



5G in industrial operations

How telcos and industrial companies stand to benefit

Introduction

Boasting features such as faster connectivity, greater reliability and security, lower latency and network slicing,¹ 5G has gained a lot of attention in the industrial world:

- In August 2018, Audi started testing 5G as a solution for robotic motion control use cases. Though the trial is ongoing, results thus far have been *“very satisfying,”* according to Henning Löser, the head of Audi’s Production Lab.²
- Matthias Fankhänel, the head of Global Engineering and Maintenance at BASF, believes that 5G networks offer the best means to meet their data transfer and connectivity plans. *“In the future, when we use 20 or more vehicles, we’ll only manage the massive data transfer with 5G technology,”* he says.³

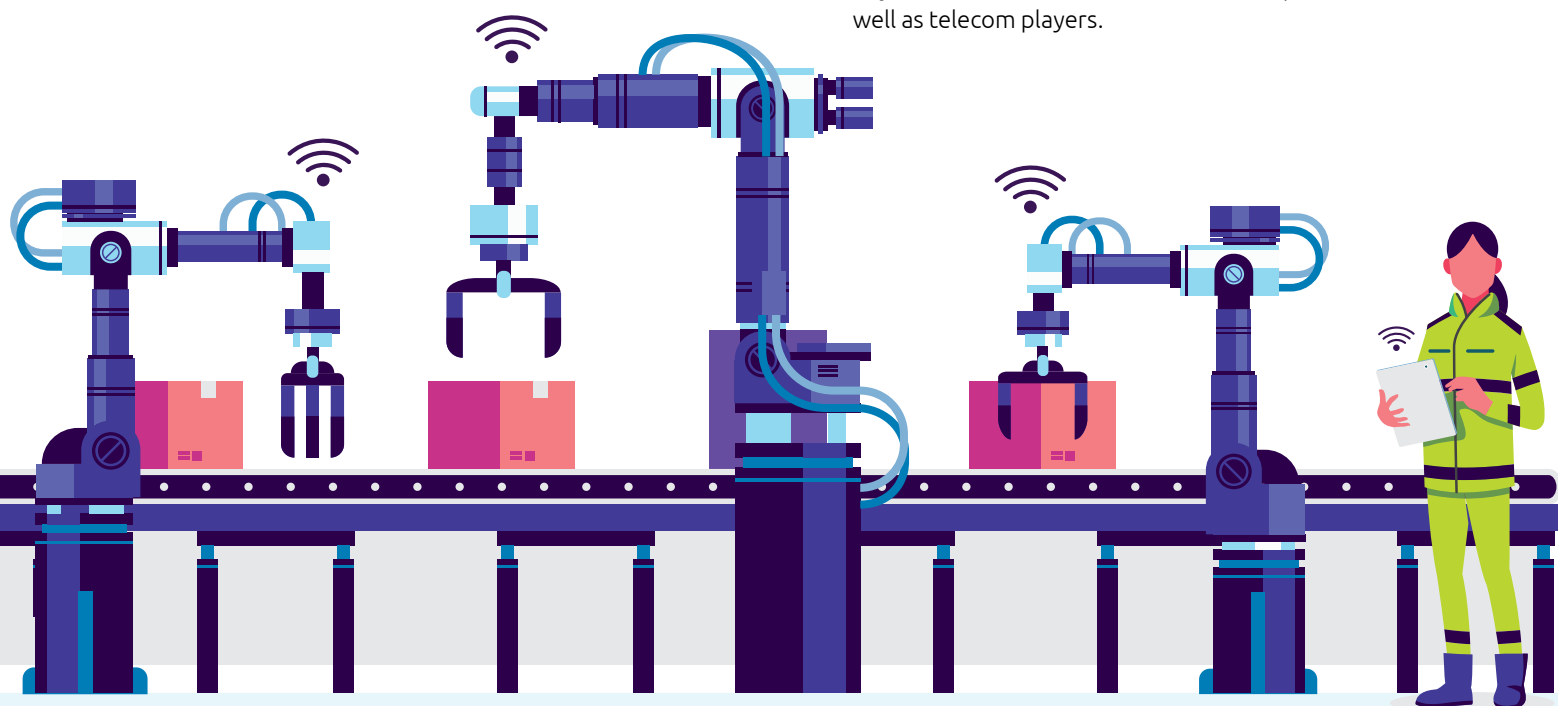
Experts believe that 5G has the potential to solve many of the connectivity issues faced in a range of industries, including manufacturing, transport hubs (harbors, airports, train stations), logistics, energy, and utilities. To really understand the transformative potential of this technology in manufacturing and asset-intensive industries, we have undertaken a comprehensive research focusing on industrial operations rather than on consumer applications. As well as conducting one-on-one interviews with more than 20 industry and telecom executives, we surveyed:

- Around 800 manufacturing and asset-intensive companies across the world, assessing their willingness to adopt 5G and the use cases where they believe 5G can add maximum value. (In this report, we will refer to these companies as “industrial companies.”)
- Some 150 telecom executives, to build an understanding of their 5G readiness.

The aim of this research is twofold. First, to help industrial companies identify the high-potential use cases for 5G and the optimum 5G adoption path to deliver on its potential. Second, to give telecom operators a comprehensive and nuanced understanding of the 5G expectations of industrial companies and how to meet those demands.

Our report looks at four areas:

1. Industrial companies’ appetite for speedy 5G adoption and the factors driving this interest
2. Why potential delays in 5G deployment are leading these companies to consider applying for 5G licenses and how that might affect telecom players
3. The potential manufacturing use cases that 5G offers
4. Key recommendations for industrial companies as well as telecom players.



5G's advantages over previous generations

5G, the latest standard of cellular networks, addresses many challenges of our connected era: coping with the exponential growth of connected devices and data traffic, reducing energy consumption, and increasing security and connectivity performance. It introduces a versatile, adaptive and programmable connectivity engine, built around several key pillars:

- A **new radio**, providing a step change from previous cellular technologies across three dimensions:
 - **Enhanced mobile broadband speed and increased capacity:** 5G can theoretically offer speeds up to 100x faster than 4G, supporting new bandwidth-hungry applications such as ultra-high definition video
 - **Ultra-reliability and low latency:** with 5G, latency can be reduced by a factor of 10, down to single-digit milliseconds. This means that it can support use cases such as autonomous vehicles or high-precision, wireless robotics
 - **Massive machine-type communications:** 5G can support a very high density of devices (up to millions per km²) supporting the expansion of IoT use cases at unprecedented scale.
- A **new architecture**, which is more **open to third parties** (partners, developers, service providers) via **APIs** and which offers:
 - More **distributed intelligence** capabilities at the edge of the network
 - A **core network mutualized** across multiple radio channels (e.g., new radio for 5G, LTE, NB-IoT, WI-FI, etc.)
 - Natively **software driven**, so that the network is flexible and adaptable in response to real-time demand and specific application requirements.
- The combination of this new radio capability and advanced architecture will allow 5G to deliver guaranteed quality of service for specific applications. It will do this through **network slicing**: the same physical network can be partitioned into multiple virtual networks, each optimized for different applications, resulting in cost savings and faster time to market.

The following table shows a quick comparison of 5G features with the previous cellular generations and the upcoming WI-FI technology:

	5G	4G (LTE-A)	WI-FI 6 ⁴
Enhanced mobile broadband speed: (peak data rate)	20 Gbps for downlink and 10 Gbps for uplink	1 Gbps for downlink and 500 Mbps for uplink	Approximately 4.8 Gbps ⁵
Massive machine type communication: (Number of connected devices per unit area)	1 million/km ²	100 thousand devices/km ²	Not defined. Depends on the bandwidth required per device
Ultra-reliability and low latency:	Network latency is less than or equals to 1 millisecond with 99.999% assurance of delivery	Network latency is 10 milliseconds	Network latency is less than 10 milliseconds for 5Ghz band

Source: *International Telecommunications Union, "Key Features and requirements of 5G/IMT-2020 networks," accessed April 2019, cisco.com, IEEE 802.11ax: The Sixth Generation of WI-FI, accessed May 2019.*

Executive summary – key takeaways

Industrial companies have a significant and immediate appetite for 5G, but not all features will materialize within the timeframes they want:

- Two-thirds of industrial companies want to implement 5G within two years of its availability.
- But, despite this eagerness to move quickly, telco players will need at least three years to roll out all 5G features.

One-third of industrial companies would consider applying for 5G licenses:

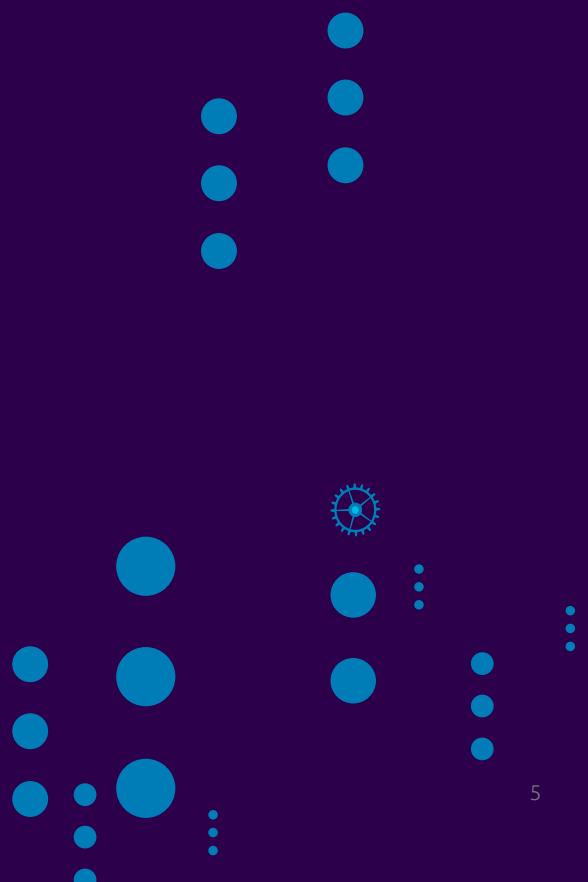
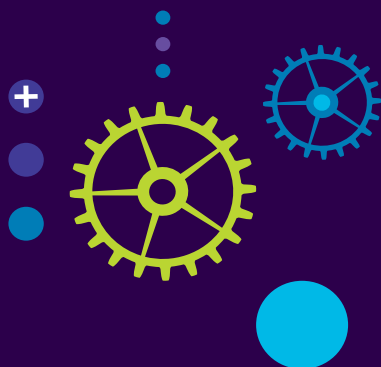
- This interest in private licenses is more prominent among large organizations – 47% of these bigger organizations are planning to have a dedicated/private network and would consider applying for a private license.
- Interest is fueled by the belief that private networks will offer more autonomy and security and that telecom operators will be too slow.
- In spite of this interest from industrial companies, not all countries will offer a regulatory environment (e.g., spectrum policy) in which this is possible.
- Telcos still have a role to play in building and operating such dedicated 5G networks.

5G offers exciting use case potential:

- Key use cases that draw on 5G range from real-time analytics based on edge computing to video surveillance of remote production lines.

Both industrial companies and telecom players need a clearly defined implementation roadmap:

- For industrial companies, this ranges from identifying the connectivity requirements for critical use cases to adjusting the connectivity roadmap as 5G evolves.
- For telco operators, this ranges from educating companies on the unique features of 5G to deploying solutions for the industrial campus.
- Telcos also need to collaborate closely with industrial companies to create a win-win business model by understanding connectivity pain points in industrial operations and adjusting the priorities of 5G network' and services' rollout.

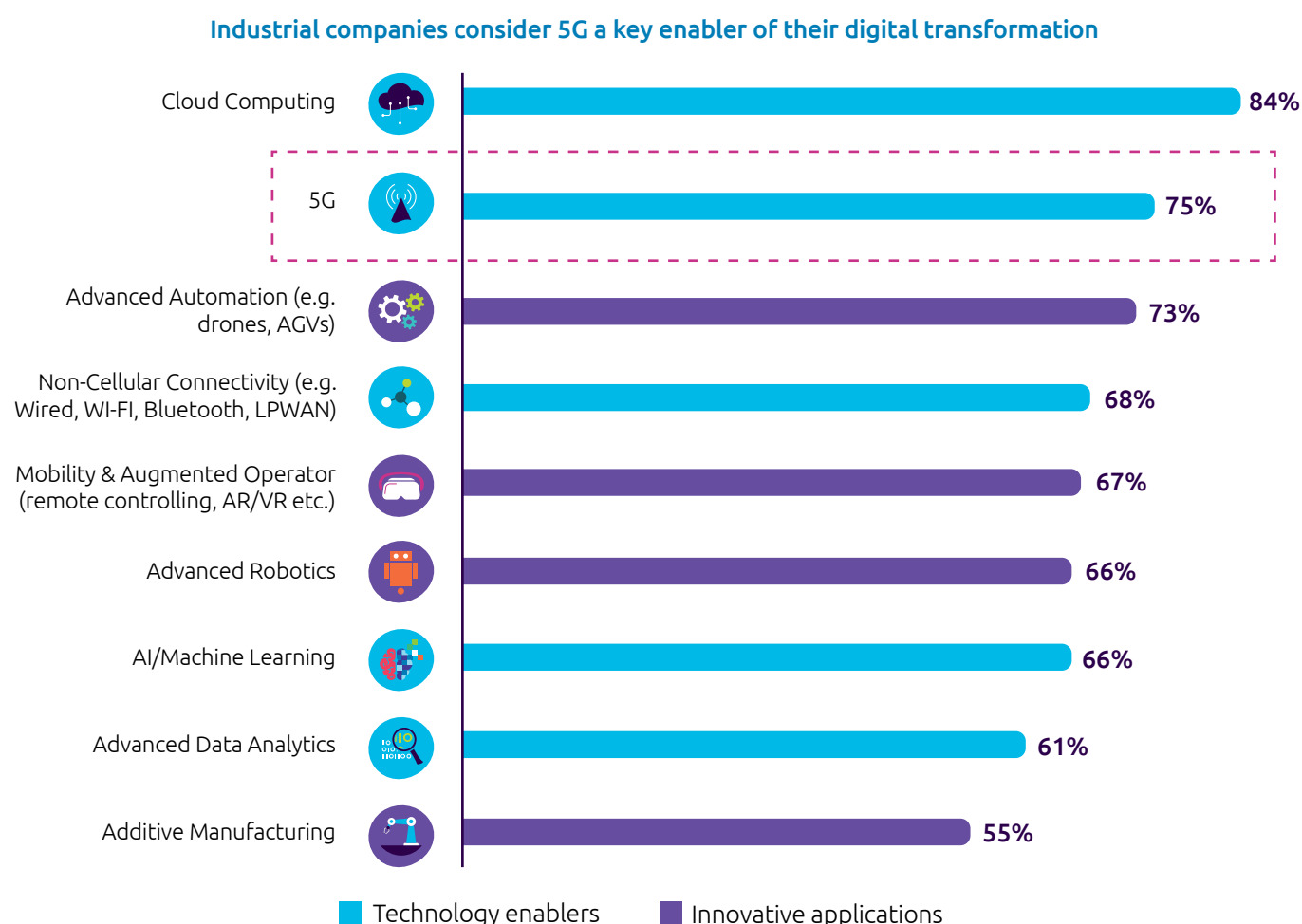


Companies across the world are ready to embrace 5G, but 5G's disruptive features will take some time to materialize

5G is seen as an attractive proposition and there is appetite to launch quickly

Three-quarters of industrial companies (75%) believe that 5G is going to be a key enabler for their digital transformation in the next five years. In fact, 5G is placed higher than artificial intelligence or advanced data analytics (see Figure 1). The reason, partly, is that 5G will be the connectivity engine that drives the development, at scale, of technologies such as real-time image processing, edge analytics, advanced automation, and AR/VR.

Figure 1. 5G ranks higher than most other enablers for digital transformation



Source: Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=806 industrial companies.



44%

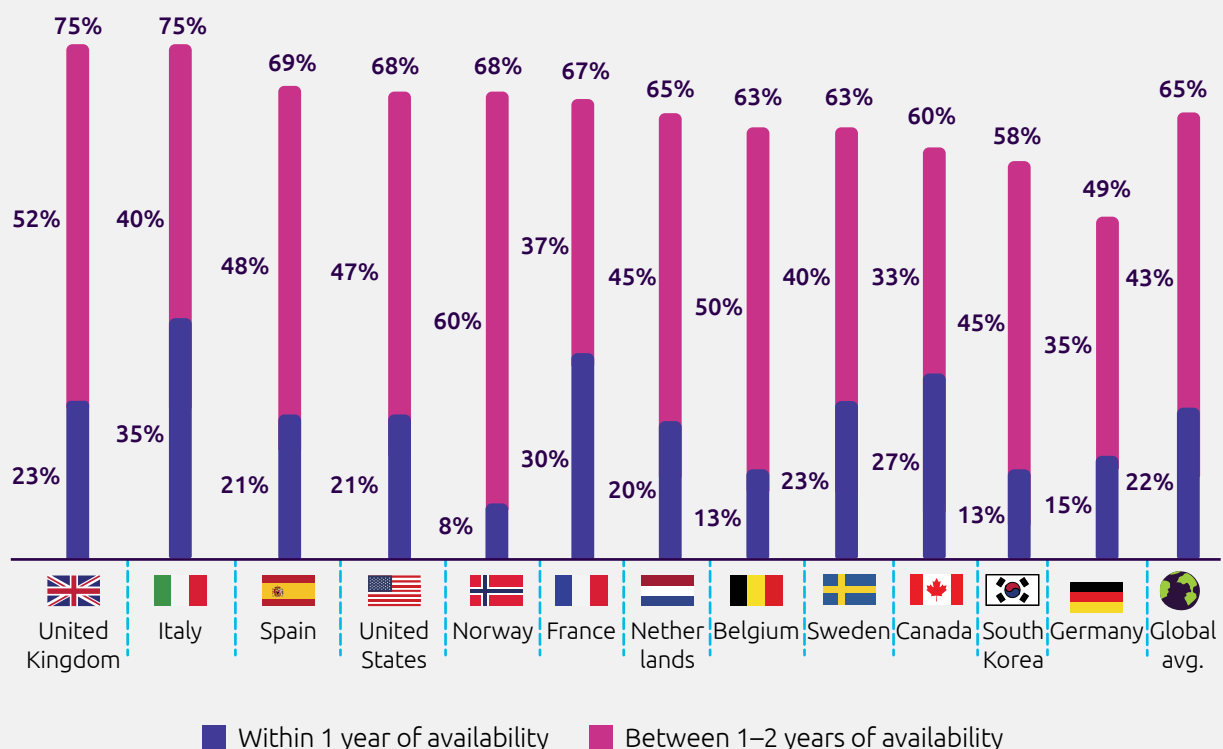
The share of industrial companies who believe connectivity issues pose big challenges for their digital transformation

Part of the attraction can be explained by 5G's ability to solve industrial organizations' connectivity challenges. Our research shows that nearly half (44%) believe that connectivity issues pose big challenges for their digital transformation initiatives. This trend is consistent across the countries we surveyed. These companies told us that their top three connectivity challenges include lack of coverage (selected by 63% of respondents), signal reliability (56%), and lack of network speed (46%).

As Figure 2 shows, close to two-thirds (65%) said they were willing to implement 5G within two years of availability. Stig Are Remmen, OT/IT convergence lead at Yara International, a Norwegian chemical company, feels 5G is a critical part of planning for the future. *"Some of our sites are geographically huge and it will be quite costly to roll out Wi-Fi,"* he says. *"So, we started looking at cellular connectivity solutions, and 5G - along with all the promises that come with it - is definitely going to impact our decision."*⁶

The majority are willing to implement 5G for operations within two years of availability

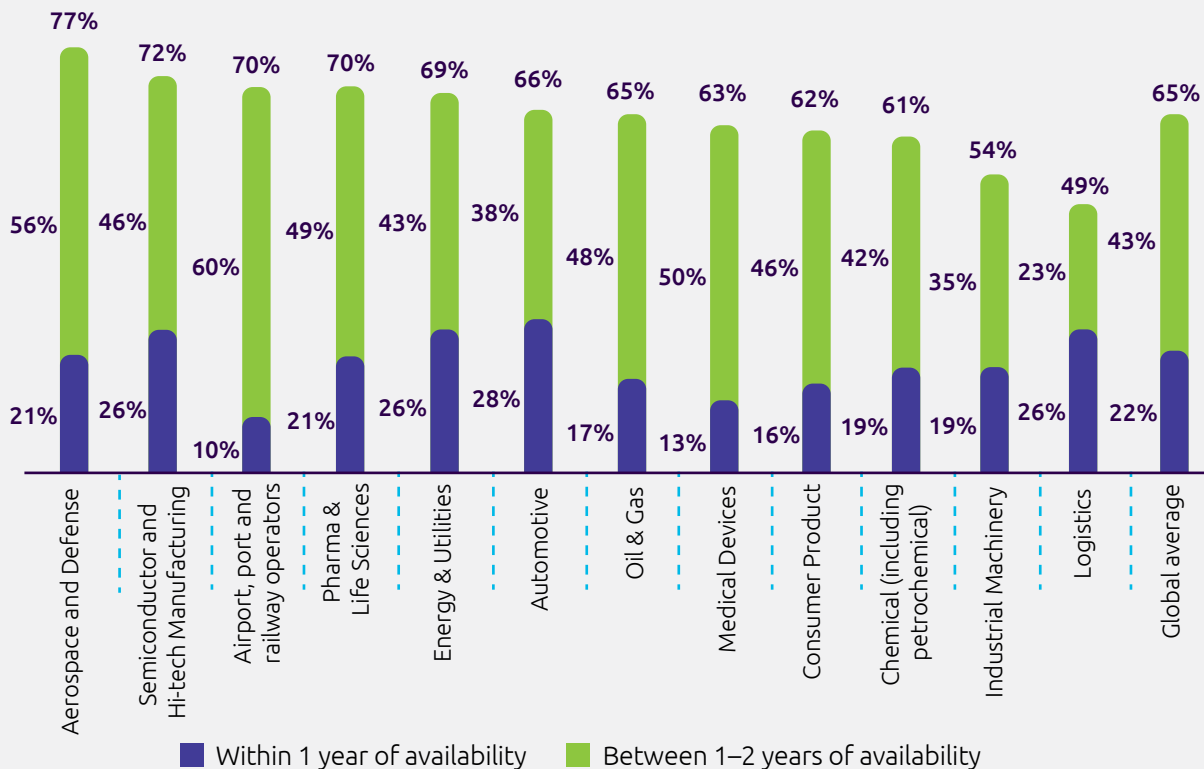
Figure 2. Organizations that are willing to implement 5G for operations - by country



Source: Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=806 industrial companies.

Out of all the countries, Germany stands out, with just 49% of respondents saying that they would adopt 5G within two years of its availability. One probable explanation is that German executives feel that they are already making strong progress in Industry 4.0: only 29% feel that their current connectivity solutions are holding back their digital transformation initiatives, which is much lower than the global average of 44%. However, we also know that a number of major German manufacturers, including BASF and Audi, have shown significant interest in 5G adoption (see Section 2 for more details).

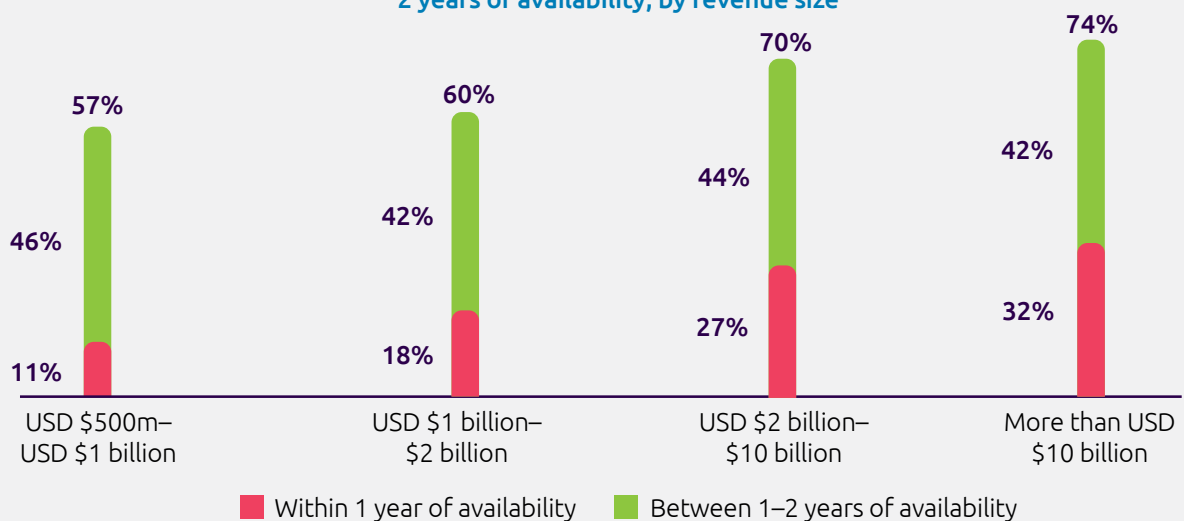
Figure 3. Organizations that are willing to implement 5G for operations - by sub-sector



Source: Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=806 industrial companies.

Figure 4. Larger companies have a greater appetite for an early adoption of 5G

Share of industrial companies that are planning to implement 5G within 2 years of availability, by revenue size



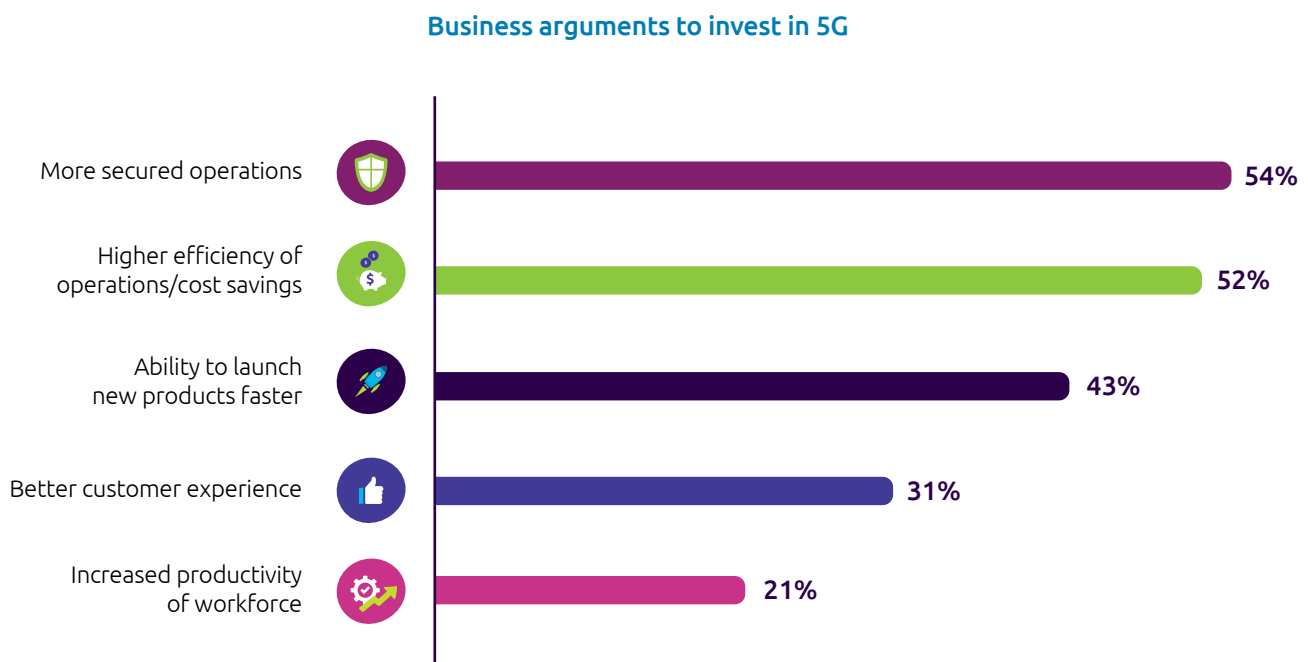
Source: Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=806 industrial companies.

When we asked industrial companies why they were so keen to invest in 5G, security of operations emerged as the top factor (see Figure 5). Certain 5G features can indeed contribute to more secure, resilient, and robust operations:

- **Enhanced security mechanisms of 5G:** A unified authentication framework, robust authentication protocol for IoT networks, and better device identity protection make 5G a more secure technology than previous generations. 5G also introduces a software-driven architecture wherein security policies can be automated and rolled out efficiently, and network slicing can be used to isolate groups of functions and users.

- **Support a range of security use cases:** from real-time alerting systems to mission-critical voice communications with PMR, or video surveillance and monitoring of distributed production systems or remote strategic assets (e.g., oil fields, mines) to detect anomalies and problems from a central location.

Figure 5. Security and efficiency in operations are the primary drivers for 5G adoption



Source: Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=806 industrial companies.

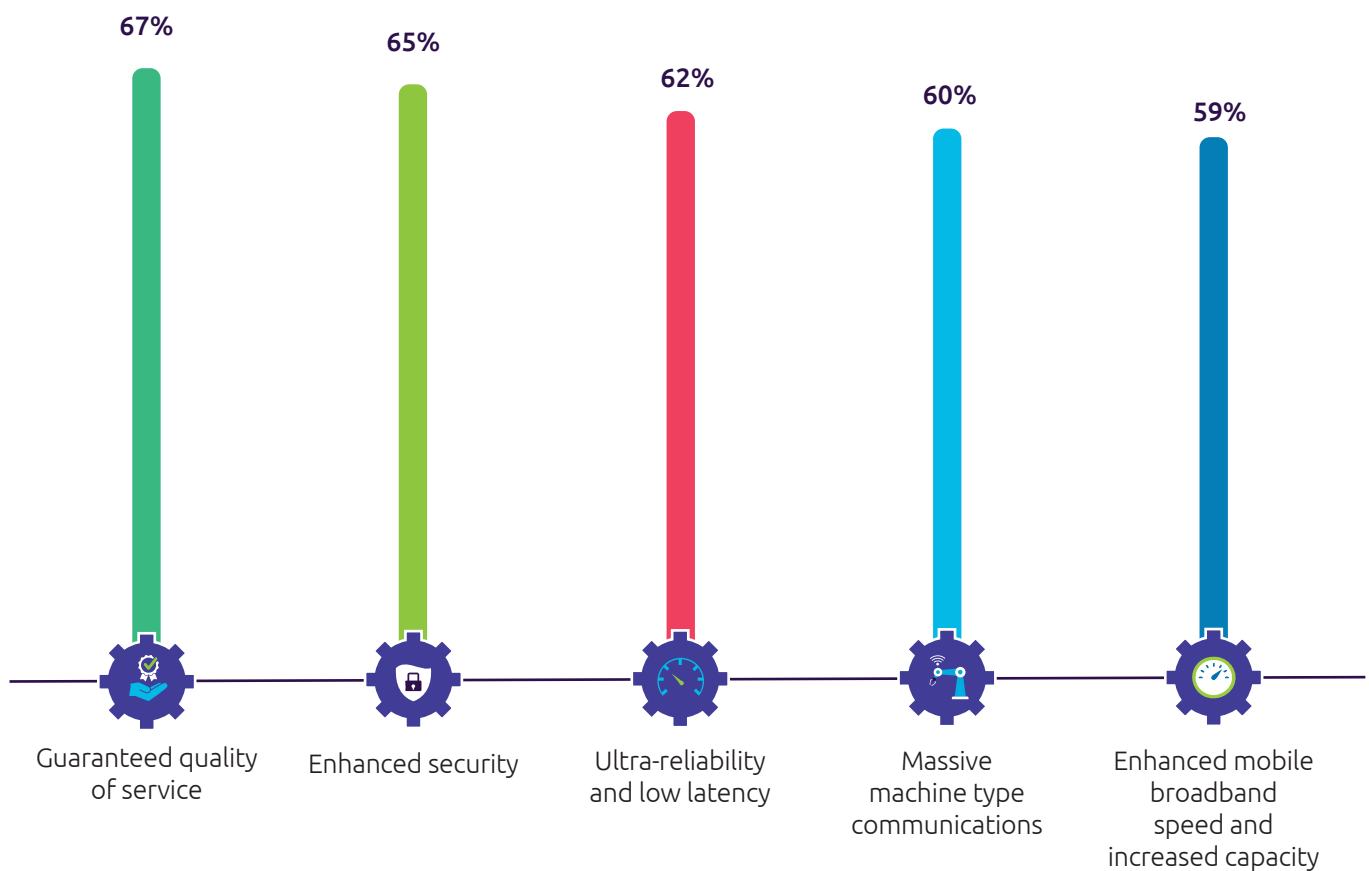
We also asked executives which 5G features they believe are most important for their digital transformation. "Guaranteed quality of service," which is primarily enabled by network slicing, emerged at the top of the list, though there is little

variance across features. This implies that all the key features are important as they contribute to 5G's ability to support very heterogeneous use cases (refer to the third section for more details), making it a compelling connectivity technology.

 **more than half** of industrial companies cite security and efficiency in operations as the primary drivers for 5G adoption

2 out of 3 industrial companies believe that guaranteed quality of service is critical for their digital transformation

Figure 6. Executives believe that several 5G features are critical for digital transformation



Source: Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=806 industrial companies.

Though enthusiastic about the prospect of 5G, industrial companies are cautious about adoption costs (from potential on-premises radio access network equipment to 5G-compatible devices and integration with legacy networks and IT).

Half (51%) of the companies we surveyed believe that the high fixed cost for 5G implementation can be a key barrier to adopting the technology. However, any 5G investment should be analyzed in light of its business impact (for example, productivity gains), versatility (the ability to support and scale heterogeneous use cases) and ability to substitute/replace multiple access technologies, thereby lowering costs and complexity in the longer term.

Telco players will need at least three years to provide all the anticipated benefits

Telcos are very much aware of the significant interest in 5G: 72% are ready to launch 5G with non-standalone core network⁷ in the next two years.

However, all telecom operators we have talked to have stressed that 5G rollout will be more of a progressive evolution rather than a revolution, both in terms of coverage and features.

The rollout of a high-frequency spectrum that can further accelerate network speed is still at least a year away

5G mid-band spectrum (3.5 GHz band) in itself will offer a step change in terms of connectivity speed compared to 4G. However, 5G millimeter-wave spectrum⁸ – in bands such as 26 or 28GHz in Europe, for instance – can increase this speed severalfold, due to the large amount of spectrum available in those higher bands.

Globally, half of telco operators say they plan to roll out millimeter wave spectrum of 5G over the next one to two years. For the remaining 50%, this rollout will take even longer.

Moreover, as the millimeter wave spectrum requires short cell range – as well as (close to) line-of-sight between the device and cell tower – the rollout of this spectrum, in industrial operations, could be limited to target locations with specific use case requirements.

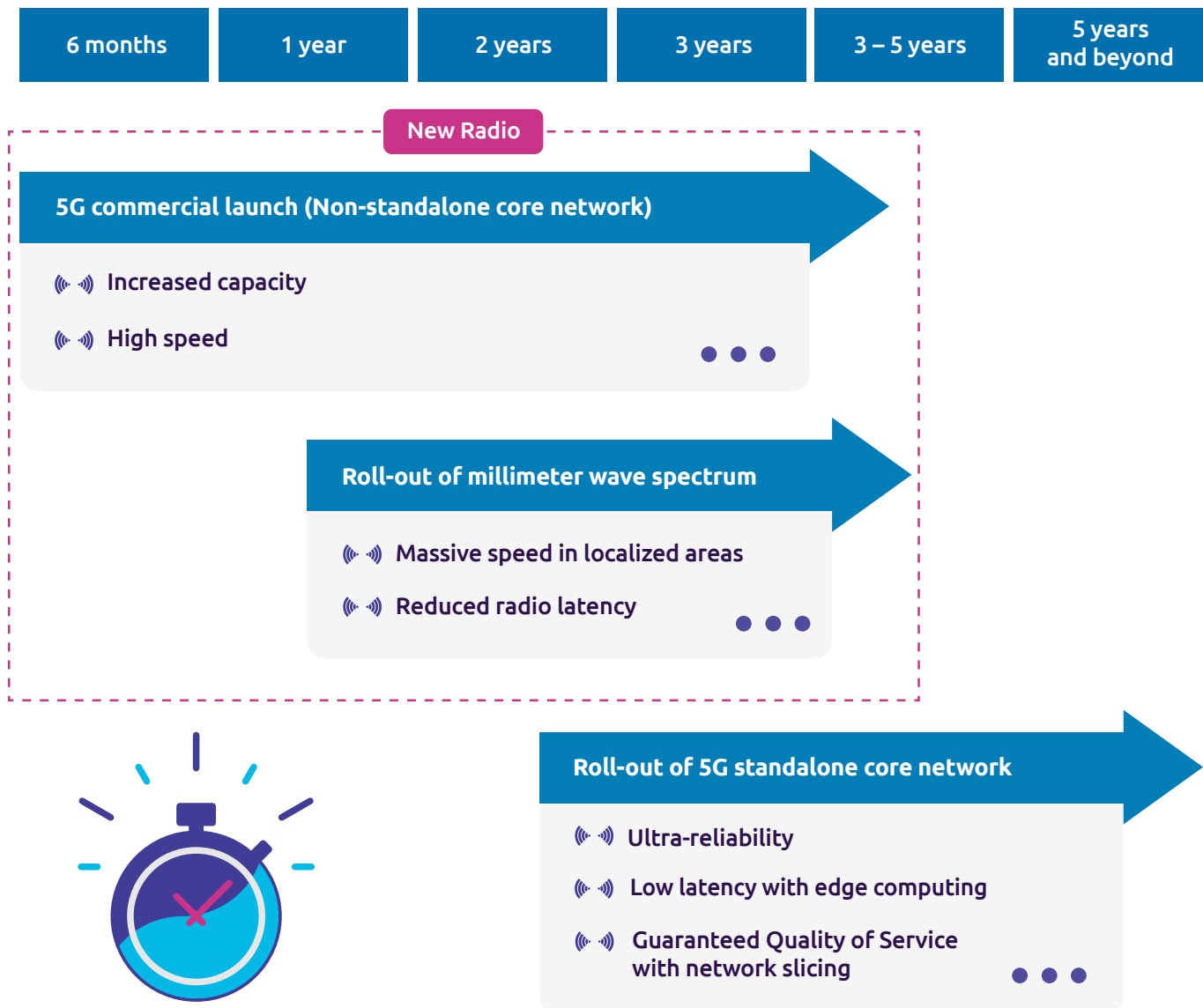
Guaranteed quality of service, a highly desirable 5G feature, will take longer to materialize at scale

Quality of service (QoS) is an essential requirement, particularly for mission-critical operations such as remotely controlling timebound robotic movements. 5G networks will

offer higher QoS levels than 4G, such as 99.999% network availability and greater reliability (5G's block error ratio is expected to be at 0.00001 in one millisecond period, compared to 0.01 in 4G).⁹ Network slicing, a mechanism introduced in 5G, will deliver this level of QoS over 5G standalone core networks.¹⁰ However, telcos across the globe expect it will take more than five years for large-scale adoption¹¹ of a 5G standalone core network. Only a minority of early adopters (some 5% of our telco respondents) will begin its rollout between two to three years. Based on these expectations, we have estimated the timing for feature availability in Figure 7.



Figure 7. Estimated timelines for 5G feature availability

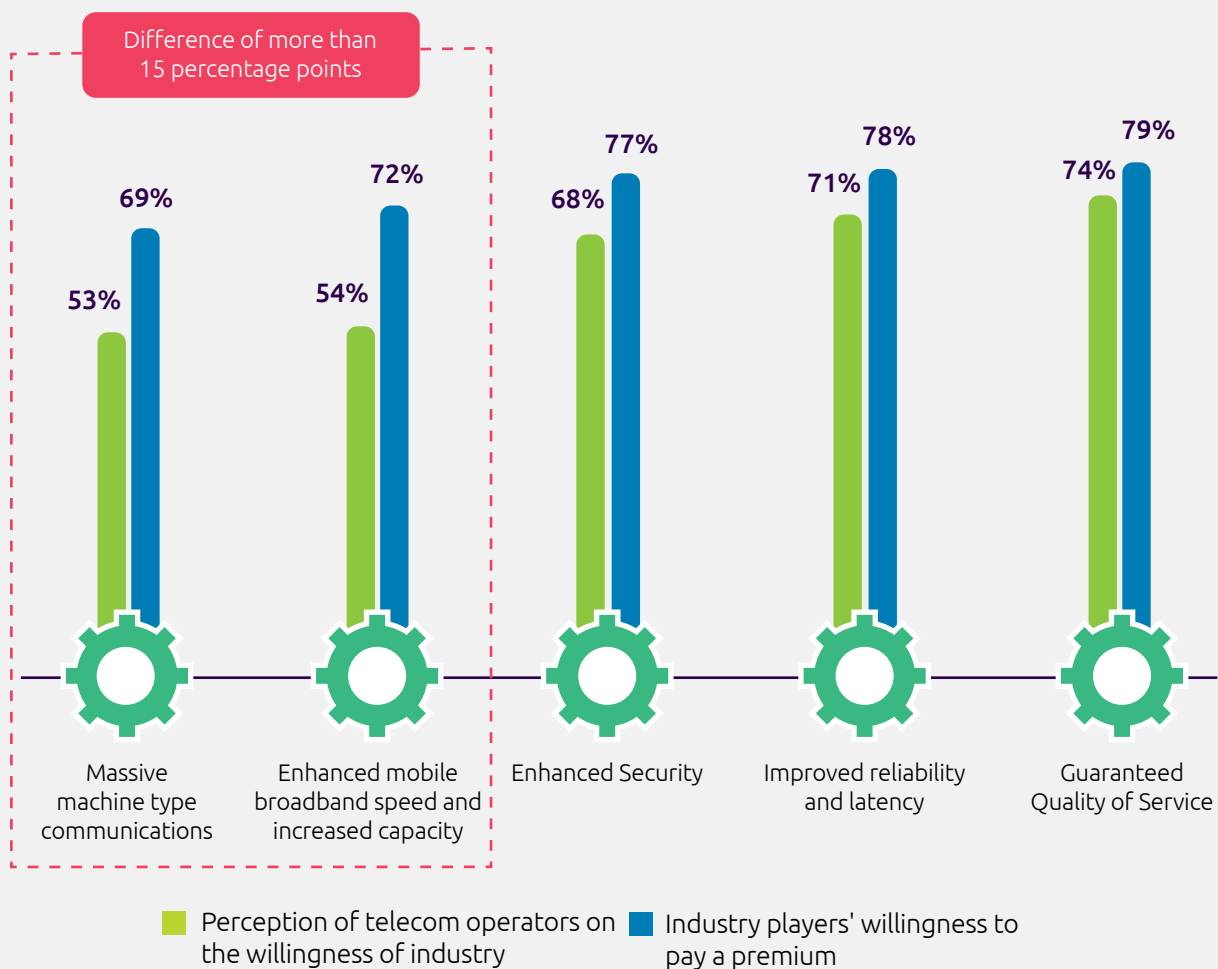


Source: Capgemini Research Institute, Telecom operators’ survey on 5G, March–April 2019, N=68 telecom organizations, 150 respondents.

Good news for telcos: clients' willingness to pay for 5G services is greater than what telcos themselves expect

While there are still uncertainties around 5G, such as deployment speed, companies' willingness to pay a premium for 5G's benefits makes for interesting reading. This is something that telcos underestimate. For example, 72% of industrial companies say they would be willing to pay a premium for Enhanced mobile broadband speed and increased capacity but only 54% of telcos think there is appetite for paying a premium. While guaranteed quality of service shows the smallest gap in expectations, greater speed and device density offer attractive pricing opportunities.

Figure 8. Difference between industry players' willingness to pay a premium and telecom players' perception of this willingness



Source: Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=806 industrial companies; Telecom operators' survey on 5G, March–April 2019, N=150 respondents.

To overcome delays, some industrial companies are considering applying for local 5G licenses

In order to realize 5G's full potential at speed, some companies are planning to apply for licenses and set up private networks. *"We cannot wait for the network operators to be ready – we are in the midst of Industrie 4.0,"* said a spokesman for Siemens, one of the companies planning to bid for a local license in Germany.¹²

One-third are interested in a local license, though there are regulatory barriers

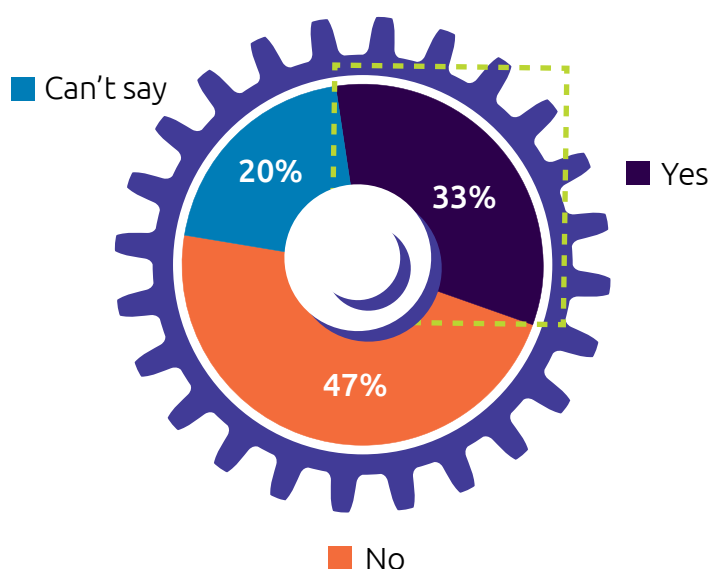
One-third of industrial companies where 5G will play an influential role would consider applying for a license or have done so (see Figure 9). *"We think having our own license is very*

beneficial because this gives us the freedom to either deploy the network alone or with a telecom operator," says Gunther May, head of Technology and Innovation, Business Unit Automation and Electrification, Bosch Rexroth AG.¹³

In some countries, industrial companies' enthusiasm could be dampened by telecom regulation. While Germany and the US have frameworks that encourage private licenses for 5G, Spain, Italy, and France are among the countries that currently do not have spectrums reserved for 5G private licensing.

Figure 9. Nearly one in three are planning to apply for 5G licenses themselves

Has your organization applied for 5G license in your country of operation (or has it been considering to do so)?



Source: Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=313 industrial companies, percentages represent the share of respondents who have 5G in their connectivity roadmap and chose to answer this question.

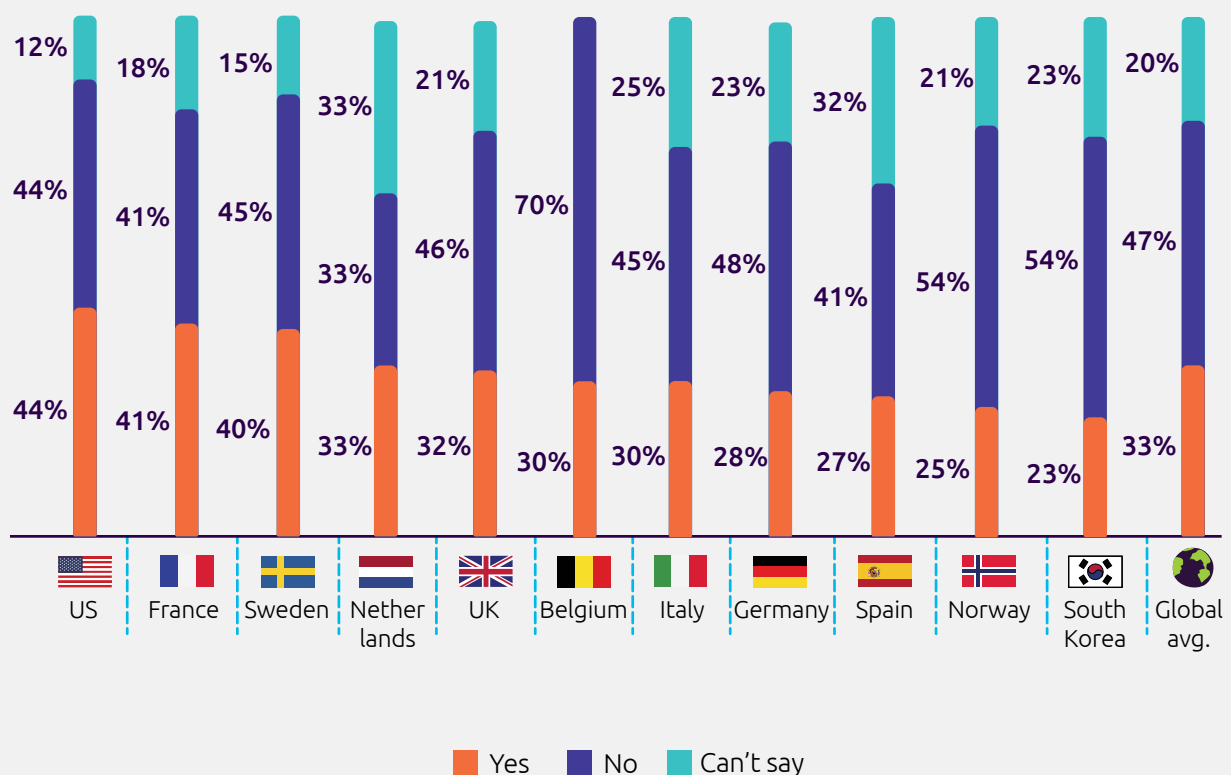


We think having our own license is very beneficial because this gives us the freedom to either deploy the network alone or with a telecom operator,”

- Gunther May, Head of Technology and Innovation, Business Unit Automation and Electrification at Bosch Rexroth AG

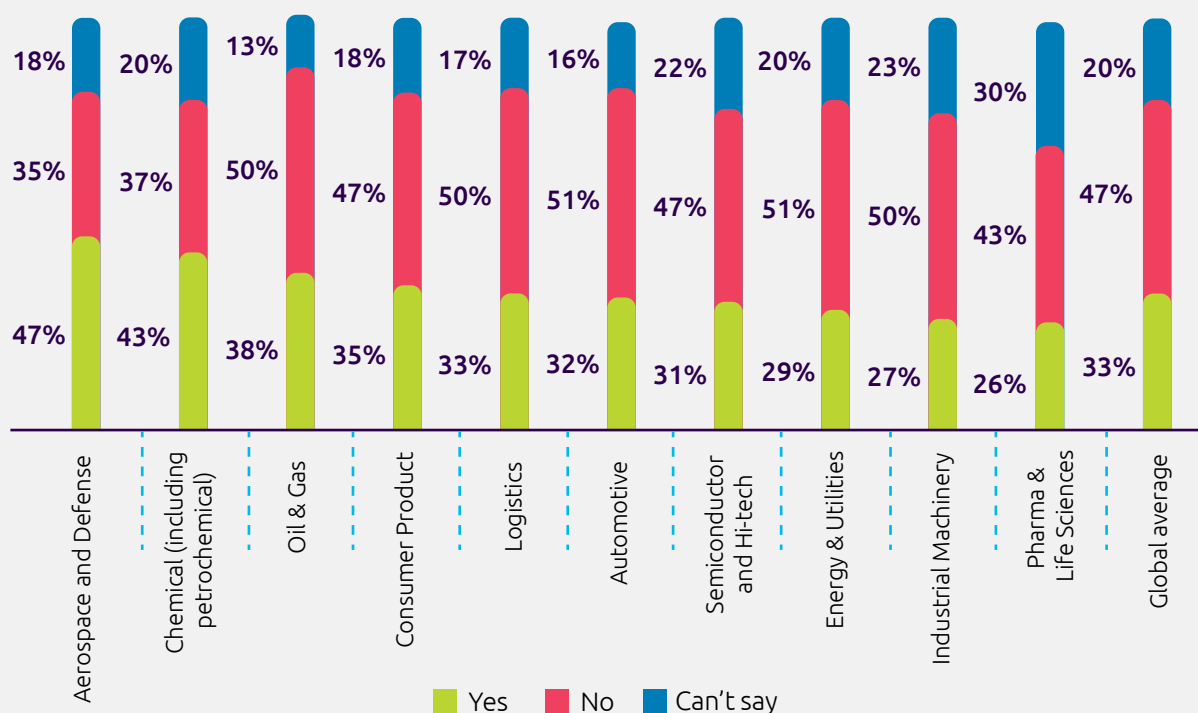
Industrial companies are keen on applying for 5G licenses

Figure 10. Interest in applying for licenses by geography



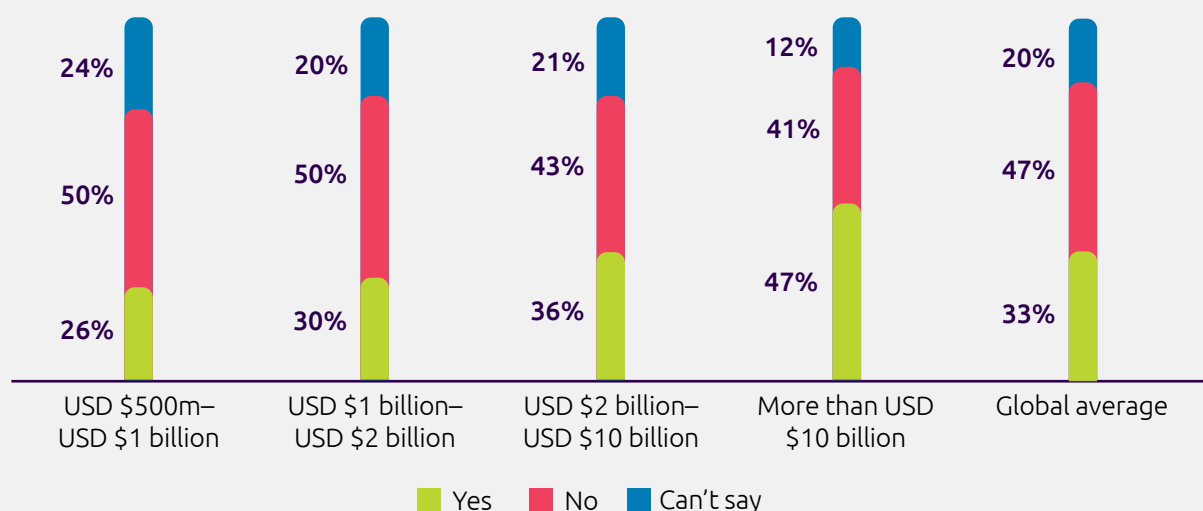
Source: Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=313 industrial companies, percentages represent the share of respondents who have 5G in their connectivity roadmap and chose to answer this question.

Figure 11. Interest in applying for licenses by sub-sector



Source: Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=313 industrial companies, percentages represent the share of respondents who have 5G in their connectivity roadmap and chose to answer this question.

Figure 12. Interest in applying for licenses by revenue



Source: Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=313 industrial companies, percentages represent the share of respondents who have 5G in their connectivity roadmap and chose to answer this question.

These results raise the question of what is driving this appetite. We believe that a number of factors are at play:

- **5G private networks will offer more autonomy and security**

Some industry players perceive their connectivity infrastructure as a strategic asset, which allows them to increase production and quality performance while also fostering innovation. Keeping this strategic asset under close control is seen as essential to building differentiation and creating a competitive advantage. *"We need our own 5G frequencies so that we can determine the security and availability of the networks,"* said BASF's Matthias Fankhänel. *"We want to set the rules of the game and be able to control the 5G network ourselves."* BASF has placed a bid for a private 5G license for its 10-kilometer square plant in Ludwigshafen, Germany. It aims to leverage the speed and reliability of ultra-fast 5G to increase the number of automated guided vehicles in use and make those vehicles faster.¹⁴ In many ways, the open and flexible 5G architecture, combined with other technology innovations, such as eUICC

(eSIM), can support more independence from telecom operators, avoiding overdependence on the telco vendor and lock-in.

- **Companies are doubtful about telecom operators' ability to meet their demands and are concerned about delays**

Though convinced about the merits of 5G, companies are doubtful about telecom operators' willingness and ability to meet their industry's requirements on security, network availability, and guaranteed quality of service. François Dalem, program director, Total's Industrial Mobility, says, *"From past experience, we found telecom companies' offers are seldom adapted to the needs of industrial sites."*¹⁵ Another executive, the head of telecoms infrastructure at a large industrial group, says, *"Telecom operators do not know how to operate critical infrastructure. They handle network faults with a statistical approach. A major cultural change is needed."*¹⁶

Industrial companies are also concerned that 5G's rollout might take too long. This lag could be due to issues such as a delay in spectrum auction or because coverage is focused on dense urban areas.^{17, 18}



Can telecom operators capture a sizeable share of the 5G industrial opportunity?

While there are still many moving parts, notably in terms of spectrum regulation, we believe that the future of connectivity for industrial players will be highly hybrid and dynamic.

Industrial players already use a wide array of connectivity solutions to support different use cases – for example, non-cellular technologies such as WI-FI or wireline LAN for robotic motion control on the shop floor, and LoRA or LTE-M for IoT solutions over a large geographical area.

In the near future, network infrastructure for industrial operations will remain a combination of non-cellular technologies, cellular macro networks, and dedicated/private networks in specific locations, relying on a mix of public and private edge clouds. The 5G architecture and standard – together with other technologies, such as eUICC/eSIM – will support this seamless integration in a flexible, cost effective, and secure way in the short term. In the long term, 5G will be able to replace other technologies currently in use in industrial operations thanks to its ability to support a large number of use cases as discussed in section 3.

We do not believe that telcos can be completely disintermediated by private networks. This is because they hold key assets needed to serve industry players:

- A broad portfolio of spectrum bands and access to technologies
- Know-how in designing, building, and operating networks
- A strong existing public network footprint and for some operators, integration capabilities and a portfolio of digital services. 5G private networks will be local networks, but industrial companies will still require connectivity over large geographical areas which will be served by public telco networks.

Yet, they might face a highly competitive environment in B2B verticals, with potential competition from private network equipment manufacturers, integrators, or specialized MVNOs aggregating connectivity from several mobile operators and adding a vertical-specific service layer. *"It is too early to have a definite opinion on the topic,"* says Jean-Christophe Oulie, head of wireless connectivity at Airbus. *"For sure, our network is going to be more open to the telco ecosystem. Some network equipment vendors [such as Nokia and Ericsson] are aggressive commercially and are developing their services around network equipment. Telecom operators are well placed to bring convergence between all our different requirements. The competition will be fierce."*⁹



47%
the share of industrial companies
that are considering applying
for local 5G licenses among the
category that earns USD \$ 10
billion or more revenue

Which 5G use cases offer the greatest value in industrial operations?

We identified twenty-five digital transformation use cases that can be enabled or enhanced by 5G. These use cases are from across the industrial operations value chain – shop floor operations and supply chain operations. We asked executives to estimate where 5G adds most value to the strategic objectives of each use case, on two dimensions:

- Standard KPIs (such as productivity)
- Longer-term business objectives (such as enabling end-to-end automation).

We then determined 5G's total value-add to the strategic objectives of these use cases, by assessing what role the technology could play in both these dimensions (see Figure 13).

Figure 13. Where 5G adds most value, by use case

5G's value addition to industrial operations use cases	
Shop-floor operations	
Real-time analytics leveraging edge computing	5G's faster wireless communication, improved reliability and ability to connect 10–100x more devices can provide real-time information from a large set of devices, which can be converted into real-time insights leveraging edge computing 5G will enable flexible management of edge and cloud resources, such as on-demand deployment of applications or data transfer
Video surveillance of remote production lines	5G's faster wireless communication can provide high quality, real-time video feed for surveillance
Remote control of distributed production line	5G's guaranteed quality of service and ultra-reliable and low-latency network can support the time-critical operations in remote plants from a central command center
AI enabled and remote-controlled motion e.g., collaborative robots, self-driven cars, drones	5G's fast and reliable data transmission capabilities can deliver the sensing or remote-control abilities of these innovations with the right level of security
Real-time service and breakdown alerts	- Low latency of 5G network will also enable the real-time emergency shutdown of remote systems 5G will increase the effectiveness of monitoring and alert systems, leveraging its ability to connect more devices over more reliable and secure network
Remote operations/maintenance/training solutions through AR/VR	5G's ultra-low latency and high bandwidth will support the development of cloud-based, high resolution AR/VR services, driving adoption
Predictive/preventive maintenance	5G will enhance predictive/preventive maintenance capabilities as it will increase real-time data collection from many more devices supported by AI/analytics. 5G will also enable remote maintenance thanks to its low latency and high reliability

Source: Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=806 industrial companies.

The benefit of 5G adoption goes beyond facilitating operations on shop floors or at industrial campuses as it can extend seamless mobility across the entire supply chain.

The following are some use cases for supply-chain operations where 5G can add significant value.

Supply-chain operations	
Self-triggered order placement based on inventory level	 5G's ability to connect 10–100 times more devices with better security protocols and 99.999% availability will make these transactions more reliable
Virtual testing of parts and packing from suppliers	 3D X-ray imaging can be used to create extremely accurate digital replicas of manufactured components to verify their specifications remotely  5G's improved speed, ability to connect 100x more devices, and improved network reliability can make this use case commercially feasible
Remote monitoring of en-route shipment conditions (e.g., temperature and humidity)	 5G's ability to connect more devices with improved security will enhance the effectiveness of this use case

Source: Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=806 industrial companies.

Discussions we held with a number of organizations illustrate some compelling real-time applications:

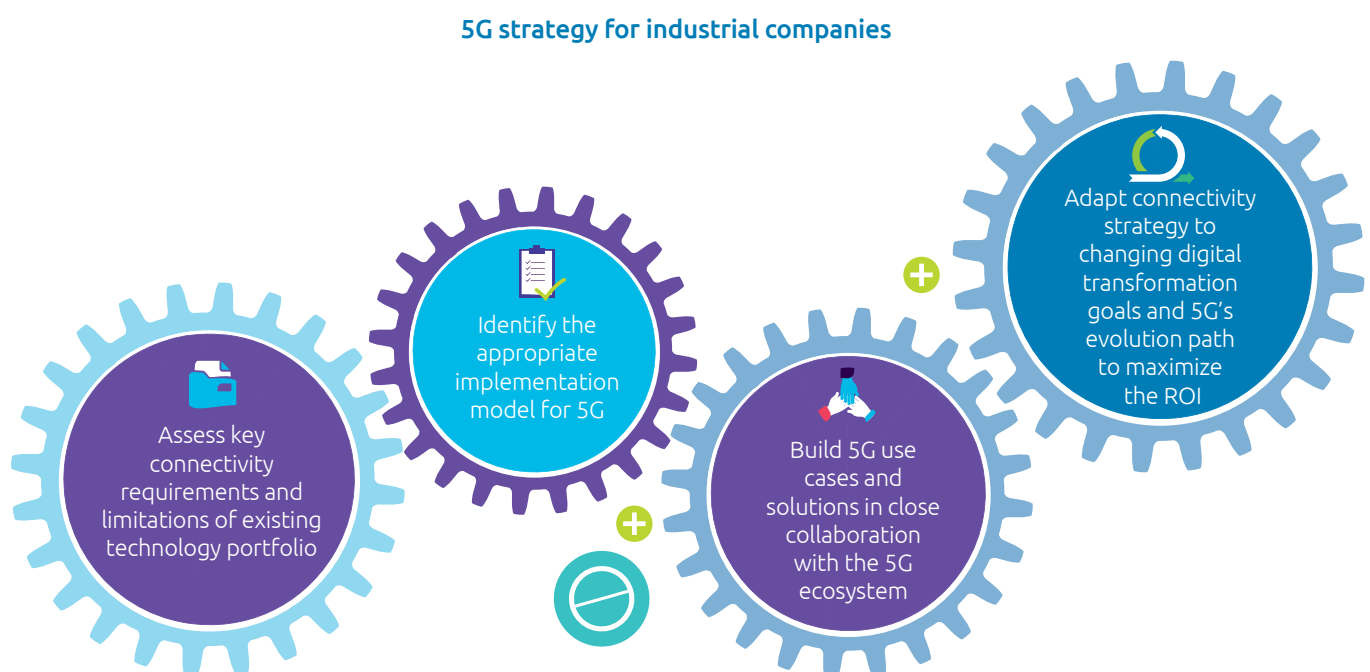
- **Real-time analytics leveraging edge computing:** *"For us, the most interesting feature of 5G is its ability to support massive IoT and edge computing, which is crucial for real-time interaction and decision making,"* says a top executive from a leading European railway company. *"Edge computing also enhances security by storing and processing data locally."*
- **Video surveillance of remote production lines:** Olivier Michelin from Eramet, a French multinational mining and metallurgy company, said, *"Today, in order to capture topographical data, we must fly the drone, capture the images, land the drone, manually retrieve the data, upload it to a computer, and then process it. 5G will allow us to streamline this process and have real-time processing of the images, saving significant time and cost."*²⁰
- **AI-enabled and remote-controlled motion, such as collaborative robots and self-driven cars:** *"We are currently working on adapting our infrastructure to automated guided vehicles (AGVs) and conducting test runs of AGVs for cleaning and waste management. In the future, we might even broaden the scope of their usage,"* says Rafael Fernández García, Innovation and Digital Strategy Director at Ferrovial – a Spanish transport infrastructure organization. *"In our opinion, the ability of the 5G network to provide below-ten-millisecond latency can add a lot of value to our AGV use cases."*²¹

How to get strategic value from 5G?

Below, we outline the optimum strategy for our two industries – industrial companies and telcos – to deliver on 5G’s potential.

Strategy for industrial companies

Figure 14. 5G strategy for industrial companies



Source: Capgemini Invent, Capgemini Research Institute analysis.

Assess key connectivity requirements and how the existing technology portfolio limits critical use cases

Connectivity is a significant challenge in manufacturing. We found that 44% say it affects their overall digital transformation. The executives we spoke to told us that problems ranged from lack of coverage and signal robustness to the difficulties of achieving real-time interactions.

Organizations need a clear picture of where their current technology portfolio would be challenged by the use cases they want to pursue. This means identifying the specific connectivity pain points for prioritized use cases, analyzing which connectivity technology is causing the problem, and building a full understanding of whether 5G holds the answer.

Build 5G use cases and solutions in close collaboration with the 5G ecosystem

Operationalizing a new technology is always challenging. Problems range from device compatibility and retrofitting software being thin on the ground to process re-engineering to skill gaps.

Building use cases and undertaking pilot programs in tandem with organizations from the 5G ecosystem can overcome these sorts of challenges. For example, collaboration with equipment vendors can provide access to compatible devices. And collaboration with telecom operators can help identify the ideal connectivity parameters for prioritized use cases.

Identify the appropriate implementation model for 5G

The opportunity with private 5G networks, which we discussed in section 2, opens up two implementation paths: private or public networks. Companies must think carefully before proceeding down a path and need to take into account the following factors:

Strategic fit: The key value propositions of a private or dedicated network include: the flexibility to develop customized solutions, control over the network, and security. For public network, the value lies in the flexibility to scale up the capacity and minimal capital expenditure. Organizations need to understand which features are more aligned with their strategic objectives.

Capabilities: To run a private network, you will need to be able to operate and maintain networks – either by outsourcing or in house. Organizations, therefore, should critically consider the cost and time implications of acquiring these capabilities.

Total cost: Organizations need to carefully evaluate the total cost of both implementation models. Initial capital expenditure is required to set up private networks. However, the accumulated, multi-year cost of industrial solutions over public networks might be even higher than establishing a small-scale private network.

Adapt your connectivity strategy to changing digital transformation goals and 5G's evolution path to maximize ROI

Organizations' digital transformation goals will evolve and change over time. They therefore need to re-examine their connectivity requirements at regular intervals, at least for the

priority use cases. This will allow them to identify potential connectivity pain points and possible solutions.

Because of its features, versatility, and flexibility, 5G can eventually become the standard communication technology, replacing various technologies (both wireline and wireless) currently in use. However, companies need to bear in mind that 5G is an emerging technology, and features such as network slicing or guaranteed quality of service will not be immediately available. Also, 5G's coverage will require many years to reach that of 4G networks.

As 5G becomes available in more locations, and its advanced features are rolled out, the applicability of 5G to critical use cases will continue to increase. Thus, the ROI of 5G adoption depends heavily on 5G's evolution path. *"On paper, network slicing is very promising. But let's remember that at this stage, the 5G spectrum is still not available in France. There is no service model, operating model, or even end-to-end testing. We are at the beginning of the 5G story; everything still has to be built and proven,"* says Sébastien Kaiser, director, connectivity & networks at SNCF, the national railway company of France.²²

With the help of connectivity partners, industrial companies need to continuously adapt their connectivity strategy by analyzing the upgradation cost and availability of specific 5G services (e.g., fine-tuned network slice) to maximize the ROI of 5G adoption by use case or location.

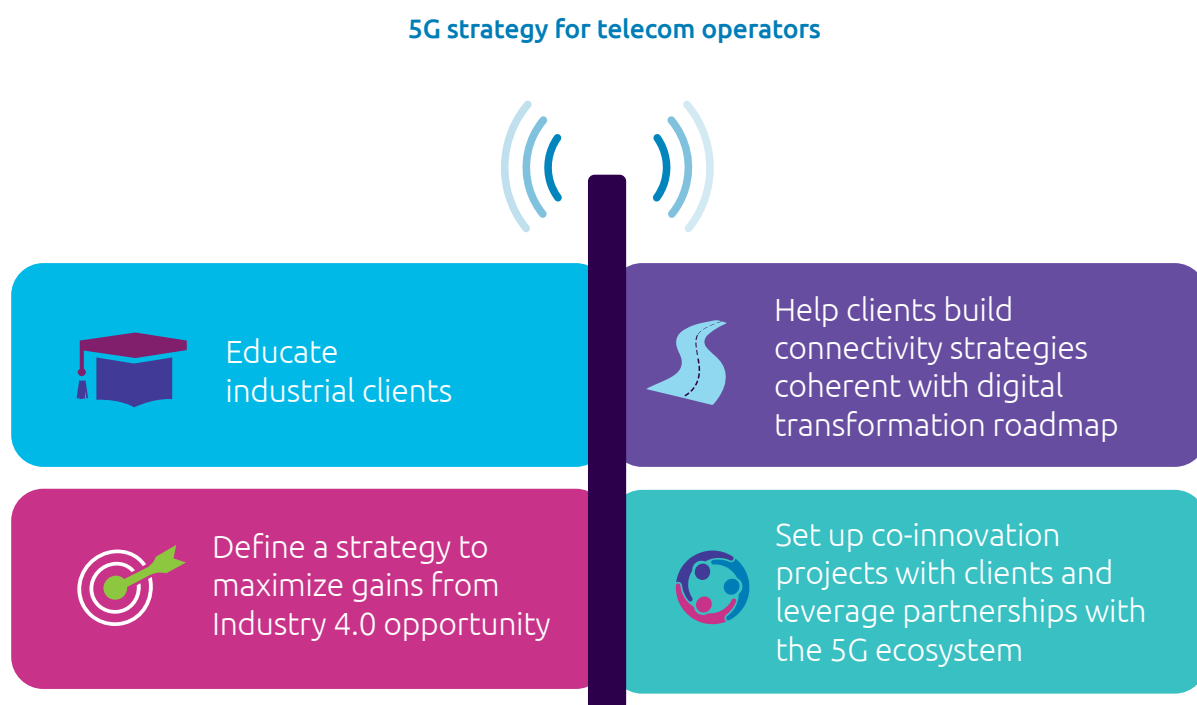


On paper, network slicing is very promising. But let's remember that at this stage, the 5G spectrum is still not available in France. There is no service model, operating model, or even end-to-end testing. We are at the beginning of the 5G story; everything still has to be built and proven."

- Sébastien Kaiser, Director, Connectivity & Networks at SNCF.

Strategy for telecom operators

Figure 15. 5G strategy for telecom operators



Source: Capgemini Invent, Capgemini Research Institute analysis.

Educate client companies

As we saw in Section 1, different 5G features will be available at different times. Telecom operators need to manage client expectations by educating them about these timelines. This process of education also needs to embrace improving clients' understanding of 5G. Our interviews revealed gaps in companies' understanding as a number of executives reported that their technical teams lack in-depth knowledge on 5G, even though their understanding of other commercially available wireless technologies is pretty sound.

Telecom players need to play a proactive role in helping their clients' technical departments develop this in-depth understanding, which will then support business case development.

Help clients build connectivity strategies that are coherent with their digital transformation roadmap

Industrial companies generally use a wide array of connectivity technologies. While technologies such as WI-FI and Bluetooth

have been around for a long time – and their limitations are understood – 4G and IoT technologies, such as LTE-M²³ or NB-IoT,²⁴ still have a lot of potential and might not require an immediate upgrade to 5G. It is difficult for industrial companies to determine which technologies are ideal for 5G migration and at what point of time. *"As we work on our connectivity roadmap strategy, the model is not fully decided yet. 5G is obviously part of the thinking process so that we avoid any investments that could become obsolete when 5G arrives,"* says Jean-Christophe Oulie, head of wireless connectivity at Airbus.²⁵

Telcos need to use their expertise to help clients build a connectivity strategy best-suited for their digital transformation roadmap and identify the optimal path to 5G migration. This will require two key activities:

- Understanding clients' target state of digitization and the time horizon to achieve it
- Analysis of connectivity technologies their clients currently use

Define a strategy to maximize gains from the Industry 4.0 opportunity

To capture a sizeable share of the Industry 4.0 opportunity, operators need to accelerate the test and build of a portfolio of connectivity/digital solutions. These can range from fully dedicated PMR networks (dedicated spectrum/radio/core network/private cloud) to “public” solutions leveraging macro networks, edge computing, and network slicing. This starts with the current private/dedicated LTE and 4G – which currently addresses most advanced requirements – but with a clear evolution path to 5G. There are a number of solutions for telcos to consider:

Managed services and solutions for private 5G network: As we discussed in Section 2, many large industrial companies – such as Audi, BASF, and Siemens – are actively looking to set up private 5G networks. Telcos need to position themselves as their partners – offering them managed services and tailor-made networking solutions for managing and maintaining their private networks.

Targeted rollout of 5G for industrial campuses: Also, rollout of 5G across a large geographical area will take significant time. Our survey finds that only 37% of operators feel that they have the right portfolio of radio site towers for 5G. The share of operators who feel that they are well-equipped with backhaul network infrastructure is even lower – 33%.

However, telcos can still meet their clients’ demand for 5G by rolling it out for a selected group of smaller areas, such as the industrial campus. The attraction of 5G solutions for the industrial campus is enhanced by the fact that around 80% of industrial companies we surveyed are willing to share the load of capex for their 5G connectivity.

Rollout of open connectivity platforms: Telcos’ 5G solutions for Industry 4.0 should also include connectivity “platforms,” which are open to third-party service providers with APIs and facilitate the integration of advanced connectivity services for bespoke digital transformation solutions.

Set up co-innovation projects with clients and leverage partnerships with the 5G ecosystem

Telecom operators need to evolve from being service providers to digital transformation partners. This involves three key activities – understanding industrial companies’ business needs, translating those needs into solutions, and taking the lead in implementing the solutions.

Our research has revealed a number of perception gaps that exist between industrial operators and telecom service providers. For example, more than 50% of industrial operators told us that making operations more secure is one of the key business rationales for 5G adoption (see Figure 5), but only around a third of telcos believe this to be the case. Similarly, manufacturing executives believe that real-time analytics, leveraging edge-computing, is the use case where 5G can add maximum value. However, this use case ranks considerably lower in the eyes of telcos.

Co-innovation projects, beginning with the ideation and proof-of-concept phases, can help to bridge these sorts of perception gaps. Once clients’ business needs are clear and perception gaps are closed, telcos need to play an active role in collaborating with the 5G ecosystem to create customized, fast, and end-to-end solutions for industrial clients. In this way, they create a win-win business model for all players in the value chain.

Telefónica España, for example, has been actively engaging with the 5G ecosystem. *“At a larger scale, we need to create an ecosystem around 5G,”* explains Alexis Hostos, product strategy manager at this leading telco player. *“We are meeting partners, startups, innovative companies that will help us keep evolving our service portfolio and adding value to their commercial offers.”*²⁶

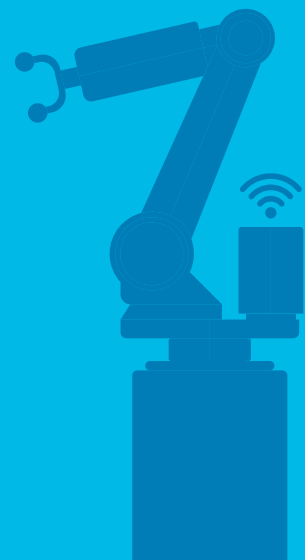


Conclusion

There has been considerable interest in 5G, the features it offers, and its disruptive potential. Our research shows that industrial companies believe in the transformative potential of this technology and are willing to quickly adopt it once it becomes available. 5G offers a wide variety of use cases, ranging from shop floor to supply chain to product and service management. It will support the reliable, secure, real-time, high-speed transmission of data, transforming the potential of a multitude of applications.

However, while these companies want to adopt 5G within two years, we find that telecom operators believe that it will take at least five years for large-scale adoption of features such as guaranteed quality of service or network slicing. These are the areas that hold rich potential for enterprise applications. This slow progress, as well as an appetite for greater autonomy and security, are creating a situation where industrial companies are considering applying for their own private licenses.

To exploit 5G's potential to digitally transform organizations, industrial companies and telecom companies need to collaborate more closely. They need to identify the areas where 5G can add value, both in the immediate and longer term, and design the right implementation road map. By working closely, the two sides can avail the full potential of this transformative technology.



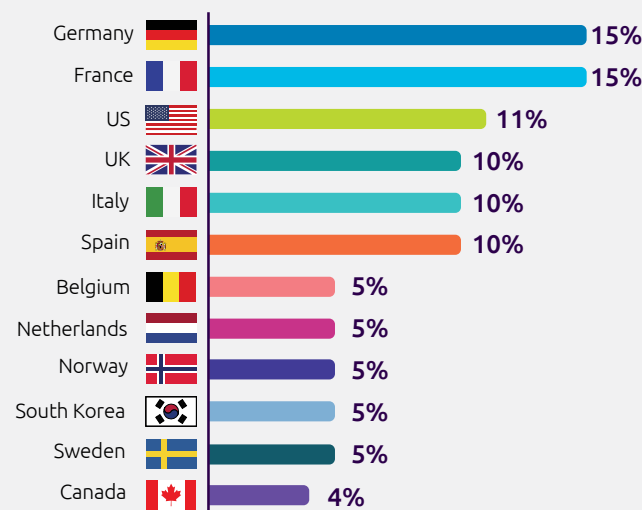
Research Methodology

We conducted extensive primary research from April to March 2019.

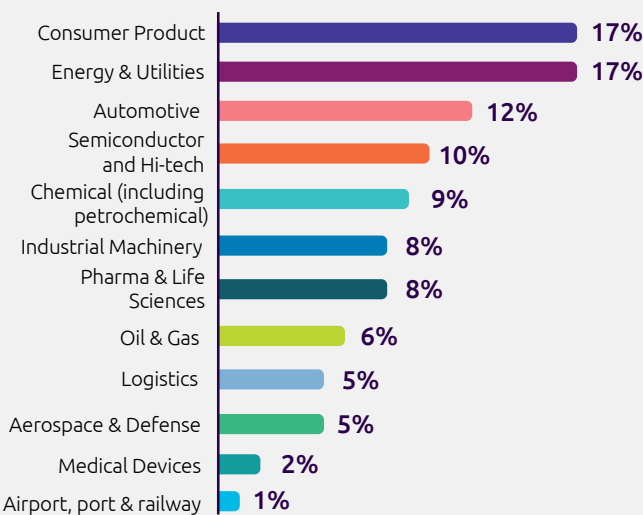
Industrial companies

We surveyed 806 executives from industrial companies with revenue greater than \$500 million in FY 2017 – 18/last fiscal year. Ninety-one percent of the organizations reported revenue of more than \$1 billion.

Organizations by country

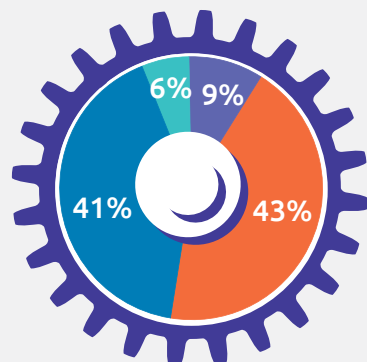


Organizations by sector



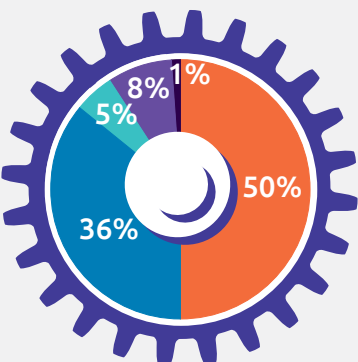
Source: Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=806 industrial companies.

Organizations by revenue



Below USD \$1 billion USD \$1 billion–\$2 billion
USD \$2 billion–\$10 billion More than USD \$10 billion

Executives by designation



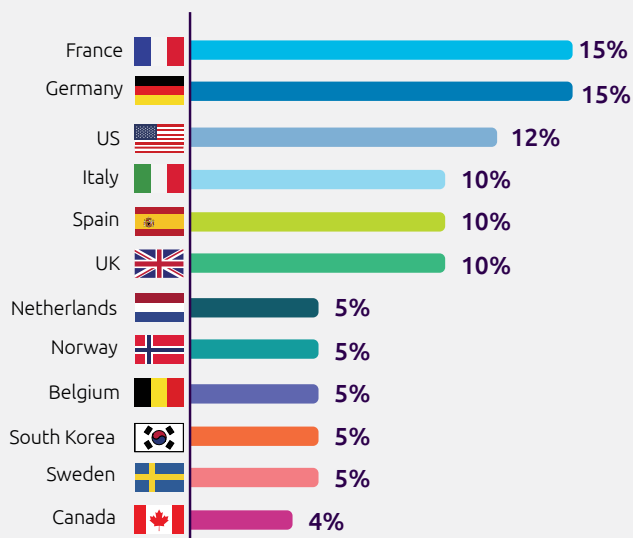
Senior Director Director VicePresident
Senior Manager President

Source: Capgemini Research Institute, Industrial companies' survey on 5G, March–April 2019, N=806 industrial companies.

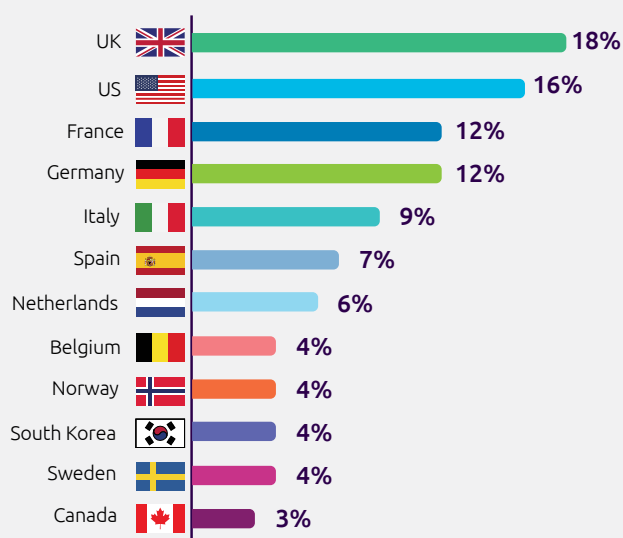
Telecom companies

We surveyed 150 executives from 68 telecom companies with revenue greater than \$1 billion in FY 2017 – 18.

Respondents by country

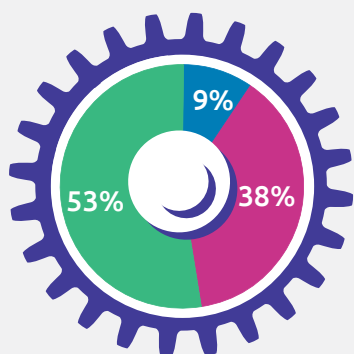


Organizations by country

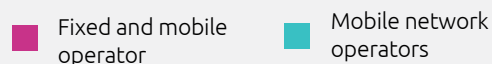
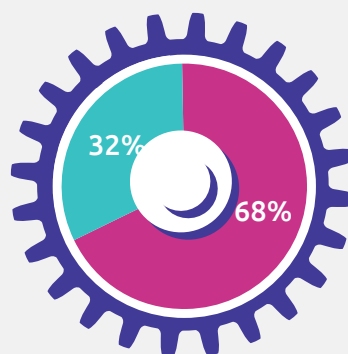


Source: Capgemini Research Institute, Telecom operators' survey on 5G, March–April 2019, N=68 organizations, 150 respondents.

Organizations by revenue



Organizations by type of operation

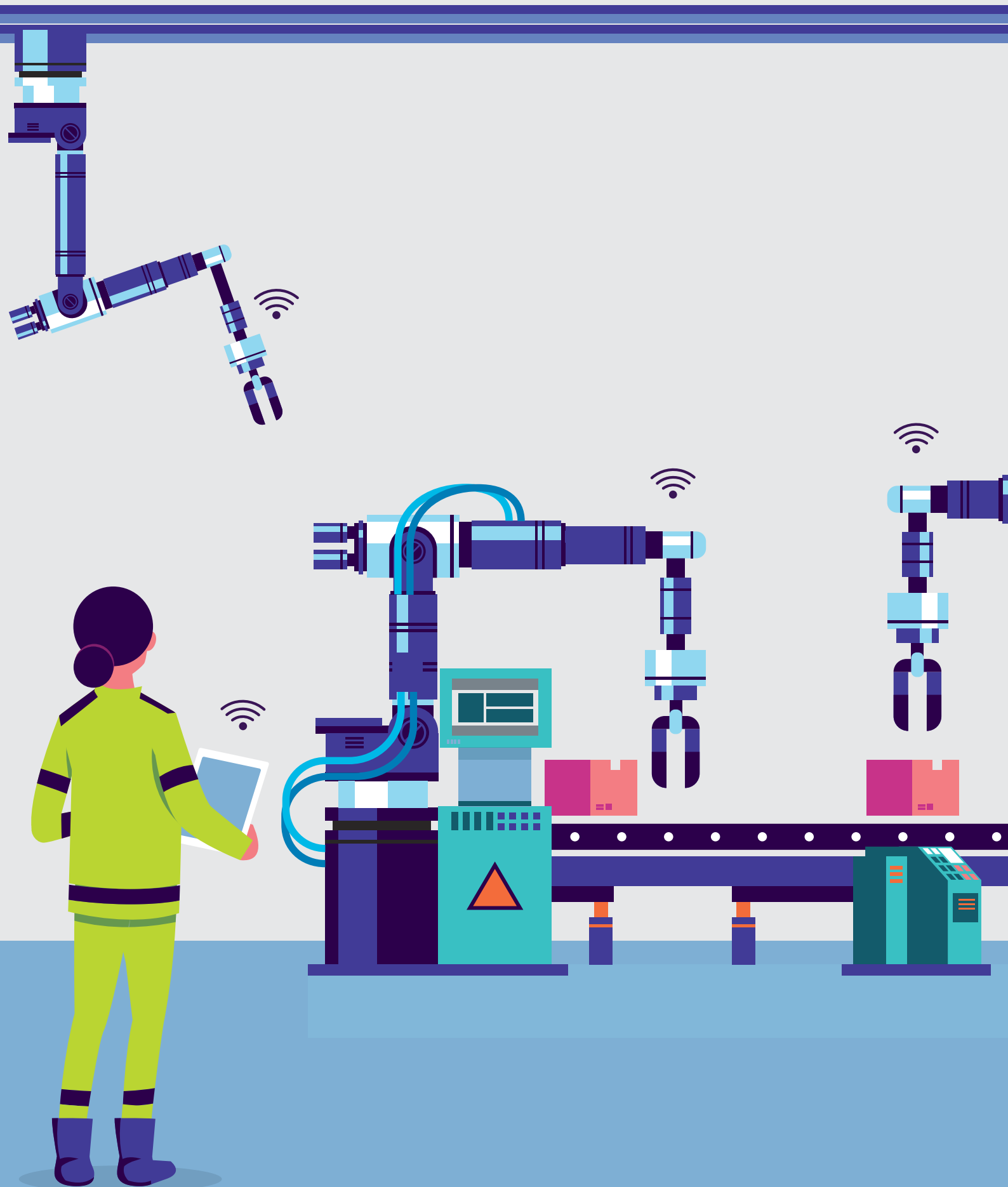


Source: Capgemini Research Institute, Telecom operators' survey on 5G, March–April 2019, N=68 organizations, 150 respondents.

We have also conducted interviews with more than 20 industry and telecom executives to understand the interest on 5G from industry, readiness from the telecom sector and challenges in adoption among others.

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Some of our sites are geographically huge and it will be quite costly to roll out WI-FI. So, we started looking at cellular connectivity solutions, and 5G - along with all the promises that come with it - is definitely going to impact our decision."

- Stig Are Remmen, OT/IT convergence lead at Yara International

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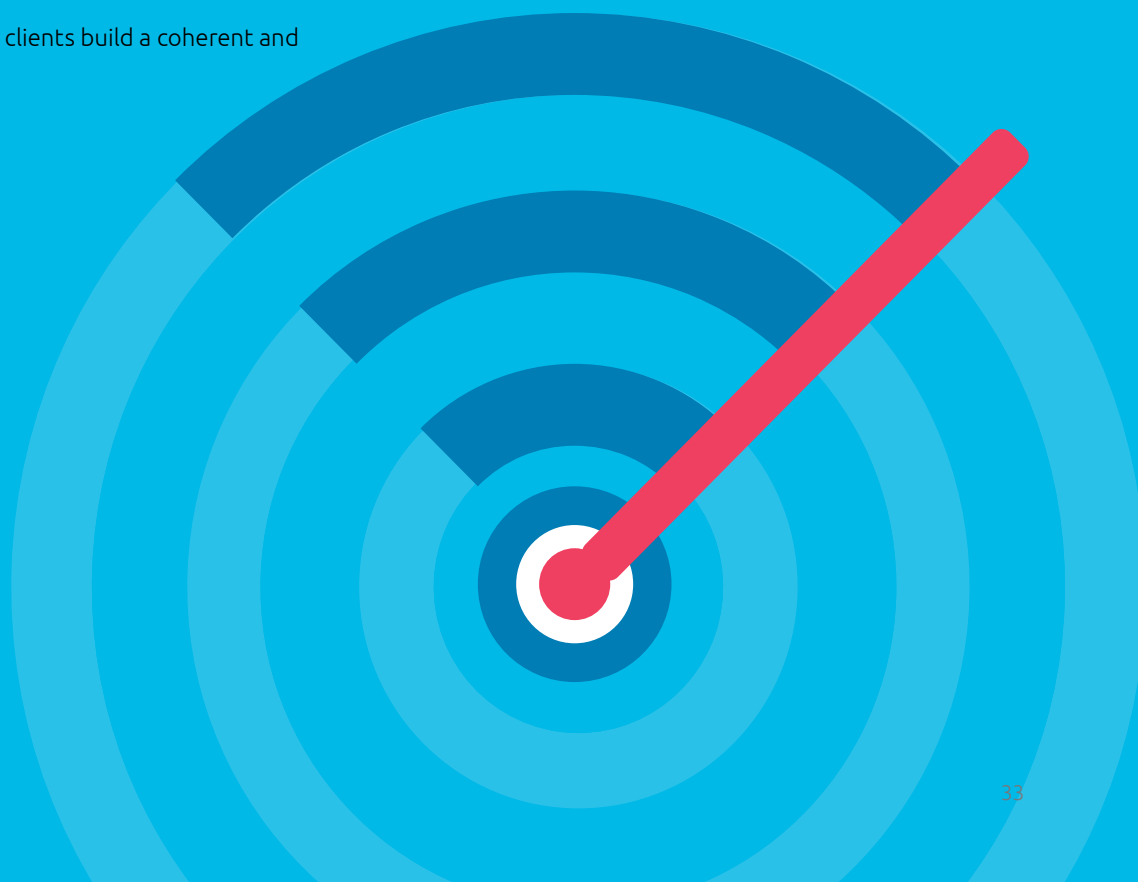
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- Proof of value design and delivery: supporting telecom and vertical players in experimenting and piloting innovative use cases
- Integrating devices, platforms, and building and industrializing vertical solutions, from IT to business process transformation and assessing the impact on organization and skills.

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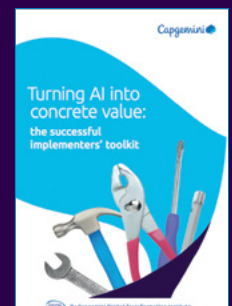
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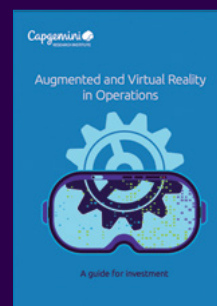
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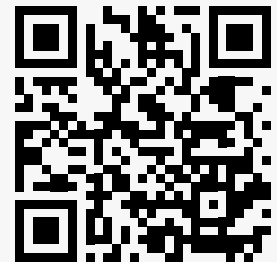
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