HUAWEI

FROM TODAY TO TOMORROW

HUAWEI MICROWAVE & MM-WAVE WHITEPAPER

February 2016

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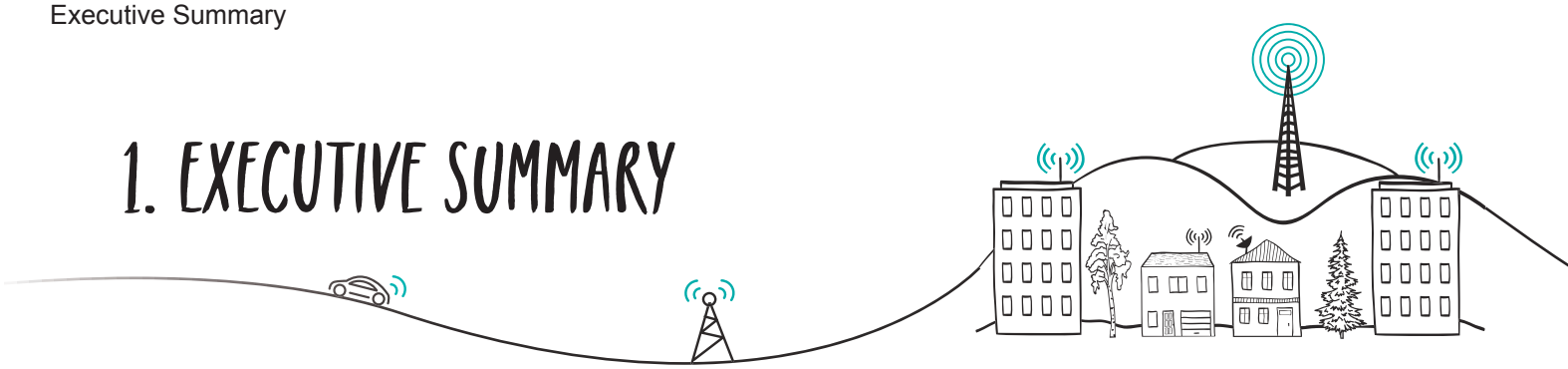
1. EXECUTIVE SUMMARY



The current mobile network deployment has started in recent years with the “4G mobile network”, also known as LTE, and is ongoing and evolving with what is sometimes called the 4.5G version, underlining that this is more an evolutionary phase, rather than a revolutionary one.It is expected that split/virtualized RAN architectures will find much more widespread adoption, requiring “front-haul” transmission, i.e. connecting the Base-band with the Radio Units over some sort of dedicated interface.

At the same time, operational concerns require to deploy more (and more complex) data services, quicker and with less effort, pushing towards the adoption of software-defined networking, self-organizing and self-optimizing network architectures.

In the long term, what is called “5G mobile network” will be introduced, promising all kinds of disruptive innovations. The target date is generally agreed to be about 2020, therefore it is imperative that the microwave industry starts working on it now, in order to be ready in time.

Microwave radio links have been key to the successful deployment of modern mobile networks, to the point where over **60%** of mobile base stations worldwide are connected via Microwave. Among the many reasons for such a success, prominent are the excellent TCO, the speed of deployment and the great flexibility, compared to alternative technologies.

- The main new challenge now comes with the deployment of Long Term Evolution (LTE) mobile networks, and their future evolution, demanding ever increasing transmission capacities, in the order of the Gbps to the macro tail site, and multiple Gbps to the aggregation sites.Thus Microwave solution should be capable to take **10Gbps** level transmission.
- Many new features that are pushing the capacity requirement, also require much lower end-to-end transmission latency, in the order of **10ms** for LTE and expected to go as low as **1 ms** for 5G networks.

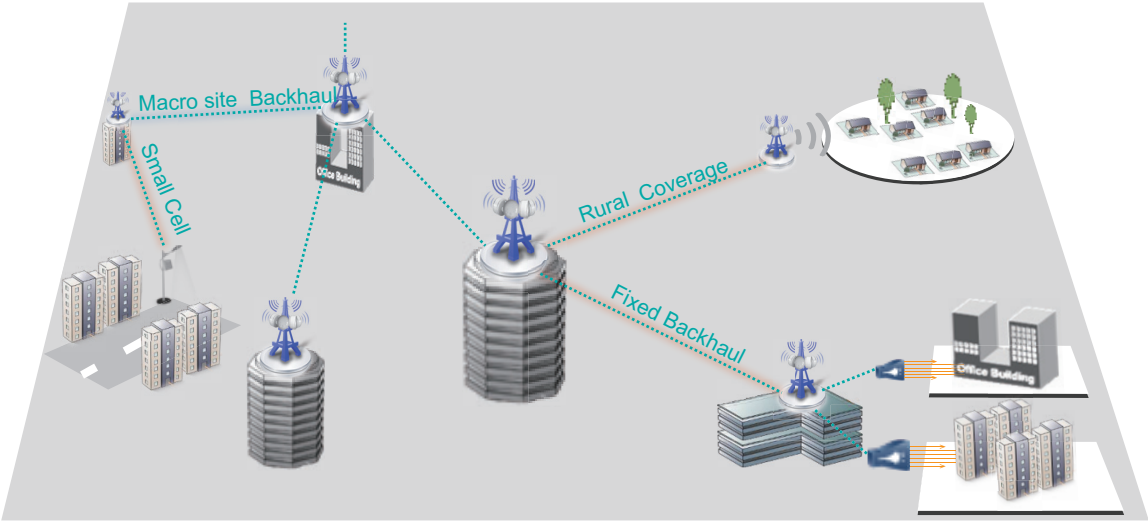
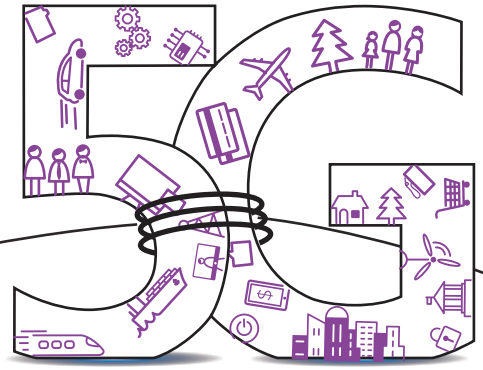


Figure 1.Microwave Application Scenario

- The network architecture and topology are evolving too: more macro sites are deployed, shortening the typical MW link length, the number of network layers must decrease, more and more often the network is shared among operators.
- Two extreme examples of such trends are the deployment of Small Cells and the introduction of C-RAN. Small cells introduce a completely new paradigm for site engineering, stressing factors like appearance, power consumption, security etc. in totally new ways, whereas C-RAN architectures require such a specific transmission solution that the term “fronthaul” is now of common use to distinguish it.
- Use of higher spectrum (above 40GHz) in the so-called “millimeter wavelength” bands is possibly the most important enabler for reaching the capacity and latency requirements.
- As operability and flexibility are key components of the network’s TCO, new operational paradigms like SDN, NFV, SON etc. are being introduced, to ensure that the complexity and performances required by the network evolution can be reached in a cost-effective manner.
- Even if mobile backhaul is by far the biggest market for microwave equipment, other markets have a growing role, including the Enterprise applications and the adoption of microwave for Fixed Broadband applications.

All the considerations above bring us to the conclusion that the microwave technology will continue to enjoy the same great success in the future, as it has for so many decades now.

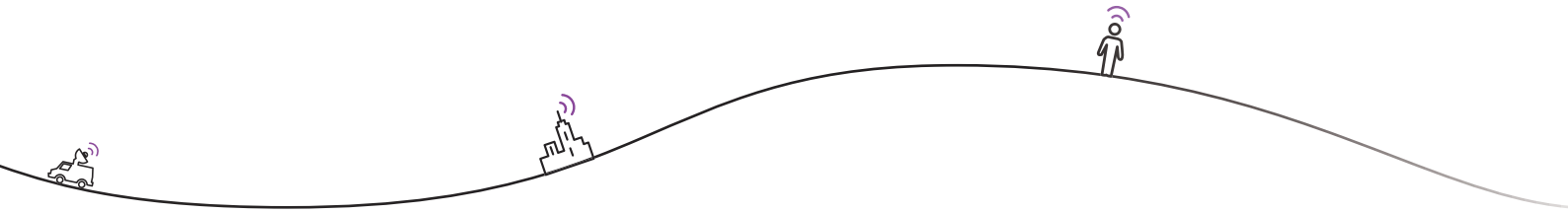
2. MW EVOLUTION ORIENTED TO 4.5G AND 5G



2.1 Mobile backhaul key requirements

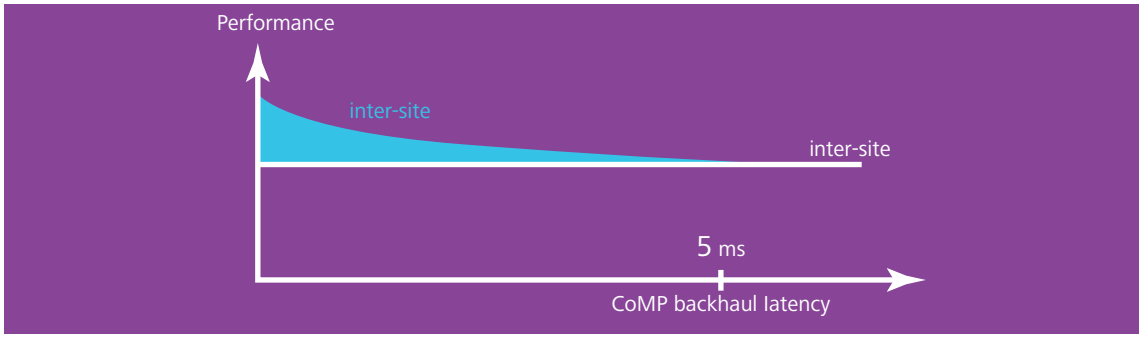
The mobile backhaul is the main scenario where microwave solution applied. Along with the wireless network gets evolute to 4.5G and 5G era, microwave also gets continuous development towards the Great Bandwidth, Low Latency, Low TCO and Site Synergy.

According to statistics, the time people spend on the mobile terminal has exceeded all other devices in the past, it has become a necessity of life. Most of the traffic is produced by video service on mobile terminals, which offers better and better visual experience. Video is exactly the foundation of mobile broadband business. It's keeping upgrading from 2K / 4K HD to the virtual reality, which will drive demand for backhaul bandwidth to grow. We estimate that it can reach 1.5Gbps per site in 4.5G era, and some sites reach 10Gbps in 5G era.



In the future IoT will permeate almost every aspect of society, including our lives,work,urban management and intelligent manufacturing. It will connect the city, transportation, public safety, smart home and others. IoT based on cellullar network will become another major mainstream business of mobile operators.Some applications such as Vehicular Ad Hoc Networks and remote control, call for a E2E network latency in ms level, then wireless access and backhaul network are facing tremendous challenges.

In order to provide a higher access rate, the CoMP and Carrier Aggregation technology will be widely adopted in wireless network, which will drive the X2 traffic percentage rise from only 3% in LTE era to 40% in 4.5G / 5G era, bearer network needs to be reconstructed according to this new traffic model. For CoMP, the lower X2 traffic delay means more gains radio base station can obtain (Up to 50%). Carrier Aggregation technology also requires X2 traffic delay in 4ms or even less. Besides the equipment inner switch optimization, less equipment nodes and shorter link distance would also help to reduce X2 traffic latency.



At the same time, Cloud BBU could provide a better synergy gain and more cost effective BBU unit, causing Fronthaul (currently based on the CPRI interface) a critical requirement for mobile backhaul, dramatically increasing the bandwidth and latency requirement for transmission equipment, unless a more efficient way is found to provide the equivalent function.

2.2 Microwave solution

2.2.1 Bandwidth Promotion

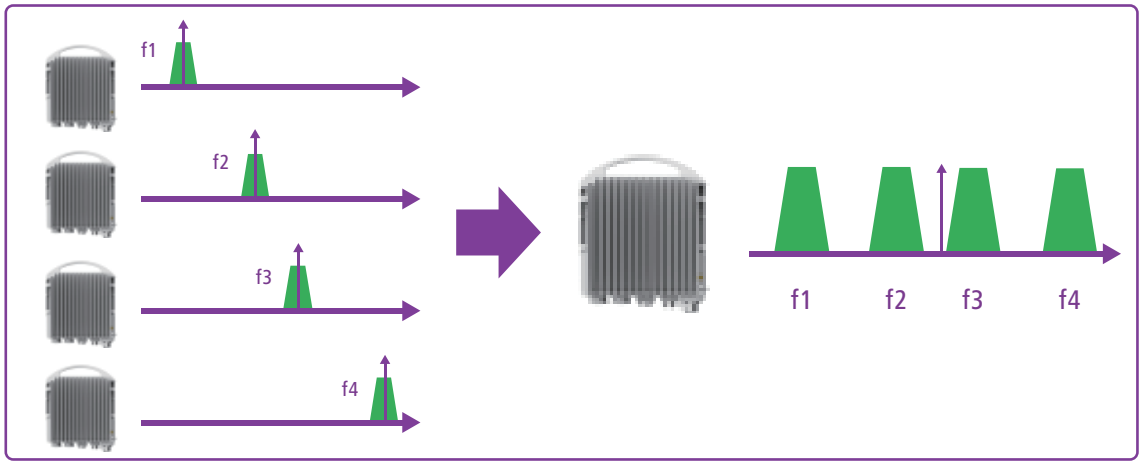
To provide sufficient bandwidth for mobile network, the various microwave spectrum resource as well as different propagation feature in different frequency bands need to be considered, and take conditional measures.We could see some significant trends which are driving microwave industry forward in recent years and future: making effort to improve traditional license band spectrum efficiency, more widely adoption of E-band, IP oriented and more compacted Long haul solution begin to be applied in metropolitan district.

- **Higher Spectrum efficiency**

Traditional 6GHz to 42GHz is the current mainstream microwave band, which already has massive commercial deployment. Very crowded bands, scarce spectrum resources and high license fees are the main drivers to improve spectrum efficiency.

With the development and cost down of high-speed AD / DA technology, microwave modulation scheme could upgrade from current 512QAM / 1024QAM to 4096QAM / 8192QAM, with a 30% spectrum efficiency improvement. These trends also drive to develop new technology to reduce stringent requirement for channel condition under high modulation scheme, and support stable application.

Considering the wide applications of microwave solution, the clean and consecutive channels became more and more unavailable, Carrier aggregation technology would help to integrate several fragmentary frequency resources, then single ODU could support several continual or non-continual carriers, helping to promote bandwidth, enormously save equipment investment, and make full use of existing frequency resource.



Wider channel spacing: before the most common used channel space included 7MHz, 14MHz and 28MHz, later on 28MHz,56MHz would gradually take a significant share, in some particular case even 112MHz, 224MHz can be a candidate choice.

MIMO Application: Presently MIMO technology has already been commercially applied, it exists as the most direct solution to improve link bandwidth, based on current limited spectrum resource. In the future microwave bandwidth capability could further benefit from the exploring for multi-channel MIMO, in both technology and engineering aspect.

Some other technologies will also possibly be used in the traditional frequency band, such as Full Duplex (transmit and receive in same frequency point), Faster Than Nyquist (use non-orthogonal transmission scheme).

With a combination of all these ways mentioned above, the traditional frequency band is expected to own 10Gbps-level transmission capability.

• E-band got wide applications

E-band owns 10GHz spectrum resource in total, accounting for 25% of the entire microwave available resource. It features with inexpensive spectrum fees, sufficient bandwidth and other the advantages. With the clear spectrum regulation policy in various nations, E-band application will have a more extensive application. Meanwhile, an innovative "dual band" solution, that combine the advantage of traditional license band and E-band, gradually evolves from concept to commercial use. This "dual band" solution utilizes the E-band module to carry high throughput traffic, together with traditional license band module to carry high reliability traffic. As a result, it helps to enable microwave link to support 10Gbps level traffic, with a guaranteed reliability.

On the other side, new technologies targeting to enhance E-band propagation capability in longer links, could also help to expand its application scenario.

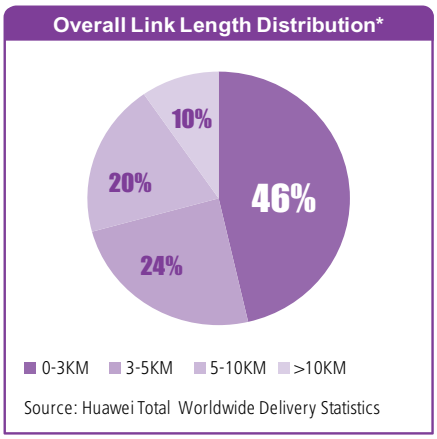
• IP oriented Longhaul launch application in urban

Due to LTE and its IP data centric requirements, long haul radios were undergoing a metamorphosis– becoming much more compact, flexible, powerful, and fast. This new concept of IP oriented long haul radios has created two categories: (1) traditional big iron long haul radios, often referred to as trunk radios, and (2) new compact IP oriented long haul radios. Although the requirement for the traditional big iron, high power trunking radios exists, we believe that growth in the long haul segment will be driven by the new IP oriented long haul radios. Mobile operators use them nearer the central office to transport the traffic generated from cell sites on the edge back to the core.

• Choose the right solution via link distance

In this context we have to classify the available and future solutions based on the required link length.

Examining the distribution of link lengths (worldwide statistic), we notice that about half of them are shorter than 3km, and almost half of them lies between 3 and 10km.



Statistical distribution of MW link lengths

- Short links

For link lengths less than 3km, the use of millimeter wavelength (mmW) spectrum, with the huge amounts of free spectrum available, allows meeting the capacity increase, easily providing up to 10Gbps throughput.

In several countries (depending on regulation and rain intensity), e-band (71-86GHz) starts being the frequency of choice for quite many of the urban links, which will deliver ultra-high speed and low latency to urban Macro and Super-Macro sites, and as a main stream, the IP MW still takes a leading share under short link scenario.

Free lower frequency blocks that are now congested and split into narrow channels (as narrow as 3.5MHz in principle), opening these bands to a re-farming into bigger channels (56, 112, 224MHz) in turn will allow higher capacity links (albeit with lower density than E-band).

- Medium links

For the ample number of links between 3km and 10km, the challenge is greater: these are typically suburban and rural areas, where the business case for laying new fiber (especially for non-incumbent Operators) can be hardly convenient.

Multiband solution, like “Dual band” concept, allows to reach the absolute availability offered by lower frequencies usually in the range 99.995% - 99.999%, while still adding the multi-Gbps capacity of mmW during clear sky conditions 99.9%. As a significant trend, technology evolution in antenna would also speed up this application, which could support both traditional license band and E-band in a single antenna.

The combination of efficient byte-level load balancing with the latest Traffic Engineering features, both at network and at device level, allow guaranteeing to each data service the appropriate Service Level (SLA), in terms of Committed Information Rate (CIR), Peak Information Rate (PIR), latency, packet loss etc.

- Long links

Even if most of the modern telecommunications infrastructure is based on optical cables, still a steady 10% of the worldwide microwave deployment is represented by long-distance links.

These links now address those cases where laying a fiber is not convenient, due to economical and/or environmental conditions (e.g. difficult terrain, small islands etc.)

“Dual band" concept

IP MW and E-Band transmission

2.2.2 Provide Lower latency

For a better user experience, the E2E network needs to be able to respond shortly, and reduce terminal standby period. As a consequent result in backhaul section, microwave equipment will provide more cache and enhanced switching capabilities to support burst throughput, reduce forward delay with an improved forward plane, reduce the air interface delay with shorter coding length, and optimised MUX interface.

2.2.3 From "L2 only" to L3

In recent years microwave is keeping evolve from TDM to Hybrid and then Packet, following the IP oriented transformation of base station, "L2 only" microwave equipment exposed some flaws in the application. Here "L3 microwave" owns great advantage: preventing broadcast storms; same OAM method with aggregation / core layer network for easy fault location, newly added/ relocated base station only have some configuration changes in tail site microwave terminal, support X2 traffic switching nearby and cut down the latency.

For the long term,"L3 microwave would gradually replace the existing "L2 only" microwave. And during this process, Network Hierarchy is a key factor that need to be considerd. Using HVPN solution could effectively cut down the routing function requirement for the access layer microwave equipment, and provide a better Capex as result.

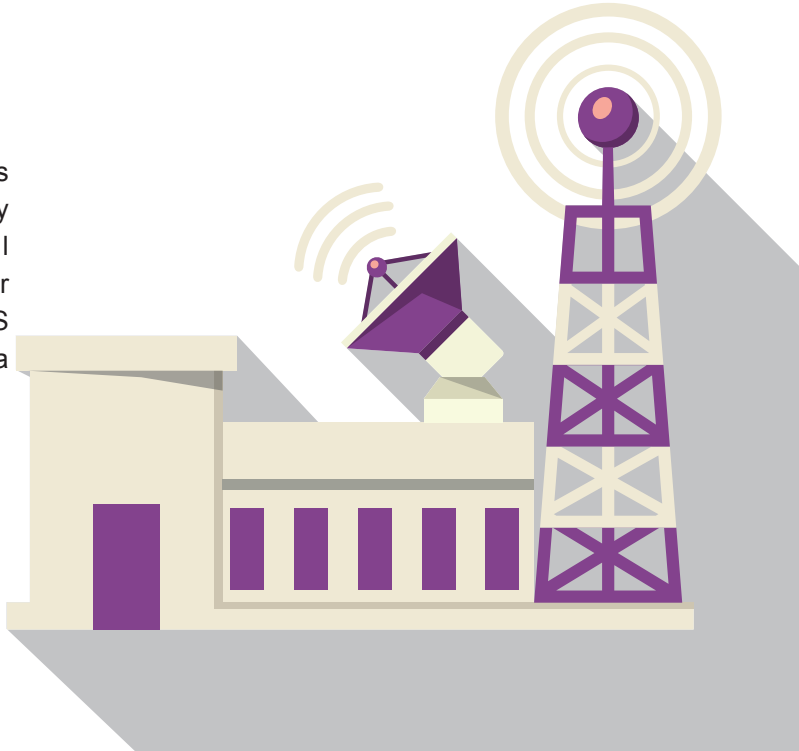
2.2.4 Optimised TCO

Extensive base station deployment call for a better TCO from microwave section, from many different perspectives:

1. In next years, it will be even more difficult to complete the site acquisition. To saving the site space, Microwave equipment is expected to be higher integrated, and fully outdoor deployment would take a bigger share among all the deployments.
2. compacted outline(including main equipment and antenna) and green design would be another trend, target to saving tower renting cost and power consumption cost.
3. Engineering delivery would utilize a series of automation/IT tool to optimise labor cost and simplify engineering, such as unmanned aerial vehicle for an intelligence site survey, toolkit for instant frequency interference scanning, network element automatic configuration, automatic site startup...
4. SDN technology will be the new potential where we could save operation cost, by instance service commissioning and network automatic OAM

2.2.5 Small cell backhaul

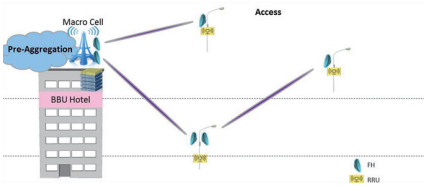
Small cell is a perfect solution to enhance wireless coverage and network speed, but due to the difficulty in site acquisition and huge investment, small cell will be mainly adopted in indoor coverage, together with partly outdoor coverage. Sub-6G (support NLOS transmission), V-band and E-band are considered as a whole basket solution for small cell backhaul.



2.2.6 C-RAN

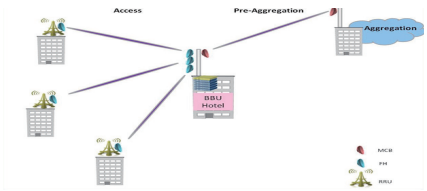
C-RAN solution can effectively enhance the wireless network performance, 4.5G/5G technology will directly drive the rapid development of CPRI speed. Currently microwave is already used to carry CPRI in C-RAN carrier network, it supports 2.5Gbos CPRI interface, and 10Gbps in the future.

This CPRI interface can easily exceed 10Gbps per a multi-band, 3-sector site, expected to grow to several tens of Gbps in the future, as the new features of LTE Advanced are deployed (Carrier Aggregation, MIMO, new spectrum).



ETSI mmw ISG's WI#2: Fronthaul data rates requirements for LTE/LTE-A small cells configurations

Total Bandwidth	MIMO	Fronthaul Line Rate(s) per Channel	Total Fronthaul Data Rate
20 MHz	2x2	2457 6 Mbps	2457,6 Mbps
[20 + 20] MHz	2x2	[2457,6 + 2457,6] Mbps	4915,2 Mbps
[20 + 20 + 20] MHz	2x2	[2457,6 + 2457,6 + 2457,6] Mbps	7372,8 Mbps
[20 + 20 + 20 + 20] MHz	2x2	[2457,6 + 2457,6 + 2457,6 + 2457,6] Mbps	9830,4 Mbps



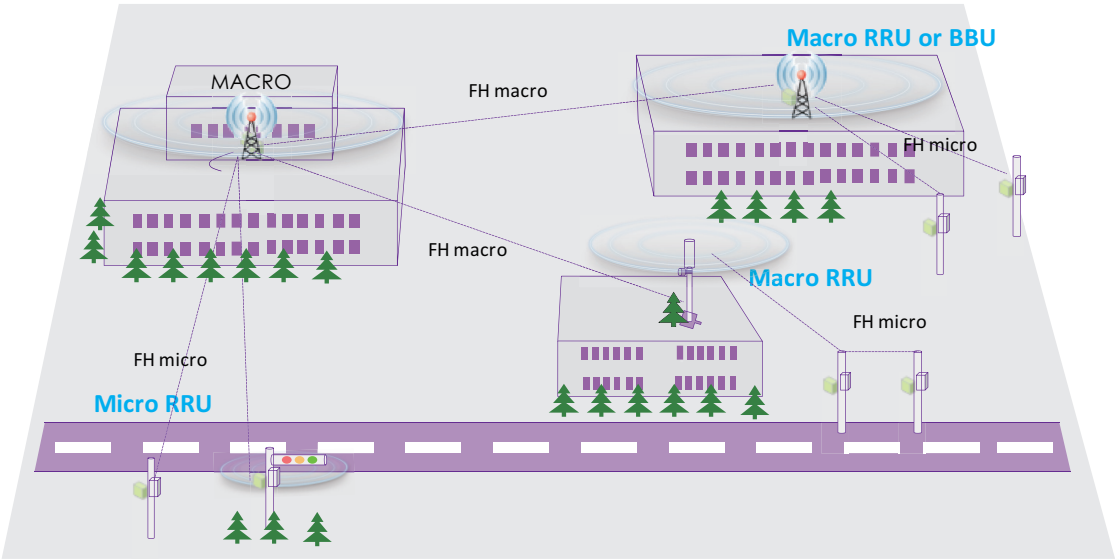
ETSI mmw ISG's WI#2: fronthaul data rate requirements for LTE/LTE-A macro cell configurations

Total Bandwidth (tri-sector site)	MIMO	Fronthaul Line Rate(s) per Channel	Total Fronthaul Data Rate
3x [10 + 20 + 20] MHz	2x2	3x [1228,8 + 2457,6 + 2457,6] Mbps	18432,0 Mbps
3x [20 + 20 + 20] MHz	2x2	3x [2457,6 + 2457,6 + 2457,6] Mbps	22118,4 Mbps
3x [20 + 20 + 20] MHz	4x4	3x [4915,2 + 4915,2 + 4915,2] Mbps	44236,8 Mbps
3x [20 + 20 + 20 +20] MHz	4x4	3x [4915,2 + 4915,2 + 4915,2 +4915,2] Mbps	58982,4 Mbps

The large-scale deployment of C-RAN is currently limited by the same reason why MW is still necessary (and will be for many decades to come) in mobile backhaul, i.e. the less than ubiquitous availability of optical fiber.

In one of the most exciting developments of MW technology, recent research addresses what is called Efficient Wireless Fronthaul™, a technology that allows packing the equivalent of a 2.5Gbps CPRI connection into a standard 28MHz MW channel. The main highlights of this technology are:

- At least one order of magnitude increase in spectrum efficiency compared to brute-force transmission of (e.g.) CPRI over the air, easily reaching the equivalent of 10Gbps CPRI in existing RF channelization
- Not dependent on RF frequency band
- All traditional MW techniques can be used, including equalization to contrast multipath, XPIC to allow for maximum spectrum efficiency etc.
- No quality degradation of the RAN, as opposite to lossy compression techniques that increase noise and distortion, still by far not achieving the required spectral efficiency (compression is limited to a 3x gain factor)

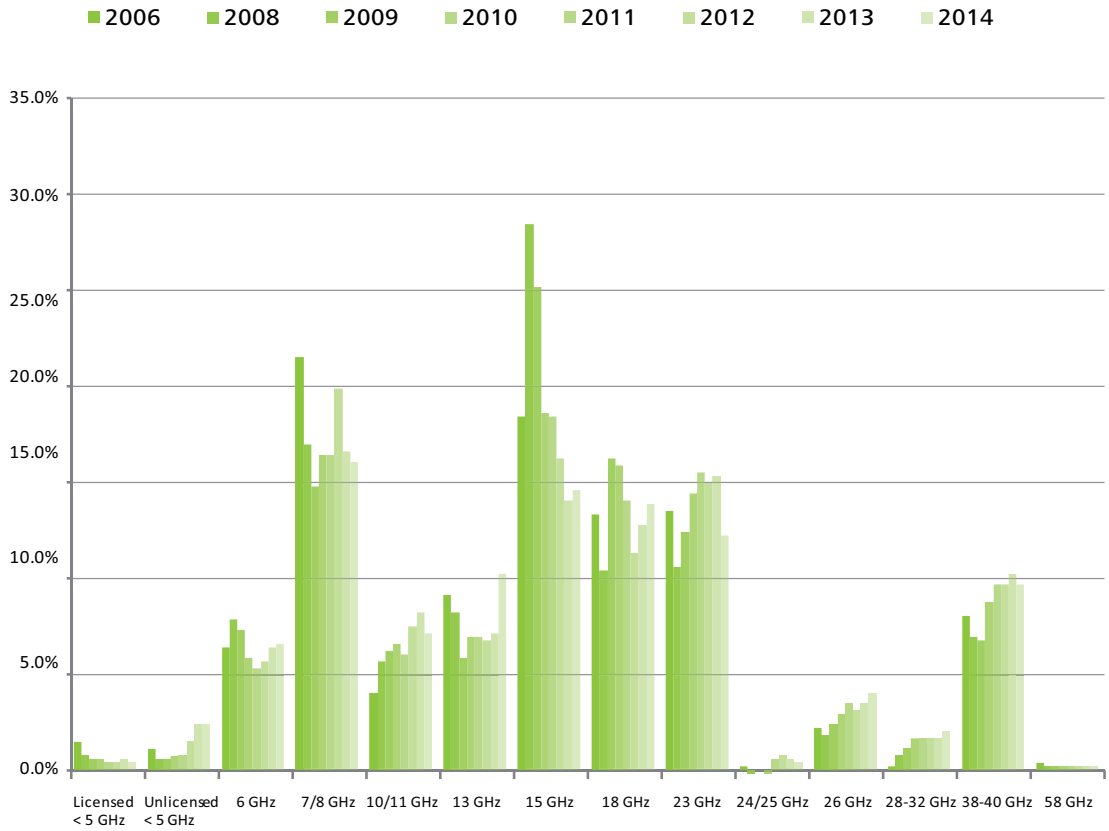


With such performances, Efficient Wireless Fronthaul is going to represent the enabling factor in one of the biggest revolutions that is coming in our near future, namely the migration towards virtualized, tightly integrated, ultra-high performance Mobile Networks.

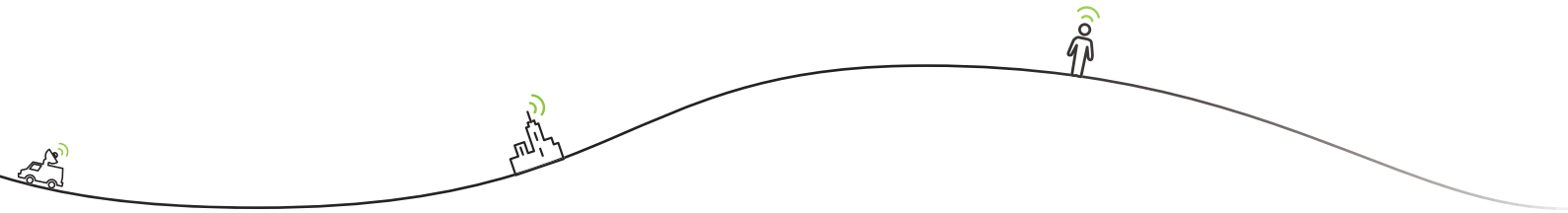
3. MW SHIFT TO HIGHER BAND TERRITORY

So far frequency bands from 6 to 42 GHz bands have been the most commonly used for fixed point-to-point services, while millimeter-wave is considered to start from 50 GHz. 13GHz,15GHz,18GHz,23GHz are common used in worldwide for split short haul link, 7GHz,8GHz are mainly reserved for Long haul microwave system; 28GHz is reserved for Point to multi-point transmission and now also for Point to Point in some countries. In Indonesia and China, only 6GHz-23GHz are regulated for point to point LOS transmission, higher band like 26GHz-38GHz are more adopted in Europe countries.

Looking at the distribution of the frequency bands usage during the past ten years, some main trends become apparent:



Due to network topology changes, and very congested spectrum, traditional bands like 7/8 GHz and 15 GHz are progressively losing importance in favor of 18/23 GHz, with a slight increase of 38/42 GHz, especially in Europe.



3.1 The Trend to Higher Bands

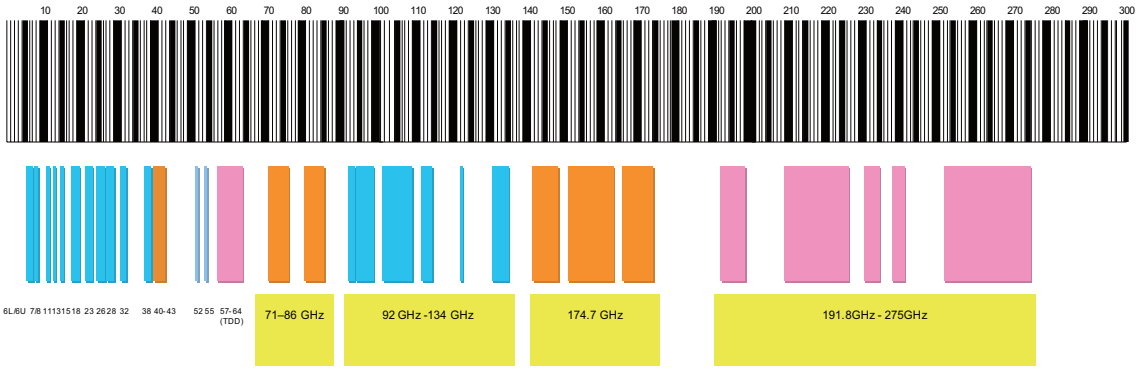
Interest in millimeter-wave bands has risen significantly in recent years due to the enormous amount of under-utilized bandwidth that lies in this part of the electromagnetic spectrum.

The significant advantages offered by the propagation characteristics in terms of frequency re-usability and large channel bandwidths, make millimeter-wave suitable for transmitting multi-Gbit/s for the connection of macro base stations. At the same time it allows for the backhaul of small cells in dense urban environment thanks to very compact antenna size that makes products “blend" in the environment.

In search for more spectrum, as a general trend all wireless applications are going to use higher frequencies. and the front- and back-haul applications that are using 60 GHz and 80 GHz now, and evolution is expected to reach even up to 200GHz and beyond.

The microwave industry realized the necessity to cooperate more, in order to facilitate the use of the millimeter-wave bands. In particular the V-band (57-66 GHz), the E-band (71-76 & 81-86 GHz), and as a result a trend of widespread adoption of E-band for urban scenarios has emerged, freeing up the higher and most congested “traditional” bands (about 23 to 42GHz).

In the future, higher frequency bands above 90 GHz are a prime candidate for large volume applications in the backhaul and fronthaul to support all services requiring high speed wireless transmission.



Standardization activities are now under way of the so-called W-Band (92 to 114.5 GHz) and D-Band (130 to 174.5 GHz).

3.2 Spectrum Regulation: Now & Future

The way spectrum licenses are regulated is fundamental to guarantee that the spectrum is actually used in an efficient way.

The key points are:

A. Interference check to guarantee investment protection. Most Operators are wary to deploy MW in unlicensed bands, because there is no legal protection from the risk of future interference.

B. Speed and cost of the interference check. These can vary widely depending on who is performing the interference check, e.g. the Operator or the Spectrum Regulator (may be a Governmental Agency or a licensed private company).

C. Cost of the spectrum (both CAPEX and OPEX) license. This is one of the most widely varying TCO items from country to country.

D. Speed and cost of the overall RF planning and licensing. This is mostly affected by the points noted above, but other considerations may come here to the forefront, like e.g. the availability of high definition 3D maps for street-level planning, the quality of the information about potentially interfering links, etc.

Examples of existing regimes range from the cost-free, license-free usage (e.g. E-band in Russia), to so called “self coordinated links” under “light license process” (like E-band in US and part of E-band in UK), to fully license in the traditional individual link basis (like E-band in Germany).

A possible tradeoff between the extremes of no licensing/coordination at all vs. full licensing/coordination is the allocation of a block of spectrum to an Operator:

1. The interference check, RF planning etc. processes are completely managed by one subject, who is performing the actual deployment and can thus closely coordinate all the logistics.

2. Cost/speed vs. interference risk tradeoff is completely managed by the Operator. Different Operators in different local conditions may want to strike different levels of tradeoff.

In the field of mmW, where most of the new spectrum is going to be found in the future, the right licensing/coordination regime is mostly yet to be defined. Therefore, giving the make-or-brake characteristic of the spectrum regulation, this is a critical juncture for the industry as a whole and many activities are ongoing about it.

3.3 The Role of the ETSI ISG mWT

After being established in December 2014, within the ETSI organization, the ISG mWT (Industry Specification Group millimetre-Wave Transmission) reached global and worldwide consensus counting around forty companies as members, among operators, system vendors, institutes and Government, antenna and components and instruments suppliers.

SYSTEM VENDORS
Alcatel-Lucent (FR)*
Aviat Networks (UK) Ltd
Blu Wireless Technology Ltd (GB)
Ceragon Networks AS (NO)
DragonWave S.a.r.l (LU)
E-Blink s.a. (FR)
Ericsson LM (SE)*
Fastback Networks (US)
Huawei Technologies (SE)
Huawei Technologies Co. Ltd (GB)*
NEC Corporation (JP)
NEC Europe LTD (GB)*
Nokia Solutions and Networks Gmbh & Co. KG (DE)
Samsung Electronics (UK)
SIAE Microelettronica SpA (IT)
Siklu Communication Ltd. (IL)

OPERATORS
Deutsche Telekom AG (DE)*
DOCOMO Communications Laboratories Europe GmbH (DE)
EE Limited (GB)*
SK Telekom (KR)
TELECOM ITALIA S.p.A. (IT)
VODAFONE Group Plc (GB)*

INSTITUTES, GOVERNMENT
Commissariat à l'énergie atomique et aux énergies alternatives (FR)
FBConsulting S.A.R.L. (LU)
French Ministry of Economy, Industry and Digital Affairs (FR)
IMEC
Layer123 (GB)
National Physical Laboratory (GB)
Partners

ANTENNA, COMPONENTS, INSTRUMENTS SUPPLIERS
Andrew AG (CH)*
BROADCOM CORPORATION (US)
HUBER+SUHNER AG (CH)
INFINEON TECHNOLOGIES (DE)*
Intel Deutschland GmbH (DE)
InterDigital Communications (US)
JDSU Deutschland GmbH (DE)
ROBERT BOSCH GmbH (DE)
Filtronic Broadband Ltd (GB)
Plasma Antennas Ltd (GB)
STMicroelectronics (CH)

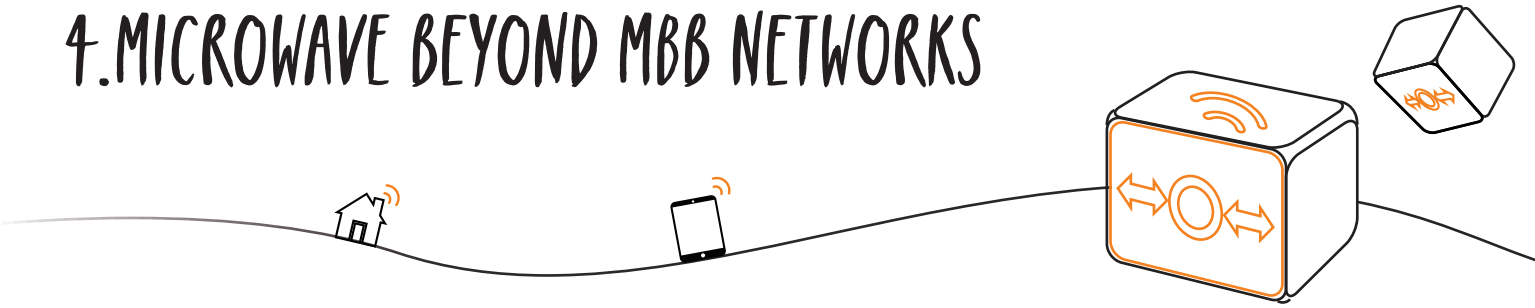
ISG mWT was founded with the aim to provide a platform and opportunity for companies, organizations and any other stakeholder involved in the microwave and millimetre wave industry chain, to exchange technical information aiming to facilitate the use of higher frequency bands (from 50 GHz up to 300 GHz) ,support large volume deployment in the back-hauling and front-hauling implementation, wireless local loop and any other service benefitting from high speed wireless transmission.

ISG mWT addresses the whole industry value chain with emphasis on:

- Current and future regulations and licensing schemes for the use of suitable spectrum in different countries
- Putting in communication the whole industry chain to share and circulate public information, regarding the applications in field in order to favor faster and more effective decisions on investments needed to provide new technologies, features and equipment
- Influencing standards for the deployment of the products
- Enhancing the confidence of all stakeholders and the general public in the use of millimetre wave technologies

Several informative documents and group specifications have been published, covering regulation and licensing schemes, propagation channel models, simulation results, measurements, semiconductor technology roadmaps, and experiences gained from early roll-outs and trials. Other ISG mWT deliverables will specifically dig into new high frequency bands management, V-band street level interference analysis, active antennas, new use cases, V/E-band regulations & licensing schemes.

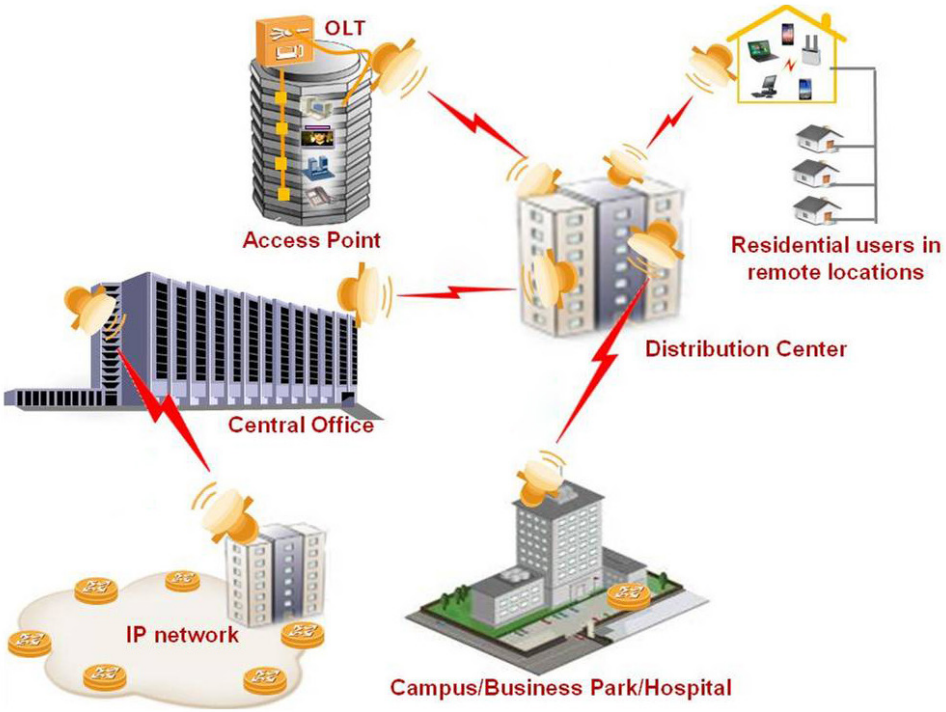
4.MICROWAVE BEYOND MBB NETWORKS



The very same characteristics of high data capacity, low TCO and fast deployment make microwave very appealing for other applications too, including Fixed Broadband networks. As it happens in mobile backhaul, also in Fixed Broadband applications fiber availability may be challenging for many reasons, both technical (permits, difficult terrain) and economical (fiber is too expensive for the business case).

In future the fixed broadband business will develop toward a higher bandwidth and more comprehensive coverage. EU, US, China, Russia, Brazil and India all proposed the National Broadband plan, aiming the target of universal broadband access (1Gbps+ in urban district, and 100Mbps+ in suburban village), and this would be a new big era for fixed broadband business.

In urban area, how to solve the last mile connection with a ubiquitious coverage? According to site infrastructure, it calls for a whole basket solution including fiber and microwave,to provide a sufficient pipe. In high density urban area, fiber takes the lead but it also worries the network operator with cost and lead-time. In order to make a balance between amount of investment and service commissioning efficiency, microwave turns out to be a right choice for rapid deployment and cost, in those places where fiber resource is unavailable or needs long time to arrive. For the outlying area,such as village or the isolated islands, microwave is gradually taking lead to set up basic connection for limited terminal users, considering the ROI bottleneck in this application scenario.



5.SUMMARY AND CONCLUSIONS

Capacity Increase and Latency Reduction

- mmW to achieve up to 10Gbps
- Network tends to star topology from fiber PoP

Fronthaul

- Fronthaul is mostly pushed by the need for tight coordination
- For fronthaul an efficient transmission technology must be developed to allow its deployment over MW

New Tranmission Spectrum is Needed

- There will always be need for wireless transmission, but current spectrum is scarce and not always optimally regulated
- mmW can provide that, even in nLoS/NLoS secnarios

The evolution of Mobile Networks towards LTE-A and 5G in the next few years poses significant challenges to the evolution of microwave technology, especially in terms of transmission capacity and latency.

The development of new technologies and the use of higher frequency bands allow microwave to remain a fundamental building block of mobile networks even in this framework of ever-increasing demands.

New architectures and applications like Small Cells and C-RAN require specifically designed solution in order to be viable, both technically and economically, and also here microwave technology demonstrates its great adaptation capability.

The whole telecommunications industry is collaborating to ensure that the entire ecosystem is viable and will allow the mind-blowing new performances promised by next generation mobile networks, including everything from the components, to the systems, to the spectrum regulations. One great example of this is the success of the ETSI ISG mWT.

Mobile applications will probably remain the main application for microwave solutions, but great promise is held in the expansion into markets like Fixed Broadband, Rural coverage and Enterprise applications, thanks to the absolute numbers involved in those markets.

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