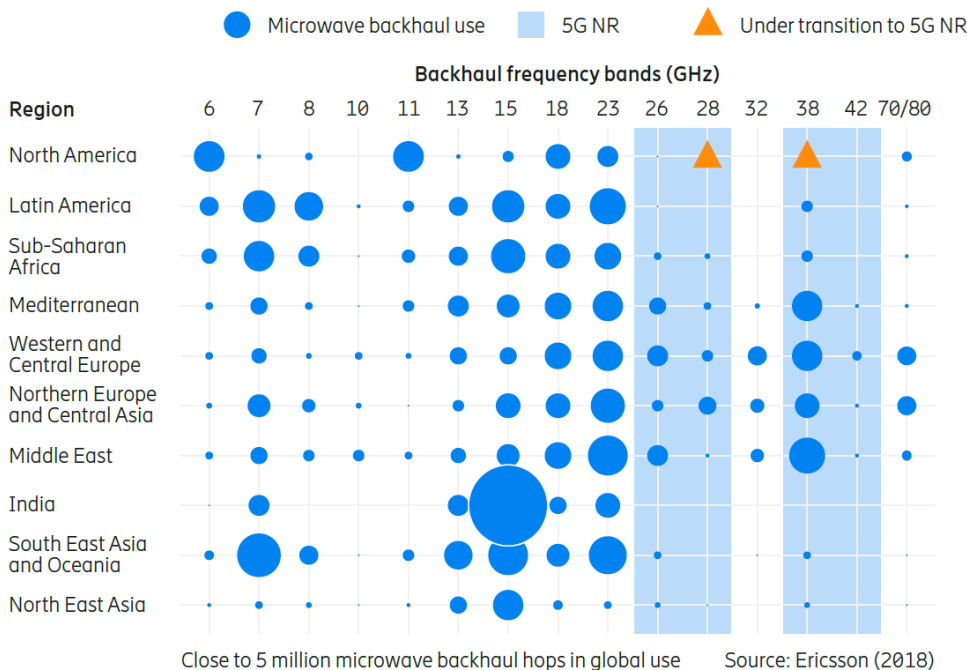
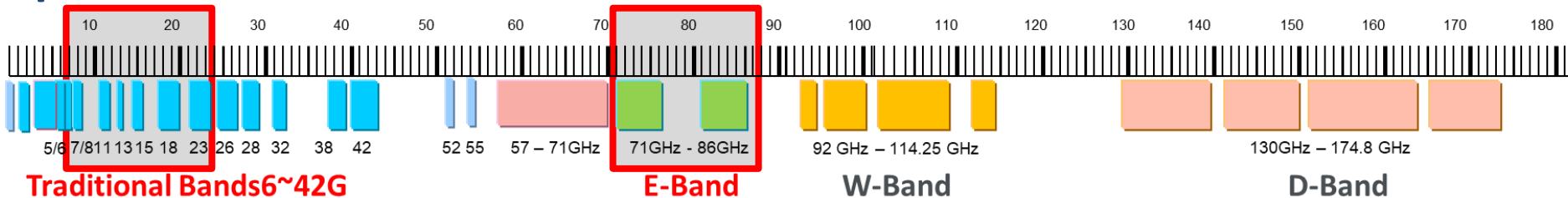


- **Over 70%** of macro sites connected with microwave backhaul, with significant regional differences
- There will always be a huge percentage of areas where the fiber connection is not feasible or too expensive
- Proper spectrum regulations and licensing permit a fast Time To Market of microwave backhaul and the deployment of high throughput 4G and 5G services

4 Million links in operation worldwide

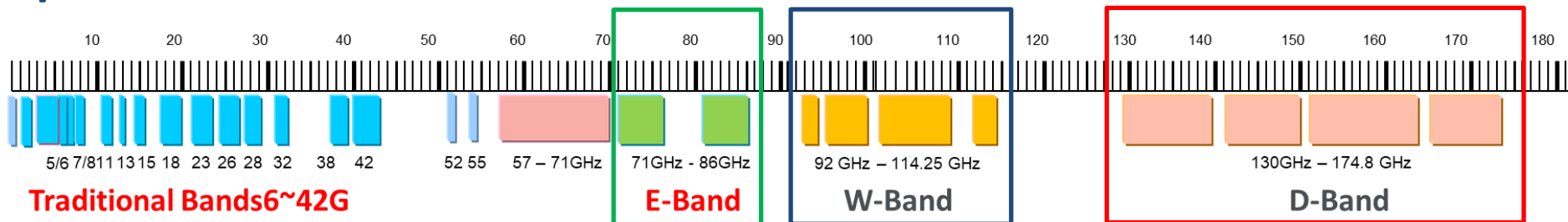
Remove current spectrum bottlenecks for an affordable deployment of wireless backhaul

Spectrum for wireless backhaul in Mobile Networks



- Most of the links in bands below 23 GHz
- Significant regional differences deriving from rain intensity statistics
 - Europe mostly on 26 and 38 GHz after 15, 18 and 23 severely crowded
 - Far East and Latin America mostly on 7/8, 15, 18 and 23 GHz
- E-Band growing fast
- Huge potential in tropical countries (i.e. India,..) in still untapped bands above 23 GHz and E-band

Spectrum for wireless backhaul in Mobile Networks



Frequency Bands	
71-76	
76-81	
81-86	
86-92	
92-94	
94-94.1	
94.1-95	
95-100	
100-102	
102-109.5	
109.5-111	
111.8-114.25	
130-134	
134-141	
141-148.5	
151.5-164	
167-174.8	

E-band

mature technology and applications

W-band

W-band: CEPT ECC released Recommendation (18)02.

Propagation characteristics and technology availability make W-Band as a sort of extension to E-Band

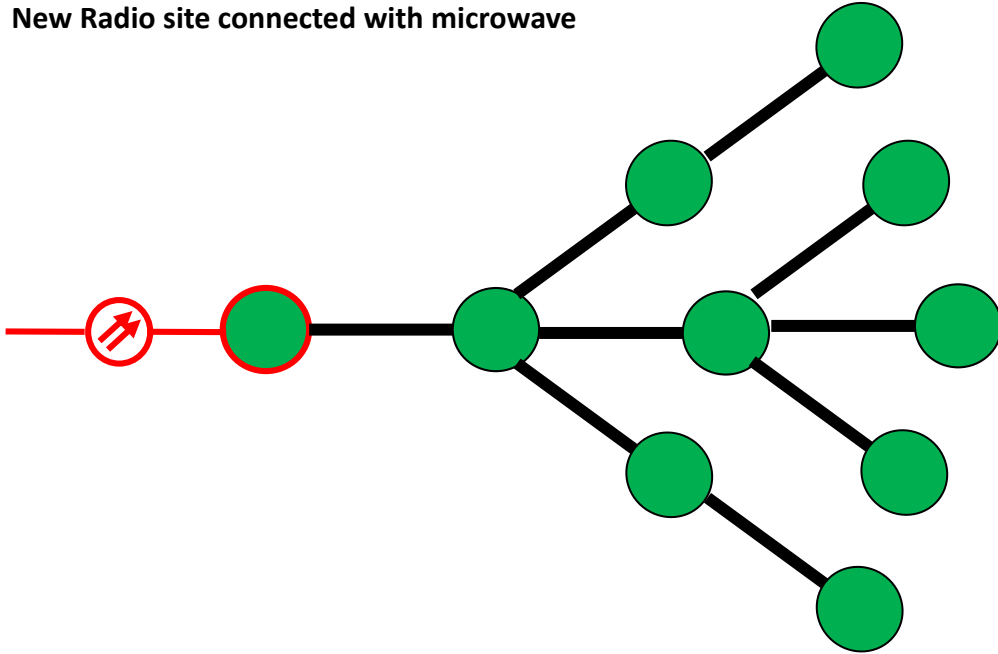
D-band

D-band: CEPT ECC released Recommendation (18)01.

The availability of huge amounts of spectrum in the D-band and its favourable propagation characteristics, makes this a high priority band for the industry

Backhaul Network Topology Evolution

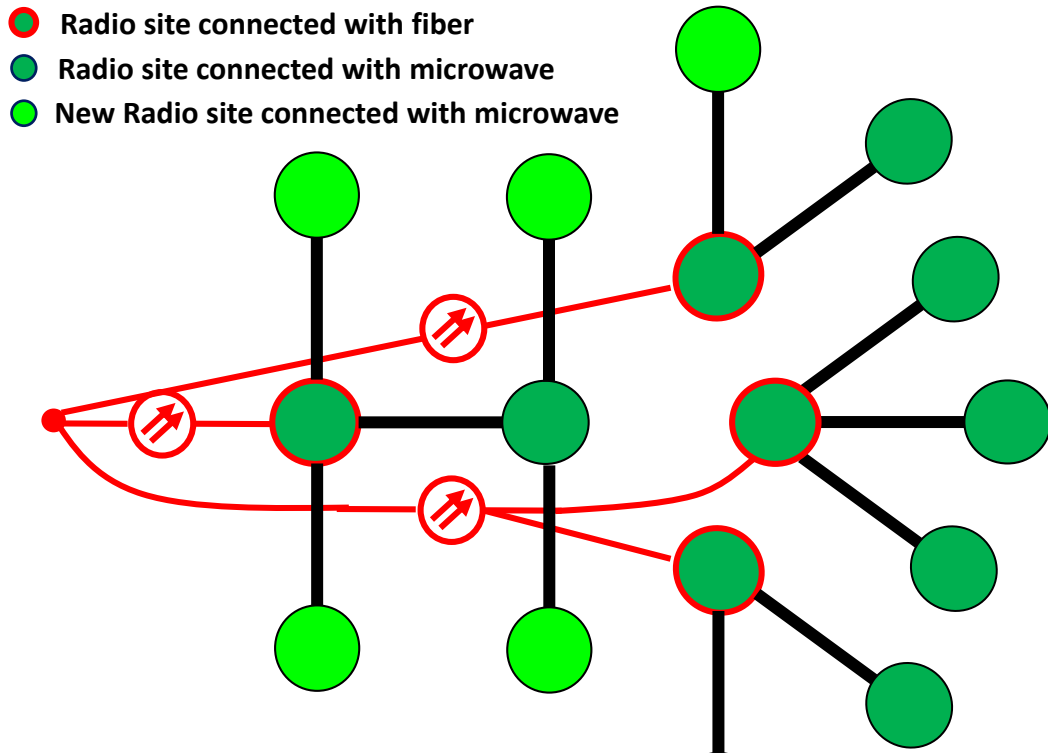
- Radio site connected with fiber
- Radio site connected with microwave
- New Radio site connected with microwave



- **Network topology change**

- Network densification
- RAN sharing and operators consolidation
- Fiber penetration from core to edge

Backhaul Network Topology Evolution

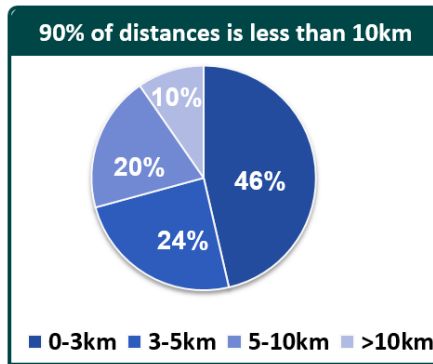


■ Network topology change

- Network densification
- RAN sharing and operators consolidation
- Fiber penetration from core to edge

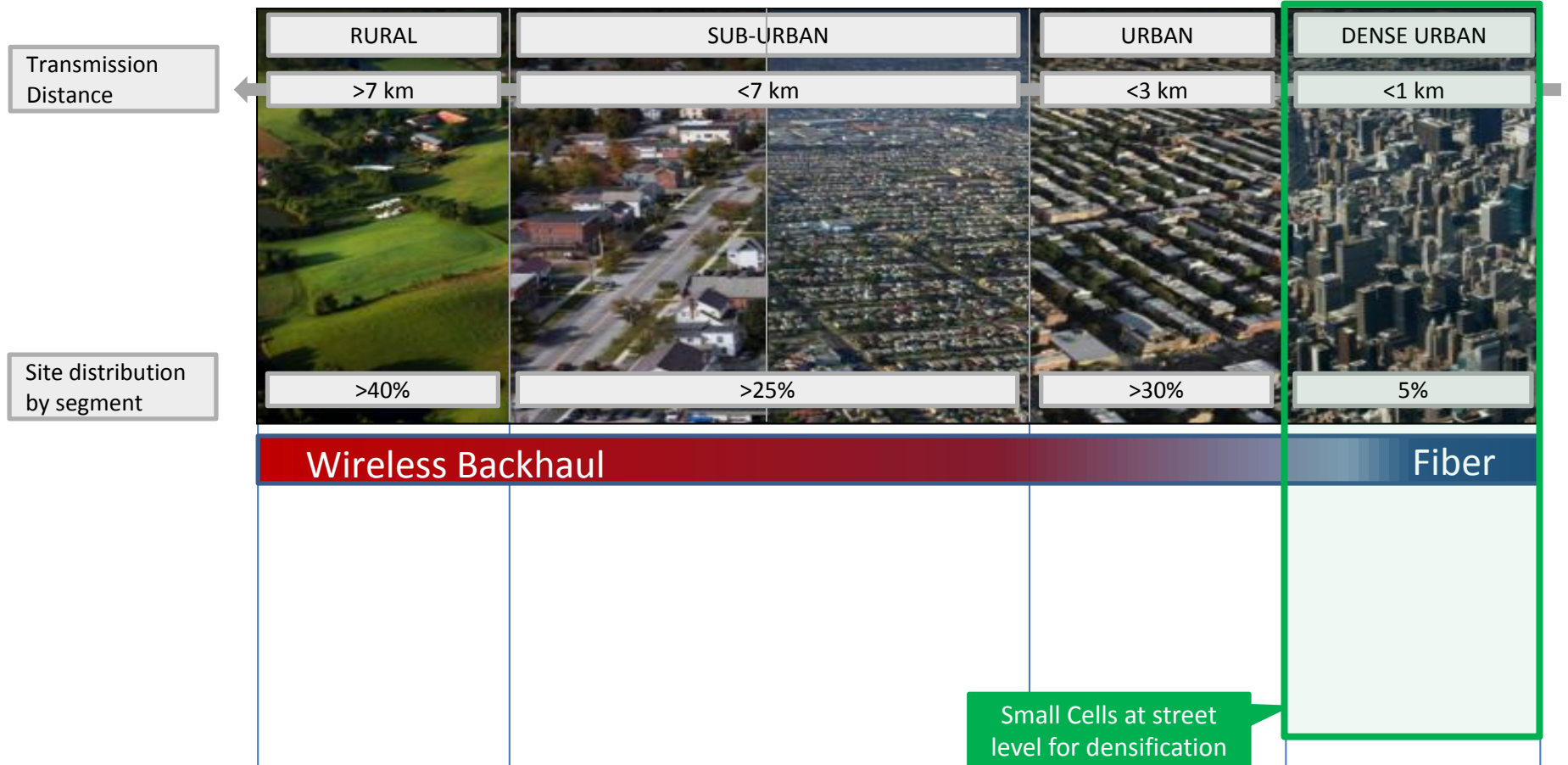
■ “Shorter networks” and shorter hops

- Shortening of microwave chains
- **Star topologies** from the fiber PoP

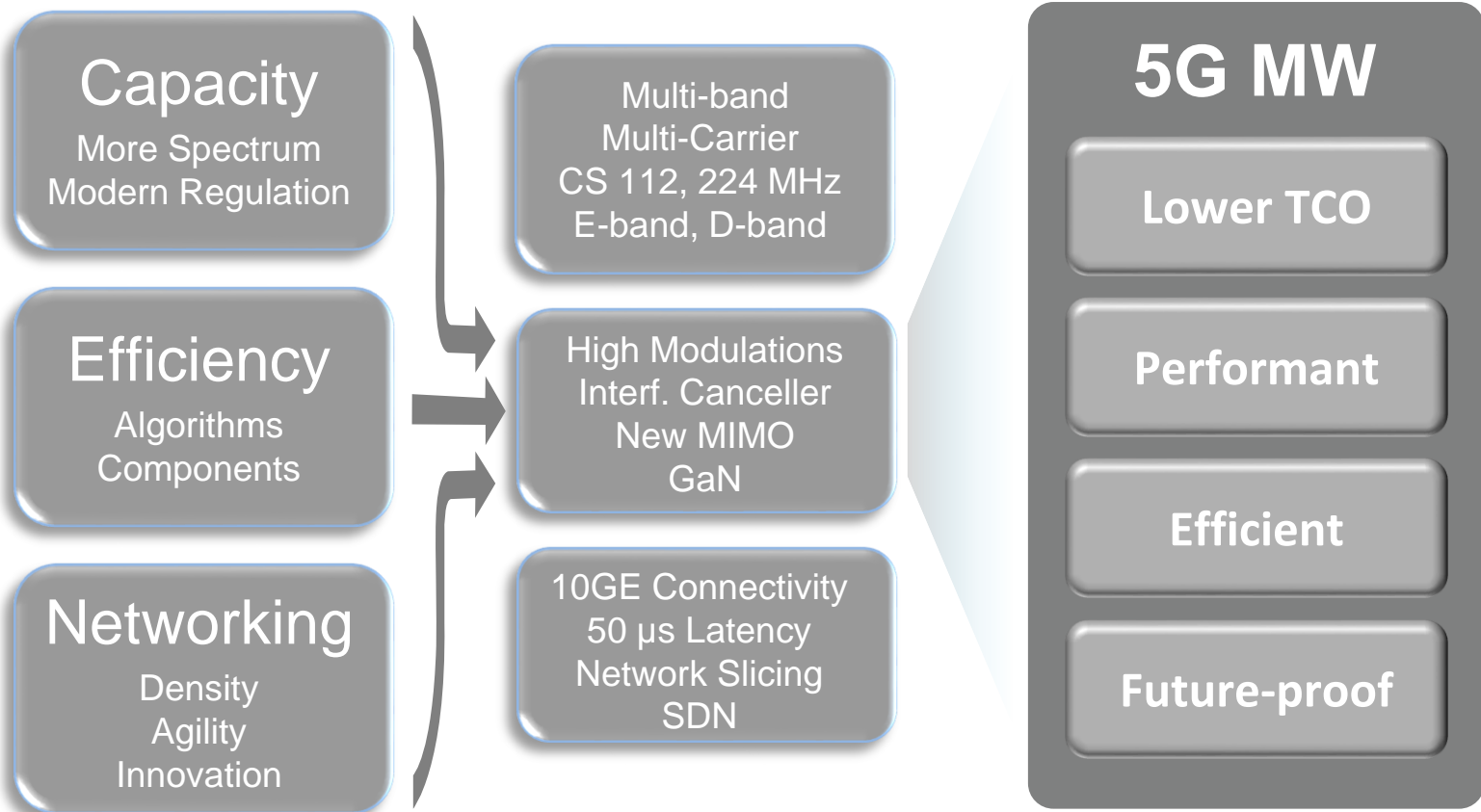


New network topology drives BH to the higher part of the spectrum

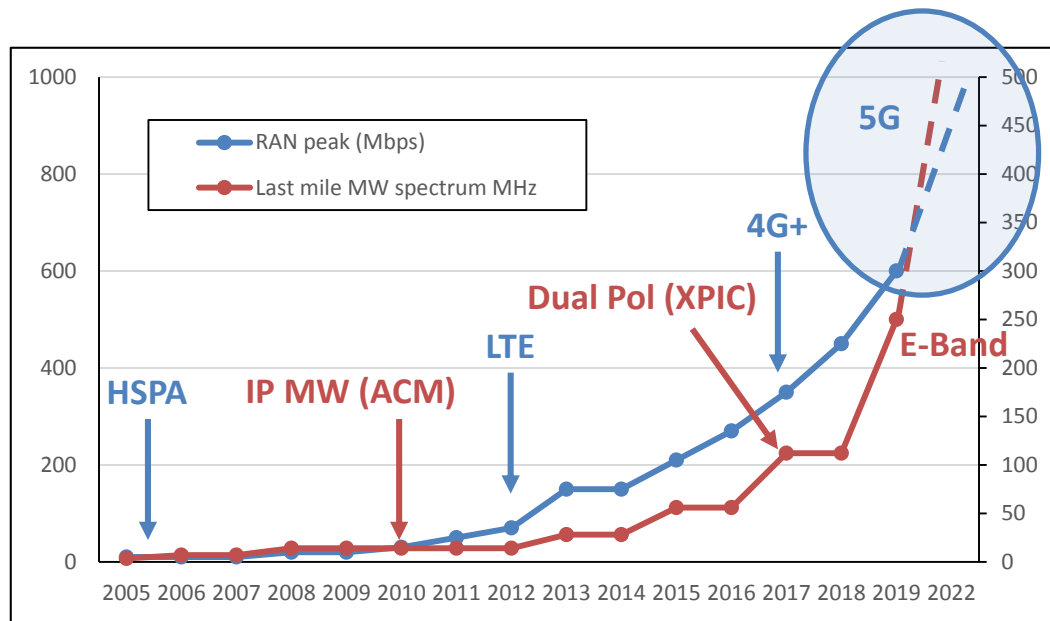
5G Access Sites Configurations and Network Segments



Microwave Technology Map



Economics of Backhaul are Changing Rapidly



During the past 10 years

- **MW capacity needs for Mobile Operators** increased **x 15** for delivering increased peak speeds
- **MW Spectrum** in the 6 – 42 GHz is not always enough for delivering today LTE peaks; that's why offload to E-Band spectrum is taking place

Spectrum fees have grown into one of the major single items in an Operator's TCO

- Raw cost of spectrum per MHz is sometimes based on formulas born when 3.5 – 7 – 14 MHz were the channel sizes of choice

Backhaul spectrum licensing schemes and fees

License scheme	Application	Coordination (interference check)	Cases	MNO's preference
Individual Licensing	link-by-link	by the Administration	Most used	✓
Light Licensing	link-by-link	licensee responsibility	E-Band in some countries	
Block Assignment	public auction, direct assignment	Guard Band and OOB	FWA (26, 28, 32 GHz)	✓
License Exempt	free	no guarantee	V-Band	

Euro/year	APAC 1	APAC 2	APAC 3	Europe 1	Europe 2	Europe 3
28 MHz @15GHz	1300	651	1720	231	156	763
56 MHz @38GHz	2600	887	2880	203	247	558
250 MHz @80GHz	2600	887	800	319	100	577
2nd Polarization	x2	x2	x2	x2	x1.5	x2

- Huge variations country by country
- In most of the used formulas the license fees grow linearly with **channel width** but do not properly incentivize spectrum efficiency that is related to the channel re-usability from geographical perspectives

- License fees cannot linearly scale with capacity and/or channel width

Evolution of the Backhaul Requires an Evolution of Rules too

During the past 10 years

- **MW capacity needs for Mobile Operators** increased x 15 for delivering increased peak speeds
- **MW Spectrum** in the 6 – 42 GHz is not always enough for delivering today LTE peaks; that's why offload to E-Band spectrum is taking place

Looking to next 10 years

- **LTE / LTE-A and 5G backhaul needs** can be supported by
 - Using the ample available E-Band spectrum
 - Making available wider channels in MW spectrum below 42 GHz
- **E-band spectrum fees** shall take into account Mobile Operators needs (1-10 Gbps) in terms of peak speeds

Licensing schemes should incentivize spectrum efficiency from geographical perspective

Next

- Importance of microwave and millimeter-wave backhaul in current and future mobile networks
- Current microwave and millimeter-wave solutions capable of meeting early stage 5G deployment
- Technology roadmap deploying features to match the most challenging requirements of mature 5G networks in terms of capacity, latency, densification,..
- Spectrum regulations and licensing need to evolve promoting innovation and making backhaul/X-Haul economically sustainable