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5G REGULATION: ENSURING SUCCESSFUL INDUSTRIAL TRANSFORMATION

5G can transform the performance of industries and generate significant social and economic value. This report explores the role of regulators and governments in ensuring that 5G's promises are realised.

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Preface

The document has been prepared by independent consulting and research firm STL Partners. It is based on extensive research into the impact of 5G on industries and leveraged the output of an interview programme and surveys with telecoms and manufacturing industry representatives, including regulators, in developing and developed countries. The research programme has kindly been supported by Huawei.

This report should be read by telecoms regulators, governments seeking to leverage 5G technology, and telecoms operators, particularly CSOs, strategists, CMOs, enterprise executives, and other ecosystem stakeholders: software/application vendors, cloud and edge computing companies, ISPs, systems integrators, developers and similar organisations. The content is also relevant to industry players who are interested in using technology to enhance operations, particularly those responsible for operations and digitalisation: COOs, CEOs and CSOs.

Mentions of companies in this document are intended as illustrations of market evolution and are not intended as endorsements or product/service recommendations.

If you find this report of interest and would like to discuss any aspects of the content further, please contact any of the following:

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STL Partners is continuously working to understand how 5G can benefit other industries and develop strategies for telecoms operators and other industries to accelerate the delivery of benefits. Should you like to learn more about this research and future projects or find out how we can help regulators, governments and operators to work more effectively together and take advantage of 5G please contact us.

Other reports in this 5G series include

- $1.4Tn Of Benefits In 2030: 5G's Impact On Industry Verticals
- 5G's Impact On Manufacturing: $740bn Of Benefits In 2030
- 5G's Healthcare Impact: 1 Billion Patients With Improved Access In 2030
- Curtailing Carbon Emissions: Can 5G Help?

Executive Summary

Pointers for regulators

- **The regulatory goals and rules should change for 5G.** 5G could have a huge social and economic impact globally by being a core enabler of industrial transformation. With this in mind, the focus of governments and regulators should be in ensuring that:
  1. It is rolled out as quickly as possible;
  2. Regulation is sufficiently flexible to reflect the needs of different industries and of consumers;
  3. Mobile network operators are encouraged to deliver more value to their customers by contributing to cross-industry activity that benefit governments, enterprises, and consumers.

- **Consider spectrum licensing beauty contests over price-dominated auctions.** Governments need to look at the longer-term benefits of 5G deployment and, *potentially*, opt for spectrum licensing 'beauty contests' – in which spectrum is allocated on a detailed raft of requirements such as rollout speed and network performance – rather than auctions. Such an approach could result in substantially greater economic and social benefit although it will vary by market. **5G leader** countries, for example, need few incentives to deploy 5G whereas **laggards** may need financial or other incentives to stimulate rapid 5G deployment.

- **Some (enterprise) 5G applications require nation-wide regulation.** Regulators in every market must ensure that consumers are adequately protected when 5G is rolled out. For example, many 5G-enabled healthcare solutions must be available to all patients, such as remote patient monitoring and virtual consultations enabled by high-definition video. The national regulator must, therefore, take a robust approach to ensuring univeral access for these services.

- **Other 5G applications and networks have local regulation implications.** Where 5G is used in manufacturing plants, construction sites or mines, it has no universal access implications as consumers are not involved. Regulation for local network solutions needs to be more limited and more nuanced to encourage a vibrant ecosystem which supports enterprise and third-party investment and ensures that investors are adequately protected. We suggest that regulators might wish to:
  - Set aside enough low-band (and potentially mid-band) spectrum for enterprises and neutral hosts seeking to build their own networks so that in-building coverage is assured while ensuring that spectrum is not fragmented to a point where it is deployed inefficiently;
  - Where spectrum is granted to enterprises and neutral hosts, rights of way are granted on the same basis as mobile network operators so that they can build ecosystems and use spectrum efficiently;

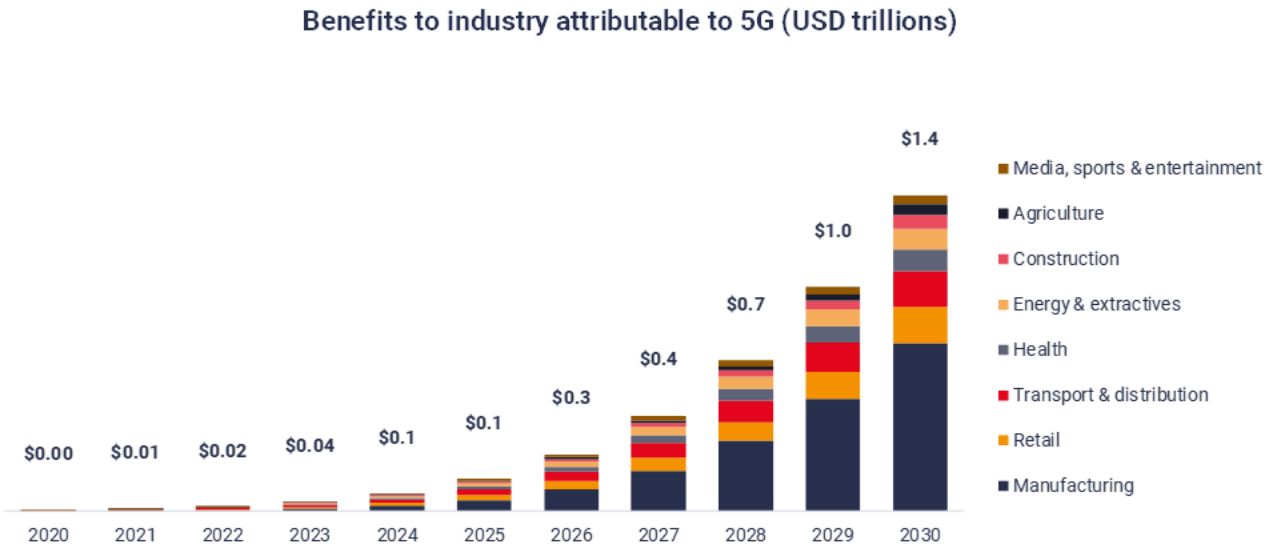
  - Work with local government planning authorities to ensure public infrastructure is made available for private network cell sites on the same basis as public networks and that the processes both public and private networks are fast and efficient;
  - Mandate mobile network operators to interconnect with private networks and/or provide roaming as well as establish an adequate wholesale market at fair prices so that enterprises can build solutions that meet their needs.

- **Overall, STL Partners has identified eight principles and options for 5G regulation relating to industrial IoT and which are detailed in the report:**

  1. Carefully consider the process and pricing of 5G spectrum to encourage deployment speed and quality.
  2. Regulate to reduce the (initial) financial investment for operators to rollout out 5G services.
  3. Regulate for a healthy and open wholesale market for 5G telecoms services.
  4. As a further corollary of a reduced financial investment for operators, regulators should stipulate the timing for a move to 5G stand-alone (SA) networks.
  5. Allow enterprises to license enough spectrum for them to be able to build non-national (private/closed user) applications and ensure this is managed to avoid inefficiencies caused by spectrum fragmentation.
  6. Cooperate with vertical enterprises and with vertical regulators to ensure telecoms and industry needs and regulatory policies are aligned.
  7. Participate in discussions around Embedded SIM (eSIM), soft SIM and other solutions to ensure the benefits of lower costs and greater operator competition is balanced against security concerns.
  8. Consider the potential net neutrality implications associated with 5G early – ideally during the granting of 5G spectrum.

5G's potential value to society justifies regulation that focuses on long-term value creation

- **5G-enabled use cases in eight industries will add an extra $1.4 trillion to global GDP in 2030.** To reach these predictions, STL Partners has interviewed more than 20 enterprises, software developers and operators and conducted more than 200 surveys with industry experts. We have explored 5G use cases across the verticals with a focus on healthcare and manufacturing and conclude that 5G can be transformational across several verticals. In addition to this, we have looked at the value 5G can bring to the telecoms industry itself in respect to its energy usage. A fast 5G rollout can significantly improve energy efficiency per gigabyte by mobile networks.



Source: STL Partners

- **Healthcare industry: substantial cost savings and improved patient care and access for 1 billion patients.** STL Partners forecasts that at an aggregated global level, 5G could bring cost savings of approximately $94 billion USD to the healthcare industry in 2030. However, the real value is likely to come from reallocating this resource to treat more patients and increase the reach and access of healthcare expertise in more remote and less developed corners of the globe. This will lead to almost 1 billion extra patients treated globally each year by 2030.

- **Manufacturing industry: 5G has the potential to grow global manufacturing GDP by 4%, or just under $740 billion, by 2030.** 5G has unique capabilities that allow it to play a significant role in using data – machine, plant, product, and environment data – more effectively. 5G means manufacturers can connect many more devices and capture more insights; ensure connections are ultra-reliable and secure to avoid loss of data; reduce latency to ultra-low levels of below 10 milliseconds so that data is captured real-time. These three 5G advantages enable several new use cases that increase manufacturing productivity.

- **5G can have a material impact on mobile network energy efficiency.** Mobile networks are predicted to see continued substantial growth in data volumes, regardless of whether these are 4G or 5G networks. Network operators need to address the ever-increasing carbon footprint of their networks in some way to meet goals set by national governments for their countries. Rolling out fast 5G networks could reduce the cumulative CO_2 footprint of mobile networks globally by over a third, compared with a slower, less ambitious, roll-out. Only by rolling out 5G rapidly can the telecoms industry see a net reduction in carbon emissions in 2020 compared with today.

Telcos (may) need to be encouraged to invest in 5G if its full benefits are to be realised

- **Globally, mobile services revenues and mobile network operators' profits are under pressure.** Globally telecoms services growth is slowing and is forecast to grow slower than GDP at less than 1% over the next three years. Significantly, this slowdown is being experienced in developing and developed markets. Profits too have been squeezed over the 4G investment cycle with global EBITDA margins dropping from 37% in 2007 to 35% in 2017. This may not seem much but in a highly leveraged industry where operating margins are 8-10%, this decline is substantial.

- **Network investment does not drive revenue and profit growth.** The rollout of 4G illustrates that end users are unlikely to pay a premium for 5G connectivity. As 4G was made available to subscribers, ARPUs did not increase for most operators. Connectivity, even with the unique benefits 5G brings (such as network slicing), is a commodity. The result is that operators (in competitive markets at least) tentatively move forward on the next 'G' and make sure they keep up with their peers and so don't suffer a competitive disadvantage. They tend to hold back with deployment as they need to protect shareholder returns – it happens over an 8-10-year cycle – which means the benefit of the new technology is delayed.

- **Fast 5G investment needs to be encouraged by governments and regulators.** Because 5G can be an economic and social 'game-changer' for countries it makes sense for regulators to explore policies that encourage investment. This can take both a 'carrot' and a 'stick' dimension:

  – Carrot: Reduce upfront charges for operators for 5G by replacing spectrum auctions with beauty contests which set stringent requirements for network rollout and, potentially, also sets clear service levels for network performance. This will create greater economic benefit than the short-term value created from auction fees.

  – Stick: Set material financial penalties for operators which fail to meet the terms of the beauty contest once they have won 5G spectrum. This could include rollout penalties and/or customer adoption penalties for operators that do not meet their obligations.

  STL Partners believes that network differentiation is becoming harder to achieve for operators. Because of this, regulation should focus on ensuring that network investments are made quickly and that all operators develop their networks in a cost-efficient way since additional investment is unlikely to create network differentiation.

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How should governments regulate 5G?

The old regulatory models are less relevant for 5G

Regulators in different markets around the world have a tried and tested formula for making spectrum available for new networks and for regulating the operators that run those networks. They have successfully used this formula for 2G, 3G, and 4G. However, 5G is different and may require a different approach for both licensing spectrum and for regulating mobile network operators' services.

As we outline in the section 5G benefits industry and society, unlike its predecessors, 5G is not simply a faster pipe which therefore benefits individual end-users. Instead, it has been designed with new capabilities that can have a profound effect on enterprises and entire industries. These capabilities and how they compare to LTE and to other wireless technologies are outlined in the Appendix. Because 5G can create so much value to all constituents of society, STL Partners contends that the focus of governments and regulators should be in ensuring that:

1. It is rolled out as quickly as possible;

2. Regulation is sufficiently flexible and focussed to reflect the needs of different industries and of consumers;

3. Mobile network operators are encouraged to deliver more value to their existing customers and potentially new ones by contributing to cross-industry activity that benefit governments, enterprises, and consumers.

Put simply, our analysis suggests that the upside from rapid 5G deployment far outweighs the short-term benefits of high spectrum licensing fees. From a pure economic perspective, 5G should contribute an additional $1.4 trillion of Gross Domestic Product globally in 2030[1]. The higher rates of employment, corporate profits, and consumer spending associated with this increased GDP will translate into significant increases in receipts of corporation and income taxes, national insurance contributions, and sales tax for governments as well as enhanced national competitiveness. These annual inflows to the public purse will be far bigger than the one-off payment from licensing spectrum. But these benefits only accrue if 5G is deployed quickly and effectively so that its full potential is realised by industry in each market. A slow 5G rollout risks enterprises investing in workaround solutions that do not require 5G and do not generate the same value.

Spectrum licensing: auctions vs beauty contests

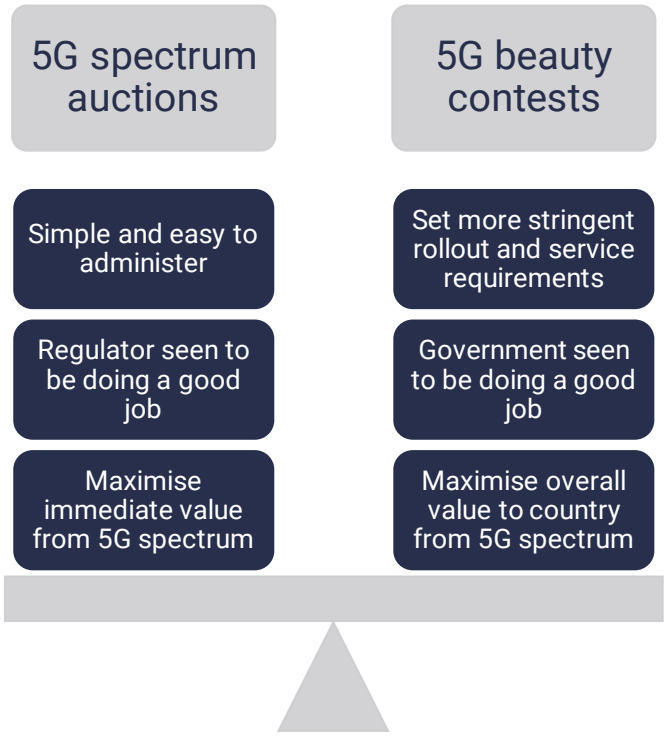
A focus on short-term auction fees could be counter-productive as it may inhibit operators' ability to invest aggressively in rolling out 5G. But as we show in Figure 1, it is easy to administer, shows the regulator is 'doing a good job', and results in higher short-term economic benefits. We believe that governments need to look at the longer-term sustainable benefits of 5G deployment and, *potentially*,

[1] See STL Partners Executive Briefing report $1.4TN of Benefits in 2030: 5G's Impact on Industrial Transformation.

opt for spectrum licensing 'beauty contests' – in which spectrum is allocated on a detailed raft of requirements such as rollout speed and network performance – rather than auctions. Such an approach may require input beyond the telecommunications regulator. For example, the treasury, health and social welfare, business, transport and energy ministries might also be needed to evaluate whether a spectrum beauty contest offers a better social and economic return than a spectrum auction.

And it's not all about money, globally 5G could result in 1 billion patients with improved access to healthcare globally in 2030[2]. Governments, therefore, need to evaluate the social benefits of 5G as well as the economic ones. But managing a regulatory approach for 5G via input from different government departments is complex and may require management at the highest level.

Figure 1: The 5G spectrum licensing conundrum



Source: STL Partners

[2] See STL Partners Executive Briefing report 5G's Healthcare Impact: 1 Billion Patients with Improved Access in 2030.

Recognising that not all markets are the same

While we have outlined above a bias towards spectrum beauty contests over auctions for 5G, it is important to note that the right approach will vary by country. Based on what we have already seen from the 5G deployments and announcements in 2018 and 2019, there is a clear delineation between countries in their 5G rollout speed. We have segmented markets into three types in Figure 2:

1. **Leaders:** countries where all operators are pushing ahead aggressively with 5G deployment (in part owing to the role of the regulator in the way they have managed spectrum licensing);

2. **Followers:** countries where 5G rollout is patchier and many operators are reluctant to deploy 5G and are essentially doing it under duress, in other words, they worry that they will suffer if they don't deploy and their competitors do so they do enough to be seen to be 'keeping up';

3. **Laggards:** (developing) countries where the current network deployment focus of operators is LTE rather than 5G.

Figure 2 outlines reasons why segments are operating at different 5G rollout speeds and offers suggestions for how governments might wish to stimulate operator 5G investment in each segment.

Figure 2: 5G spectrum licensing country segmentation

Country Segment	Market competition	5G rollout speed	Reasons for 5G rollout speed	Examples	Implications for spectrum licensing
Leaders	Low or Medium	Fast – all operators deploying	• Strong financial positions (P&L and balance sheet) coupled with enough competition to encourage investment from operators seeking differentiation and new revenues • Strong encouragement from governments (may even have a stake in one or more mobile network operators)	• China • US • UAE • Korea • Japan	• Many of these markets have moved forward quickly because the regulator has taken a relatively benign approach to pricing: – In Japan all operators were granted 5G spectrum in return for stringent conditions attached to investment levels, rollout speeds, and security. – In China the approach has been to minimise licensing costs and stipulate how operators should rollout their 5G networks. This contrasts with Germany where the regulator has achieved high spectrum prices which may stymy rollout.
Followers	High	Patchy, many operators dragging their feet	• Weaker financial positions stemming from intense competition (and weaker economies) mean many operators are moving forward slowly with 5G as they see a repeat of what happened with 4G – high investment and low returns	• Parts of western Europe • Central and Eastern Europe • India	• In some of these markets 5G spectrum has already been licensed. Where it hasn't, regulators and governments should explore how to stimulate investment and accelerate rollout speeds by specifying clear requirements for coverage and network performance within the spectrum licensing process. Allow operators to re-farm 2G (and potentially 3G) spectrum for 5G usage (and potentially also encourage spectrum trading)
Laggards	Not applicable	Slow	• Economies are substantially less developed; consumer disposable incomes are low; operators are still focused on rolling out 3G and 4G technology. Some consumers still using 2G and 3G devices and unlikely to rapidly purchase 5G devices	• Latin America • Africa	• 5G licensing has not generally been carried out. Governments and regulators should accelerate this by potentially releasing operators from their 4G obligations if technical options to move directly to 5G are developed by vendors. Further incentives to encourage operators' 5G rollout could include government subsidies to encourage consumers to switch to 5G devices and progressive spectrum re-farming policies

Source: STL Partners

Local vs national regulatory issues

Some 5G services require regulation at a national level…

Regulators in every market must ensure that consumers are adequately protected when new technologies are rolled out. Clearly, some services should be provided to the full population (or as near to that as is possible). Core telecoms services – voice, messaging, connectivity – fall into this category. Many 5G-enabled healthcare solutions must also be provided on a national basis because consumers have a right to universal access to services and not offering them to sections of the population is likely to be highly controversial. Examples from a recent STL Partners report include remote patient monitoring, virtual consultations enabled by high-definition video[3].

Regulation is required to ensure that people in remote locations receive the same services that those more densely populated areas. In fact, the value of 5G should be greater in remote locations where the availability of GPs and specialist healthcare providers is limited.

…whereas others require regulation locally (or not at all)

At the other extreme, several enterprise applications using 5G do not involve consumers at all. For example, mining, construction, and manufacturing sites which wish to leverage 5G for advanced remote monitoring of machinery or to use augmented reality headsets to increase employee safety or productivity largely operate in a 'closed' environment and require 5G in a localised area which they may even own. In these cases, universal access is less relevant. Instead, 5G is competing with non-regulated technologies such as Wi-Fi, Zigbee, and Bluetooth and regulation needs be considerable lighter if 5G benefits are to be realised.

Regulation for local network solutions needs to be more limited and more nuanced to encourage a vibrant ecosystem which supports enterprise and third-party investment and ensures that investors are adequately protected and keen to keep investing.

We outline some of the differences between national and local networks and the regulatory implications in Figure 3 overleaf.

[3] 5G's Healthcare Impact: 1 Billion Patients with Improved Access in 2030

Figure 3: Managing national and local mobile networks and services

	National mobile networks and services	Local mobile networks and services
Needs & network numbers	• Universal access • 3-5 networks in most markets	• Local, restricted access • 100s of networks (eventually)
Examples	• Consumer mobile broadband • Healthcare solutions • Transport & distribution solutions	• Extractive industries – oil, gas, mining • Construction • Manufacturing
Role of regulation	• Ensure that telecommunications networks and services are provided to all people on an equal basis • Encourage healthy competition among service providers • Manage fair wholesale and end user pricing	• Give enterprises requiring 5G network services a range of options to buy or build solutions that work for them • Encourage a healthy ecosystem of players so that enterprises can pick from a range of 5G network solutions[4], e.g. – Buying a virtual network slice from an operator – Establishing their own MVNO – Buying spectrum and building their own private network • Ensure these local networks have fair access/interconnect with mobile network operator networks
What might regulators seek to do?	• Status quo – largely continue to manage regulation as they currently do • Exploring options for increasing the proportion of shared infrastructure so operator investment is minimised • Work closely with regulators from other verticals (e.g. health) to ensure that relevant services are adequately regulated and that all parties (vertical enterprises and mobile network operators) fulfil their obligations	• Set aside enough low-band (and potentially mid-band) spectrum for enterprises and neutral hosts seeking to build their own networks so that in-building coverage is assured while ensuring spectrum fragmentation is avoided • Ensure rights of way for enterprises and neutral hosts are granted on the same basis as mobile network operators • Work with local government planning authorities to ensure public infrastructure is made available for private network cell sites on the same basis as public networks • Mandate mobile network operators to interconnect with private networks and/or provide roaming as well as establish an adequate wholesale market at fair prices so that enterprises can build solutions that meet their needs

Source: STL Partners

[4] For more on enterprise private network options and the associated implications see our report Vertical and Private Cellular Networks: Threats and Opportunities.

Principles and options for 5G regulation relating to industrial IoT

1. **Carefully consider the process and pricing of 5G spectrum to encourage deployment speed and quality.** Consider a beauty contest rather than an auction with multiple criteria for evaluating bids (such as network coverage and performance, network design, financial stability, wholesale offerings, and offer price). Weight offer price relatively lowly and other criteria higher to encourage operator focus on 5G network rollout and quality of service.

2. **Regulate to reduce the (initial) financial investment for operators to rollout out 5G services**:

    2.1. Consider allowing or encouraging operators to turn off 2G networks and re-farm spectrum for 5G offerings;

    2.2. Explore financial incentives for operators that switch consumers from 2G handsets to 5G ones;

    2.3. Mandate network-sharing by operators for fronthaul and backhaul elements of 5G networks to reduce financial burden (especially for mobile-only operators with a weak fibre infrastructure).

3. **Regulate for a healthy and open wholesale market for 5G telecoms services** (as an accompaniment to network-sharing and other financial benefits offered in 2.):

    3.1. Mandate national roaming to minimise 'white spots';

    3.2. Explore whether to introduce a Wholesale-only Open Access Operator (WOAN) which would make network available to retail MNOs and MVNOs and regulate terms on which the WOAN operates;

    3.3. Ensure broadband backbone infrastructure is made available on fair and open basis for all operators so that mobile-only players are not disadvantaged by lack of backhaul infrastructure.

4. **As a further corollary of a reduced financial investment for operators, regulators should stipulate the timing for a move to 5G stand-alone (SA) networks[5].** 5G SA enables low-latency and other advanced capabilities which unlock a raft of valuable enterprise solutions that will generate significant economic and social value.

5. **Allow enterprises to license spectrum for non-national (private/closed user) applications.** Make available enough high-band and mid-band spectrum for enterprises so they can build appropriate local networks and achieve in-building coverage (e.g. for manufacturers). Ensure

[5] A 5G stand-alone network has its own dedicated core network such that the 5G radio access network does not run on 4G core network.

they enjoy the same rights to use as mobile network operators so they can establish a healthy ecosystem (including an open wholesale market) that supports public and private local networks. Such a wholesale market will also ensure that spectrum is used efficiently and avoid the risks of spectrum fragmentation.

6. **Cooperate with vertical enterprises and with vertical regulators to ensure telecoms and industry needs and regulatory policies are aligned.** This is particularly important for solutions that need to be made available on a national basis such as those in the health, aviation, and transport industries. For example, 5G is not required to implement autonomous vehicles but it is likely to form part of the overall solution as it will be required to provide a back-up to direct car-to-car communications as well as integration with public transport infrastructure (such as traffic lights and toll systems) or enterprise fleet management or asset tracking solutions.

7. **Participate in discussions around Embedded SIM (eSIM), soft SIM and other solutions to ensure the benefits of lower costs and greater operator competition is balanced against security concerns.** Many 5G solutions will require international roaming and the ability to switch networks. There are several solutions available for this including MVNOs which have negotiated bilateral agreements with local operators. All these solutions will require a healthy global wholesale market and one which sets prices that work for enterprises seeking to build IoT solutions.

   eSIM and soft SIM solutions will need to be given further attention so that customers can benefit from the flexibility of being able to remotely provision the SIM. Essentially, regulation will be needed to prevent operators potentially locking SIMs to devices. Verizon and AT&T were investigated by the Department of Justice in the US relating to this issue. Furthermore, regulation may be required to address concerns relating to soft SIM security (where there is no hardware layer at all).

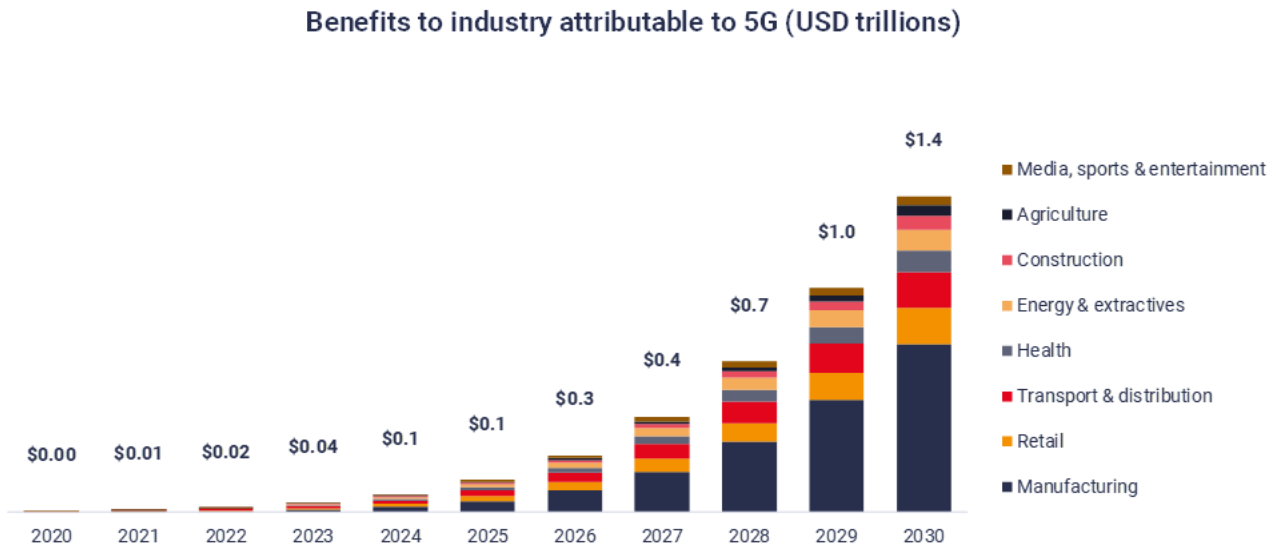
8. **Consider the potential net neutrality implications associated with 5G early – ideally during the granting of 5G spectrum.** 5G offers the opportunity for operators to offer differentiated network solutions to customers. For example, an enterprise such as a gaming provider could purchase a network slice with specific latency and security characteristics. This might leverage new and unique telco assets such as telco edge compute (compute power provided close to the customer at the edge of the telco network). Regulation should ensure that network slices are provided to all customers openly and at a fair and consistent market price

5G benefits industry and society

Introduction: 5G is estimated to add c.$1.4 trillion to global GDP in 2030

5G-enabled use cases will enable eight industries to add an extra $1.4 trillion to global GDP in 2030. To reach these predictions, STL Partners has interviewed more than 20 enterprises, software developers and operators and conducted more than 200 surveys with industry experts. We have explored 5G use cases across the verticals with a focus on healthcare and manufacturing. In addition to this, we have looked at the value 5G can bring to the telecoms industry itself in respect to its energy usage. A fast 5G rollout can significantly reduce energy usage by mobile networks compared with a slower approach.

Figure 4: 5G will contribute around USD1.4 trillion to global GDP by 2030[6]



Source: STL Partners

Healthcare benefits

Significant potential cost savings

Based on research involving hundreds of executives from the healthcare and telecoms sectors, STL Partners forecasts that at an aggregated global level, 5G could bring cost savings of approximately $94 billion USD to the healthcare industry in 2030[7]. 5G will enable a suite of use cases to be adopted

[6] Healthcare GDP is calculated from the total global cost of healthcare – the figure shown is cost savings thanks to 5G-enabled use cases.
[7] The assumptions and analysis to generate this forecast were informed by interviews with healthcare and telecoms industry representatives and a survey of over 100 healthcare providers worldwide.

at scale, through a perceived increase in reliability of service in the field and not just in a lab environment.

The principal use cases within healthcare identified and quantified in our research are:

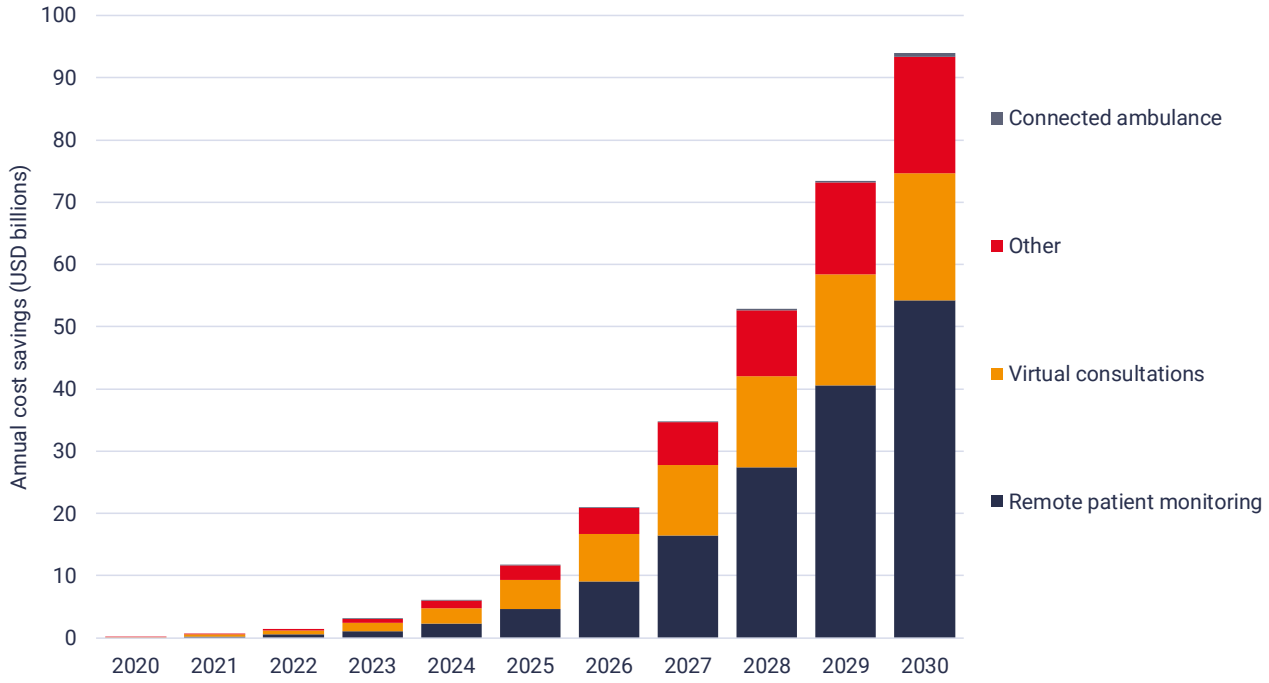
1. **Remote patient monitoring:** real-time streaming, analysis, and monitoring of patient data from e-health devices and patient wearables. An example of this is Diabetacare[8] – a solution which provides 24/7 monitoring and support for those suffering from diabetes. Only 5G can guarantee connectivity round the cloud and cope with such large numbers of sensors.

2. **Virtual consultations via high-definition (HD) video:** HD, two-way video streaming between doctor and patient (e.g. for routine appointment) or primary care and specialist doctor (e.g. for a referral appointment). One enterprise which is helping to deliver a similar solution is Babylon Health.

3. **Connected ambulances:** real-time streaming of patient data and information from sensors and high-definition cameras between ambulance crews and in-hospital emergency departments. BT in the UK is running 5G tests for connected ambulances in Birmingham – currently the connected ambulance connects paramedics to doctors in the hospital and allows the doctor to seamlessly guide the on-site paramedic through a remote ultrasound diagnosis as well as speed up treatment which sometimes initiated in transit.

[8] Diabetacare

Figure 5: Global impact of 5G on healthcare (annual cost savings USD Billions)



Source: STL Partners

Better patient care quality and increased access to healthcare services

In healthcare, it's not all about the money. Although we have forecast significant annual cost savings, the real value comes from reallocating this resource to treat more patients and increase the reach and access of healthcare expertise in more remote and less developed corners of the globe. This will lead to almost 1 billion extra patients treated globally each year by 2030.

This is driven by the adoption of new or enhanced use cases that help to bring better coordination across the healthcare ecosystem. 5G and the use cases we have described in this report will support the healthcare industry in making better use of their limited resources (both financially and in terms of available skills/infrastructure) and help get the necessary expertise, assets, and information to the right place, in the right time, successfully[9].

Manufacturing benefits

5G has the potential to grow global manufacturing Gross Domestic Product (GDP) by 4%, or just under $740 billion, by 2030. This forecast is driven by new use cases and improvements in existing applications that 5G uniquely brings compared to other technologies (see Appendix for details), and how these improvements will impact productivity.

[9] See more on our research into the Coordination Age

Increased global competition is putting pressure on prices, consumer demands are changing more quickly than ever before, and there are significant skills shortages in the industry.

The manufacturing industry is responding to this by going through a period of rapid digital transformation and is increasingly using data and technology to improve efficiencies within the plant, enhance productivity, and enable new business models, in an environment where external pressures are mounting.

5G has unique capabilties that allow it to play a signfiicant role in using data – machine, plant, product, and environment data – more effectively. For the manufacturing industry, the most important three advantages stemming from 5G are:

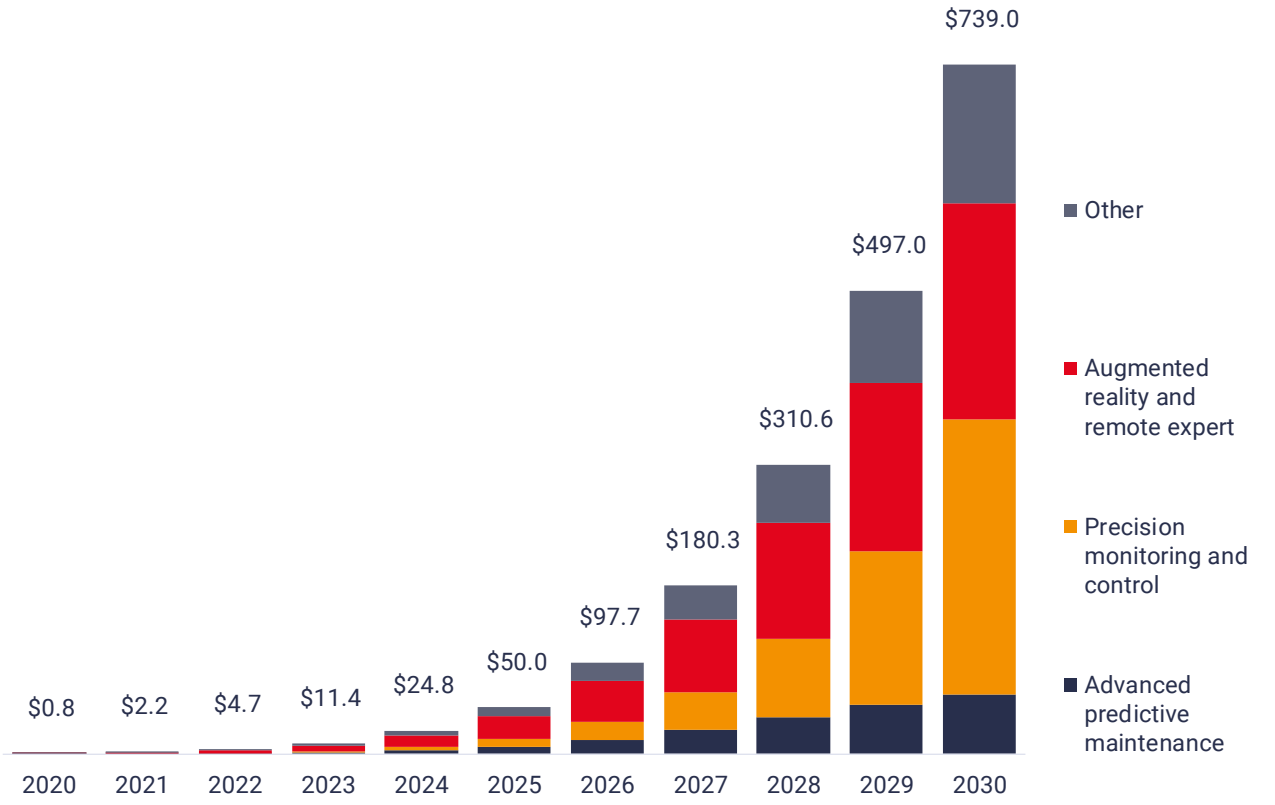
1. The ability to connect vastly more devices and capture more data;
2. Ensuring connections are ultra-reliable and secure to avoid loss of data;
3. Reduce latency to ultra-low levels of below 10 milliseconds so that data is captured virtually real-time.

These three 5G advantages enable several new use cases. Three of them are particularly important:

- **Advanced predictive maintenance**: collecting huge amounts of data to accurately predict when a machine will fail and reduce unplanned downtime.
- **Precision monitoring and control**: monitoring the entire plant and its processes continuously and adapting processes in real-time to maximise productivity and reduce defect rates.
- **Augmented reality and remote expert**: streaming content for augmented reality headsets to improve efficiency and support workers in maintenance, operational processes, and training.

The economic benefits associated with these and other use cases are outline in Figure 6 below and show the importance of precision monitoring and control and augmented reality remote expert in creating value for manufacturers.

Figure 6: Benefits from 5G to global manufacturing (USD Billions) by use case



Source: STL Partners

Telecoms industry energy efficiency benefits

Mobile networks are predicted to see substantial growth in data volumes, regardless of whether these are 4G or 5G networks. Network operators need to address the ever-increasing carbon footprint of their networks in some way. In a recent report, Curtailing carbon emissions: Can 5G help?, STL Partners identified six ways that the accelerated adoption of 5G can do this:

1. **Direct curtailment of energy consumption in mobile access networks** through the better energy "performance" of 5G network equipment and operational practices relative to 4G.

2. **Direct curtailment of energy consumption in 5G core networks** through the better energy "performance" of network equipment and operational practices relative to 4G core networks.

3. **Reduced energy consumption by devices** (particularly smartphones and IoT devices).

4. **Decarbonising the grid:** indirectly enabling lower levels of national carbon emissions from electricity generation through 5G supported "smart-grid" applications, increasing the

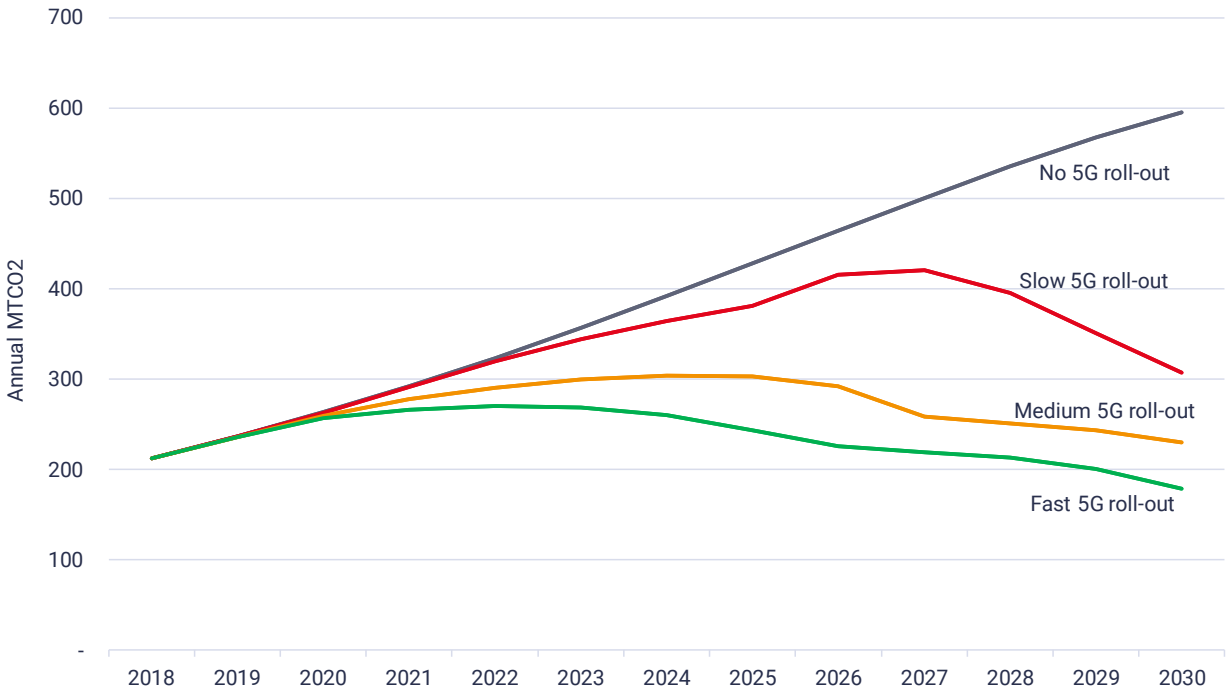
proportion contributed by renewables and improving wider efficiencies in distribution and non-renewables generation.

5. **Indirectly improving energy efficiency across all sectors through reducing waste and improving operations.** Reduced emissions are largely a by-product of improved productivity and process efficiencies.

6. **Reducing carbon emissions from travel through reducing the number of journeys** (e.g. remote monitoring and management, virtual meetings) and reducing the emission per journey.

We believe that quickly rolling out fast 5G networks could reduce the cumulative CO_2 footprint of mobile networks globally by over a third, compared with a slow roll-out. The difference between a quick roll-out and medium "base-case" roll-out of 5G networks is also significant – cumulative global savings would be 0.4 billion tonnes of CO_2, slightly less than the annual carbon emission of all international aviation in 2018. Only by rolling out 5G rapidly can the telecoms industry see a net reduction in carbon emissions in 2020 compared with today. This is likely to be increasingly important to governments moving forwards.

Figure 7: Annual global emissions from mobile networks under 4 scenarios (metric tonnes of CO_2)



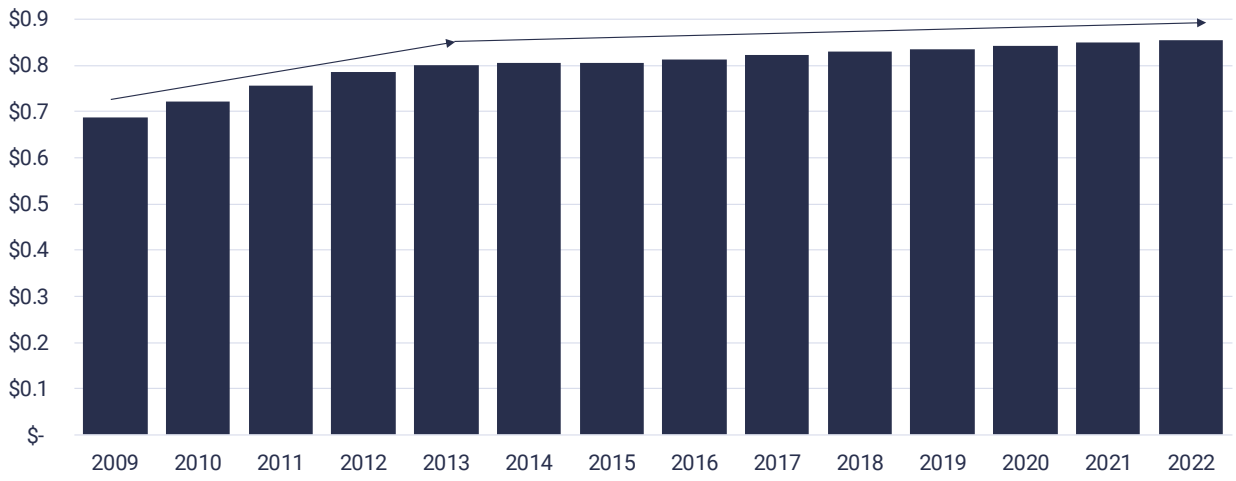
Source: STL Partners

Telcos (may) need encouragement to invest in 5G

Lower revenues, lower profits

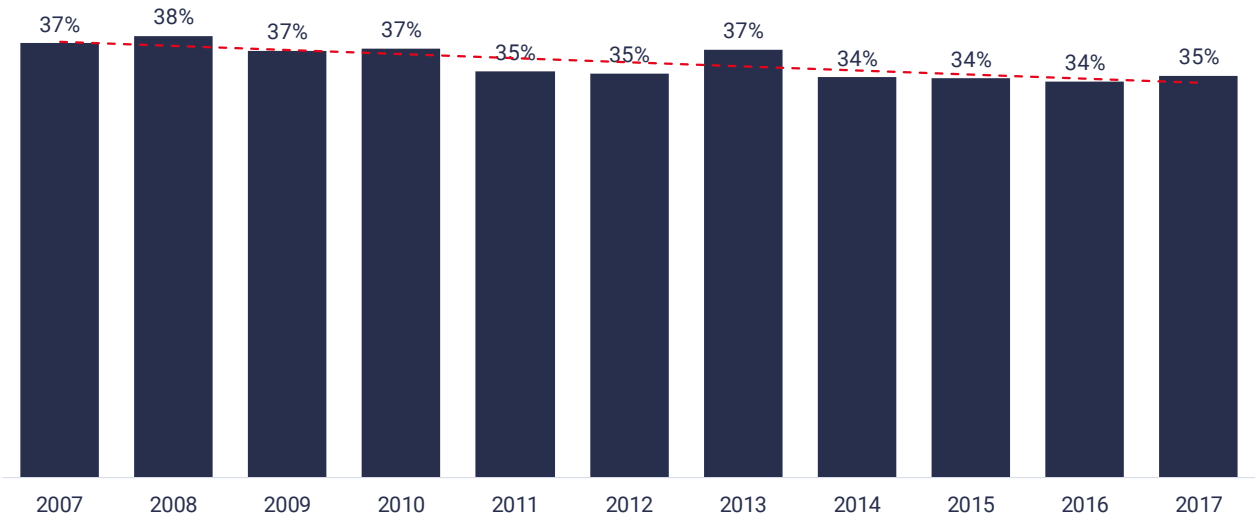
Globally telecoms services growth is slowing and is forecast to grow slower than GDP at less than 1% over the next three years. Significantly, this slowdown is being experienced in developing and developed markets. Profits too have been squeezed over the 4G investment cycle with global EBITDA margins dropping from 37% in 2007 to 35% in 2017.

Figure 8: Global mobile services revenues 2009-2022 (USD Trillions)



Source: 165 operators annual reports; STL Partners analysis & forecast

Figure 9: Global mobile operators EBITDA margins 2007-2017



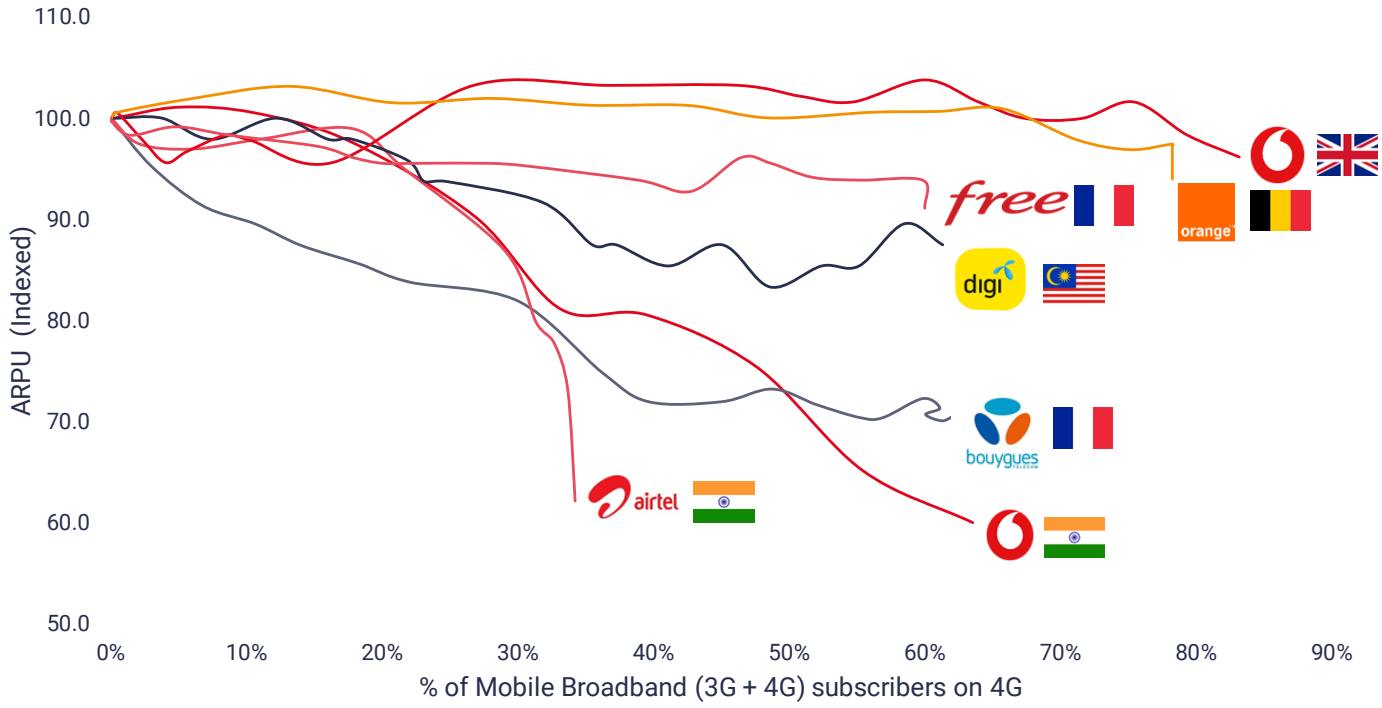
Source: 165 operators annual reports; STL Partners analysis

5G per se won't change the game for operators

The rollout of 4G illustrates that end users are unlikely to pay a premium for 5G connectivity. As 4G was made available to subscribers, ARPUs did not increase for most operators. Connectivity, even with the unique benefits 5G brings (such as network slicing), is considered a commodity. This is because almost all operators have similar network characteristics at their disposal and even if a player can gain first-mover advantage from launching a new generation of network, their competitors rapidly follow.

Most telcos have been forced, therefore, to compete primarily on price. Figure 10 shows that established operators in mature, consolidated markets who rolled out 4G, such as Vodafone in the UK and Orange in France, were able to only maintain their previous ARPU. Those in markets which were disrupted by new entrants, like Airtel in India, saw their ARPU plummet despite 4G.

Figure 10: 4G rollout did not produce sustainable revenue increase



Source: STL Partners

Deploying new networks is, therefore, not a competitive advantage for operators but a reluctant necessity stemming from being caught in a prisoner's dilemma. Each operator would benefit from **not** deploying the latest expensive technology, but the risk of losing customers if they don't deploy and a competitor does is so great that they must move forward with investment. The result is that operators (in competitive markets at least) tentatively move forward on the next 'G' and make sure they keep up with their peers and so don't suffer a competitive disadvantage. But they tend not to be aggressive with deployment – it happens over an 8-10-year cycle – which means the benefit of the new technology is delayed.

Fast 5G network deployment needs to be encouraged

Because 5G can be an economic and social 'game-changer' it makes sense for regulators to explore policies that reduce the impact of the 'prisoner's dilemma' problem that stymies network investment. This can take both a 'carrot' and a 'stick' dimension:

- **Carrot:** Reduce upfront charges for operators for 5G by replacing spectrum auctions with beauty contests which set stringent requirements for network rollout and, potentially, also sets clear service levels for network performance.
- **Stick:** Set material financial penalties for operators which fail to meet the terms of the beauty contest once they have won 5G spectrum.

STL Partners believes that network differentiation is becoming harder to achieve for operators. Because of this, regulation should focus on ensuring that network investments are made quickly and that all operators develop their networks in a cost-efficient way. We outline how regulators might consider this in the section **How should governments regulate 5G?**

Appendix

Comparing apples with apples: how to compare nascent 5G with established 4G

If you compare the technological specifications for 3GPP release 14 and 3GPP release 15 (the first 5G release), you might be underwhelmed. Despite the hype that 5G will be transformative, it does not appear to be delivering much more than incremental increases in speed and reliability. But, of course, 4G is now a mature form of connectivity (having been in-life for 6+ years) whereas 5G is still nascent. To compare apples with apples, it makes sense to compare 5G release 16, where capabilities such as ultra-reliable low-latency and network slicing are being added, with LTE today (See Figure 11).

Figure 11: Mature 5G benchmarked against the capabilities of mature 4G

Specification		LTE (Rel. 12-13)	→	5G (Rel. 16/IMT-2020)
Average data rate per user	Downlink	10Mb/s	**10x**	100Mb/s
	Uplink	0.5Mb/s	**100x**	50Mb/s
Peak data rate	Downlink	1Gb/s	**20x**	20Gb/s
	Uplink	150Mb/s	**100x**	10Gb/s
Latency	End-to-end	<100ms	**10%**	<10ms
	Airlink	<10ms	**10%**	<1ms
Density / capacity	Traffic capacity	100Kb/s/m^2	**100-1000x**	10-100Mb/s/m^2
	Device density	100K	**10x**	1M
Reliability				99.999%
Mobility		350km/h	**1.5x**	500km/h
Spectral efficiency			**3-4X**	
Energy efficiency			**10%**	
Device battery life			**10x(?)**	
Network slicing		Limited		End-to-end
Location accuracy		10-50m		<1m

Source: ITU, 5G lecture, ublox, gps world

Of course, these figures represent a best-case scenario occurring in a laboratory environment. This is true for both the 4G and 5G numbers. It's also true that it will take time before we see commercialised rollout of enhanced mobile broadband ("pure 5G") rather than enhanced mobile broadband with 4G fall-back alongside fixed wireless access. Despite this, these figures make clear that when 5G reaches maturity, it will far outstrip the capabilities of 4G, and unlock new use cases.

Our assumption is that by 2025 5G technology will be mature, enabling massive M2M / IoT use cases as well as those that require ultra-reliable low-latency communications. Several of the 5G use cases we'll go on to explore in more detail are reliant on this technology, so it is important to acknowledge that their commercialisation is only likely to start from around 2023 and in many markets they still won't be fully deployed in 2030.

It's not all about LTE: 5G must be compared to all available technology

Mobile is not the only form of connectivity used by enterprises. Plenty of industries are also making use of Wi-Fi, LPWAN, Zigbee, Bluetooth and fixed connectivity as part of their overall connectivity solution. When 5G is rolled out, in some cases, it will need to integrate with these existing technologies rather than replace them. Figure 12 summarises some of the key benefits and shortcomings of current technologies, including highlighting the sorts of situations in which industries are making use of them.

Figure 12: 5G can address some key shortcomings with existing technologies

Type of connectivity	Current industry example	Key benefits	Key shortcomings
LTE	• Used widely across industries	• **Flexible** and **mobile** • **No installation fees**	• **Performance** and **reliability** not in the lab not good enough for mission critical communications • Cannot enable **network slicing** • Cannot handle **cell density** that comes with massive IoT
Wi-Fi	• Used for general site connectivity in industries with long term indoor sites e.g. manufacturing	• **Cheaper** than a fixed line solution • Unlimited data allowances possible	• Deemed by many in industry as not **secure** enough • Takes relatively long time (often weeks) to set up • Cannot handle **cell density** that comes with massive IoT • **Indoor coverage** can be patchy
Fixed / Ethernet	• Used in industries where fixed sites are common and speed and latency are top priorities e.g. media, sports and entertainment	• Often the **fastest** and most **reliable** of the current solutions, particularly when high bandwidth required	• Takes a long time to set up (often months) • Lack of **mobility** and **flexibility**

Type of connectivity	Current industry example	Key benefits	Key shortcomings
LPWAN (e.g. LoRA and Sigfox)	• Used for low data rate applications such as alarm systems and asset tracking	• Cheaper than licensed technology • Connectivity can penetrate to underground equipment and supports **wide area coverage**	• Will not be able to support number of devices and **cell density** of massive IoT • **Unlicensed technology** means no control of number of devices on the network • **Infrastructure** currently thinly spread
NB-IoT	• Used for low data rate applications such as wearables, asset tracking and some smart infrastructure	• Some degree of **network quality** can be guaranteed as **congestion** can be managed • Better **scalability** and **quality of service** than unlicensed alternatives	• Less suitable for **high data rate** applications • Roaming and voice transmission not supported • Scarce **coverage** (currently)
Zigbee	• Used for machine-to-machine communication in low data rate applications like sensors and actuators	• Device-to-device **interoperability** possible • Less **complex** than Bluetooth with fewer points of failure	• Will not be able to support number of devices **and cell density** of massive IoT • Cannot support **wide area** use cases
Bluetooth	• Used for low data rate applications such as indoor asset tracking	• Long **battery life** • Easy to deploy • **Cost-effective**	• Will not be able to support number of devices and **cell density** of massive IoT • Lack of **security**

Source: STL Partners

There are clear scenarios where 5G will be superior to existing technologies and bring significant benefits to industrial users. Ultimately, in particular, 5G will enable:

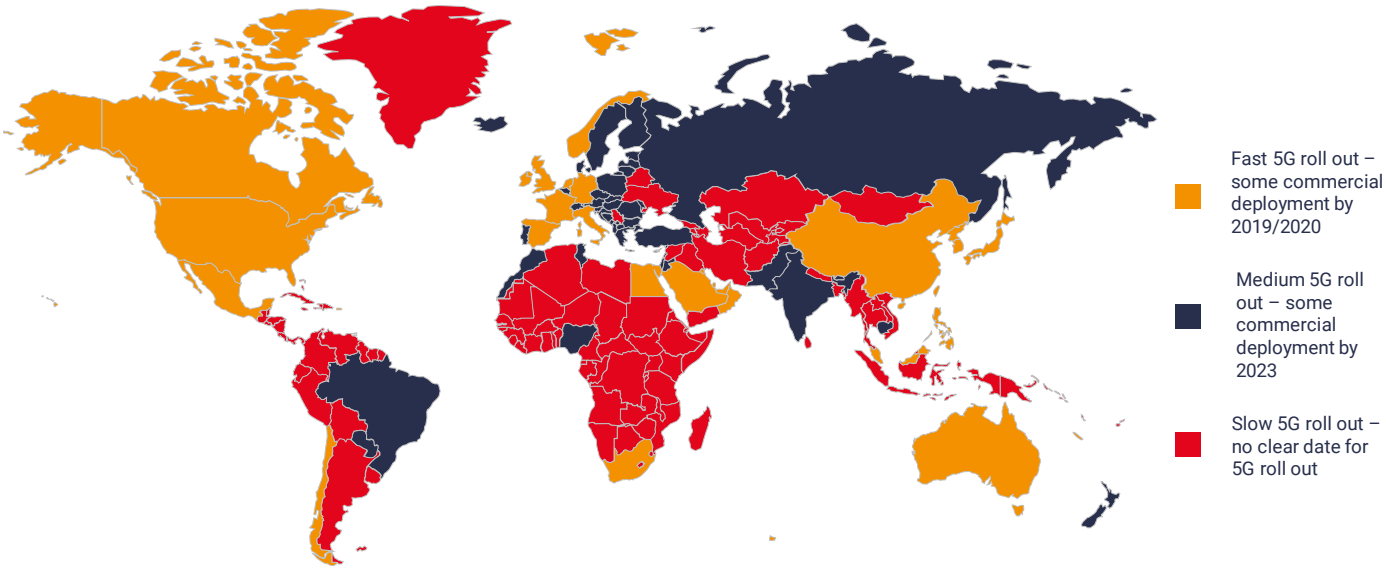
1. Low latency and high bandwidth requirements for wireless connectivity

1. Massive IoT through ability to handle high cell density (numbers of connected devices)

2. Ultra-reliable and secure connectivity.

5G deployment: 5G will mature over the next ten years

Figure 13: Forecast of 5G deployment in major regions



Source: STL Partners

It will take time for the benefits of 5G to be fully realised, both in terms of performance by the network and in terms of financial benefits for operators rolling it out. Figure 13 indicates a high-level overview of when countries are expected to gain 5G.[10] Figure 13 rollouts are based on 5G for enhanced mobile broadband. Most operators have indicated that the types of 5G use case that require network slicing or ultra-reliable low latency will be further out, with fast adopters expecting this by 2023 while those with no clear date for 5G rollout probably only having sufficient coverage for these use cases from 2028 onwards. Each economic forecast takes these 5G rollout timelines into account in addition to the speed at which we predict industries will adopt each solution.

[10] The chart reflects population coverage rather than geographic coverage, hence countries like Australia fall into the fast 5G roll out category (as most of their population will receive 5G relatively quickly despite the roll out being concentrated on the top five most populous cities).

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