

# 5G

[ 5G ecosystem, impact on sectors, and strategic priorities ]

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# Agenda



# 1. Introduction

# 5G is set to change our lives, not just in terms of speed

What is 5G?

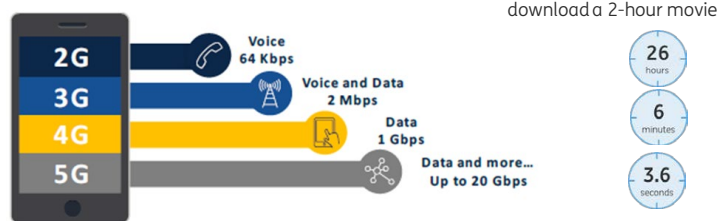


- 5G refers to the fifth generation of mobile phone networks. Since the introduction of the first standardized mobile phone network in 1982, succeeding standards have been adopted and deployed approximately every nine years.
- 5G is expected to bring an exponential increase in data speeds that will change how users interact with the internet and applications. It will provide speeds faster than any previous generation, **comparable to fixed lines** and **offer lower latency, more reliability, and better flexibility**.

How Fast is 5G?

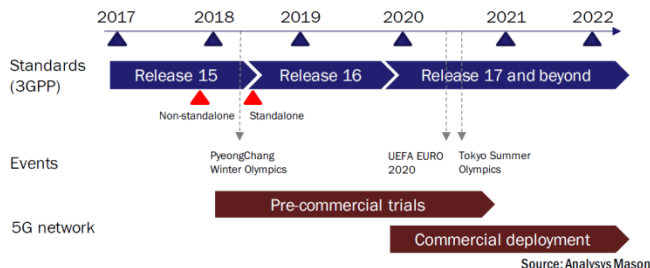


## Mobile networks by speed



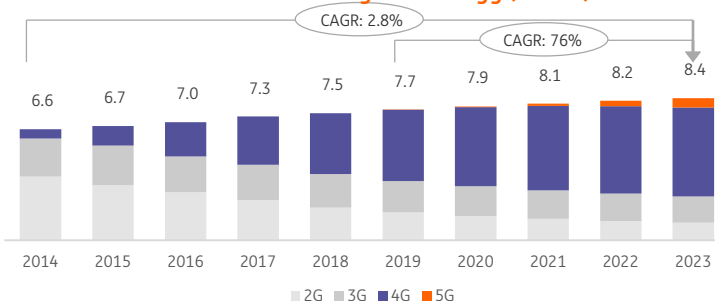
Source: DotEcon and Axon

## 5G release timeline and major events where 5G will be showcased



Source: Analysys Mason

## Worldwide mobile connection by technology (billion)



Source: Analysys Mason, DotEcon and Axon

6

**Lower Latency**  
Reduced through switching protocols that more efficiently route signals. Improves reliability and responsiveness for new uses.

1

**Higher Speed**  
Typical speeds of 0.3 - 1Gbps in a real world environment although theoretical max speed may reach 20Gbps.

2

**Higher Network Capacity**  
of the technology allows for faster, more complex and multimedia applications.

THE POWER OF 5G!

**Lower Power Consumption**  
Power is saved by structuring multiple mode settings into the protocol so that transmission is conserved, extending battery life to several years for simple sensors.

5

**Very Flexible Spectrum Possibilities**  
Wider channels and higher frequencies, heterogeneous networks, and possibility to optimise mobile signals for efficiency and faster network experience.

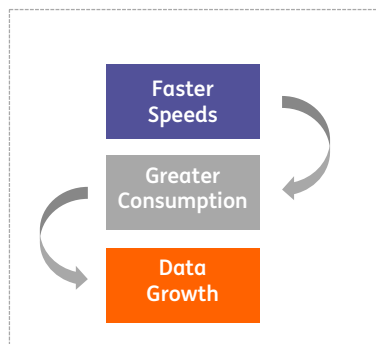
**Higher Connectivity Density**  
more capacity so that smart devices and sensors can work together simultaneously on the same network / cell, to allow for IoT / smart city implementation.

3

4

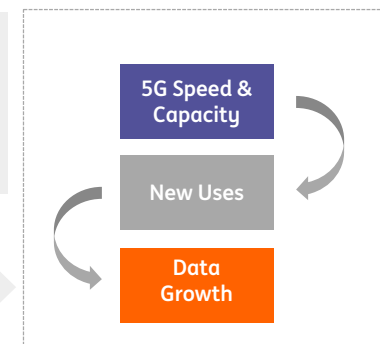
# 5G to coincide with data boom and further empower business and consumer uses

... thereby, perpetuating more data creation and new business opportunities

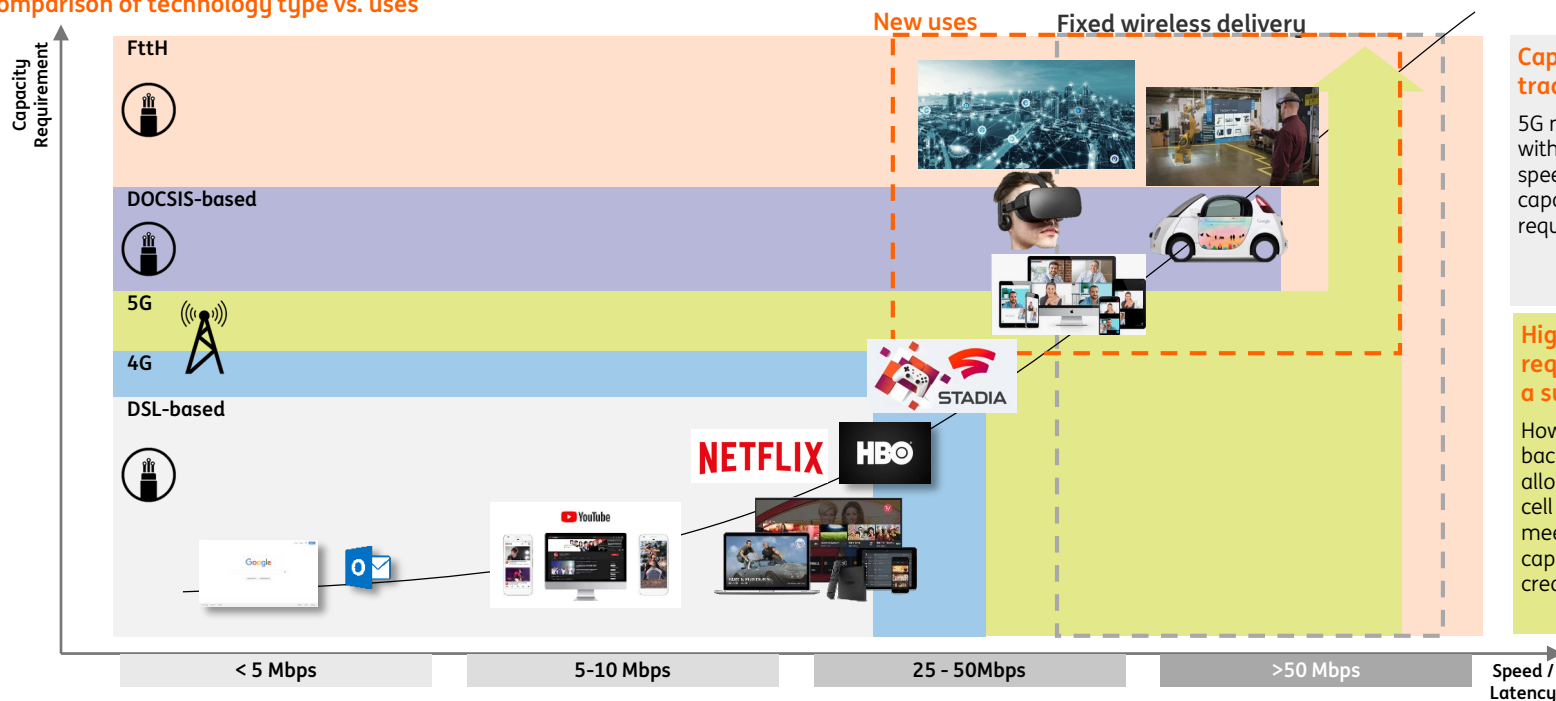


- Consumer driven data boom**
- Mobile data traffic is expected to grow at a CAGR<sub>18-24</sub> of 31% to 136 exabytes per month. This means each smartphone user will consume 21GB data per month.
  - 74% of which will be media and entertainment – e.g. Netflix, Google Stadia, VR/AR gaming.
  - Studies have shown that at higher speeds, data usage grows correspondingly because of the possibility to do more / consume more in less time.

- Enterprise driven data boom**
- 5G is expected to unlock new enterprise uses such as driverless cars, AR/VR, IoTs, which will generate exponential amounts of data needing to be transmitted close to end users



## Comparison of technology type vs. uses



Source: Ericsson

# 5G to bring about significant positive impact to global economy ... (1/2)

... with monetisation to be driven largely from the enterprise side





5G's full economic effect will be realized across the globe by **2035**, supporting a wide range of industries and potentially producing up to **\$12tn** worth of goods and services.



5G value chain (OEMs, operators, content creators, app developers and consumers) could alone generate up to **\$3.5tn** in overall aggregate revenue by 2035 and support up to **22m** jobs.

**Summary of 5G driven industry trends and uses** → The requirements for 5G stems from growing needs of telco providers and other industries, as they seek to improve productivity and develop attractive new services and products for customers ....

Impact	Industry Trend	Example Uses	Role of 5G	Growth
	<b>Connectivity:</b> growth in devices, content and data traffic	<ul style="list-style-type: none"> <li>Faster communication using more advance 5G enabled smartphones</li> <li>HD video conferencing through cloud based systems</li> <li>Drones</li> <li>Quickly transmitting large files for business, healthcare, and educational purposes</li> </ul>	<ul style="list-style-type: none"> <li>Handle growth in cost-effective, high-speed, and energy-efficient manner</li> <li>Enhanced mobile broadband (eMBB)</li> </ul>	<ul style="list-style-type: none"> <li>Analysys Mason expect total 5G connections to grow from 3.3m in 2019 to 547m translating to 258% CAGR<sub>19-23</sub> growth in retail revenue to \$124bn by 2023</li> <li>Individual monthly video data usage will increase from an average of 11.7GB per subscriber in 2019 to 84.4GB by 2028</li> </ul>
	<b>Internet of Things:</b> explosion of connected devices	<ul style="list-style-type: none"> <li>Smart cities and surveillance</li> <li>Autonomous driving</li> <li>Sensors to enhance manufacturing and retail processes</li> <li>Telemedicine</li> </ul>	<ul style="list-style-type: none"> <li>Connect everything, from smartphones to cars and homes</li> <li>Improve latency capabilities and increase efficiency</li> <li>Multitude of potential commercial uses across various industries (see figure)</li> <li>Leveraging public and private network to support different IoT connectivity models</li> </ul>	<ul style="list-style-type: none"> <li>Gartner estimates there will be 20.4bn connected devices by 2020 with a value of \$3tn</li> <li>Gartner expects IoT security to reach \$3bn by 2021</li> </ul>






5G offers enormous opportunity for expansion of both preventative and monitoring practices via wearable devices, and even tele-surgery. *E.g. AT&T partnership with Rush University Medical Centre to be first US hospital to leverage 5G.*



5G will help drones transmit real-time HD video when moving quickly. Drone services will be highly value-added in the security, construction, energy, agriculture, transport, and content production field.

# 5G to bring about significant positive impact to global economy ... (2/2)

... with seemingly endless use cases and partnership between traditional telcos and other industries

Impact	Industry Trend	Example Uses	Role of 5G	Growth
	<b>Fixed Wireless Access:</b> offers massive scale deployments and better services for customers	<ul style="list-style-type: none"> <li>Traditional uses access to less densely populated areas</li> </ul>	<ul style="list-style-type: none"> <li>Utilize higher frequency bands than current 4G networks</li> <li>Solve the “last mile” problem</li> </ul>	<ul style="list-style-type: none"> <li>ABI research predicts the fixed wireless broadband market to grow by 26% CAGR<sub>18-22</sub> and generate \$45.2bn globally</li> </ul>
	<b>Proliferation of OTT players:</b> traditional telcos need to adapt and compete against providers of value-added services	<ul style="list-style-type: none"> <li>Entertainment - HD video streaming (i.e. 8K, AR/VR, 360-degree videos), AR/VR game streaming</li> <li>Improve business to consumer interaction</li> </ul>	<ul style="list-style-type: none"> <li>Support evolution of rich content types</li> <li>Enable telcos to compete against OTT players through quality offerings</li> </ul>	<ul style="list-style-type: none"> <li>According to Bain, global OTT platform market is expected to grow from €35bn in 2017 to €124bn by 2025.</li> </ul>
	<b>Consolidation of Industry:</b> Consolidation between fixed/cable and mobile as the economics of integration become more critical. M&A to create unique product offerings and services	n/a	<ul style="list-style-type: none"> <li>Consolidation of industry could lead to return on investments in 5G networks</li> <li>Operators buying IT operations to expand their portfolios</li> </ul>	n/a



- Supported by regulator allocating spectrum for local services, German manufacturing giants like BASF, Siemens, VW, Daimler are investing in factory networks.



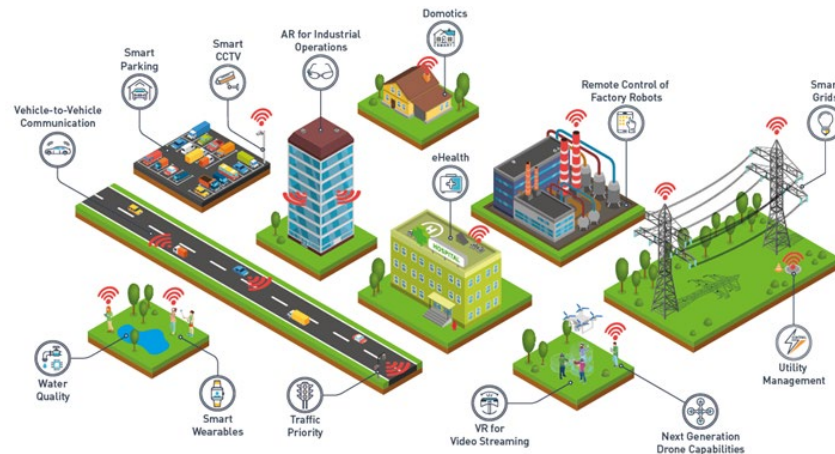
- 5G technology is set to underpin a wider variety of services that will change the way brands interact with mobile customers. *E.g. NFL and Verizon are reaching out to game developers to create league-themed mobile games that work with 5G.*



- 5G availability would mean a greater density of sensors in the environment and faster data transmission from centralized servers, leading to faster improvement via machine learning algorithms. *E.g. BASF is testing self-driving fuel tanker truck, to supply gas to its facilities.*

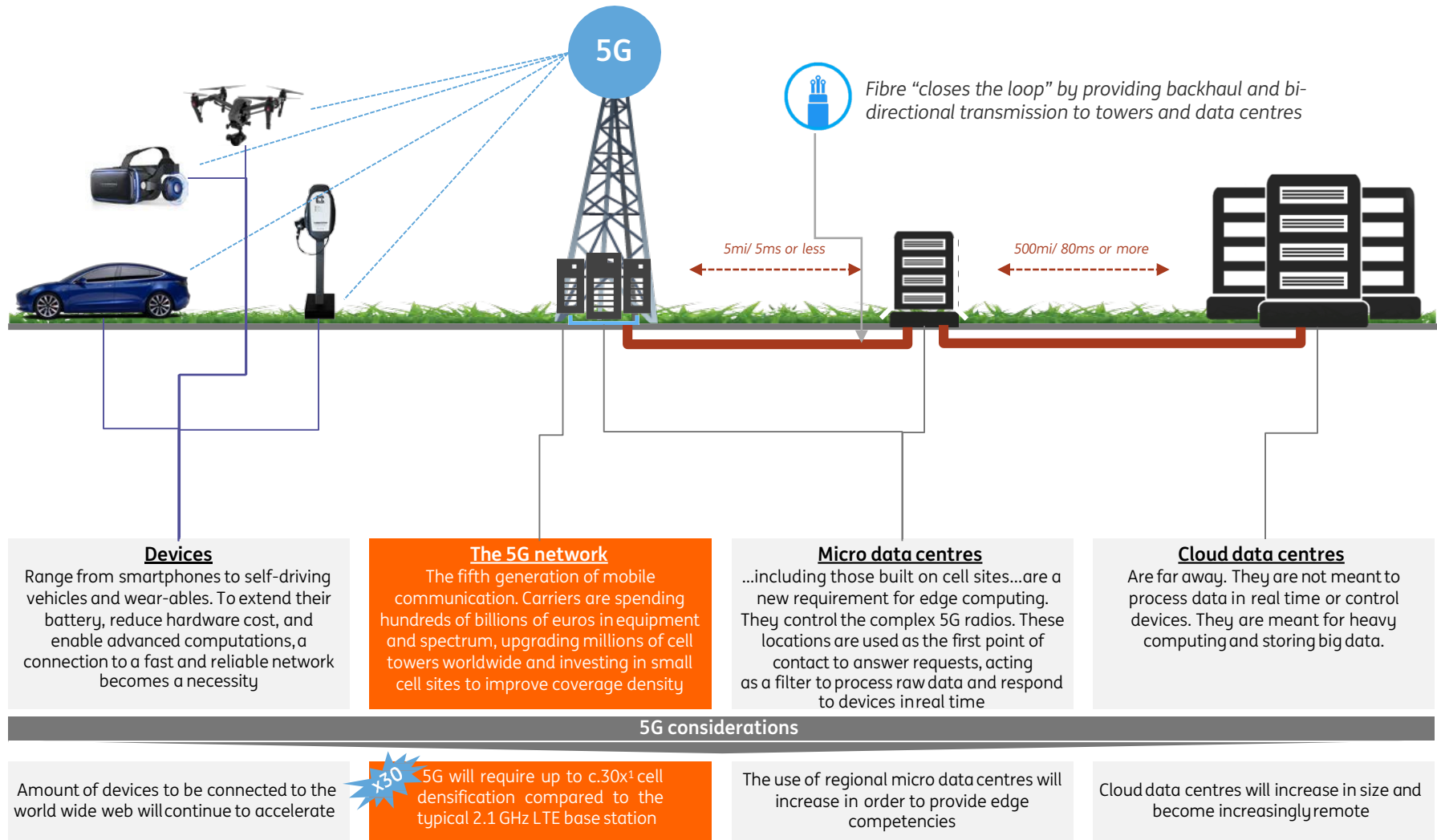


- Ericsson has partnered with the world's fourth-largest mobile provider China Unicom to develop a 5G “smart” harbour at the Port of Qingdao, China. Est. 70% of labour costs could be saved. *E.g. support the lifting of a container by an automated ship-to-shore (STS) crane operated from a control centre.*



Source: DotEcon and Axon

# Infrastructure layer to grow in tandem with 5G



Source: McKinsey, Technavio, Qualcomm; 1. In urban areas, rural areas will require up to 6x tower density



## 2. 5G Ecosystem

# 5G ecosystem will leverage passive infrastructure assets...

... many of which are the same within a modern 4G network

## • Data Centers / Edge Computing

- Data Centers are real estate facilities where servers, used to process data, are stored. There are fibre optic cables, as part of the broader telecommunications network, that connect to these facilities, to allow data to move to and from the relevant servers.
- Edge Computing is required in a 5G network as data and processing needs to move closer to the network to reduce latency.

## • Macro Towers / Small Cells & DAS

- Macro Towers serve as the first point of connection for end-user devices and remain the most cost-efficient manner to deploy wireless spectrum. The structures are unlikely to change in a 5G environment though the equipment deployed to them will evolve to make use of the latest spectrum bands and developments.
- Small Cells and distributed antenna systems (DAS) serve as the edge of a wireless network in higher-demand environments such as dense urban areas. They optimize network performance and offload demand from overburdened macro sites sometimes operated by a “Neutral Host”.

## • Wireless Spectrum

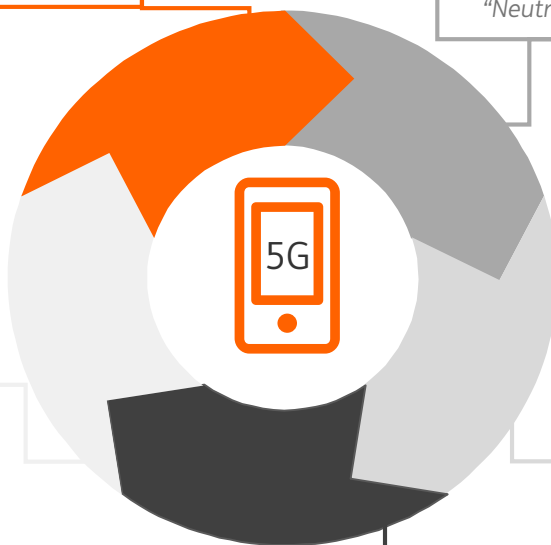
- Spectrum is used to carry information wirelessly for a vast number of vital services such as television and radio broadcasts, mobile phones, Wi-Fi, GPS, and radar. A robust 5G network will require a combination of low, mid, and high spectrum bands.

## • Fiber Networks

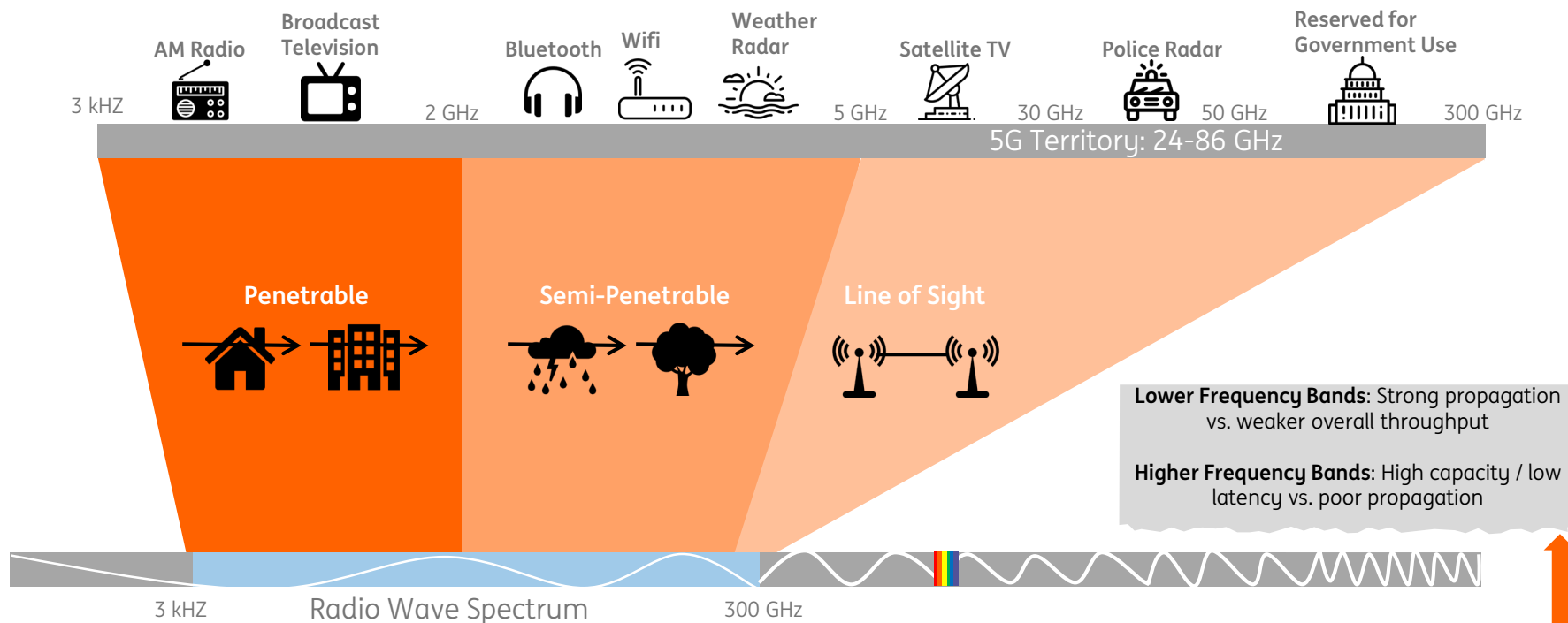
- Fiber is the nervous system to the mobile network. It provides the backhaul from towers, small cells, and data centers to carrier aggregation points and ultimately the mobile network core. In a 5G environment, a higher density of fibre is needed as additional edge nodes / equipment are deployed to serve higher demand and meet the network capacity standards of 5G.

## • Mobile Operators

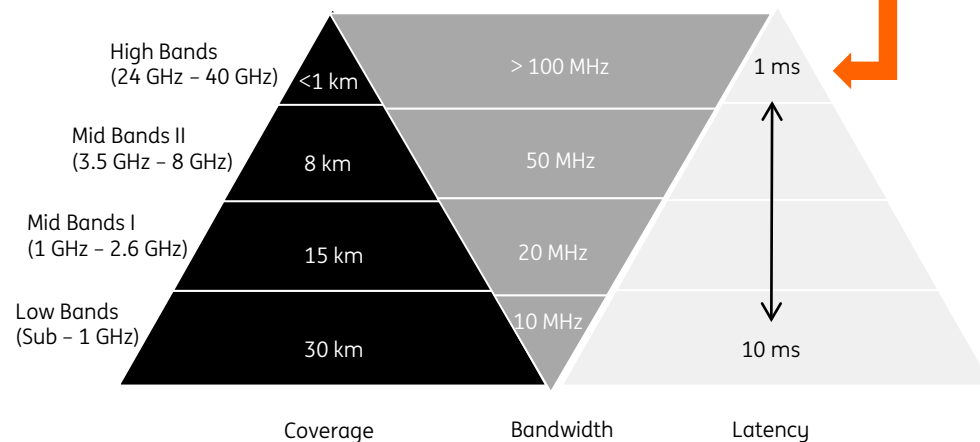
- Fixed and / or mobile operators such as telecommunication incumbents, cable operators, pure mobile network operators, or B2B / Altnets are the backbone of the communications network.



# 5G spectrum market



- As the world's dependency on wireless services such as radio and television increases, the demands being placed on the scarce supply of usable radio waves are rapidly growing. With the increased usage of the radio spectrum, the risk of **interference** between different services grows.
- Frequently, regulators assign spectrum licenses through auctions; thereby, controlling how much spectrum is assigned to telecommunication providers and how it may be subsequently used. **5G requires the use of new bands within the radio wave spectrum.**
- While 5G will work on low-band radio spectrum, for faster speeds, low latency and greater capacity, it will need much larger blocks of higher radio frequencies **requiring large swaths of wireless spectrum** that can support 1 GHz of aggregated bandwidth compared with 100 MHz for 4G.



Source: CBInsights, Ericsson

# 5G networks will impact telecom sub-sectors

## Telecom sub-sectors





## Available options / 5G strategy



## Opportunities



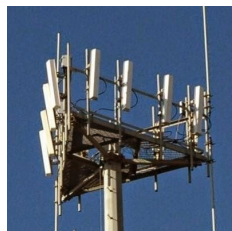
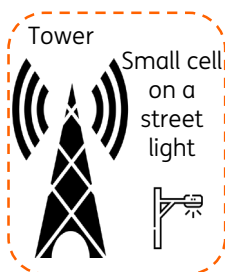
## Risks

Fixed and / or mobile operators	<b>Incumbents</b> <ul style="list-style-type: none"> <li>Often originally state-owned telecom operators providing fixed line services through (upgraded) ADSL-VDSL (and potentially FttX), and mobile services</li> <li>Incumbents' home market is usually core but some are international</li> </ul> 	<ul style="list-style-type: none"> <li>Network sharing, independent/neutral host network (via spin-offs when operators adopt netco/opco model) could help alleviate substantial deployment capex</li> <li>FWA using same 5G infra cuts cables and avoids "last-mile" expenses</li> <li>New revenue via new uses especially on enterprise (e.g. IoT)</li> <li>Network slicing enables MVNOs to run "mini networks." Slicing enables more precise control and MVNOs to target vertical applications (i.e. mobile network for gaming or Netflix)</li> <li>Managed service providers alleviating some tech aspects of rollout (e.g. virtualization)</li> </ul>	<ul style="list-style-type: none"> <li>Balance sheets already stretched; deteriorating credit quality</li> <li>Long-term revenue proposition uncertain</li> <li>Line of sight issues: overpaying on wireless spectrum while balancing infra build costs (e.g. fibre for US operators)</li> <li>Incumbent expected to lead / comply with rollout direction of regulator</li> <li>Rollout complexity may present operational challenge to traditional operator model</li> </ul>
	<b>Pure Mobile Operators</b> <ul style="list-style-type: none"> <li>Independent Mobile Network Operator (MNO's, with originally no fixed line offering) or MVNO's providing mobile services over the network of an MNO</li> <li>5G offers the opportunity for mobile only operators to offer broadband without owning a fixed-line network.</li> <li>More and more seeking quad play offering through acquiring fixed line operators or wholesale agreements</li> </ul> 		
	<b>Cable Operators</b> <ul style="list-style-type: none"> <li>Alternative network based on DOCSIS 3.0 / 3.1; originally started with TV offering but developed towards triple/quad play services</li> <li>Network coverage depends on country-by-country characteristics; often competing head-to-head with the incumbents</li> </ul> 	<ul style="list-style-type: none"> <li>The cost for cable providers to upgrade their networks to DOCSIS 3.1 is less significant vs. 5G/ fibre roll-out</li> <li>Current cable proposition will likely have a comparable or better network coverage in most countries, new wireless options will have to offer a compelling economic reason for customers to switch</li> <li>Full 5G rollout is still several years out while cable is currently reliable alternative</li> </ul>	<ul style="list-style-type: none"> <li>Technological substitution risk from 5G/ Fibre</li> <li>Rise of OTT platforms eroding Pay TV revenues</li> <li>Encroachment of MNOs (i.e. Verizon into Comcast and Charter markets in Houston, LA, etc.)</li> </ul>
	<b>B2B / Altnets</b> <ul style="list-style-type: none"> <li>Alternative provider of (fibre) fixed networks, metro networks, business parks, etc. connecting the network of mobile operators.</li> <li>Often started as alternative operator, challenging incumbents on wholesale and/or corporate segment</li> </ul> 	<ul style="list-style-type: none"> <li>Provide wholesale access to passive infrastructure which is the backbone for 5G network</li> <li>Rollout in underserved areas which are now relevant given the density required to empower 5G and FWA</li> </ul>	<ul style="list-style-type: none"> <li>Lack of consumer business means wholesale providers are dependent on ISPs / operators</li> <li>Wholesale pricing regulation</li> </ul>

# 5G Macro tower & Small cell market

## Macro Towers

- 5G will share many network components with 4G, and to deploy it **does not require the ripping-out and replacement** of many 4G components.
- Carriers will deploy a **lot of new equipment and technologies** in the next few years, **few of which are specific for 5G** and instead are being deployed initially to create additional 4G LTE capacity. 4G is still very much evolving, particularly in emerging markets, and will continue to support additional improvements as well as new commercial applications.
- Many modern base stations are 5G upgradable, and antennas are 5G capable, but are often being replaced along with the on-tower radio heads to **enable things like MIMO and beamforming** that increase capacity in both LTE and 5G.



## Small Cells/ Distributed Antenna Systems

- The purpose of installing small cells is to **increase capacity** in densely populated urban areas and **extending coverage** to rural areas that cannot be sustained by macro cells alone. Many small cells, which are easy to install, are mounted on street lights or telephone poles and unlike macro towers, are **relatively discreet**
- Small cells are relatively **more costly** to build than macro towers since deployments rely on **expensive fibre backhaul** and typically require several small cells. They are subject to the same regulatory permitting process and fees as a standard macro tower, with federal regulations accounting for 29% of small-cell deployment costs.
- Analysys Mason forecasts that smartphones will account for 76% of all handsets by 2022. This will drive the need for **network availability, particularly indoors**, where macro cell signal penetration is lower. Indoor small cells will exceed outdoor small cells in terms of units deployed
- MNOs have been deploying DAS for several years; however, these are **more costly and complex** to deploy than the small-cell solutions that are available today



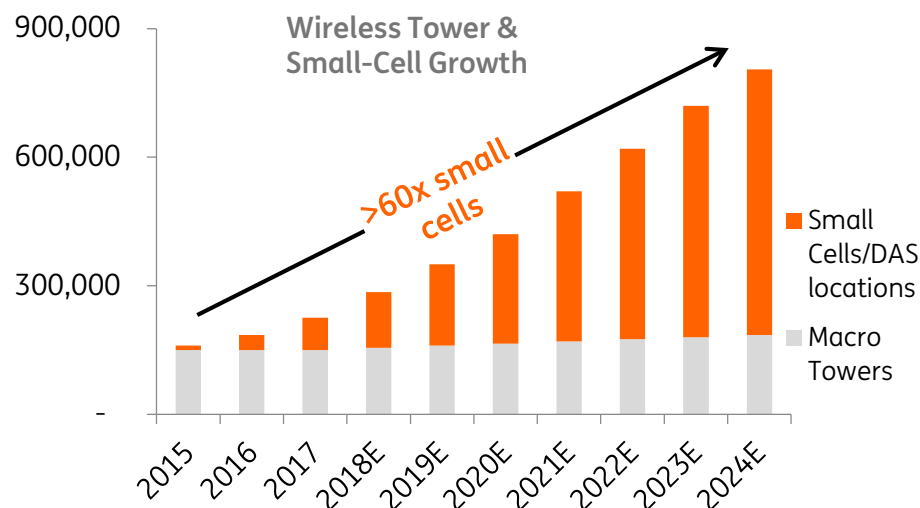
### Opportunities

- Deployment of new equipment / amendments; modern base stations remain relevant**  
Financing opportunities for new equipment such as antenna technologies. Freeing up C-band spectrum will propel additional leasing.
- 4G deployment**  
Still substantial growth ahead in 4G deployment, particularly in large emerging markets
- 5G uses requires more small cells which opens up new slate of financing opportunities**  
Existing tower companies will likely require financing for the small cell backhaul. Crown Castle stated small cell deployments "call for 2.5 small-cell nodes per fibre mile on avg. and as many as 7 to 12 per mile in denser markets." Towercos are key for making neutral host model work.



### Risks

- Increased network complexity / operational processes**  
Underestimating the scope of network and operational complexity introduces the risk of higher costs and less flexibility. There needs to be an established architecture that can seamlessly operate across multiple technology bases and between licenses and unlicensed spectrums.
- Increased mergers or consolidations at MNO level**  
Trend of consolidation of MNOs is expected to increase. The consolidation among tenants reduces demand for towerco communication infrastructure (increased churn as seen in India w/ American Tower).
- Bankruptcies**  
Wireless service providers unable to continue making lease payments. Credit risk of the wireless carriers is expected to continue to deteriorate.



Source: JP Morgan: Telecom Services, Cable & Satellite, Analysys Mason, S&P

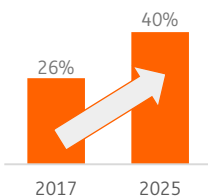
# 5G impact on the Fibre market ...

... greater demand for backhaul will unlock various opportunities ... while substitution risk is limited in reality



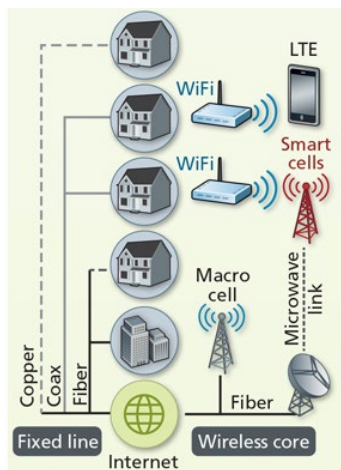
“The road to 5G is paved with Fibre”

Global Fibre backhaul (% of total)

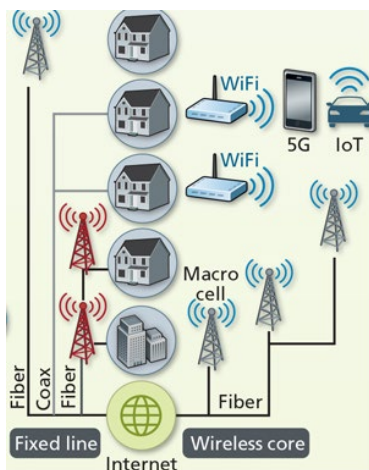


- Fibre boasts - long service life (c.30 years), increased speeds (>100 Gbps) with lower attenuation, immunity to electromagnetic interference, small size, and virtually unlimited bandwidth potential.
- Fibre is the preferred medium for existing wireless backhaul. Going forward, its significance is to connect a dense mesh of 5G small cells to ensure networks meet the capacity and latency requirements for 5G uses.

Current mobile backhaul setup



After deep fibre



## Opportunities

- Additional Fibre financing and investment opportunities**  
The growth in backhaul required to deploy 5G and support new uses mean larger capex for operators that needs to be funded.
- Spin-off**  
The large capex requirements mean that telcos would be better off spinning off its network infra asset layer into a netco/opco structure or entering into network sharing agreements.



## Risks

- Tech substitution risk: 5G vs. fixed broadband**
  - 5G mobile network remains a shared medium: customers that connect to the same base station have to share the capacity of that base station.
  - Theoretically, 5G is able to reach speeds which rival fixed FttH networks of today but this will require substantial capex and future upgrades to keep up with consumer bandwidth demand growth.
- Tech substitution risk: 5G vs. fixed wireless**
  - Fixed Wireless Access ("FWA") is an umbrella-term that includes multiple internet access technologies where the last mile to connecting a premise is done via a wireless solution. 5G is in fact one of the mediums to deliver FWA with many FWA propositions actually using 5G ready equipment.
  - MNOs need to decide on capex and spectrum allocation given limited capacity - whether it is allocated to consumer/ enterprise 5G uses or FWA.
  - FWA can in fact be part of a convergence strategy for operators to capture the rural broadband market.

## Total estimated fibre investment in the next 5 – 7 yrs ...



\$130 – 150 bn



€220 – 250 bn

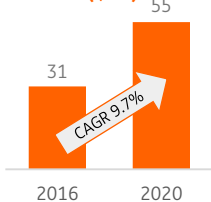
# 5G impact on the Datacentre market ...

... 5G uses will require DCs to be smaller and distributed closer to the end user

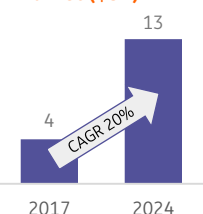


"IDC reports that 45% of data created by IoT will be stored, processed, and analyzed by edge computing"

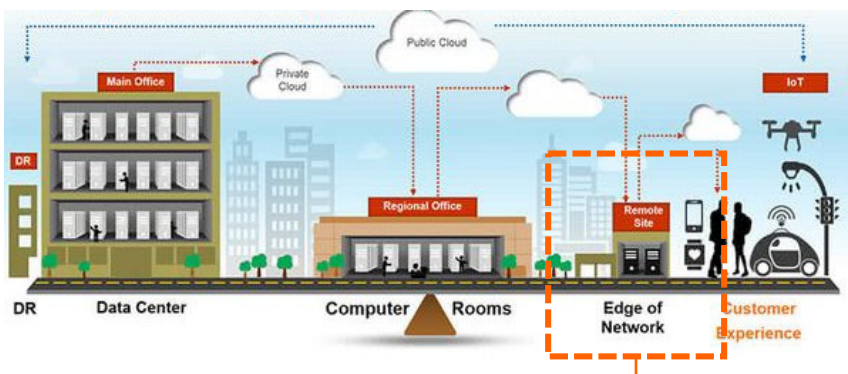
Global colo market (\$bn)



Global edge DC market (\$bn)



- 5G is expected to fuel the exponential data growth of consumers while new uses will require faster data processing, and lower latency connecting billions of devices.
- On top of that, the vast pools of data generated will need to be processed in real time (Seagate: c.20% of total by 2025).
- As such, data hosting requirements will change as local caching/ instances will be required to ensure end user experience is maintained for uses such as OTT. Collection of IoT/ M2M data can also be done locally or be part of the wider network to share compute power.
- Therefore, rise of edge computing will see the rise of smaller DC sites built closer to population centres.
- DC operations will require more energy-efficient and cost-effective upgrades that can handle resource-intensive data
- Apart from low latency, edge computing promises (i) network efficiency, (ii) security, (iii) resiliency, (iv) cost-savings, (v) low-end device power usage, and (vi) optimal allocation.



## Opportunities

### 1 5G / IoT uses requires more edge DCs or micro DCs which opens up new slate of financing opportunities

Existing edge DC operators are set to grow while expect traditional players to also expand into new space.

### 2 Infra investment opportunities

As with traditional DCs, edge DC investment could be shared by telcos, data center operators, and information service providers.



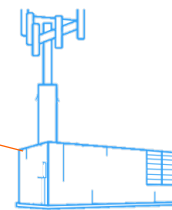
## Risks

### 1 Traditional smaller DC models will become obsolete

- The rise of edge computing could see a larger number of smaller DCs built closer to end users which may render some older less strategic sites obsolete.
- Overall, data centre demand will continue to grow with the 3 forms working seamlessly together: (i) closer to users – edge DCs, (ii) regional DCs at connections, and (iii) highly secured huge hyperscale data center / repositories for data storage.

**Managed services boom:** Demand for managed service providers are also expected to increase given the complexity of the rollout for traditional operators. Spending on their services is forecast to increase from \$56bn in 2016 to \$105bn in 2021 (13.4% CAGR).

Vapor IO, an Austin-based DC technology startup, is launching a colo service by offering leased DC capacity at cellular network towers.



Doing this locally can reduce capacity constraints at the central DC/repository and increase the speed at which data is processed

These micro DCs are small, compact, self-contained and provide local caching/ hosting services within limited space at the tower site (as little as 100 sqft).

### 3. Geographic Developments



# North American Market

# U.S. lagging in fibre infrastructure, spectrum auctions expected to ramp up

... in both U.S. and Canada



## 5G developments

1

Despite the demand and potential economic benefits of fibre deployment, the U.S. lacks the fibre density required for a 5G rollout. To meet future broadband needs, the U.S. needs an estimated \$130 – 150bn of fibre infrastructure investment in the next 5 – 7 years. Such ambitious infrastructure investment could derive from a variety of sources including communications service providers, financial investors and public-private partnerships.

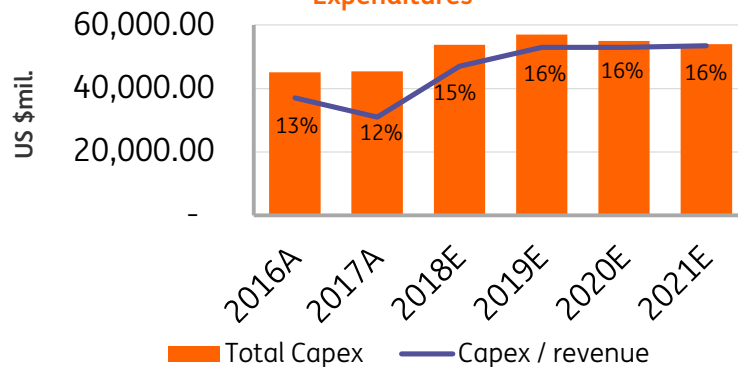
2

In November, the FCC launched the agency's first high-band spectrum auction in the 28 and 24 GHz band. In early 2019, the auction of 3 more mmWave spectrum bands, 37GHz, 39 GHz, and 47GHz, are expected. The U.S. is lagging behind South Korea, the UK, Spain, Italy, and Australia in terms of spectrum auctions. Trump is creating a White House Spectrum Strategy Task Force to ramp up U.S. spectrum.

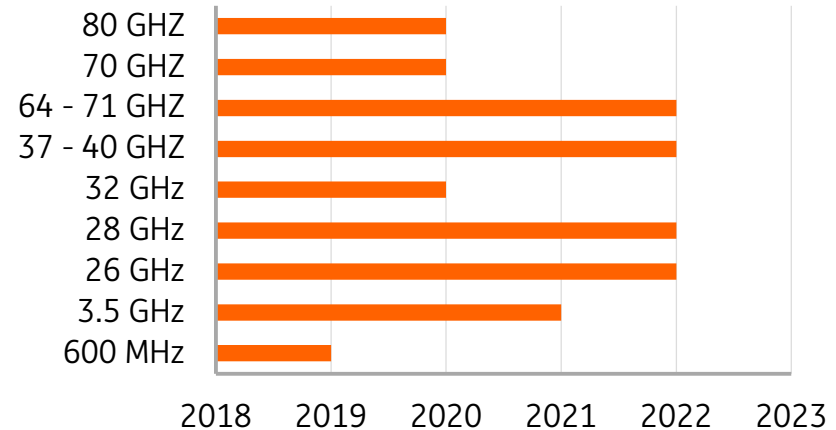
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From 2019 through 2021, S&P expects capital spending for all the U.S. carriers to remain elevated relative to historical trends as they build out 5G network infrastructure, which includes densifying their networks with small cell deployments and new equipment on towers. Given the desire to be the first to market with 5G wireless services, carriers will be saddled by elevated equipment purchasing costs until they are able to achieve scale.

## U.S. Telcos Capital Expenditures



## Upcoming Canadian 5G Auctions



## 5G developments

1

Canadian providers are expected to follow the U.S., with commercial availability of 5G mobile services by 2020, initially targeting the five largest cities. Rollouts in Canada are expected to be limited in scope, due to key spectrum availability and carriers' desire to monetize 4G investments.

2

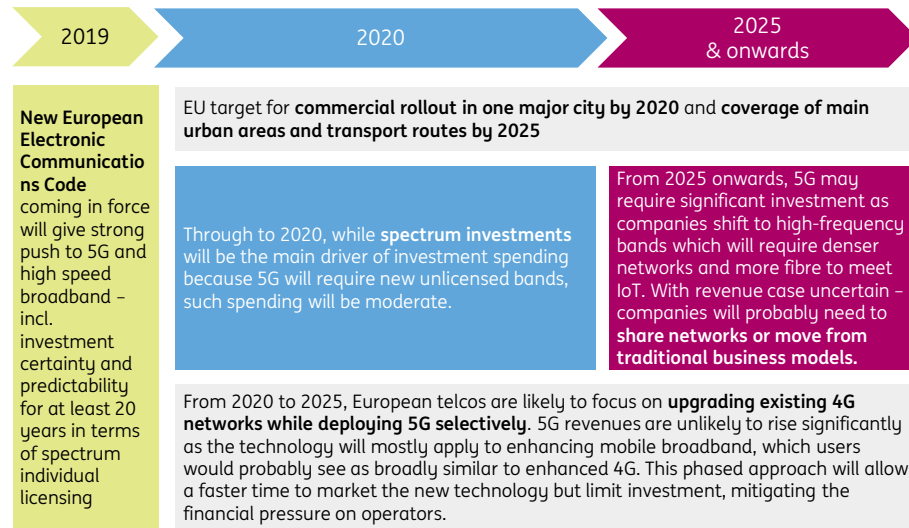
Unlike the U.S., the population in Canada is geographically concentrated. Canada can get up to 90% of fibre coverage by covering 3% of its geography. To fulfill the same objective in the U.S., the coverage required is 31%. Given the variances in population concentration, the feasibility of the national fibre network favors Canada.

# European Market

# Slow and steady 5G strategy means that ...

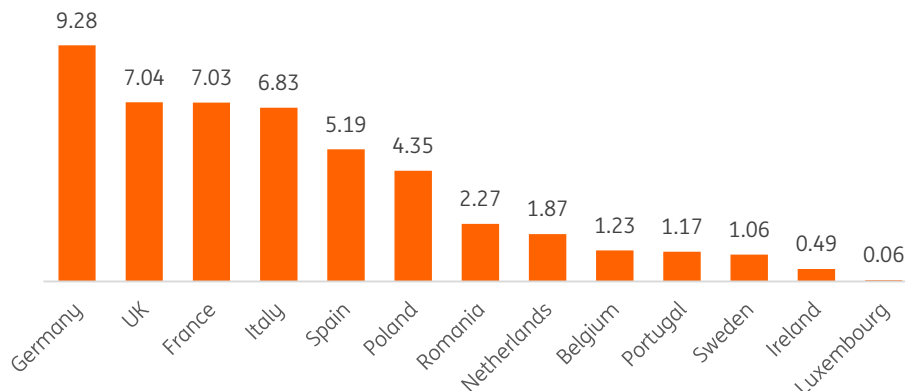
introduction of 5G is expected to be credit neutral for European telecoms operators

## Current 5G developments/ targets



## €55bn+ investment in 5G across EU required by 2020<sup>(1)</sup>

Estimated public and private sector investment on radio network and transmission links (€bn)

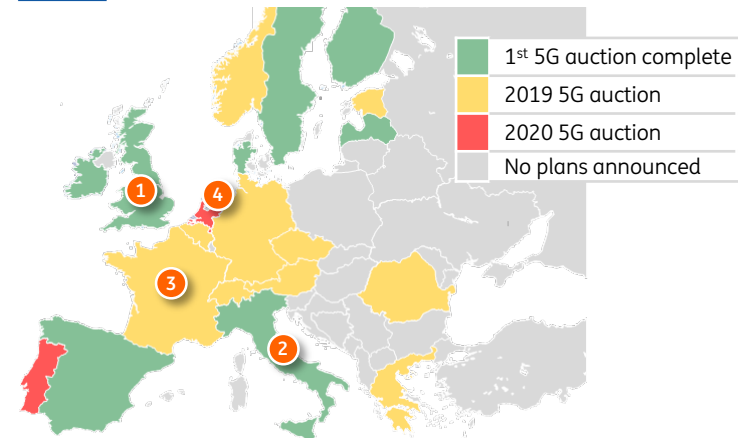


Source: Boston Consulting Group, European Commission, ING TMT&H research, Moody's

## European 5G Spectrum Auctions have begun

Spectrum assigned and usable in 2020 in 12 member states as of Dec'18:

5G PIONEER SPECTRUM	Assigned and usable in 2020	700 MHz	10.7%	7.1%	82.1%
	Assigned but not usable in 2020	3.4-3.8 GHz	11.5%	1.3%	87.1%
	To be assigned	26 GHz	3.50%		96.4%



## Notable market observations

1 UK	2 Italy	3 France	4 Netherlands
April 2018 auction raises £1.36bn, highlighting strong operator demand and 5G as strategic necessity	Auction launched in July 2018; €6.6bn was raised, more than double expected range of €3.0-3.5bn	Gov. states it seeks to avoid letting telecom operators overpay for 2019 spectrum auction as happened in Italy	First part of the auction in 2020 with the 3.5Ghz band only released in 2022.

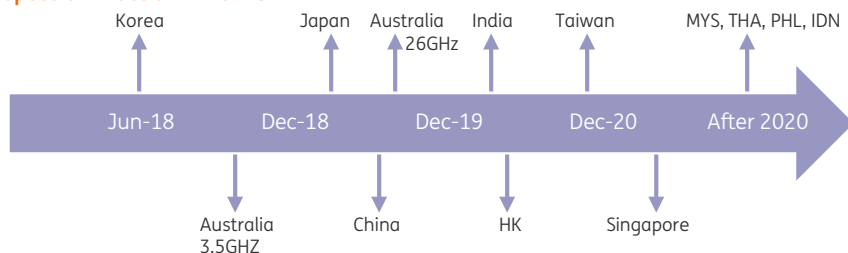
# Asian Market

# Asia Shows Diverging Speeds in 5G Development

## Brief Overview

- Asia's telcos will launch 5G earlier than their European peers and commercial deployment is expected to start in 2019 in Korea followed 2020 by China, Australia, and Japan. In many Asian countries, there is a large influence of the government in technology deployment and several governments (notably Korea and China) have pushed for an early 5G launch.
- 3.5GHz is the favored spectrum band for 5G in Asia. To date, only Korea and Australia had auctions (in China and Japan spectrum was allotted by the government). The price paid for 5G spectrum has been between 50-90% lower than for 4G 2-3 years earlier, given that the latest iteration of 4G already facilitates high data transmission, the rollout costs for 5G and underlying doubts over potential monetisation.

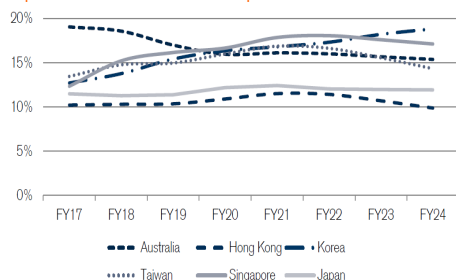
### Spectrum Auction Timeline



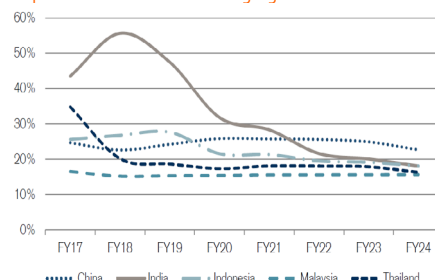
### Capex Impact

- 5G doesn't present near-term capex risk as most of the operators set to launch first already have extensive small-cell and fibre coverage. Exceptions are Korea and Japan given relatively strong equipment lobbies and political agendas as well as China where there is strong political pressure to 'prebuild' as much 5G support infrastructure as possible. Total Asia capex was USD90.3bn in FY18 and projected to peak at USD98.9bn in FY23 on the back of the 5G and thanks primarily to a projected 23.4% increase in China.

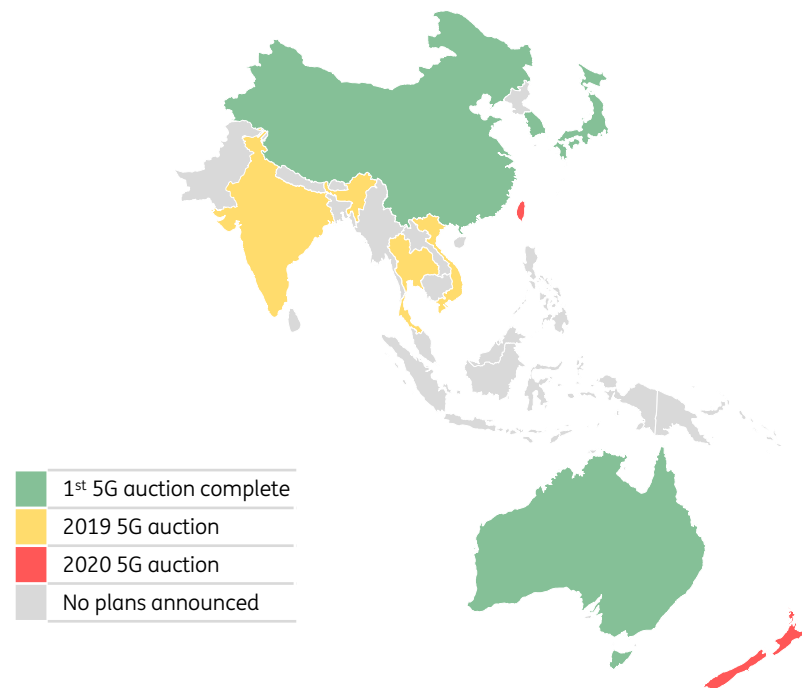
### Capex-to-sales ratio – Developed Asia



### Capex-to-sales ratio – Emerging Asia



## 5G Spectrum Auctions have begun



### Observations from recent spectrum auctions / allocations

Australia	China	Korea	Japan
Dec-18 auction raises AUD853m for the 3.6GHz spectrum allocated among 4 bidders (Telstra, Optus, TPG-VHA JV, and wholesale service provider Dense Air)	In Dec-18, the gov. allocated 5G spectrum to China Telecom and China Unicom 100MHz in the 3.5GHz band, while China Mobile obtained 260MHz of spectrum in the 2.6GHz and 4.8GHz bands.	In Jun-18 Korea completed world's first 5G auction securing KRW3.6trn (~EUR2.8bn) for 280MHz bandwidth of 3.5GHz spectrum and 2400MHz bandwidth in the 28GHz spectrum allocated among the 3 telcos.	Limited 3.5GHz spectrum bands have been awarded to the 3 big telcos on a usage fee basis. An auction for further bands is expected for 2019.











Source: Buddcom, JPM, Credit Suisse, ING TMT&H research

## 4. Key Takeaways

# 5G Key Takeaways ...

... near-term risks and opportunities limited but 5G can be potentially industry changing in mid-long term driven by exponential data growth and new uses

- 1 **Gradual proliferation:** Rather than a 'big bang' like the introduction of 4G. Current and near-term demand in terms of capacity, speed, and latency can be fulfilled with the 4G / 4G LTE. 5G will be more of an incremental process growing in tandem with new uses as operators seek to justify business case.
- 2 **Globally diverging rollout speed:** Emerging markets will be slower in 5G rollout because there is still significant space to exploit 4G and internet penetration still lags behind developed markets. This may require regulatory support and direction.
- 3 **Limited near-term monetisation:** Telcos can meet current retail demand with 4G / 4G LTE. The enterprise segment (e.g. IoT, driverless cars) could potentially provide mid-term opportunities. Independent tower companies are poised to benefit from increased demand and a more sustainable cost proposition.
- 4 **Massive capex requirements:** Largely in relation to required network densification. While balance sheets of many telcos are already stretched, network / spectrum sharing in addition to outsourcing of network services, and infrastructure could be a way to control costs.

Sub-sector	Opportunities	Risks
<b>Incumbents/ Mobile Operators</b>	 <ul style="list-style-type: none"> <li>Determine business case and new uses. Consumer data consumption/ creation to sustain existing business.</li> <li>Network sharing and spin-off into independent netco</li> </ul>	 <ul style="list-style-type: none"> <li>Capex for new tower/ equipment upgrade</li> <li>Overpaying for spectrum</li> <li>Deteriorating credit quality</li> </ul>
<b>Cable operators</b>	 <ul style="list-style-type: none"> <li>Full scale 5G rollout is still several years out</li> <li>Cable still attractive proposition with extensive coverage</li> </ul>	 <ul style="list-style-type: none"> <li>Technological substitution risk from 5G/ fibre</li> </ul>
<b>Towers</b>	 <ul style="list-style-type: none"> <li>Deployment of new equipment, towers and small cells required for 5G rollout (incl. continued 4G LTE roll-out)</li> <li>Rise of independent tower co</li> </ul>	 <ul style="list-style-type: none"> <li>Underestimating complexity of network required to support new uses will lead to higher costs/ capex leading to potential credit issues</li> </ul>
<b>Fibre</b>	 <ul style="list-style-type: none"> <li>5G deployment will lead to larger and denser backhaul requirement</li> <li>Network sharing and spin-off into independent netco</li> </ul>	 <ul style="list-style-type: none"> <li>Technological substitution from 5G</li> </ul>
<b>Datacentres</b>	 <ul style="list-style-type: none"> <li>More edge/ micro DCs closer to end user</li> </ul>	 <ul style="list-style-type: none"> <li>Traditional DC models will become obsolete</li> </ul>










## 5. Appendices

# Asia Shows Diverging Speeds in 5G Development

Country	5G Development Plans and Progress	<div> <div></div> Early           <div></div> Advanced         </div> <div>Progress</div>
Korea	<ul style="list-style-type: none"> <li>Korea is likely to be the first country commercially launching 5G on a large scale based on high level of government intervention in both tariffs and network spending plans and timing. 5G was switched on during the Winter Olympics in 2018 initially being available for limited enterprise customers. Further roll-out is scheduled to begin in Apr-19 and full (retail) commercial launch is expected in 2020. Operators expect to introduce 5G smartphones in April and pricing plans in 1H19.</li> <li>The early 5G auction (Jun-18) gave telcos time to gradually build out their infrastructure. Going forward, 5G-related capex spend is projected to be limited as telco managements adopt a 'hotspot' approach due to limited near-term revenue opportunities.</li> </ul>	
Australia	<ul style="list-style-type: none"> <li>Australia held a 3.4GHz auction in Oct-18 where 125MHz of spectrum was auctioned. Each of the three mobile telcos and new entrant Dense Air won rights. Optus and Telstra are well underway with their 5G network roll-out in capital cities and are expected to offer 5G services during 2019 while VHA is expected to offer its first 5G services in 2020.</li> <li>The existing carriers have close to 100% 4G coverage in metro areas (in some regional areas coverage is still 3G, but these are being progressively upgraded). However, capex remains elevated across the industry (avg. of ~16% in terms of sales) as operators invest in network densification ahead of 5G and to cater for increased data traffic.</li> </ul>	
Japan	<ul style="list-style-type: none"> <li>The Japanese regulator has already awarded some 3.5GHz spectrum, but only 20MHz paired per carrier. It is scheduled to allocate further 5G spectrum by end-Apr-19 (5x100MHz in the 3.7GHz band, 1x00MHz in the 4.5GHz band, and 4x400MHz in the 28GHz band). In Japan, carriers pay usage fees rather than upfront fees for spectrum rights. While this keeps spectrum allocation costs low, carriers awarded spectrum must expand their service areas and invest in the required facilities.</li> <li>High level of fibre backhaul, variety of spectrum in use and extensive small cell deployment limits 5G related capex risks and Japanese telcos do not appear to accelerate a large-scale country-wide 5G roll-out.</li> <li>5G pre-service will begin in Sep-19 ahead of the 2020 Tokyo Olympics. NTT is scheduled to begin commercial service in 1H20.</li> </ul>	
China	<ul style="list-style-type: none"> <li>5G is critical to the Made in China 2025 program which identifies and facilitates critical high-tech industries. With 5G, China looks to cooperate with the ITU on 5G standards and consolidate its improved position in 4G, after the failure of its push to single-handedly create an export standard for 3G.</li> <li>Spectrum bands are not auctioned but allotted by the regulator. In Dec-18, 5G spectrum in the bands of 2.6GHz, 3.5GHz, and 4.9GHz was allocated to the three major telcos China Mobile, China Telecom and China Unicom for large-scale nationwide trials. While preliminary commercial launch is expected in 2H19, the broader rollout will not happen before 2020. However, GSMA projects 460m 5G connections in China by 2025.</li> <li>China has been more active in its push towards 5G compared to the US and since 2015 China has outspent the US by around USD24bn in wireless communications infrastructure and built 350,000 new sites, while the US built fewer than 30,000. There is a high risk of aggressive 5G-related rollout and network 'overbuild'. The MIIT estimates that 5G-related capex will be USD411bn between 2020-30.</li> </ul>	
Taiwan	<ul style="list-style-type: none"> <li>The first 5G spectrum auction is expected in 2020, most likely allocating bands in the 3.5GHz spectrum. Timing is uncertain as this band is currently occupied by satellite providers.</li> <li>NCC wants Taiwan to be one of the early adopters of the 5G technology and is actively promoting its development. Commercial launch expected in 2H21.</li> <li>Taiwan's 4G penetration of 91% is the highest in Asia and 5G network roll-out is expected to be progressive with some jump in cellular capex from 2021-23</li> </ul>	

# Asia Shows Diverging Speeds in 5G Development

Country	5G Development Plans and Progress	Progress	
		Early	Advanced
Singapore	<ul style="list-style-type: none"> <li>As the first batch of 5G spectrum allocation will not happen before 2020, 5G is not expected to be commercialized before 2H21, with initial revenue opportunities restricted to the enterprise and public infrastructure segment. The regulator is likely to adopt spectrum bands similar to its regional peers (i.e., 3.5GHz, 26GHz and 28GHz).</li> <li>To facilitate 5G network trials, the government has waived frequency fees for such trials since May-17. While telcos are already gradually upgrading their technology in preparation for 5G, 5G-related capex is expected to pick up post 2020.</li> </ul>		
Hong Kong	<ul style="list-style-type: none"> <li>The regulator is planning to auction 3.5GHz spectrum in late 2019 and 2020. The spectrum band is likely to be available for commercial use in Apr-20 and operators are expected to launch 5G services in 2021. The leading HK operators (HKT, SmarTone, and HTHKH) currently have a good mix of low band and high band spectrums to offer quality 4G services which is expected to result in a less competitive 5G auction.</li> <li>Capex spend on 5G is expected to be more conservative than previously for 4G. HKT appears to be best placed in terms of cellular / fixed network resources.</li> </ul>		
Thailand	<ul style="list-style-type: none"> <li>5G spectrum has not yet been allocated (expected in 2019 in the 3500MHz and 2800MHz bands). Thailand plans to achieve nationwide roll-out of 5G services by Dec-20 and commercial launch is expected in 2021.</li> <li>Some carriers have expressed hesitation in participating in the 5G spectrum auction and there seems to be little risk of risk of aggressive 5G rollout based on the careful spending culture of Thai telco and lessons from the extremely expensive 4G spectrum.</li> </ul>		
Vietnam	<ul style="list-style-type: none"> <li>Vietnam was a late adopter in 4G but plans to be a forerunner in 5G. It began testing of the 5G network in Hanoi &amp; HCM in Jan-19, and plans to achieve nationwide coverage as early as 2020. Allocations (Vietnam does not do auctions) of 5G spectrum is expected in later in 2019.</li> <li>The first trial 5G license was awarded to state-owned telco Viettel in Jan-19, which plans to roll out 5G services in 2021. Another three telcos - Vietnamobile, and two other state-owned entities, Vietnam Posts and VNPT are expected to receive 5G testing licenses in 2019.</li> </ul>		
Indonesia	<ul style="list-style-type: none"> <li>No specific timeline has been announced for 5G auctions and commercial deployment of the 5G network. The government has announced that they will leave it to telco operators to decide if they would adopt 5G technology. Commercial launch is not expected before 2021.</li> <li>Little risk of aggressive 5G rollout and network 'overbuild' as telcos focus on further exploitation of 4G (4G penetration has reached only 50% as at Dec-18) and indicated that they will follow a 'hotspot' approach to 5G. A first 5G network trial (operated by Telkomsel) was rolled out during the Asian Games in Aug-18, where people can purchase a Telkomsel SIM card, and try out the 5G network at the Asian Games venue.</li> </ul>		
India	<ul style="list-style-type: none"> <li>While the government has identified the 3.3-3.6GHz spectrum for 5G services, an auction initially scheduled for 2019 is not certain and 5G rollout is likely to happen post 2021.</li> <li>The operators are low on appetite for 5G service launch as (i) 4G investments are yet to be fully exploited, (ii) the disruptor last time (Jio) is fully aligned with Bharti and Vodafone in ensuring 4G's success, (iii) stretched operators' balance sheets has led telcos to focus more on deleveraging and may not allow government to reach revenue targets from the spectrum sale, (iv) fibre infrastructure is inadequate, and (v) limited handset availability (at mass-market prices) is likely to limit broader 5G adoption in the next few years.</li> </ul>		
Malaysia	<ul style="list-style-type: none"> <li>5G spectrum has not yet been allocated and commercial launch is not expected before 2021-22. The regulator is expected to wait for other countries' confirmation of the 5G frequencies before setting up its own auction.</li> <li>5G test-bed sites have been started, with the aim of assessing the feasibility and modes of implementation for future deployment of 5G. A 5G Nationwide Implementation Plan is expected to be delivered by 3Q19.</li> </ul>		

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