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RESEARCH INSTITUTE

Accelerating the

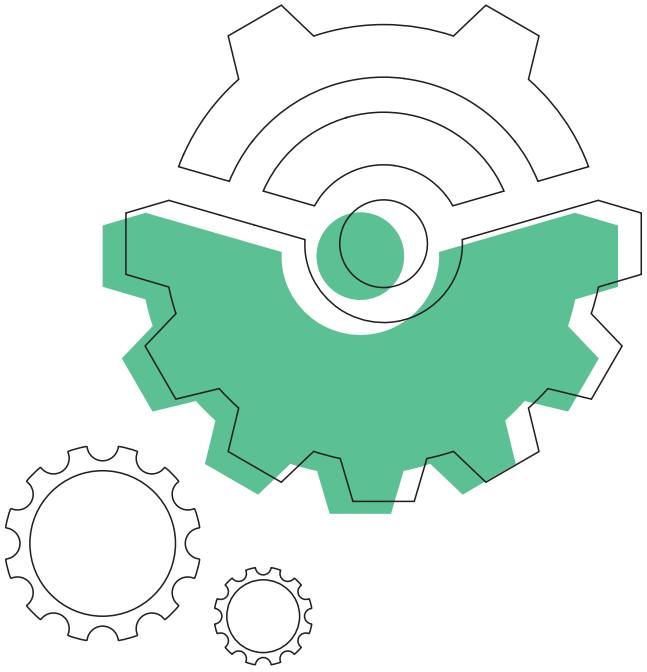
# 5G Industrial Revolution

State of 5G and edge in industrial operations

# Introduction

5G is widely recognized as a cornerstone of Industry 4.0 and a driver of digital innovation. When we examined this issue back in our 2019 research, three-quarters of industrial organizations saw 5G as a key enabler of digital transformation.[1] Highlighting the key role that 5G is expected to play in industrial operations, Eckard Eberle, CEO of process automation at Siemens, says, *"Industrial 5G is the gateway to an all-encompassing, wireless network for production, maintenance, and logistics. High data rates, ultra-reliable transmission, and extremely low latencies will allow significant increases in efficiency and flexibility in industrial added value."*[2] Our previous research also revealed a strong appetite for speedy 5G adoption among industrial organizations. Almost two thirds (65%) planned to implement 5G within two years of availability.[3]

Since 2019, commercial 5G services have been rolled out in many parts of the world, and the mid-2020 launch of "Release 16" – the latest 5G specifications – has paved the way for a range of industry use cases. Therefore, this research seeks to explore whether 2019's high level of interest has translated into on-the-ground adoption and what lessons have emerged for early adopters.



To investigate these areas, we surveyed senior executives from 1,000 industrial organizations that plan to adopt 5G as part of their operations, and 150 senior executives from 75 telecom organizations that have rolled out or are planning to roll out 5G networks. Our survey covered organizations from the US, the UK, Germany, France, Italy, Spain, Sweden, the Netherlands, Belgium, Luxembourg, South Korea, China, Australia, and India. We also conducted in-depth interviews with 25 senior executives.

We found that industrial organizations are at the early stages of 5G adoption. Most organizations that intend to adopt 5G are at the planning and ideation stages and less than a third (30%) have progressed to trials and real-world implementations. However, early adopters have already begun to realize business benefits. Early 5G trials and implementations have delivered promising results and organizations are optimistic about the opportunities that 5G offers. However, to make the most of 5G's potential, organizations will need to address a number of challenges.

To understand the current state of play, and how industrial organizations can accelerate their 5G implementations, this research looks at the following areas:

1. Where industrial organizations stand today in their 5G journey
2. The benefits that industrial organizations are deriving from their 5G implementations
3. The use cases that are generating business impact
4. The challenges that are holding back more widespread adoption of 5G
5. The path to more rapid industrial adoption of 5G and how telcos can aid their industrial clients in their 5G journey.

# Executive Summary

## These are early days for industrial 5G adoption

- The majority of industrial organizations that want to implement 5G are currently at the ideation and planning stages, and less than a third have moved to the pilot stage and beyond.
- 40% of industrial organizations expect to roll out 5G at a single site within two years.
- Private 5G networks are the most preferred model of industrial 5G implementation overall.
- Industrial organizations view edge computing as key to realizing the full potential of 5G.
- Telcos are aligning their enterprise 5G strategy with the demand for private 5G networks and 5G-based edge computing services.

## The experience of early adopters indicates that 5G is proving its value

- 5G features have matched or exceeded expectations for the majority of early adopters.
- 5G trials and early implementations are already delivering strong business benefits – as many as 60% of early adopters say that 5G has helped them realize higher operational efficiency.
- Key use cases that are generating business impact include the use of 5G to conduct video-based quality inspection, remotely control and operate machinery, run AGVs and other autonomous robots, and enable remote collaboration using AR/VR-based applications.
- Industrial organizations are optimistic that 5G will drive revenues going forward by enabling the introduction of new products, services, and business models.

## However, most industrial organizations are struggling with various aspects of 5G adoption

- Challenges with integrating 5G with existing networks and systems, identifying the right 5G use cases, accessing vertical-specific solutions, managing cybersecurity, and orchestrating a multi-vendor environment are some of the key barriers that industrial organizations face with 5G implementations.

## Organizations are conscious of the environmental impact of 5G implementations

- 5G offers many direct and indirect environmental benefits through its inherently energy-efficient design, and its ability to enable environmental and sustainability focused use cases (e.g., energy monitoring via massive sensor networks).
- However, 5G also poses certain environmental concerns due to increased carbon emissions from increased data center operations (to process the increased volumes of data from 5G-capable devices) and from the manufacture and use of endpoint devices.
- 51% of industrial organizations are concerned about the potential negative environmental impact of 5G.
- More than two thirds (67%) plan to take the sustainability credentials of 5G operators, vendors, and suppliers into account as part of their 5G procurement decisions.

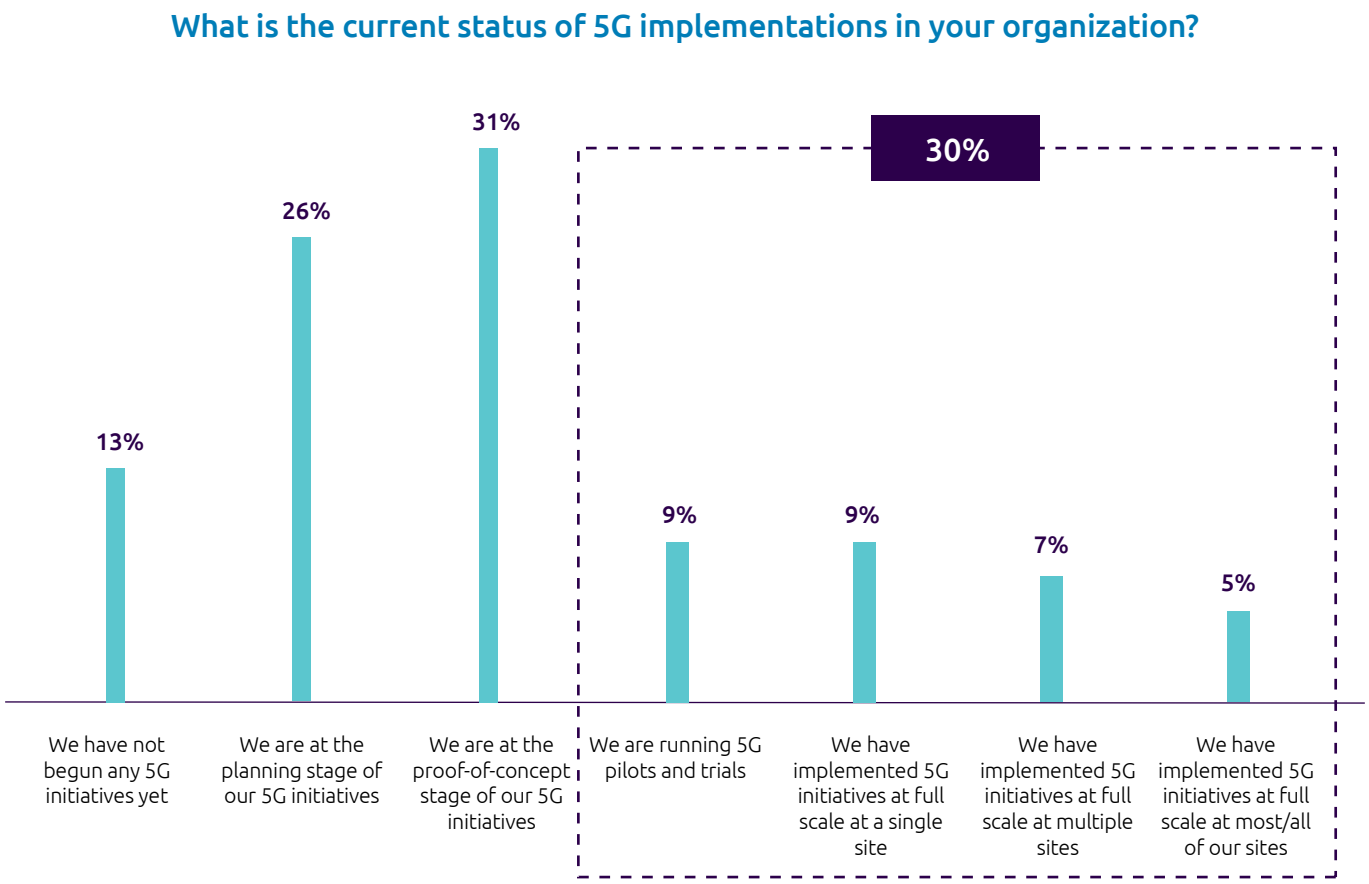
## Accelerating the pace of 5G adoption will require concerted effort, and telcos can play a key role in aiding their industrial clients' 5G journey

- Industrial organizations need to build a clear picture of the capabilities that 5G and edge computing offer and where they can truly add value. They also need to identify the network deployment models (e.g., private, hybrid, public networks) that will best fit their business needs and evaluate the trade-offs involved in each. Industrial organizations should also seek to leverage external ecosystems to tap into shared expertise, and to jointly test and validate the benefits of 5G.
- Telcos must work on helping industrial organizations visualize the impact of 5G and select the right use cases, offer a portfolio of solutions targeted at multiple network deployment scenarios, expand the availability of vertical-specific solutions, and build trusted relationships with ecosystem partners to offer end-to-end solutions and services to industrial customers. Telcos must also help industrial clients understand the security implications of various network deployment scenarios and build the necessary countermeasures.

# These are early days for industrial 5G adoption

Our research shows that most industrial organizations that intend to adopt 5G are currently in the planning and ideation stages. Less than a third (30%) have progressed to trials or real-world implementations (see Figure 1).

**Figure 1** Status of 5G implementations in industrial organizations




**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=1,000 industrial organizations that have adopted or are planning to adopt 5G.

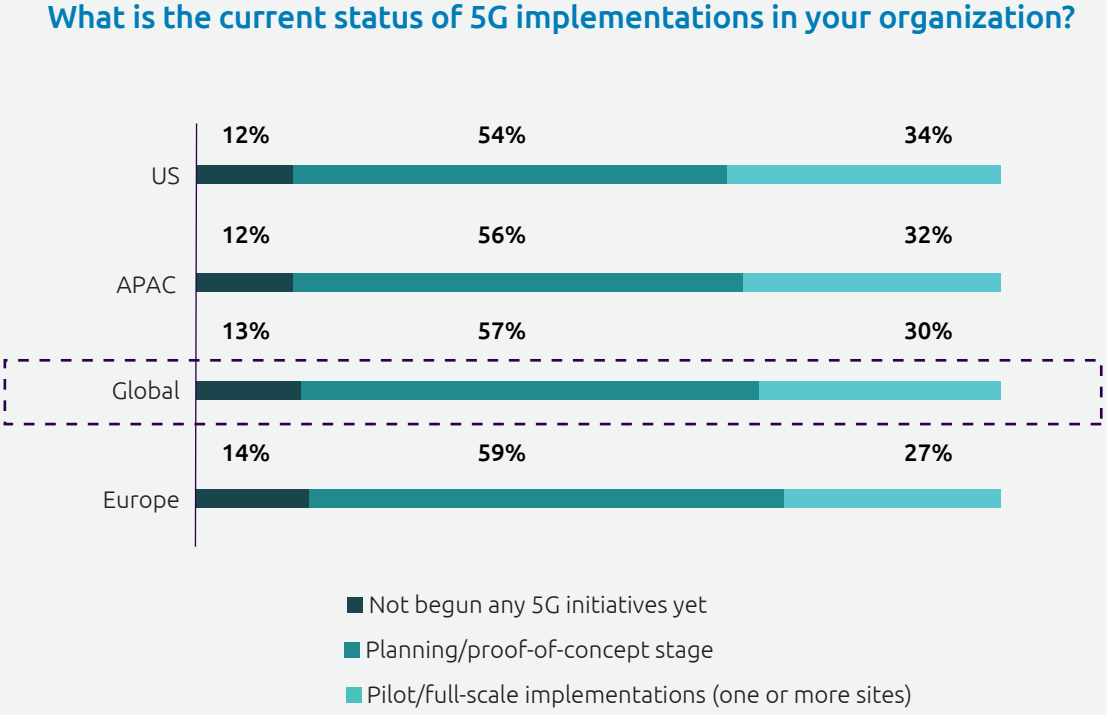
On a regional basis, as Figure 2 shows, the US leads the way, with 34% of industrial organizations having progressed to trials and implementations. Within Asia Pacific, where 32% are at trial and implementation, South Korea stands apart.

We found that 43% of industrial organizations in the country are conducting 5G trials and implementations – the highest among the countries covered in our survey.

## Status of industrial 5G adoption

- **By region**

**Figure 2** Status of industrial 5G adoption by region




**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=1,000 industrial organizations that have adopted or are planning to adopt 5G.

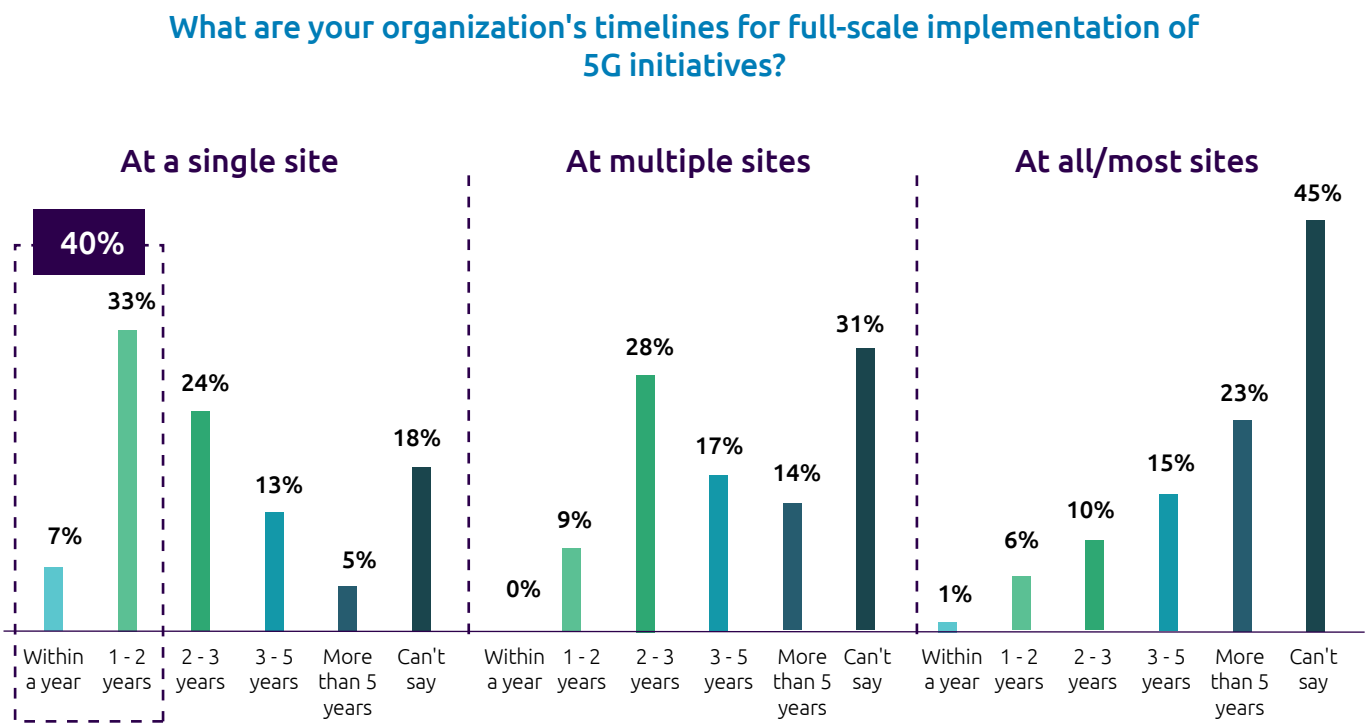
- **By sector**

**Figure 3** Status of industrial 5G adoption by sector


**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=1,000 industrial organizations that have adopted or are planning to adopt 5G.

Overall, 40% of industrial organizations in our survey expect to roll out 5G at scale at a single site within two years (see Figure 4). However, wider implementation of 5G is expected to take longer. Only 9% of industrial organizations expect to roll out 5G across multiple sites within two years. In addition, a significant proportion of organizations are unclear about the time that it will take to implement 5G at scale on a wider basis. For instance, 31% of industrial organizations do not have visibility on when 5G will be rolled out at scale across multiple sites (see Figure 4).

**Figure 4** Timelines for 5G adoption at scale




**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=789 industrial organizations that are at the pilot or earlier stages of 5G adoption; N=875 industrial organizations that have implemented 5G at a single site or are at the pilot or earlier stages of 5G adoption; N=946 industrial organizations that have implemented 5G at scale at multiple sites, single site, or are at the pilot or earlier stages of 5G adoption.

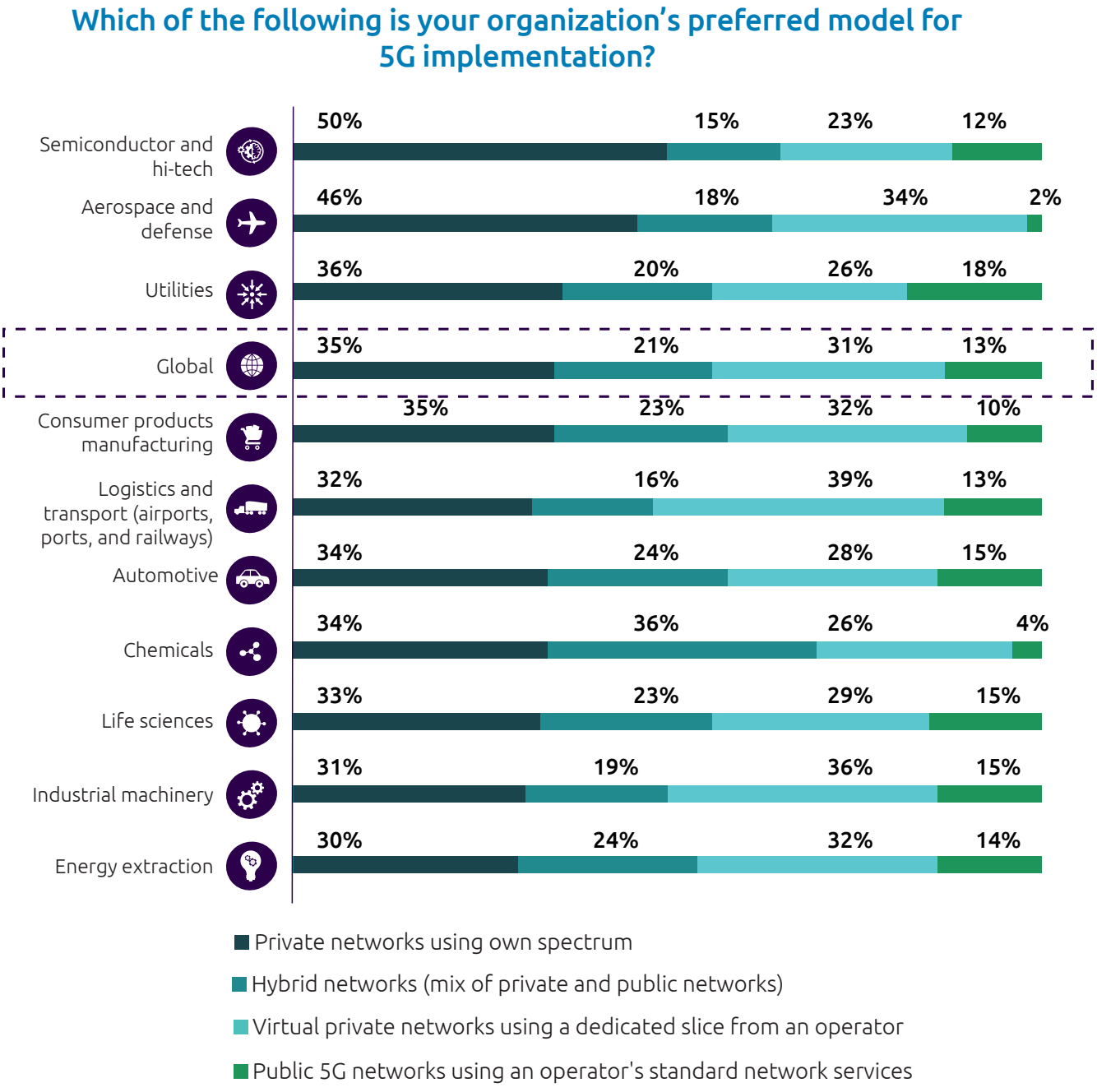
## More than a third of industrial organizations prefer to deploy private 5G networks

Private 5G networks are the preferred model of industrial 5G implementation overall (by that we mean 5G networks set up within an industrial site or campus using privately purchased 5G spectrum or leasing an operator's spectrum in countries where industries cannot purchase their own private spectrum). More than a third (35%) of industrial organizations in our survey prefer private 5G networks compared to alternate implementation models (see Figure 5). Given that they are physically isolated from public networks, private 5G networks provide organizations with complete control over their networks and data. In addition, they promise higher performance levels given that they are free from wireless interference. We found that 58% of organizations see higher performance as a major driver of private network adoption.

Our research also shows that interest in private 5G networks spans sectors and is led by the semiconductor and high-tech sector (see Figure 5). Highlighting the benefits of private 5G networks, Albert Chen, senior vice president at Taiwan-based IT hardware manufacturer Inventec – which was the first to

roll out a private 5G network in Taiwan – says, *"As the most critical component of IoT and Smart Manufacturing, connectivity must be ubiquitous, reliable, and secure. After evaluating some of the more traditional approaches, we realized that the implementation of our own Private 5G network was the best way to ensure we had 'always on' coverage."*[4]

**Figure 5** **Preferred 5G implementation models**




**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=1,000 industrial organizations that have adopted or are planning to adopt 5G.

# 35%

## Share of industrial organizations that prefer to deploy private 5G networks

The regulatory environment – in areas such as spectrum policy – has evolved to meet the demand for private 5G networks, including in Germany, France, the UK, Japan, and the US. Many large industrial firms in Germany, for instance, have already applied for local 5G licenses and are rolling out private networks. In November 2020, Bundesnetzagentur (BNetzA) – the German telecoms regulator – announced that it had received 93 applications over the course of the year for the 3.7 GHz-3.8 GHz spectrum set aside for private 5G networks and had granted 88 licenses. These include companies across sectors, including automakers Audi and Mercedes Benz, chemicals manufacturer Evonik Industries, and power grid and gas network operator Netz Leipzig GmbH.[5]

Bosch, for instance, has rolled out a private 5G network (also referred to as a "campus network") at its main Germany factory in Stuttgart-Feuerbach. The goal is to run critical industrial applications that require high levels of precision and safety. The private 5G network provides Bosch with ubiquitous coverage at the plant, the ability to tailor the network according to the requirements of various applications, and the ability to benefit from 5G's high reliability, low latency, and faster data transfer rates – all while maintaining complete sovereignty over data. *"Campus networks give us control – over what happens in the factory and over how data is transferred both within and beyond the factory walls,"* says Dr. Michael Bolle, member of the board and CDO/CTO at Bosch. Bosch views private 5G networks as a critical building block of its Industry 4.0 strategy and plans to roll them out progressively across all its 250 plants worldwide.[6]

**Figure 6** Across sectors, industrial organizations are experimenting with private 5G networks

**Ford** has deployed a private 5G network at its plant in Essex, UK in partnership with **Vodafone**

**BASF** will install the first 5G private network in the Spanish chemical industry in collaboration with **Cellnex**

**Associated British Ports (ABP)** is partnering with Verizon to equip the UK **port of Southampton** with a private 5G network

**Centrica** is implementing a private 5G network at its gas storage and processing unit in the UK in collaboration with **Vodafone**

**Sandvik Mining and Rock Technology** has implemented a private 5G network in a test mine in Finland

**Bosch** has set up a private 5G network in partnership with **Nokia** at its Stuttgart-Feuerbach factory in Germany

**Source:**
TM Forum, "5GEM use case: Ford deploys real-time process analysis & control," February 2021.
Cellnex Telecom, "BASF and Cellnex will bring 5G technology to the Tarragona production centre," November 2020.
ABP, "Verizon Business signs its first European Private 5G contract with Associated British Ports," April 2021.
Vodafone, "Centrica chooses Vodafone to build 5G mobile private network for gas plant," August 2020.
Mining Global, "Sandvik introduces Nokia 5G wireless at test mine in Finland," June 2020.
Bosch, "Bosch puts first 5G campus network into operation," November 2020.

Close to a third of industrial organizations (31%) is also open to virtual private 5G networks – i.e., 5G networks that are set up using a dedicated slice of a wireless service provider's public 5G network. While they are not physically isolated, and therefore do not provide the same complete control over networks and data as private 5G networks, they provide increased security, privacy and control compared to standard public 5G services (which they achieve by allowing network traffic to be isolated virtually). These are key requirements for industrial organizations as highlighted by Hesham Noman, IoT & connectivity architect at TotalEnergies: *"In the end, based on the use case, going to public networks will depend on the service level and the economic value provided by operators using network slicing. If we don't have enough autonomy, reliability, and security, it will be difficult to proceed with 5G in public networks even with network slicing. So, it will depend mainly on what operators will be able to guarantee."*

Our research also revealed an interest in shared district networks – a model where a 5G network is shared among organizations that are part of an industrial district – as an alternative to private networks. Nearly a quarter (24%) of industrial organizations are open to opting for such shared district networks. Orange Belgium, for instance, has set up a 5G network at the Port of Antwerp as a 5G test center for large industrial organizations located around the port. The 5G campus is being used jointly by chemical companies BASF, Borealis and Covestro, as well as the Port of Antwerp, to test 5G applications. At the campus, 5G's network slicing feature is used to ensure that each organization's traffic is kept isolated from others.[7]

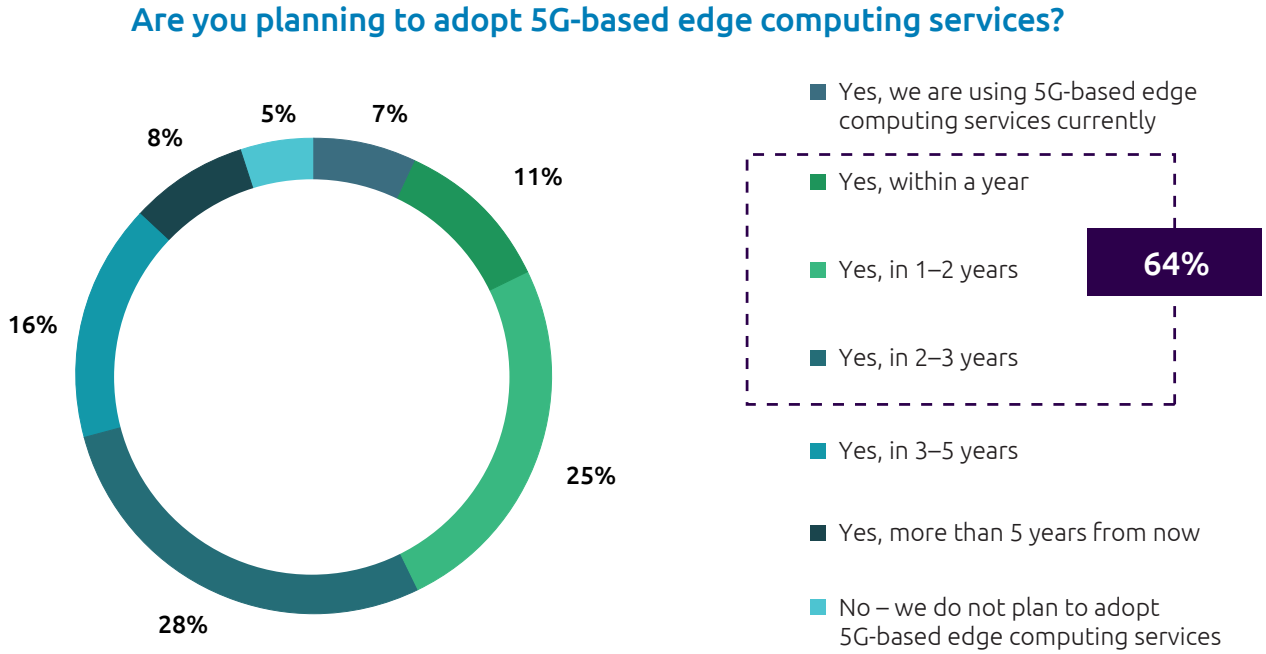
## Industrial organizations view edge computing as key to realizing the full potential of 5G

5G offers a significant reduction in latency and improvements in network performance over existing connectivity technologies. This is vital for time-sensitive and mission critical applications within a network. However, 5G enables this for the last mile of data transmission – for example, between the tower and the endpoint. Much of this gain in performance and speed is lost if data needs to travel from the tower to a remote cloud location for further processing and then return to the source.

Edge architecture offers significant improvements by enabling advanced data processing on-premise and avoiding the latency introduced by remote cloud locations. AT&T, for instance, found that moving data processing from the cloud to a local edge network using 5G can decrease latency by 10x, from 60 milliseconds to six milliseconds in one test.[8]

Organizations are aware of the role of edge computing in their 5G initiatives. Our research found that close to two thirds (64%) of organizations plan to adopt edge computing services within three years, while a small share (7%) of organizations are already using 5G-based edge computing services (see Figure 7). Gartner expects three-fourths of enterprise data to be generated and processed at an edge location by 2025, up from around 10% in 2018.[9]

**Figure 7** **64% of industrial organizations plan to adopt 5G-based edge computing services within the next three years**



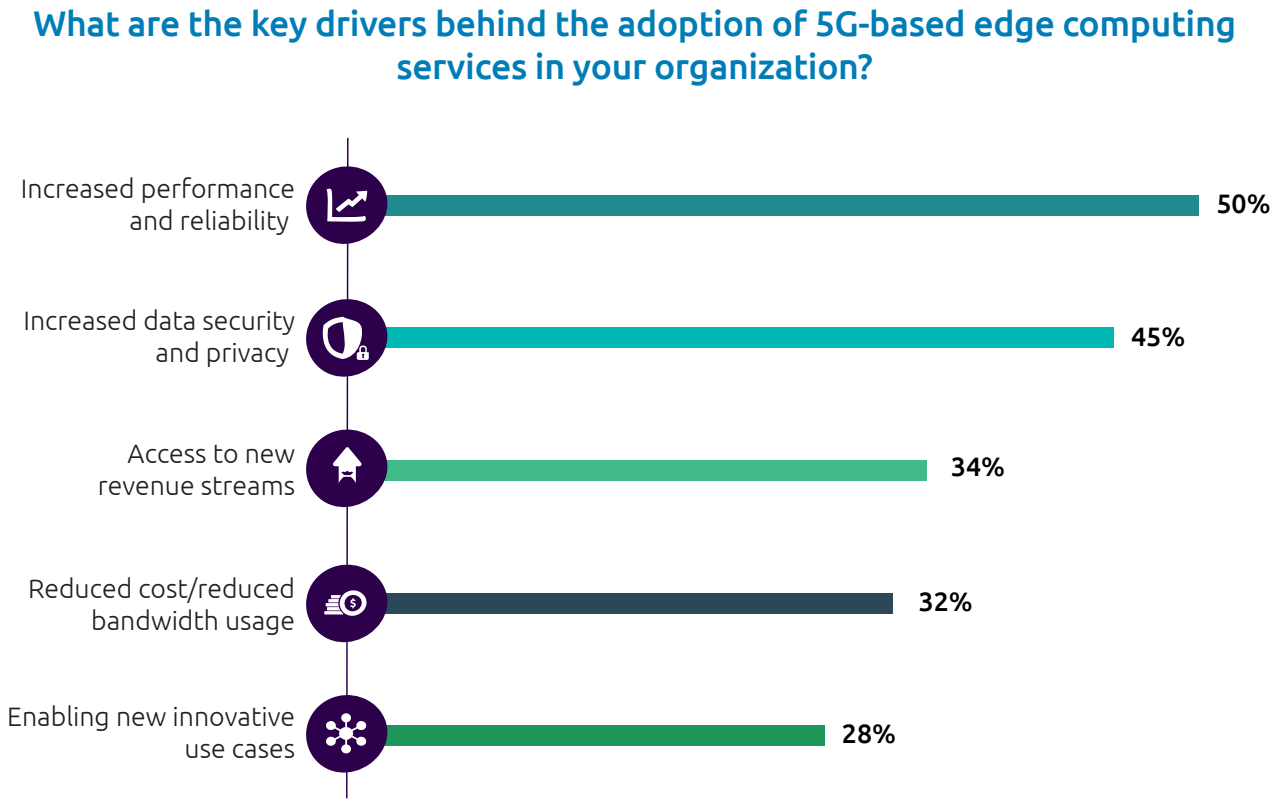

**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=1,000 industrial organizations that have adopted or are planning to adopt 5G.

## Increased performance and reliability are the main drivers of edge computing adoption

5G-enabled edge computing offers multiple benefits to industrial organizations:

- As Figure 8 shows, the biggest driver for adopting edge computing is increased performance and reliability (selected by 50% of respondents). Since data does not need to travel to remote locations for processing and analysis, organizations can shave off precious milliseconds on network performance and achieve higher performance and faster speeds.
- This is followed by increased data security and privacy (selected by 45% of organizations). On-premise distributed edge computing helps organizations insulate their network from cyberattacks and distributed denial of service (DDoS) attacks to a centralized location such as a cloud location. There is also reduced risk of data being intercepted in transit, further adding to the security and privacy features of edge computing. Edge computing also enables organizations to comply more strictly with jurisdictional data regulations and data sovereignty laws by allowing data to be processed closer to its source.

**Figure 8** Drivers of edge computing adoption among industrial organizations




**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=953 industrial organizations that have adopted or are planning to adopt 5G-based edge computing services.

# Telcos are aligned with trends in industrial 5G adoption

Since our 2019 study, telcos in many parts of the world have rolled out 5G networks. More than two thirds (68%) of telcos in our survey have launched commercial 5G services, while the remaining are at advanced stages of rolling them out.

Commercial services can be broken down into three principal bands. The low frequency bands (under 1 GHz) support wide area coverage but at lower speeds. The mid frequency bands (3.3-4.2 GHz) offer a good balance between capacity and coverage, while high frequency bands (26GHz, 28GHz, and 40 GHz) support the highest speeds but with significantly lower coverage. The combination of high capacity and coverage makes mid-band 5G an attractive choice for a variety of industrial use cases. Most commercial 5G rollouts use mid-band 5G spectrum.[10]

## The majority of telcos view private 5G networks as an opportunity

Our research shows that telcos are aligning their enterprise 5G strategy with the demand for private 5G networks. The majority (55%) believe that private 5G networks will positively impact their revenues. Verizon, for instance, sees itself as an end-to-end partner for private 5G network implementations, positioning itself to provide services right from helping organizations purchase local 5G spectrum to setting up and managing the private networks on their behalf.[11]

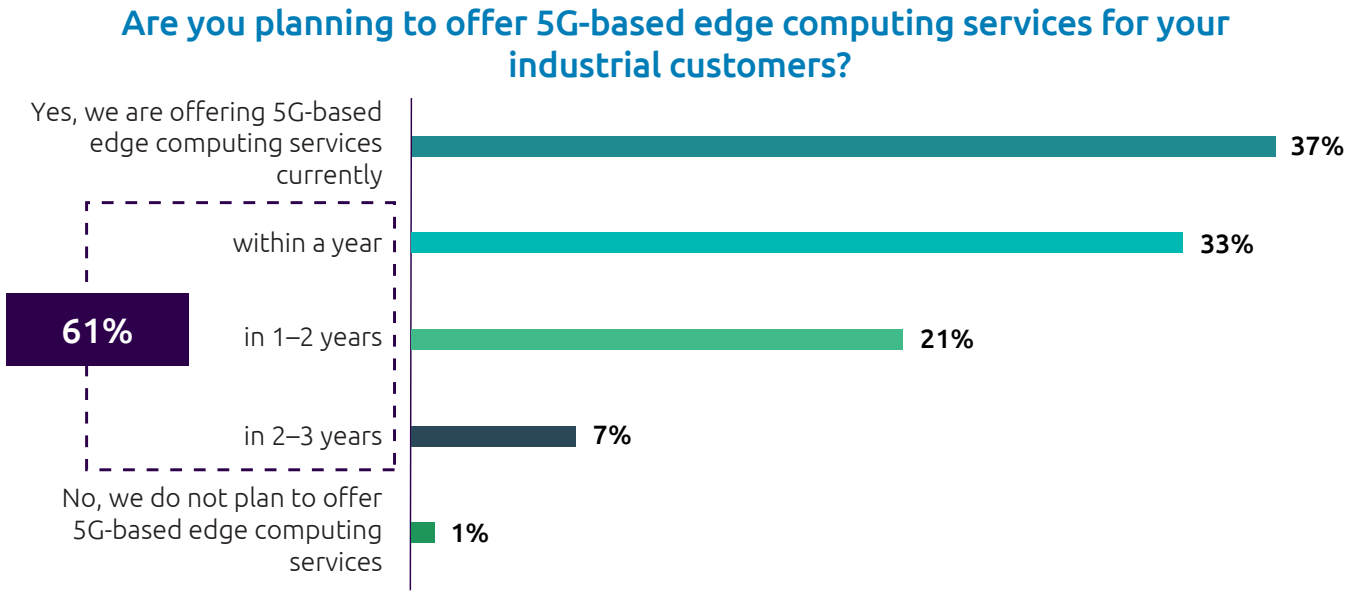
Nearly two thirds (63%) of telcos in our survey have launched industrial grade private network solutions to address the private network opportunity and meet the needs of industrial customers. In addition, 86% of the rest plan to roll out such offers within the next two years. Phillip Coleman, director at AT&T, says, *"Telcos like AT&T are pivoting to a mode where they are more focused on customer outcomes. We are evolving beyond traditional telco models and leveraging our expertise to solve customer problems as seen with private networks. This means bringing in the benefits of mobility like stability and cost efficiencies, and working with each customer to ensure the success of their private 5G network deployments."*

## Telcos view edge computing as a critical part of their 5G strategy

As demand for low latency applications and real-time decision making grows, the market for edge computing is estimated to reach USD15.7 billion by 2025.[12] Telcos recognize this opportunity and 56% have an overarching edge strategy. Telcos are also aligned with industry demand for 5G-enabled edge computing services – 43% of telcos in our survey have an edge computing strategy that is closely linked with their 5G strategy.

Further, more than a third (37%) have already rolled out 5G-enabled edge computing services and 61% plan to do so within the next three years (see Figure 9). For instance, AT&T's on-premise edge portfolio already includes 5G-capable edge computing and Verizon has also launched a 5G-based edge platform.[13]

**Figure 9** Timelines for rollout of 5G-based edge computing services




**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=75 telecom operators.

## Despite high interest in 2019, 5G adoption limited by delays due to the pandemic

In our 2019 survey, 65% of industrial organizations planned to implement 5G within two years of availability. In our current survey, we surveyed industrial organizations that intend to adopt 5G, and as seen in Figure 1, we found that the majority (57%) are still at the planning and ideation stages and less than a third (30%) have implemented 5G as part of pilots or on a larger scale.

The delay in implementation can be attributed to the impact of the COVID-19 pandemic. The pandemic slowed down 5G standards development, leading to delays in the launch of Release 16.[14] It also led to delays in spectrum auctions across the world. Many of these auctions were related to mid-band 5G spectrum, which is especially suited for industrial use cases.[15] In addition, supply chain disruptions caused by the pandemic impacted telecom OEMs,[16] leading to a cascading effect across the entire value chain. Finally, cash pressures caused by the pandemic impacted industrial organizations' ability to invest in innovation linked initiatives such as 5G.

However, the pandemic's impact on 5G adoption is expected to be short-lived. The pandemic has shown the value of advanced connectivity for remote operations and collaboration, and the impact of 5G's robustness and high performance. This is demonstrated by the experiences of organizations such as Lufthansa Technik that were able to leverage 5G networks to service customers remotely during the pandemic (see next section for more details). Signs of growing momentum in 5G adoption are already visible. Governments and telcos globally are accelerating the adoption of digital technologies and 5G. Several countries have conducted 5G auctions since late last year, including the US, UK, France, Spain, and Australia.[17] 5G solution providers have used the delay due to the pandemic to incorporate Release 16 capabilities in their offerings and have them commercially available by end 2021. Qualcomm, for instance, plans to launch a 5G-enabled IoT modem targeted at industrial IoT applications in the second half of 2021.[18] Ericsson has also continued to step up investments in its 5G portfolio. *"The ongoing global pandemic has fast-forwarded the digitalization of societies, placing a significant economic and social premium on high-quality network connectivity. A resilient global digital infrastructure is critical. We see positive signs of governments and enterprises increasingly recognizing 5G as a preferred choice for connectivity with accelerating deployment,"* Ericsson's President and CEO Börje Ekholm said while sharing financial results for the first quarter of 2021.[19]

# Early implementations are turning 5G hype into on-the-ground reality

## 5G features have matched or exceeded expectations for the majority of early adopters

Results from 5G trials and early implementations show that 5G features are measuring up to expectations (see Figure 10). For instance, 5G's ultra-high reliability and low latency features have met or exceeded the expectations of 74% of early adopters that view this feature as critical. Similarly, 69% of early adopters for whom 5G's enhanced speed and capacity are critical say that these features have met or exceeded their expectations.

- Lufthansa Technik – German airline Lufthansa's aircraft maintenance and services division – set up two private 5G networks at its campus in Hamburg in January 2020. Sharing early experiences after the networks went live, Dr. Claudius Noack, project lead, Lufthansa Industry Solutions, said, *"In early phases, the private wireless network has shown to be technically first rate as well as being flexible to deploy and easy to tailor to our applications and work environment."*[20] Over the last year, Lufthansa Technik has experienced significant improvements in latency (the company reported achieving a latency of seven milliseconds) and reliability compared to its Wi-Fi networks.[21] Highlighting the reliability of their private 5G networks, Dr. Noack says, *"The network that we set up in January, [has] had not one minute of failure since we set it up."*[22]
- Atlas Copco has rolled out private 5G networks at two of its plants and is using 5G for a wide range of use cases that require mobility. These include AGVs with mounted cameras that stream video over a private network and are used to conduct inspections on the shop floor. Speaking on Atlas Copco's experience with 5G, Bavo Tielemans, smart factory leader at Atlas Copco, says, *"So far, it's been really reliable. The uptime of the network has been great."*

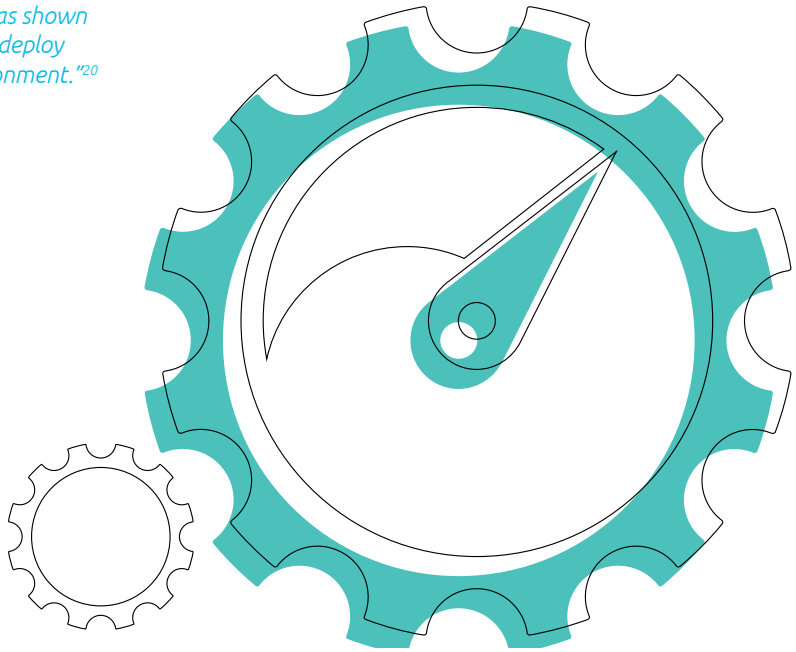


**Figure 10** 5G features have met or exceeded the expectations of organizations that have tried them


**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=89 for network slicing with Quality of Service (QoS) control, N=76 for edge computing, N=88 for enhanced security, N=95 for mission-critical voice, data, and video services, N=105 for ultra-reliability and low latency, N=88 for enhanced mobile broadband speed and increased capacity.

# Early adopters have already realized business benefits from 5G

Our research found that 5G trials and early implementations are already delivering strong business benefits. As many as 60% of early adopters say that 5G has helped them realize higher operational efficiency, while 43% say they have experienced increased flexibility (see Figure 11).

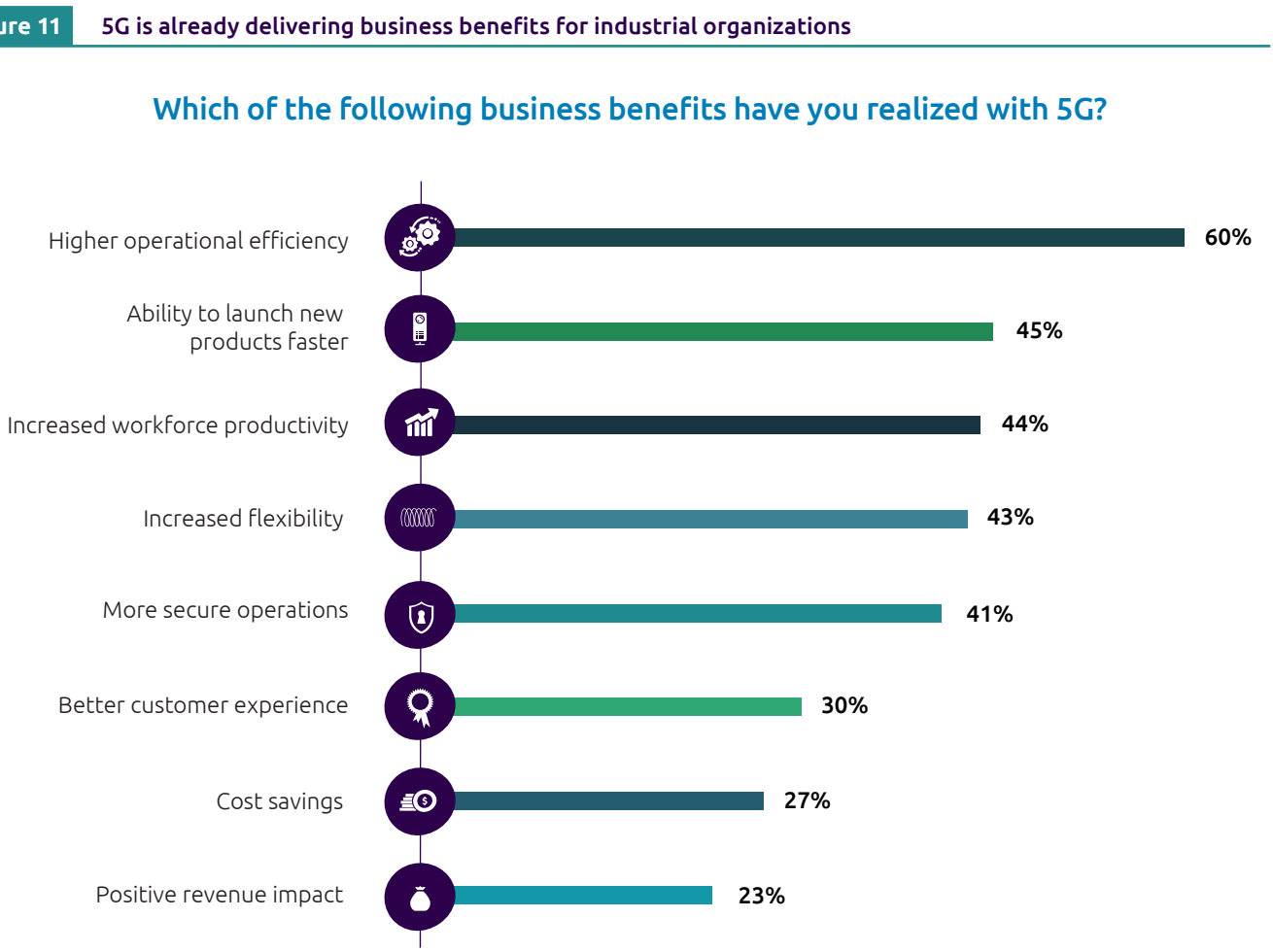
- Taiwan-based IT hardware manufacturer Inventec has deployed a live private 5G network at one of its plants. The network is part of an active production line and was set up with the goal of increasing efficiency and reducing manpower using AI-based Automatic Optical Inspection (AOI) in the assembly line.

  The network has delivered significant improvements in quality and productivity, including an increase in first pass yield[23] (FPY) from 70% to over 85% and reduction in re-inspection labor force of 50%. It has also enabled Inventec to adjust production lines faster.[24]

- The Port of Qingdao in China has deployed 5G to remotely control cranes for the loading and unloading of containers. The use of 5G has increased loading and unloading efficiency from an average of 24.2 containers per hour to 36.2 containers per hour (with peak efficiency reaching 43.8 containers per hour).[25]

- UK-based industrial manufacturing firm Worcester Bosch has realized a nearly 2% increase in output as part of 5G trials at its factory in the UK.[26,27]

**Figure 11** 5G is already delivering business benefits for industrial organizations




**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=302 industrial organizations that have run pilots/trials or full-scale implementations of 5G.

Our research also shows that 5G use cases are generating business impact for early adopters (see Figure 12). We segregated 5G use cases into four categories:

**Remote monitoring and control.** With its higher bandwidth and lower latency, 5G can be used to transmit high resolution videos and inputs that are vital for real-time monitoring and enhanced control of critical manufacturing operations. For example, for quality control using machine vision, a high resolution, low-latency video feed enabled by 5G and edge computing can help industrial organizations detect faults faster and more accurately. In Japan, NEC Corporation, telecom operator KDDI and construction company Obayashi have jointly and successfully tested a 5G-enabled remote monitoring and control system to remotely operate construction machinery. 2K and 4K cameras were used on construction machines to transmit video and image data in real time using 5G.[28]

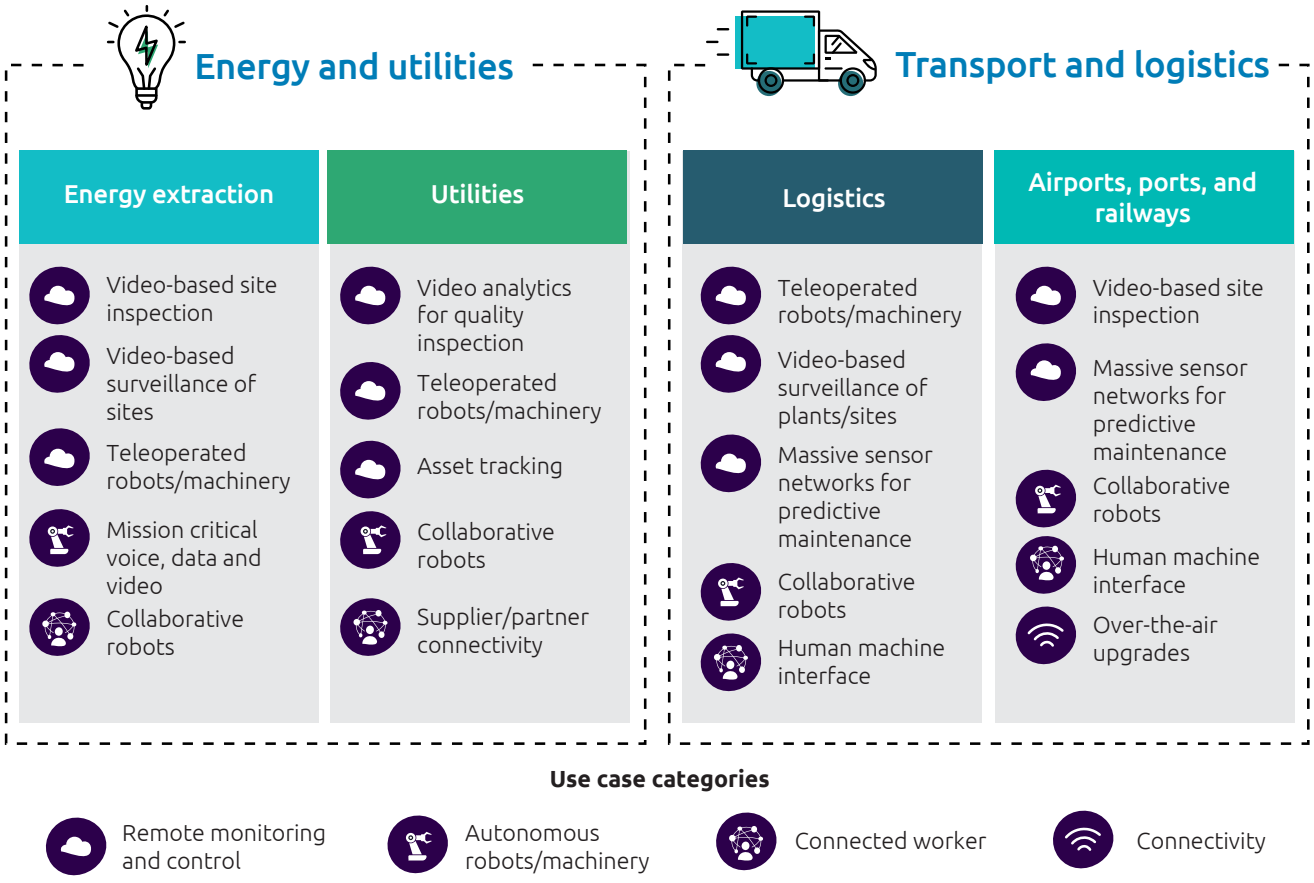
**Autonomous robots and machinery.** 5G can greatly enhance the range of operation of autonomous robots and vehicles while exceeding the service levels offered by existing connectivity technologies such as WiFi. As per a study, the global 5G-enabled autonomous robots market will reach USD73.77 billion by 2030.[29] Audi and Ericsson, for instance, are testing use cases that leverage 5G's features of mobility, Quality of Service, and low latency to run autonomous robots and machinery on the factory floor.[30] At Mercedes Benz's "Factory56" plant, that is equipped with a private 5G network, traditional assembly lines have been replaced with driverless transport systems/AGVs that increase the overall flexibility of the production process.[31]

**Connected worker.** 5G helps augment human operators in industrial environments in a variety of ways. One such area of application is with AR/VR. For a truly immersive AR/VR experience that provides high quality two-way communication and accurate control, a high bandwidth connection is critical. 5G helps with reducing end-to-end

latency and provides a stable, high-bandwidth connection that opens up a number of remote collaboration opportunities using AR/VR in the areas of design, production, maintenance and customer service. AR/VR applications enabled by 5G can be used to provide remote expertise and assistance, conduct remote virtual inspections, design reviews and virtual site visits. Schneider Electric, for instance, is testing the use of 5G to conduct maintenance activities using AR/VR.[32]

**Connectivity.** 5G offers industrial organizations the ability to tailor Quality of Service based on the needs of industrial applications using dedicated network slices. This ensures that critical communications, for instance, can be insulated from the load on the larger network. 5G can also provide organizations with dedicated channels of communication for their supply chain partners to ensure data security and privacy.

**Figure 12** Top five use cases by business impact in each sector




**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=302 industrial organizations that have run pilots/trials or full-scale implementations of 5G.

## Industrial organizations are optimistic that 5G will drive revenues going forward

5G offers a paradigm shift in connectivity that can not only deliver significant improvements in operational efficiency, but also paves the way for the launch of new products and services. More than half (51%) of organizations in our survey plan to leverage 5G to offer new products. Bosch, for instance, has launched a range of 5G-enabled automated guided vehicles (AGVs). These "ActiveShuttle" vehicles are targeted at the logistics sector.[33]

As many as 60% of industrial organizations also plan to offer new services enabled by 5G. Lufthansa Technik, for instance, has been using its private 5G network to offer AR-based remote maintenance services to its customers. This has been especially beneficial during the pandemic. Previously, services such as these could only be performed on-site. This was because WiFi networks could not provide the stable, reliable connectivity that AR-based applications require.[34]

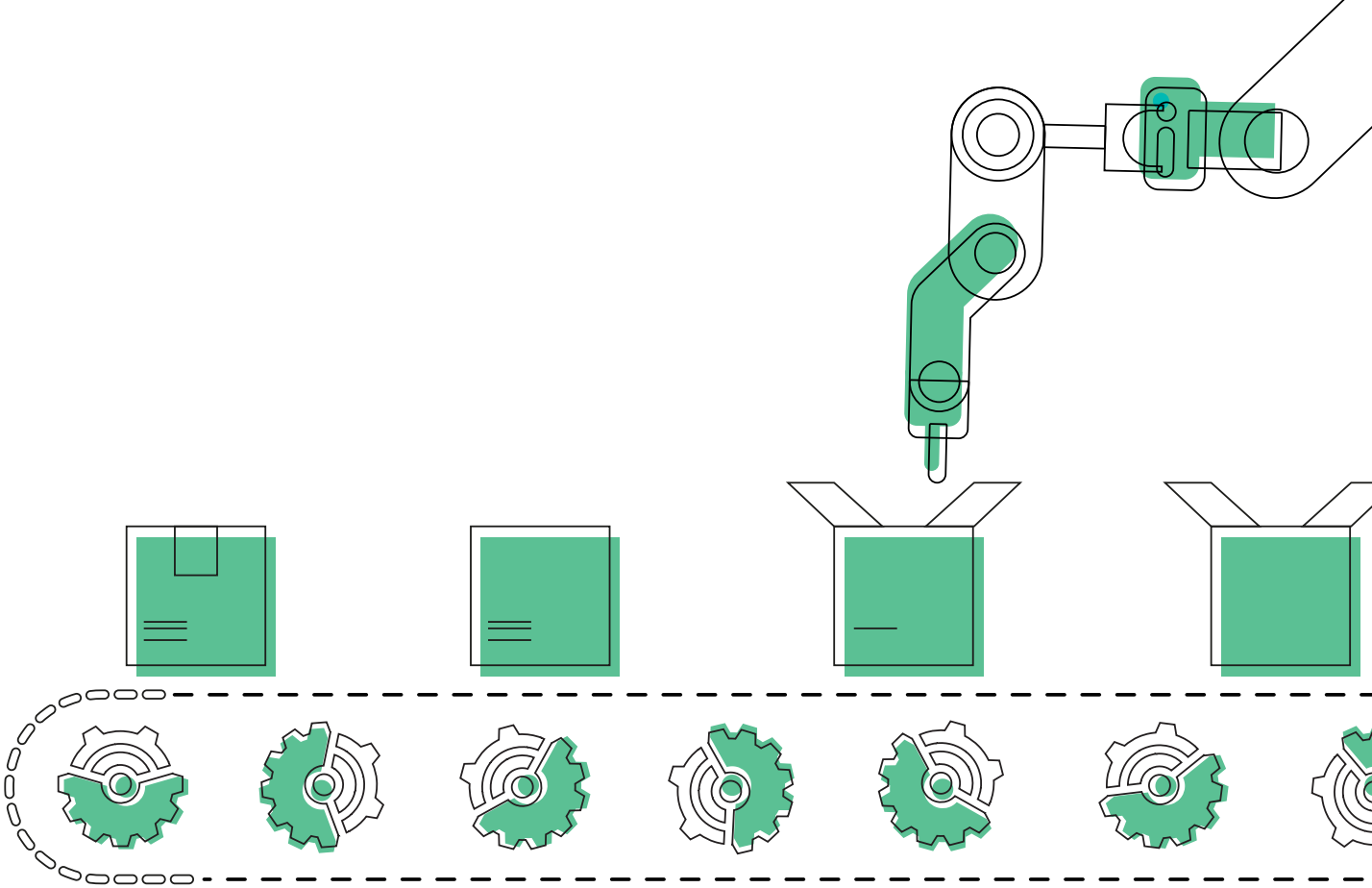
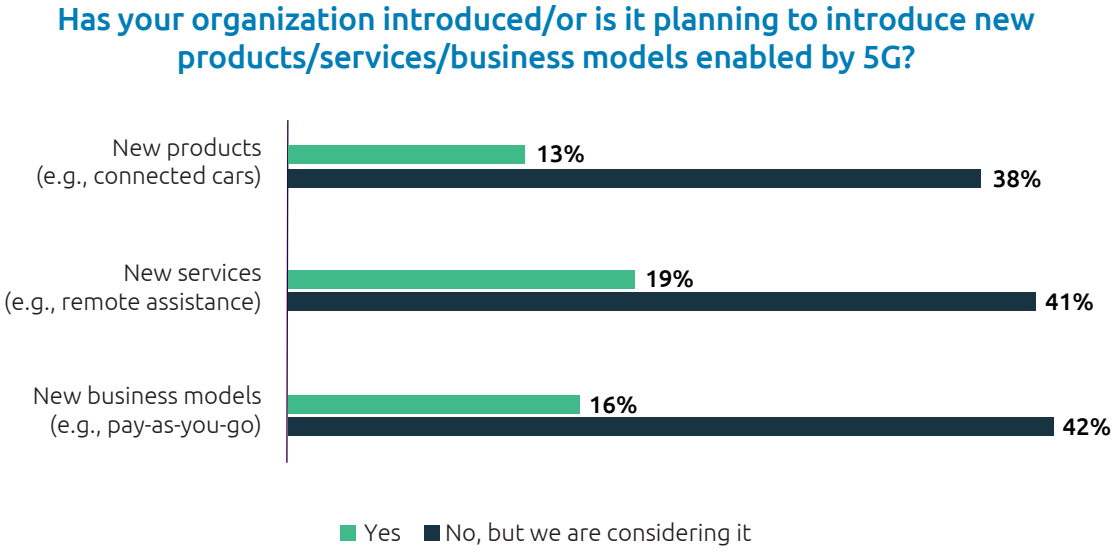


**Figure 13** Most industrial organizations plan to leverage 5G to offer new products, services, and business models

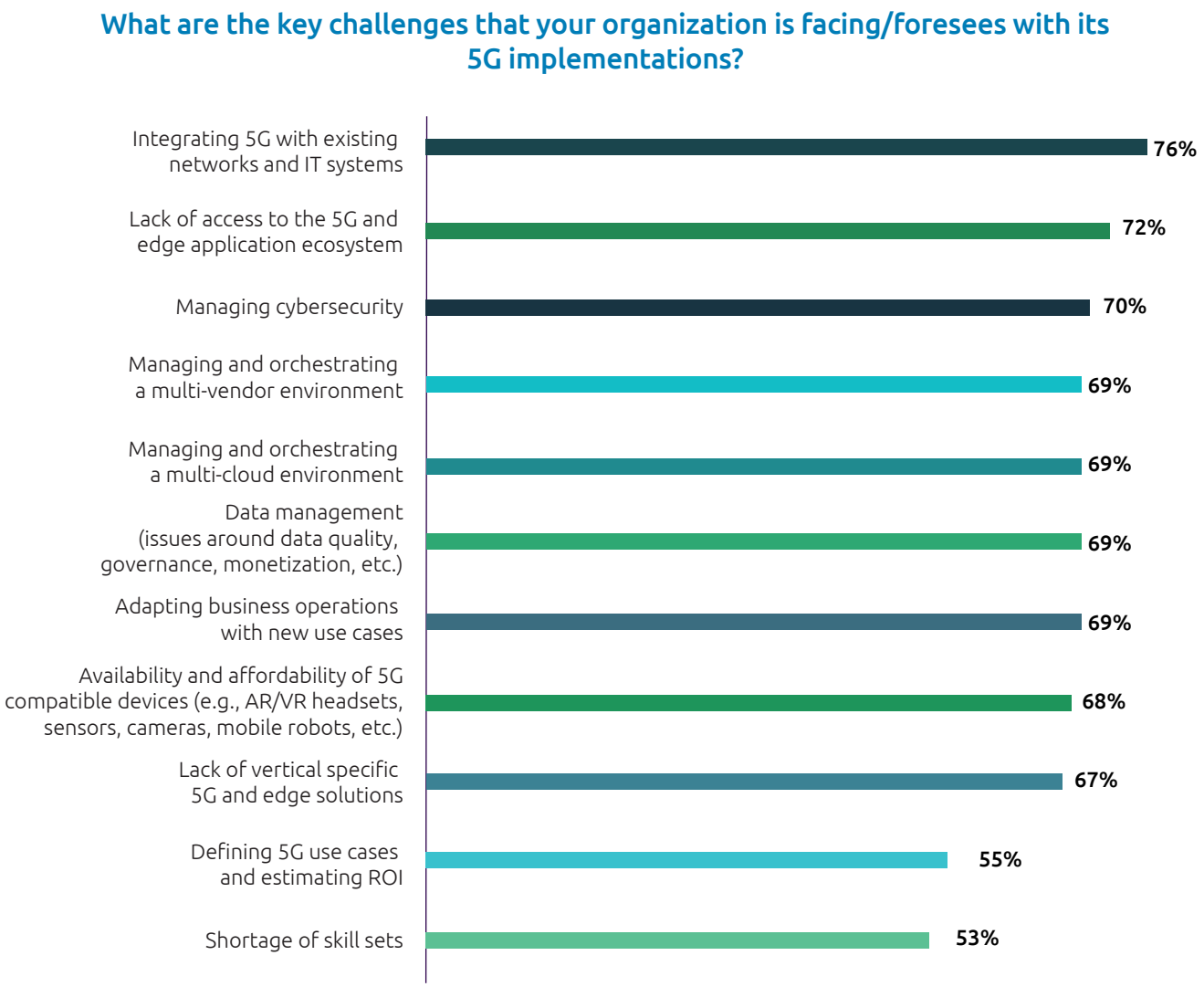



**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=1,000 industrial organizations that have adopted or are planning to adopt 5G.

# What is holding back more widespread implementation of 5G?

Our research shows that there are several challenges that industrial organizations foresee with 5G implementations (see Figure 14). These range from more immediate concerns to the longer-term. For example, in the short term, you have the lack of 5G compatible devices (this can be seen as more temporary in nature as it is likely to be resolved as the 5G ecosystem matures). In this section, we focus on the key longer-term 5G implementation challenges that emerged from our survey and our discussions with senior industry executives.

**Figure 14** Industrial organizations face a range of 5G implementation challenges




**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=1,000 industrial organizations that have adopted or are planning to adopt 5G.

### 1. Integrating 5G with existing networks and IT systems

Due to its cloud-native architecture, 5G can be simpler for enterprise IT teams to deploy and integrate compared to previous generations of cellular technologies. However, 5G still poses a number of integration challenges. As many as 76% of industrial organizations in our research view the integration of 5G networks with their existing networks and IT systems as a key implementation challenge. Ehsanul Islam, an expert on 5G based in Taiwan, says, *"An existing factory will already have some connectivity technologies in place. These technologies will come with their own dashboards and how they feed into the various operations of the business. This can make integration of 5G into business operations more challenging."*

Key issues include the lack of standardized, interoperable solutions. This, in turn, creates challenges for assembly and testing. This is reflected in Ford's experience with rolling out 5G at its plant in Dunton, UK. Chris White, manager for Ford's 5G Enabled Manufacturing (5GEM) project, says, *"As 'non-telecoms' people, we at Ford had a very limited appreciation of what is involved. The MPN (mobile private network) has taken several months to install, partly due to the pandemic, but also because we were ill-prepared for what is required: fiber links, power supplies, GPS antennae locations… It's certainly not yet an 'out of the box' solution, with assembly and testing also taking a significant amount of time. I am sure this will change, as 5G MPNs become mainstream. Installations will need to be reconfigurable quickly."*[35]

5G implementations also require interoperability testing across multiple components on the factory floor, including AGVs, AI cameras and other connected devices, which can also be a challenge.

Many legacy devices and industrial automation systems are not adapted to run with 5G. Industrial protocols will need to be integrated with 5G, in order to enable interoperability and pave the way for wider industrial adoption of 5G. Among the most significant of these is the OPC UA (Open Platform Communications Unified Architecture) protocol – an open communication standard for secure, standardized exchange of data between Industrial IoT (IIoT) devices. The recently announced collaboration between the OPC Foundation[36] and the 5G-ACIA[37] to enable the integration of OPC UA with 5G is a key step in this direction.[38]

Further, legacy brownfield devices will need to be enabled to run on 5G networks. This will require integration with industrial gateways and customer premise equipment (CPE) devices. The availability of such gateways and devices is growing and according to a recent report by the Global Mobile Suppliers Association, 37 industrial gateways/routers/modems and 50 fixed wireless access CPE devices were commercially available as of late March 2021.[39]

### 2. Defining 5G use cases and accessing 5G applications

While 5G presents numerous opportunities for industrial organizations, our research revealed that organizations are struggling with identifying the right opportunities and operationalizing them. Organizations we spoke with are grappling with questions such as:

- What are the use cases that can generate an immediate business impact?
- What are some readily available 5G applications?
- How can the use cases be integrated with existing operations?

Each of these areas is acting as a barrier to 5G implementation. We found that 55% of industrial organizations report difficulties with defining 5G use cases and estimating their ROI (which can be an even bigger challenge in brownfield environments where the ROI of 5G use cases will need to be measured against existing options such as wired connections, and the cost of replacing cables), 67% cite difficulties with accessing vertical-specific 5G solutions as barriers to implementation, and 69% cite challenges with adapting business operations with 5G use cases.

### 3. Managing cybersecurity

While 5G standards provide for various security enhancements, 5G networks are still a source of concern for industrial organizations due to a number of factors:

- A significantly expanded attack surface driven by the increase in volume and variety of connected endpoints. The number of industrial IoT connections is estimated to grow by 107% from 17.7 billion in 2020 to 36.8 billion in 2025.[40]
- Threats and vulnerabilities emerging from "backdoors" at the device or network level
- The need to manage data security and privacy for the growing volumes of data generated by connected devices.

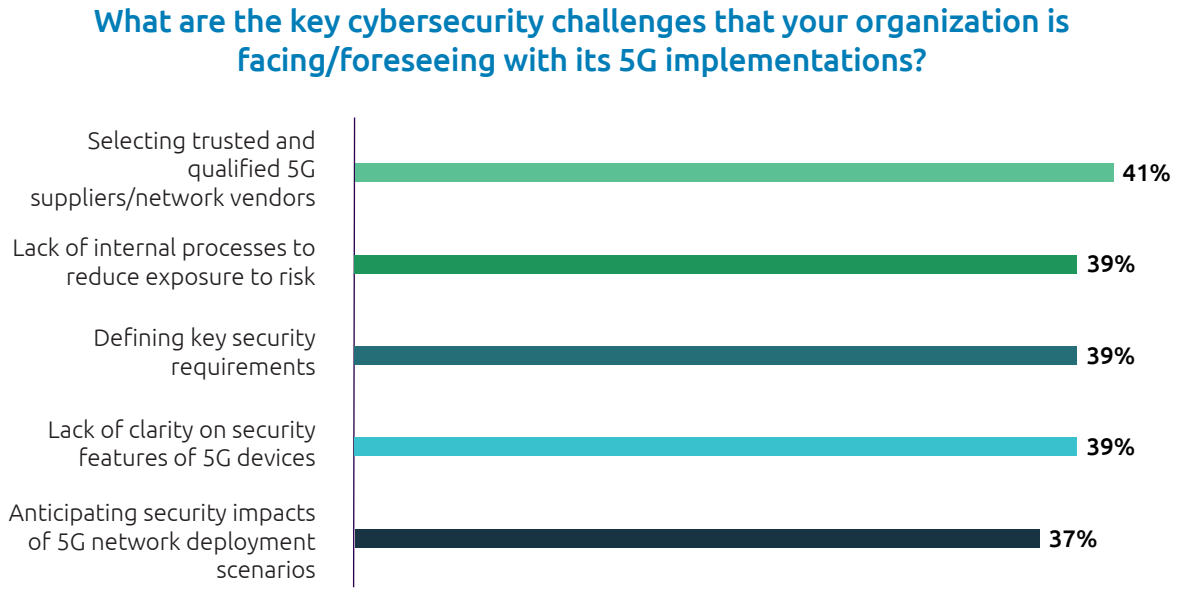
As many as 70% of industrial organizations view the management of cybersecurity as a key challenge associated with 5G implementations. As Figure 15 shows, key issues involved in managing security include difficulties in selecting trusted and qualified vendors (cited by 41% of industrial organizations) and a lack of internal processes to reduce exposure to risk (cited by 39% of industrial organizations). *"Organizations face questions such as whether their devices are secure, and who will evaluate them and make sure there are no security holes,"* says 5G expert Ehsanul Islam. *"There are a lot of unknowns."*

Private network deployments can compound these challenges, raising new issues that organizations may not have the expertise to deal with in-house. Highlighting these issues, Didier Wylomanski, business development director

for EMEA and 5G expert at Thales, says, *"Ultimately companies who wish to benefit from 5G service via the deployment of their own Private Mobile Network, which is a highly expected deployment model of 5G, will need to act as their own managed security services provider. This means they must deploy a security strategy which is under their full control just like they would have done for any of their traditional IT systems. In practice, this includes ensuring the privacy of their communications, the internal access control to applications and data, and their protection of data at rest and in motion."*[41]

Jason Inskeep, director, 5G Center of Excellence, AT&T adds, *"For companies that have been using mainly WiFi, managing security in a private 5G environment can feel very new and different, and they may not have the current expertise to manage it according to those nuances. So, we work with our customers to educate them on the differences, and also to help them understand where adding security would be beneficial in a private network – for example, at aggregation points."*

**Figure 15** **Managing cybersecurity is a key challenge for the majority of industrial organizations**




**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=684 organizations that view managing cybersecurity as a major 5G implementation challenge.

**4. Orchestrating a multi-vendor environment**

With the development of open network based 5G networks, 5G offers industrial organizations the opportunity to work with multiple partners and avoid vendor lock-in. However, putting together the multiple functional components that industrial 5G solutions consist of, including devices, applications, platforms, network infrastructure, and connectivity, can be a major challenge. Bringing these components together requires identifying, onboarding, and managing multiple vendors, which 69% of industrial organizations in our survey view as a key barrier in their 5G implementations.

On the one hand, identifying the right vendors to deliver the components can be an issue given that the 5G vendor ecosystem is yet to mature. Managing a multi-vendor environment is another challenge, leading organizations to prefer partners who can provide them with an end-to-end service.

# Industrial organizations are conscious of the environmental impact of 5G adoption

5G will enable massive device connectivity and will generate enormous data, which in turn has led to concerns about its environmental and sustainability impact. A recent study from Nokia and Telefonica shows that 5G is up to 90% more energy efficient than 4G on a per traffic unit.[42] Over existing technologies, 5G can help in the following ways:

- **Higher throughput:** Due to higher throughput per kilowatt of energy consumed, there are longer periods when the connection between the base station and the endpoint is idle.
- **5G beamforming [43]:**this allows for more focused communication between devices and the base station, leading to energy savings.
- **Small cells:** 5G networks are enabled by small cells that are nearer to the end points, leading to energy savings (since signals need to travel shorter distances to reach a base station). These small cells can also be used to meet demand fluctuations and modify capacity as needed.
- **Sleep mode:** Sleep modes allow networks to switch off certain parts when usage is low. While a basic form of sleep mode is already possible with 4G (first level out of four levels), 5G will be able to go up to level 3 under specific conditions, leading to an energy savings of around 50%.[44]

In addition to these direct environmental benefits, 5G also offers indirect benefits by enabling more effective remote collaboration, which in turn reduces the need for travel, and by enabling a range of environmental and sustainability-focused use cases such as improved energy monitoring through massive sensor networks. In addition, the use of edge computing in conjunction with 5G can help reduce network traffic, and related carbon emissions, by processing data closer to the source.

However, 5G also raises certain environmental issues. These include:

- The increased energy consumed by 5G network hardware itself, combined with the energy needed to run data centers to process the increased volumes of data traffic that 5G enables
- The emissions resulting from the manufacture and use of increasing volumes of endpoint devices.

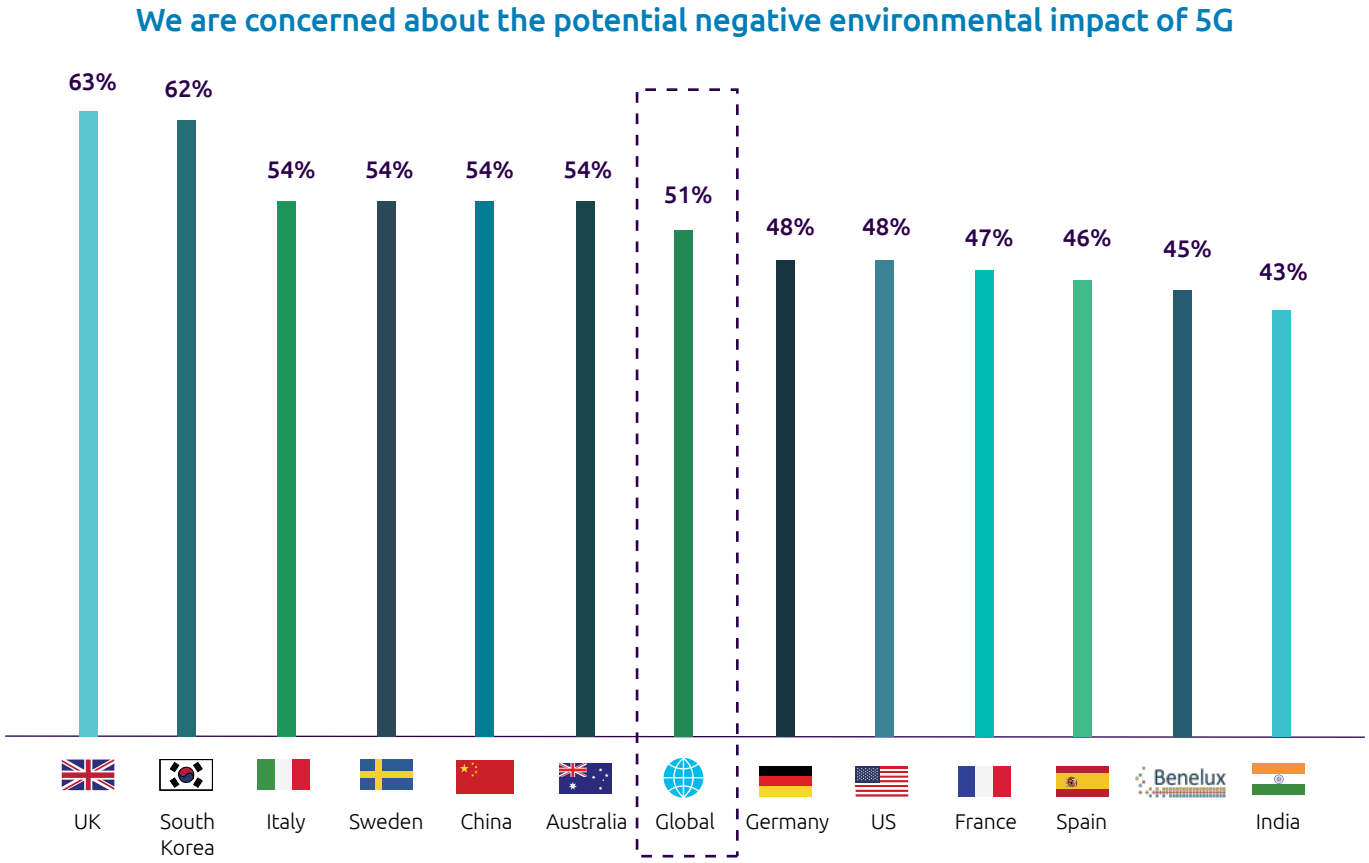
The data centers needed to store and process data generated by 5G-enabled devices are expected to lead to significant additional carbon footprint. A report from France's High Council on Climate found that 5G networks could be responsible for an extra three to seven billion tons of CO2 released into the environment. A large portion of these emissions will come from data centers and manufacturing of electronic devices.[45]

Our research shows that organizations are conscious of the potential impact of 5G implementations on the environment. More than half (51%) of the organizations surveyed say that they are concerned about the potential of negative environmental impact of 5G.

**51%**

Share of industrial organizations that are concerned about the potential negative environmental impact of 5G

**Figure 16** Organizations are concerned about the negative environmental impact of 5G




**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=971 organizations.

A large share (56%) of organizations are concerned about the increase in energy consumption due to 5G while more than half (52%) are concerned about the mining of rare earth metals/non-renewable resources to produce 5G components and devices.

**Figure 17** Organizations are aware of areas of environmental impact due to 5G


We are concerned about increased energy consumption due to 5G (e.g., increased carbon footprint due to increased production and use of connected devices)

We are concerned about increased mining for rare earths/non-renewable metals to produce 5G components and devices

**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=494 organizations who are concerned about the potential negative impact of 5G.

## Industrial organizations will prioritize minimizing the environmental impact of 5G implementation

The majority of industrial organizations say they will prioritize minimizing the environmental impact of 5G implementations. More than half (53%) of industrial organizations say that reducing the environmental impact of their 5G implementations is a priority for their organization.

Scope 1, 2, and 3 can have varying contributions to carbon emissions in a 5G value chain. Organizations are aware of this and more than two thirds (67%) say their choice of a 5G operator/vendor/supplier will be impacted by their sustainability credentials.

**Figure 18** Organizations expect their vendors and partners to align with their sustainability requirements


**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=1,000 industrial organizations that have adopted or are planning to adopt 5G.

## Governments play their part in accelerating industrial 5G adoption

Governments across the world are introducing policy incentives to accelerate industrial 5G deployments.

**UK** – The UK government has launched a national innovation network – "UK5G" – to promote research and collaboration on industrial applications of 5G and develop a 5G ecosystem in the UK. The government has also earmarked £200 million for investments as part of the "5G Testbeds and Trials Programme" (5GTT) to identify ways in which 5G can boost productivity and drive growth for industries. Matt Warman, Minister for Digital Infrastructure, says, *"5G is about so much more than faster mobile internet speeds so we're investing millions to help some of Britain's brightest innovators explore the huge potential of the technology to improve and enrich our lives."*[46]

**US** – The US Federal Communications Commission (FCC) launched the "5G Facilitate America's Superiority in 5G Technology Plan" (5G FAST Plan) in 2018, and is taking action to free-up additional spectrum (such as the mid-band spectrum auction in the 3.7-3.98 GHz band in December 2020)[47], speed up government reviews at various stages of 5G deployments, and modernize regulations to accelerate 5G rollouts.[48] The US Department of Defense announced funding worth $600 million to run large-scale 5G tests across five US military sites, exploring use cases such as 5G-enabled AR/VR, warehouse management, and distributed command and control.[49]

**European Union** – The European Commission set up the 5G public-private partnership (5G-PPP) in 2013 and earmarked public funding worth more than €700 million to support research and innovation on 5G. As part of the 5G-PPP, the Commission recently announced funding worth €100 million on seven new research and innovation projects, aimed at conducting large-scale 5G trials across a range of industry verticals including manufacturing, transportation, and energy.[50]

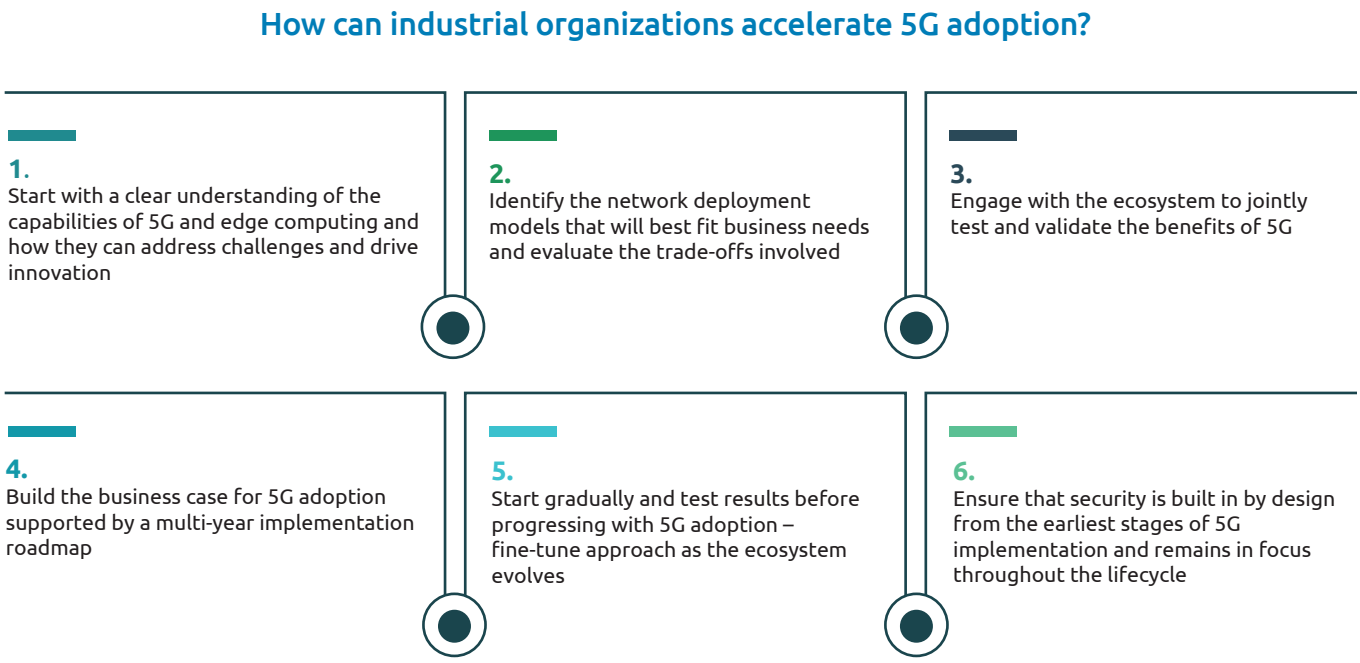
**APAC** – The South Korean government has launched an initiative called "5G+ Strategy" to create a 5G ecosystem and provide tax incentives worth $27 billion by 2022 to promote the development of 5G-based industries and services.[51] Singapore's Infocomm Media Development Authority (IMDA) and the National Research Foundation (NRF) have set aside S$40 million to build an open innovation ecosystem to support 5G trials on industry use cases.[52] Australia has launched the "Australian 5G Innovation Initiative" to provide grants to help businesses test 5G use cases in sectors such as mining, manufacturing and construction.[53]

# Recommendations

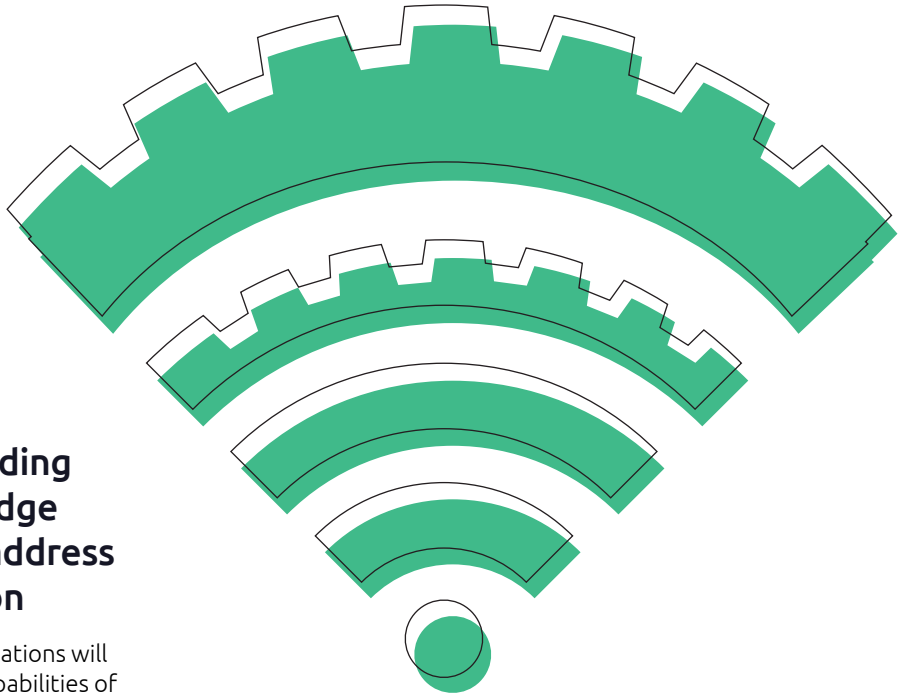
## How can industrial organizations accelerate 5G adoption?

While 5G standards will continue to evolve, there are many benefits that 5G already offers, as the experience of early adopters shows. To accelerate 5G adoption, industrial organizations should begin testing its capabilities and applying them to address business challenges and drive innovation, while progressively fine-tuning their approach as new features become available. They must also engage with a wide range of stakeholders internally as well as externally to identify the right use cases. In this section, we look at the key steps that industrial organizations should take to ensure that they are well-positioned to take advantage of the benefits that 5G offers.

**Figure 19** Engage with stakeholders internally and externally to accelerate 5G adoption




**Source:** Capgemini Research Institute analysis.



## 1. Start with a clear understanding of the capabilities of 5G and edge computing and how they can address challenges and drive innovation

As they begin their 5G journey, industrial organizations will need to develop a clear understanding of the capabilities of 5G and edge computing and where these technologies can truly add value. This is essential to ensure that the adoption of 5G and edge computing address actual business challenges instead of becoming a goal in itself. Hirotaka Fuchigami, Expert, Smart Industry Division, Enterprise Business Unit, at NEC Japan, emphasizes this when he says, *"Using 5G has become the end goal for many organizations. 'What are you going to do using 5G?' should be the right question to ask."* Organizations will need to evaluate how they can enable or enhance relevant use cases using 5G capabilities. In addition to looking at opportunities to transform processes using 5G, organizations should also look at leveraging 5G to transform their product portfolios by adding increased intelligence into products. Finally, organizations should also assess how 5G and edge computing can help enhance their existing data-driven digital transformation efforts and fit into their overall data management strategy spanning products, operations, and services.

Aligning with business teams is critical to ensure that the use cases selected for implementation solve real business problems. Bavo Tielemans, smart factory leader at Atlas Copco, believes this is essential to ensure that 5G use cases meet the needs of the business. *"In the beginning we tried to think of use cases ourselves, but if there wasn't a real need in production, we saw that the adoption rate was really low,"* he explains. *"We actually wait until we see a need from the business. So, we get a question either from production or from process engineering where we need to solve a problem and that's where we look at 5G as one of the tools we have to potentially solve the issue. And that's how the use cases really come to life – because then there is an actual demand from production, and they are motivated to use the solution we provided. We have a service desk within the smart factory team where the requests from business teams come in and that's where we do the initial analysis. Then, we have further discussions with the business teams about what exactly they are expecting or how they want to see the solution implemented."*

> We get a question either from production or from process engineering where we need to solve a problem and that's where we look at 5G as one of the tools we have to potentially solve the issue. And that's how the use cases really come to life."
>
> **Bavo Tielemans**
> **Smart Factory Leader, Atlas Copco**

## 2. Identify the network deployment models that best fit business needs and evaluate the trade-offs involved

Once they have a clear understanding of the use cases where 5G adoption can make a difference, industrial organizations will then need to select the network deployment scenarios that best fit the requirements of these use cases. As Chris White, manager of 5GEM[54] at Ford Motors, has said: *"There are many choices to make in how to adopt 5G. Dedicated private networks are suited to this use case (robotic welding of components for electric cars), but hybrid or public networks become more interesting when you start to interact with assets that go beyond the factory walls (for example, logistics use cases)."*[55]

Given they now can choose to own and operate their own 5G network, organizations must analyze their own unique set of requirements along with the trade-offs involved between private vs public networks (see Figure 20). There are a number of factors that organizations should consider:

- Cost associated with deployment
- Technical complexities involved in network design
- Ability to control network characteristics
- Ability to roam/interact with external entities
- Security requirements of the network.

**Figure 20** Trade-offs involved in the choice between private and public 5G networks

| | **Private network** (standalone/dedicated networks) | **Public network** (hybrid/virtual private/ fully public networks) |
|---|---|---|
| Cost of deployment | | Public networks can be more cost-effective to deploy with potentially lower set-up costs |
| Technical complexity in network design | Private networks can be less complex to design compared to using public networks due to the growing availability of pre-packaged mobile private network solutions that enable faster installation, and the relatively fewer design considerations, especially from a security standpoint | |
| Ability to roam/interact with external entities | Private networks offer more granular control with the ability to modify characteristics as per need | |
| Ability to control network characteristics | | Public networks provide seamless connectivity outside the industrial campus |
| Security requirements of the network | Private networks offer higher security with lower interference | |

**Source:** Capgemini Research Institute analysis.

## 3. Engage with the ecosystem to tap into shared expertise and jointly test and develop solutions

Given the challenges involved in identifying 5G use cases and estimating their ROI, and the lack of available vertical-specific solutions, industrial organizations should consider engaging closely with the larger 5G ecosystem to tap into shared expertise and experiences.

- **Engage with a wide range of participants within the 5G ecosystem.** Engaging with a wide variety of players within the ecosystem will allow organizations to stay informed of developments in device and application availability and enable them to make more informed choices. This is critical given that the device and application landscapes are at early stages of maturity and, as a result, getting locked into early choices can be problematic at later stages of 5G implementation. Adrian Talbot, head of the Center of Excellence for Mobility at Spanish transport infrastructure organization Ferrovial, highlights the need for engaging the ecosystem. *"We have been speaking with pretty much every vendor one way or another,"* he says. *"Both the large service providers and traditional players, but also some of the smaller startups that are offering different levels of applications across the value chain. We are giving all of them opportunities to pitch their solutions and approach to us. And while there are some similarities between them, there are also some significant differences."*
- **Jointly test solutions to validate the benefits of 5G and develop solutions.** The ability to leverage external input from partners allows organizations to build clarity on what 5G offers, test and validate its benefits, and identify and develop the use cases that would add most value for them. It also allows them to share the risk involved in developing such solutions
  - In the UK, an 11-member consortium of organizations – including Siemens, Toshiba, Solvay, Baker Hughes, and Telefonica – has come together to jointly explore new business models and applications for private 5G networks in the manufacturing sector. The consortium is investigating three industrial 5G use cases that include AR/VR, asset tracking, and monitoring of industrial systems.[56]
  - Spanish transport infrastructure organization Ferrovial has launched an initiative called AIVIA. Its goal is to bring together multiple partners within the smart road infrastructure ecosystem to jointly develop solutions using 5G. Explaining the rationale behind the initiative, Ferrovial's Adrian Talbot says, *"We felt that we would come up with a better solution if we work together with other partners. We would also mitigate our own risk to a certain extent by having that external input."*

## 4. Build the business case for 5G adoption supported by a multi-year implementation roadmap

As part of their 5G journey, industrial organizations will need to prepare a detailed business case for 5G adoption. The business case should be supported by a multi-year implementation roadmap that accounts for the network roll-out plan, introduction of new features, migration of existing use cases/development of new use cases. Key factors that organizations should consider while building a business case for 5G adoption include:

**Top line and bottom line impact of 5G adoption**. Organizations should consider both the top line and bottom line impact of 5G use cases – 5G use cases that deliver bottom line impact by improving operational efficiency and productivity for instance, as well as use cases that drive top line impact by increasing the speed of innovation, reducing time to market, and enabling the introduction and monetization of new connected products and services.

**Installation and operations costs for the 5G network.** Organizations will also need to evaluate the installation and operations costs for their 5G network, depending on the network deployment model (for instance, private networks or hybrid set-ups with public network operators), and their service model strategy (in-house network operations or managed services). They will also need to keep in mind that 5G network costs will go down with time (like in the case of 3G and 4G) as the technology matures and adoption/volumes scale up.

**Savings that can be derived over the long term from an optimized connectivity portfolio.** 5G can help organizations reduce network operating costs by enabling multiple narrow-purpose and often expensive networks (such as TETRA for example) to be replaced with a single network that supports heterogenous use cases. Further, the use of network slicing, that allows Quality of Service to be tailored to application requirements, can also bring down network infrastructure costs by optimizing the use of network resources. While evaluating the ROI of 5G deployments, organizations should therefore consider the cost of their as-is connectivity portfolio and assess how 5G can deliver cost savings over the long term.

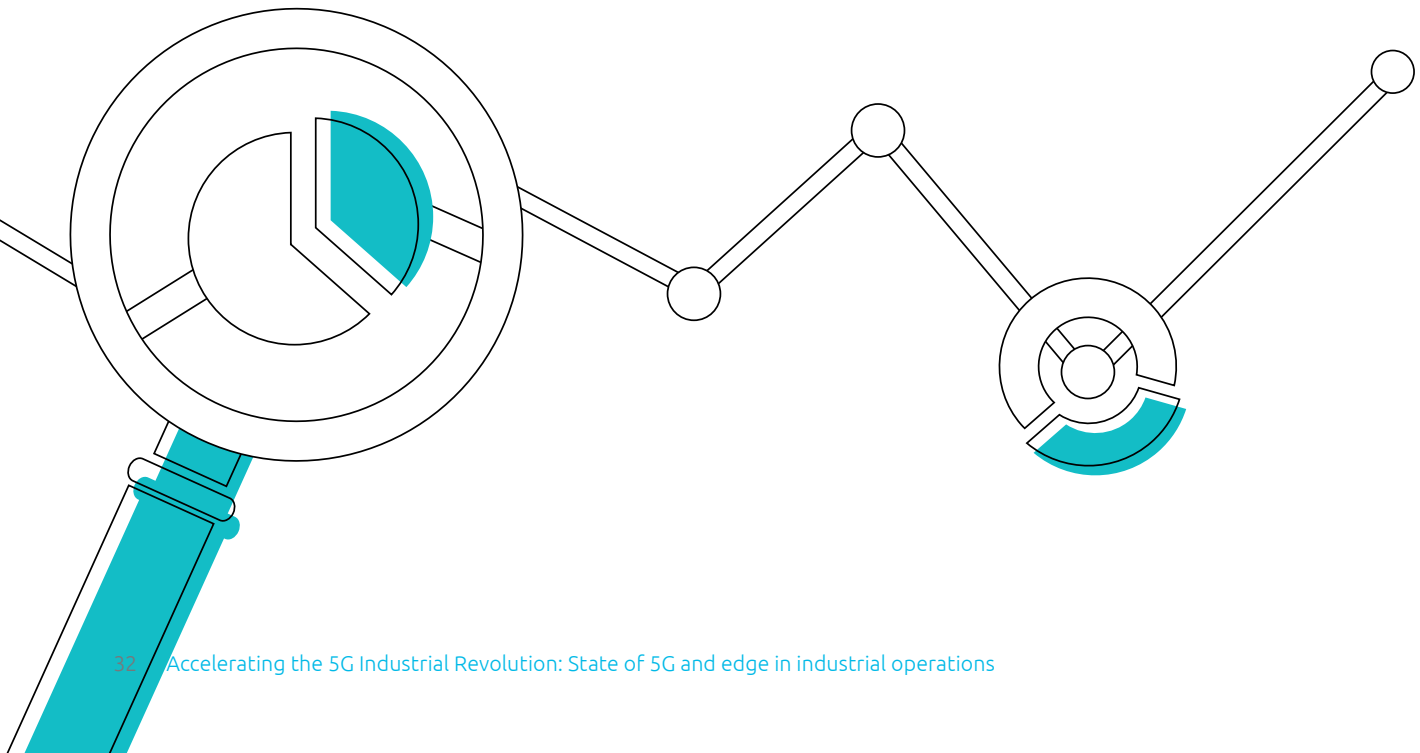
**Differences between greenfield and brownfield deployments.** The 5G business case will also need to consider whether deployments will take place in a greenfield or brownfield environment. In a greenfield environment, the absence of legacy infrastructure can mean that the ROI of 5G investments is relatively easier to quantify in comparison to brownfield environments.

## 5. Take a measured approach towards operationalizing use cases

**Start gradually and test results before progressing.** Operationalizing an emerging technology requires a gradual approach, given that many components of the overall solution are still maturing. Adopting a test bed route is one way of doing this. Another approach would be to test 5G out on relatively non-critical areas first, before extending its use gradually to critical requirements.

**Fine-tune approach as new 5G features become available and the overall 5G ecosystem matures.** Given that 5G standards are still evolving and new features will become available as standards mature, industrial organizations should create a 5G roadmap that incorporates new features into the testing and adoption cycle as they become available. The roadmap should also factor in the growth in availability of devices as the 5G device ecosystem matures. In practical terms, this means that while organizations will need to use gateways to integrate 5G with existing devices and systems in the early stages, this approach will need to evolve as 5G-enabled devices become more readily available in the future. Overall, organizations should plan to test and fine-tune their approach as they progress with 5G adoption so that they are aligned with the evolution of the 5G ecosystem.

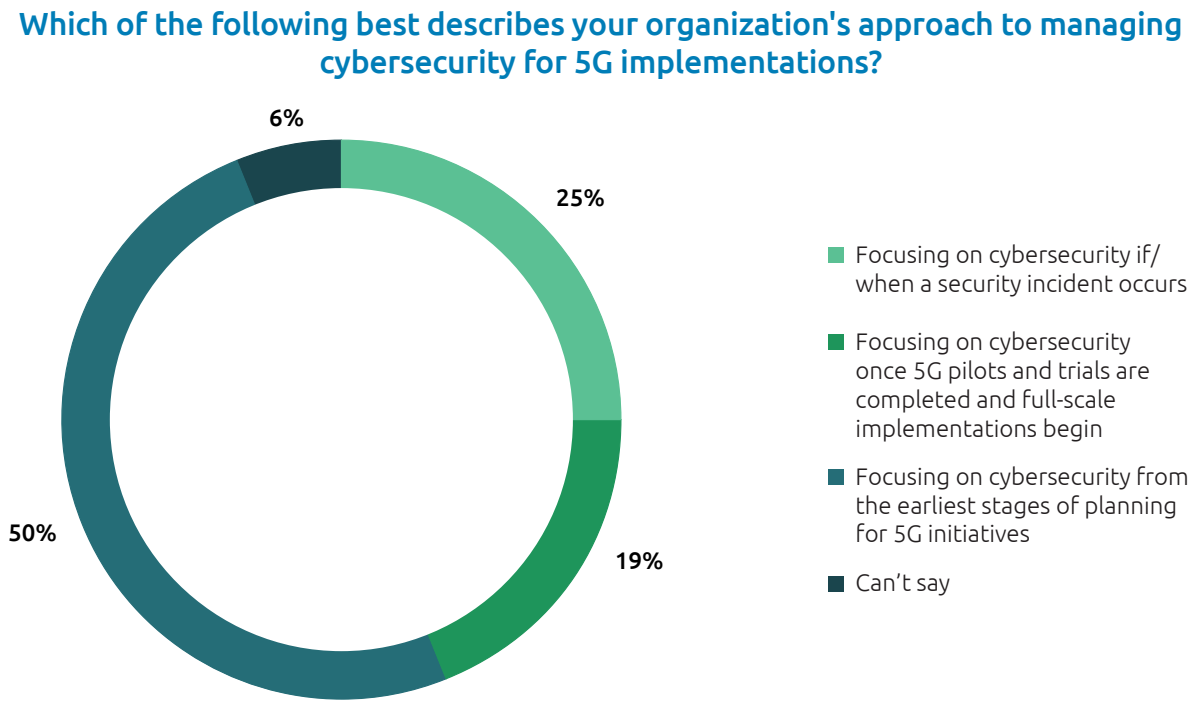
> We felt that we would come up with a better solution if we work together with partners. We would also mitigate our own risk to a certain extent by having that external input."
>
> **Adrian Talbot**
> **Head of the Center of Excellence, Ferrovial**



## 6. Ensure that security is built in by design from the earliest stages of 5G implementation

We found that close to one in five industrial organizations (19%) only plan to look into security once trials are complete and full implementation is about to begin, and another 25% only plan to focus on security if and when a security incident occurs. Such a reactive approach towards security can be a key vulnerability. In order to prepare for potential risks arising from 5G adoption, industrial organizations should focus on security from the earliest stages of planning and ideation. Only 50% of organizations do this currently (see Figure 21).

**Figure 21** A significant proportion of industrial organizations have a reactive approach to managing cybersecurity




**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=1,000 industrial organizations that have adopted or are planning to adopt 5G.

Industrial organizations will need to assess the security implications of different network deployment models. Where integration with public networks is needed (e.g., in the case of hybrid or virtual private 5G networks), organizations will need to determine the kinds of data that they would be willing to transmit over public networks and data that they want to keep on-premise. In addition, organizations will also need to be mindful of security considerations in the selection of service providers and vendors.

5G also brings in new opportunities when it comes to securing networks. Given that it is natively software-driven, 5G provides more data on network traffic. With the right network analytics, organizations can exploit this data to better manage cybersecurity.

# How can telcos aid their industrial clients' 5G journey?

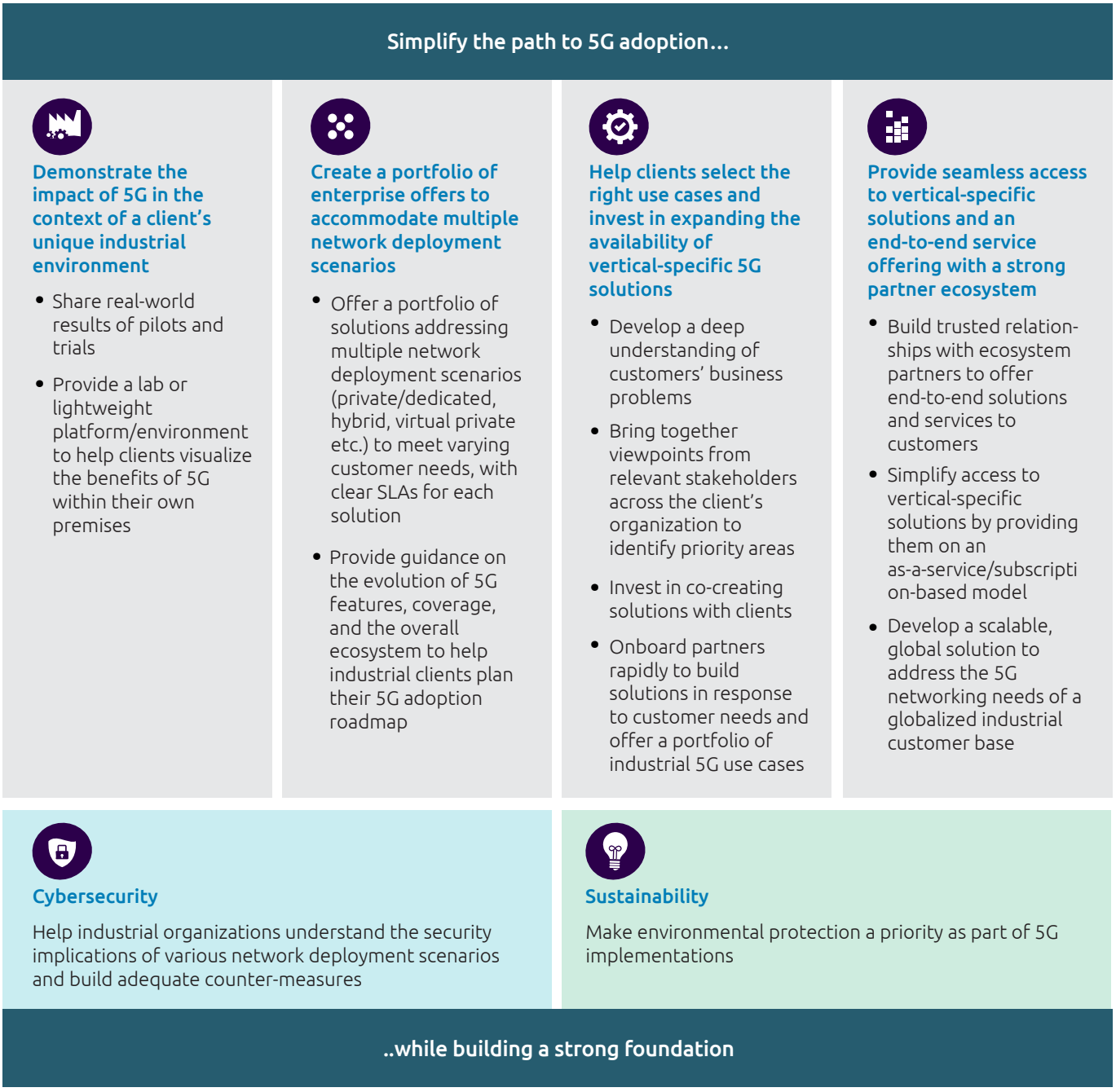
There are a number of measures that telcos can take to help industrial organizations address the challenges involved in 5G implementations (see Figure 22):

- Helping them visualize the impact of 5G within their own premises
- Offering a portfolio of solutions that address multiple network deployment scenarios to meet varying customer needs

- Playing an active role in helping them select use cases and develop vertical-specific solutions
- Helping them build and operate networks seamlessly.

In addition, it is critical that telcos stay focused on security and sustainability in order to ensure that the networks they help build are resilient and future-proofed.

**Figure 22** Simplify the path to 5G adoption and lay a strong foundation for 5G implementations




**Source:** Capgemini Research Institute analysis.

## Demonstrate the impact of 5G in the context of a client's unique industrial environment

Our interviews revealed that one of the factors holding back industrial 5G adoption is lack of clarity on whether 5G features will translate into on-the-ground reality. Industrial organizations understand what is theoretically possible with 5G but are unclear on what can realistically be achieved. To address this issue, telcos should take proactive steps to educate industrial customers about the real-world results of 5G trials and implementations. In addition, telcos should also help industrial customers visualize what the features of 5G will mean for them in practical terms and in the context of their own specific environments. For instance, what improved speed, latency and reliability will look like in the clients' own plants or sites. Highlighting the need for an environment that simplifies the evaluation of 5G use cases, Nobunari Kurachi, General Manager, Automobile Electronic Systems Development Department, at Suzuki Japan, says, *"We need to create a 5G environment to conduct the evaluation, and we hope we can do that flexibly. If it takes a lot of system implementation, it will be difficult to run even a proof-of-concept on a small scale. It would be helpful to have a lightweight environment that we can use to evaluate 5G."*

T-Mobile and Singtel provide examples of how this can be done:

- Helping customers visualize and experience the benefits of 5G is a key element of T-Mobile's approach to planning private 5G network deployments. Andrew Rainone, VP of Strategic and Global Accounts at T-Mobile, says, *"We customize the solutions and enable the customer to see the solutions visually in our lab so that they can experience expected throughput."*
- Singapore-based operator Singtel has launched a portable "5G-in-a-box" platform called "GENIE" that enterprises can install within their premises. It allows them to test 5G or verify the performance of use cases. The platform enables enterprises to better understand the benefits of 5G without incurring large installation costs. *"Seeing what 5G can do in their own premises will help more enterprises adopt 5G and speed up their digital transformation,"* says Dennis Wong, vice president, 5G Enterprise and Cloud Group Enterprise at Singtel.[57]

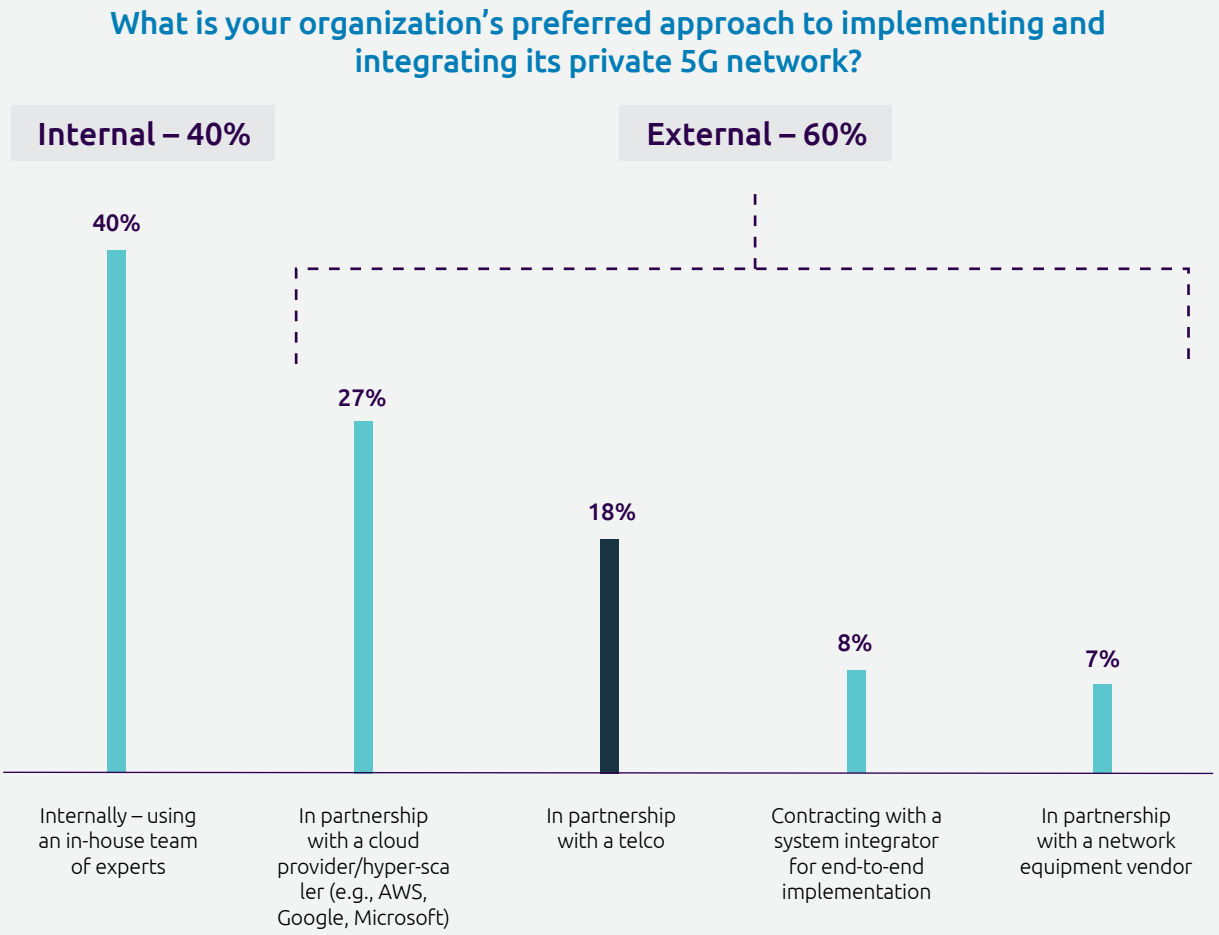
> We customize the solutions and enable the customer to see the solutions visually in our lab so that they can experience expected throughput."
>
> **Andrew Rainone**
> **VP of Strategic and Global Accounts, T-Mobile**

### Telcos need to move fast to claim the 5G enterprise solutions space

Telecom players have historically been viewed as providers of connectivity rather than value added services. In the consumer space, as smartphones became mainstream, most of the value generated via services enabled by high-speed connectivity, such as video streaming, was cornered by OTT players. This restricted the role of telcos, making them simply the providers of the connectivity "pipes" through which high-value data and services flowed. As a result, in the consumer space, telcos were left with a very small share of the overall retail consumer wallet.

There is a risk of this scenario repeating in the enterprise space for 5G services. Our survey shows that only 18% of industrial organizations see telcos as their preferred partners for the implementation and integration of private 5G networks. In contrast, more than a quarter (27%) prefer partnering with a cloud provider/hyper-scaler, such as AWS, Google, or Microsoft to implement private 5G networks (see Figure 23). In our discussions with senior executives, we found that for industrial organizations, 5G is not just about connectivity. Industrial organizations see 5G as an enabler of new and transformative industrial use cases. However, telcos are often not seen as solution providers with expertise in addressing vertical-specific business challenges.

**Figure 23** More industrial organizations see cloud providers as preferred partners for private 5G network implementations than telcos




**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=311 industrial organizations that prefer private networks.

Telcos are aware of the opportunity that 5G provides in the enterprise space. Half (51%) of the telcos surveyed said they expect to play the role of providing integrated, industry-vertical solutions consisting of connectivity, platforms, applications, and devices directly to enterprises. However, the perception of telcos being purely connectivity providers can be a hindrance. Telcos will need to build capabilities to claim the enterprise solution space for 5G services. Matteo Gatta, CEO of Belgacom International Carrier Services (BICS), highlights the shift that telcos will need to make when he says, *"Telcos have to redesign their entire engagement in the market by becoming truly solution-driven. They need to reimagine their role as an integral part of their target customers' digital transformation, investing in a much deeper understanding of those needs in order to provide unrivalled value."*

> Telcos have to redesign their entire engagement in the market by becoming truly solution-driven. They need to reimagine their role as an integral part of their target customers' digital transformation."
>
> **Matteo Gatta**
> **CEO, Belgacom International Carrier Services (BICS)**

## Create a portfolio of enterprise offers to accommodate multiple network deployment scenarios

To fully address industrial 5G requirements, telcos should adapt their portfolio of 5G enterprise offers and provide solutions targeted at a variety of network deployment scenarios (e.g., private, hybrid, or virtual private networks). Each solution should be supported by clear SLAs. Telcos should also provide customers with a clear picture of the advantages and disadvantages of various network deployment models to help them take the right decisions and select the model that best fits their requirements. In addition, telcos should help industrial organizations understand trends in the evolution of 5G features, coverage, and the overall ecosystem to help them plan their deployments better. This includes providing guidance on the timelines for the availability of new features, and the expansion of coverage both locally and globally. Our interviews revealed that lack of clarity on such aspects is a challenge for organizations and can hold back 5G adoption.

## Help industrial organizations select the right use cases and expand the availability of vertical-specific 5G solutions

As we saw earlier, difficulties with identifying the right 5G use cases and the lack of readily available 5G applications are holding back industrial 5G implementations. To help their industrial clients address these issues, telcos should consider the following:

- **Develop a deep understanding of the business problems that customers are trying to solve.** As a first step towards becoming more solution-driven, telcos will need to focus on understanding the business problems that customers are trying to address and the business outcomes that they are trying to achieve. John Vickery, principal technology partner and Enterprise CTIO at BT, highlights this when he says, *"The first thing is to have really deep relationships with customers. When you're speaking to a customer, you want to get right down to what their key performance indicators are – the metrics that they're looking to improve upon as a business. Don't look at it in the context of 5G or edge compute – instead look at it in the context of the outcome that the customer is trying to drive – for example, reducing unproductive container moves to increase available capacity and drive revenues. It's important to have deep discussions where you start to understand what your customer wants, and then looking at the solutions that you need to develop that can help them improve those metrics. And once you do that for one customer, it's quite likely that you can apply that across a sector."*

> The first thing is to have really deep relationships with customers. When you're speaking to a customer, you want to get right down to what their key performance indicators are – the metrics that they're looking to improve upon as a business."
>
> **John Vickery**
> **Principal Technology Partner and Enterprise CTIO, BT**

> Investing in a specific new technology in an early stage is always going to bring risk. If telcos participate in co-developing some business applications, I think a lot of potential customers will listen. It will help telcos gain the trust of their clients."
>
> **Guy Van Wijmeersch**
> **Director of Innovation and Design Thinking, BARCO**

- **Bring together viewpoints from relevant stakeholders across the client's organization to identify priority areas.** To help industrial organizations understand how best they can leverage 5G, telcos should consider initiating a dialogue with relevant stakeholders, focusing on those in the client organizations who will be impacted by 5G adoption. This is an approach that has worked well for Belgium-based operator Citymesh, for instance. It identified more than 100 use cases for one of its clients, based on extensive discussions with stakeholders from across the organization. In one example Citymesh shared with us, CEO Mitch De Geest outlined how stakeholder discussions prompted field workers to think about how 5G could help *"make their job easier, safer, and more efficient."* Such an approach can provide a more solid starting point for 5G implementations, by helping organizations see the full set of possibilities that 5G provides for their organizations before they identify priority areas. It also ensures that the choice of use cases is grounded in the actual needs of the organization.
- **Invest in co-creating solutions with clients.** Our discussions revealed that the investments required to develop 5G applications and the risk of failure can also act as deterrents to 5G implementation. To help alleviate such concerns, telcos should consider investing in co-creating solutions with their industrial clients. Guy Van Wijmeersch, director of Innovation and Design Thinking at Belgian technology company BARCO, highlights the role of trust between organizations and their suppliers in increasing the adoption of an emerging technology such as 5G, and how co-creating solutions is one way of building trust. *"Investing in a specific new technology in an early stage is always going to bring risk,"* he explains. *"So, anything that can increase trust levels between companies and their suppliers can help with increasing the adoption ratio. Co-investing, perhaps in some cases, at least in early stages, would be an interesting proposition. If telcos participate in co-developing some business applications, I think a lot of potential customers will listen. It will help telcos gain the trust of their clients."*
- **Onboard partners rapidly to build solutions in response to customer needs and offer a portfolio of industrial 5G use cases.** Once they have a clear picture of the business problems that customers are trying to solve, telcos should move rapidly to onboard partners to deliver solutions. BT's John Vickery says, *"As operators, if we're looking at vertical solutions, we need to start to think about things in a slightly different way, and not just think that we can reuse our old processes on procurement. Operators have to be a lot more agile in onboarding new partners and building products and propositions."*
  A senior telecom executive at a leading global telecom operator outlines how they are building an ecosystem of small- and medium-sized device and application companies. The goal is to develop a portfolio of prototypes for 5G use cases as well as customized solutions for enterprise customers. *"We do have a lot of internal expertise to build end applications,"* he says. *"But at same time we work with a lot of software companies and device manufacturers who provide IoT devices, modems, or routers. We give them access to our network and our test labs for them to come and develop and test their applications and certify their devices on our network. We are building an ecosystem of hardware and software partners – mainly small- and medium-sized companies – to build functionality for say a connected car or connected factory. We are working with them to build prototypes so that we can show them to our enterprise customers and tell them that we can deploy a similar ecosystem in their factory. We are also working with our partner ecosystem to build applications on demand for our customers based on our customers' requirements."*

As they seek to better address their industrial client's business challenges, telcos will also need to equip their go-to-market teams with the skill sets needed to sell not just infrastructure but also industry-specific solutions.

Matteo Gatta, CEO of Belgacom International Carrier Services (BICS), summarizes the capabilities that telcos will need to build in order to offer scalable and compelling industrial use cases around 5G. *"First, telcos need to fully grasp the potential of 5G Standalone technology and develop proof of concepts to achieve the credibility they need to succeed in the enterprise market space. This can come from a software and application-based approach that integrates with their networks, which favors the development of use cases. They further need to invest in software skills, specifically sourcing talent that can work in a DevOps mode, to create and manage customer-centric solutions. Through launching minimum viable products, they can develop, test and target these cases together with enterprise customers to build a community of early adopters, in order to build a portfolio of scalable and compelling 5G use cases,"* he says.

Jennifer Artley, Senior Vice President, Strategic Initiatives, Verizon Business, adds, *"It is important to have a defined framework for enterprises that enables the creation of a flexible, programmable, and scalable technology experience with a path to 5G. Leveraging and working with our partner ecosystem allows us to support the most complicated deployments, deliver long-term digital transformation growth and a continuous innovation roadmap for our customers."*

## Provide seamless access to vertical-specific solutions and an end-to-end service offering with a strong partner ecosystem

**Build trusted relationships with ecosystem partners to offer an end-to-end service to customers.** As we saw earlier, managing a multi-vendor environment is a key barrier in 5G implementations. Our interviews with senior industry executives revealed significant interest in an integrated end-to-end 5G service offering that allows organizations to focus on using 5G to address their business needs without worrying about managing a multi-vendor 5G environment. Telcos should therefore focus on building an integrated service offering that combines connectivity with devices, applications, and the security layer – all of which are essential components of an overall 5G solution. This will require building trusted relationships with a range of ecosystem partners, including cloud providers, edge compute providers, network equipment vendors, hardware providers, and system integrators. T-Mobile's Andrew Rainone points out that building trusted relationships is key to offering a complete solution to industrial customers, saying: *"You need to have a trusted relationship with cloud service providers and a good communication path with hardware vendors. And, if it's not a pure wireless private network, you need to have a really great relationship with providers who might be hosting the Wi-Fi access points inside of a facility."*

**Simplify access to vertical-specific solutions by providing them on an as-a-service/subscription-based model.** Our discussions with senior industry executives also revealed the need for simplified access to vertical-specific solutions. *"Telcos or service providers should provide vertical-based end-to-end solutions – such as IoT as a service or solution as a service,"* says Ehsanul Islam, an expert on 5G based in Taiwan. *"They can provide a dashboard and charge on a monthly basis. Partners can share the costs and revenue so that everyone can benefit."* South Korea's SK Telecom, for instance, launched a subscription-based smart factory solution for SMEs that enables organizations to optimize equipment maintenance using 5G-enabled sensors placed on manufacturing equipment.[58] Our research suggests that large organizations are also receptive to such solutions.

**Develop a scalable, global solution to address the 5G networking needs of a globalized industrial customer base.** Given that their industrial customers will likely have a global presence, telcos will need to offer solutions that work seamlessly across borders. This will require building a common, group-wide approach to addressing the needs of industrial customers that have a globalized presence. This is often not the case given that telco strategies are typically aligned primarily around domestic market needs.

Fujio Matsuda, senior adviser – DX Promotion Group, at Hitachi Construction Machinery, Japan, that is evaluating the use of 5G for the remote control and maintenance of construction machinery, says, *"5G will not become widespread overnight. Even if we adopt a standard solution, will we be able to use it anywhere in the world? We will need to validate the global usability of our applications."*

In addition to simplifying the path to 5G adoption, it is critical that telcos stay focused on building the right foundations for 5G implementations. Securing 5G network implementations against the threat of cyber-attacks and building measures right from the start to mitigate the environmental impact of 5G implementations are two critical aspects of this. We look at each of these below.

> 5G will not become widespread overnight. Even if we adopt a standard solution, will we be able to use it anywhere in the world? We will need to validate the global usability of our applications."
>
> **Fujio Matsuda**
> **Senior Adviser, DX Promotion Group**
> **Hitachi Construction Machinery, Japan**

Security will need to be a critical part of telecom players' 5G value proposition. Our interviews revealed that industrial organizations are looking at service providers to ensure that cybersecurity is given due attention during 5G implementations. Sharing their expectations from service providers, a senior executive from a large industrial manufacturing organization says, *"It is the responsibility of whoever is putting together the private network to ensure that multilayer hardware and software protections are provided, precautions are taken to prevent attacks and processes are in place to quickly recover from an attack, if it happens."*

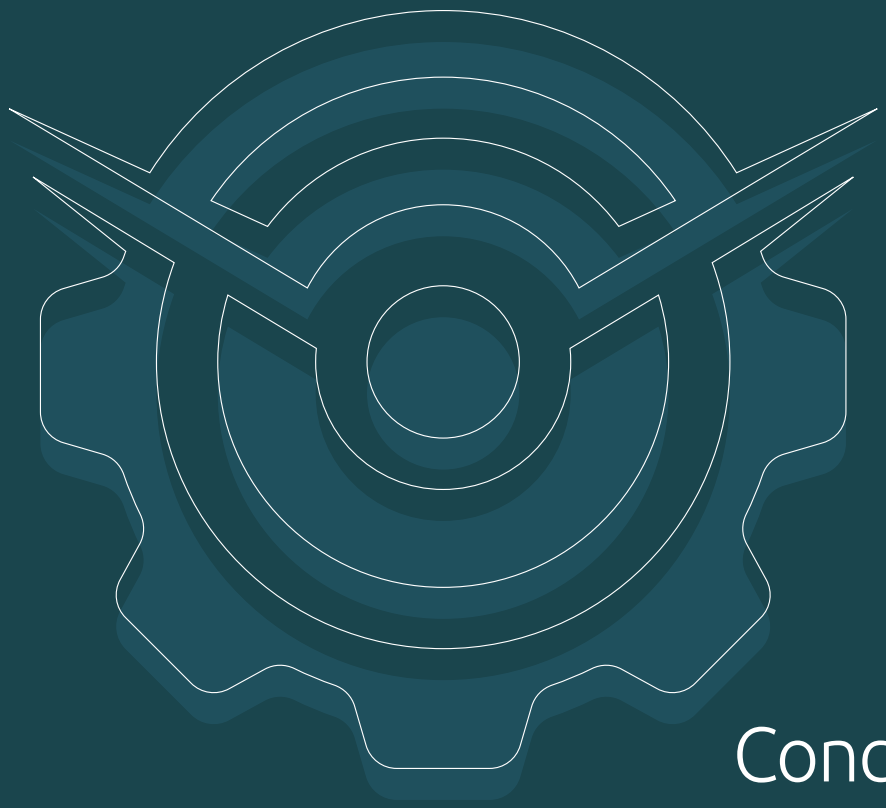
Telcos should therefore make security a key focus of their 5G network implementations, ensuring that they understand their clients' security concerns and help address them. This includes providing an assessment of the risks associated with different network deployment scenarios and the measures that can be taken to mitigate the risks. Citymesh's Mitch De Geest says, *"There are a lot of ways to tackle security issues within the 5G protocol. But, as a best practice, we really sit down with the customer to try to understand what they're trying to achieve and to see how we can secure their data."*

A senior telecom executive at a leading global telecom operator we spoke with emphasized the need to view security as a mandatory component of 5G implementation and not as a value add, saying, *"When we provide solutions such as a 5G private network or IoT network to our customers, we make sure that we put security at the forefront of those solutions and make sure everything has been protected. Our partners are also part of this from the beginning, from the first stage. We make sure we do not take any device to a customer or deploy any device in a customer's infrastructure or network without testing it from a security point of view as well. In some cases, security comes before anything else. So, it is not optional, and it is not value added – it is a mandatory service to have."*

## Make environmental protection a priority as part of 5G implementations

Telcos should also ensure that sustainability is factored into the decision-making process as part of 5G rollouts and steps are taken to offset the increase in power consumption due to 5G networks. Nokia and Telefonica, for instance, are collaborating to use AI and machine learning to further improve the energy efficiency of 5G networks. The two companies are also looking at building "green 5G networks" using sustainable hardware and software features to limit emissions from 5G networks themselves.[59] In addition to taking steps towards reducing the carbon footprint of their 5G rollouts, telcos should also proactively and transparently share the measures they are taking with their industrial clients. This can help alleviate clients' concerns regarding the environmental impact of 5G implementations.

> There are a lot of ways to tackle security issues within the 5G protocol. But, as a best practice, we really sit down with the customer to try to understand what they're trying to achieve and to see how we can secure their data."
>
> **Mitch De Geest**
> **CEO, Citymesh**



# Conclusion

5G is a paradigm shift for industrial organizations. By offering lower latency, higher throughout and reliability, and supporting a significantly larger number of devices with higher QoS, 5G combined with edge computing can help organizations unlock value through new industrial use cases that were previously not possible. While these are early days for 5G adoption, the early benefits realized so far are encouraging and demonstrate the value that 5G brings. These benefits include increased efficiency and flexibility of industrial operations.

However, there are a range of challenges that are holding back more widespread adoption of 5G in the industrial sector. The lack of 5G devices is a major impediment. In addition, there are challenges associated with integrating 5G with existing networks, difficulties in identifying the right use cases and the lack of vertical-specific solutions, and managing cybersecurity, among others.

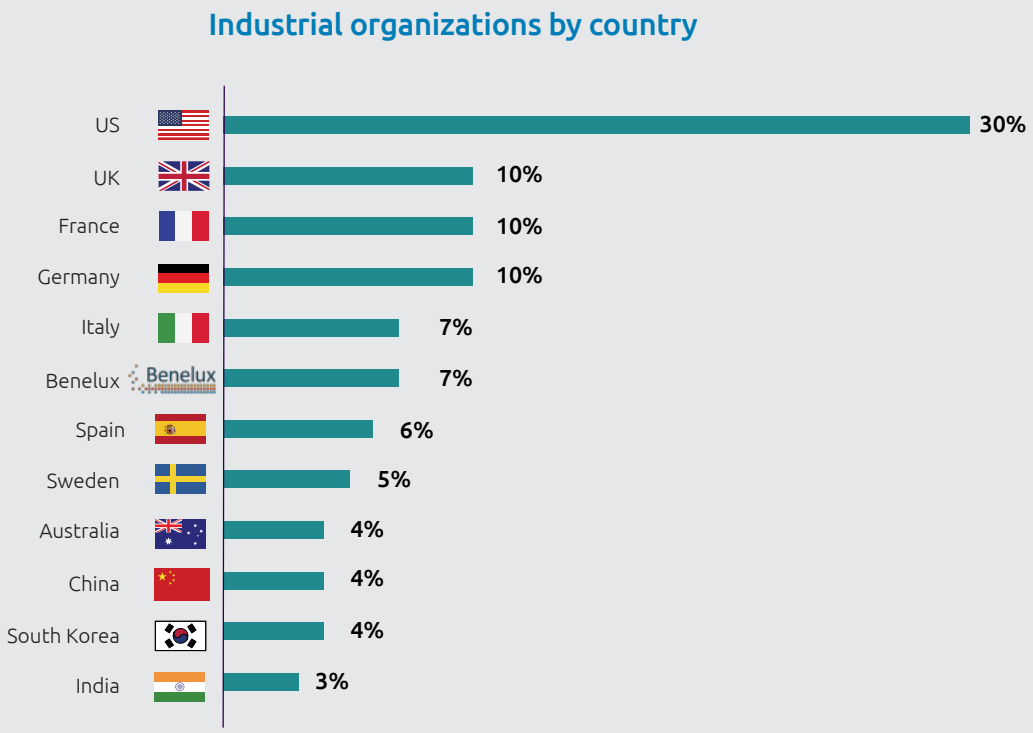
When implementing 5G, organizations need to determine the optimum network model, the right set of partners, and the most impactful use cases that best fit their needs. Organizations must also be mindful of the sustainability impact of their 5G plans and account for additional carbon emissions due to their 5G devices and data generated. Telcos also need to quickly build essential capabilities to move from being connectivity providers to providers of vertical-specific solutions. Given that these are early days for 5G implementation, telcos, cloud providers, OEMs, and other partners must also work together to build an ecosystem of devices, solutions, and service offerings to accelerate the adoption of 5G in the industrial sector.

# Research Methodology

We surveyed 1,000 senior executives (director and above) from industrial organizations who have adopted or plan to adopt 5G. We also surveyed 150 senior executives from 75 telcos across Europe, US, and APAC who have rolled out or plan to roll out 5G.

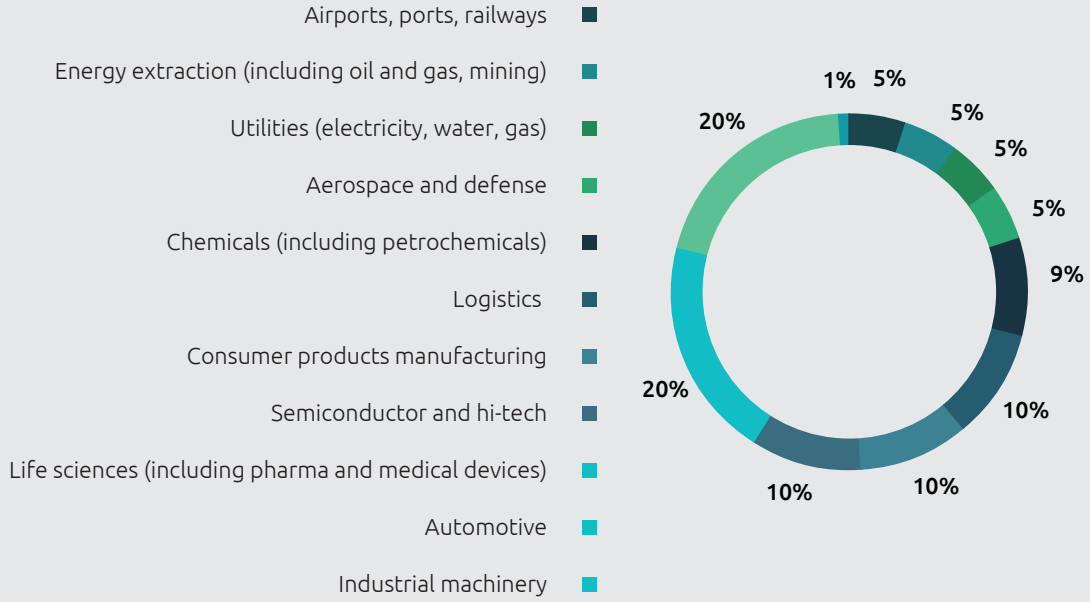
In addition, we also conducted in-depth interviews with 25 senior executives.

**Distribution of industrial organizations**



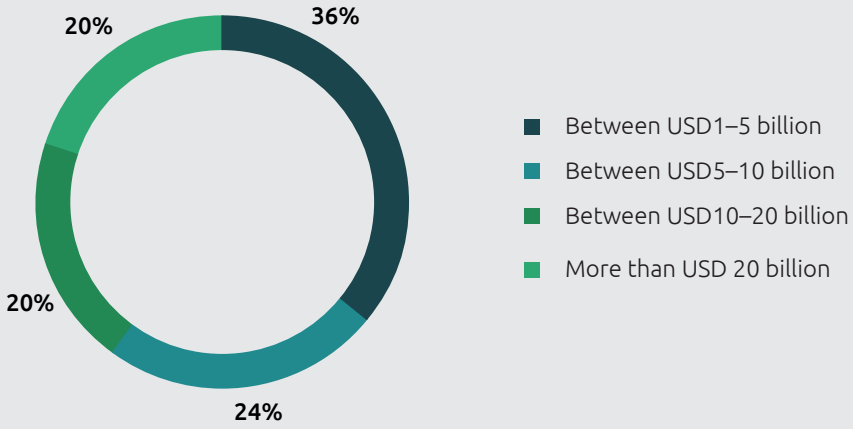

**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=1,000 industrial organizations that have adopted or are planning to adopt 5G.

## Industrial organizations by sector



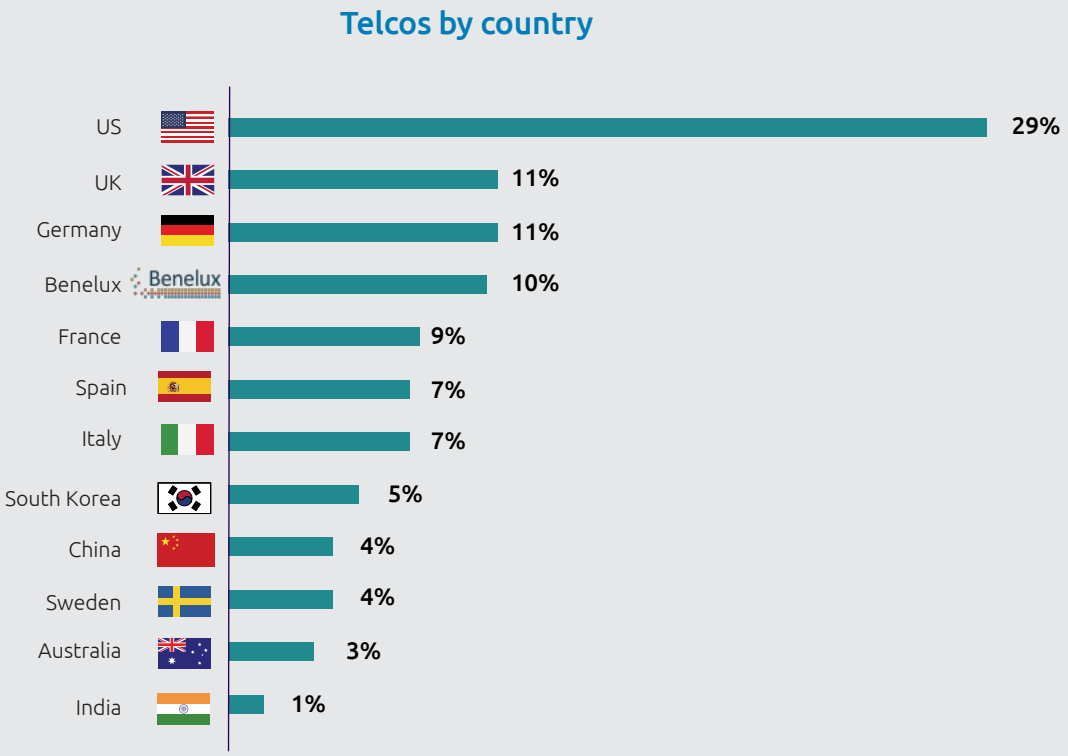

**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=1,000 industrial organizations that have adopted or are planning to adopt 5G.

## Industrial organizations by annual revenue



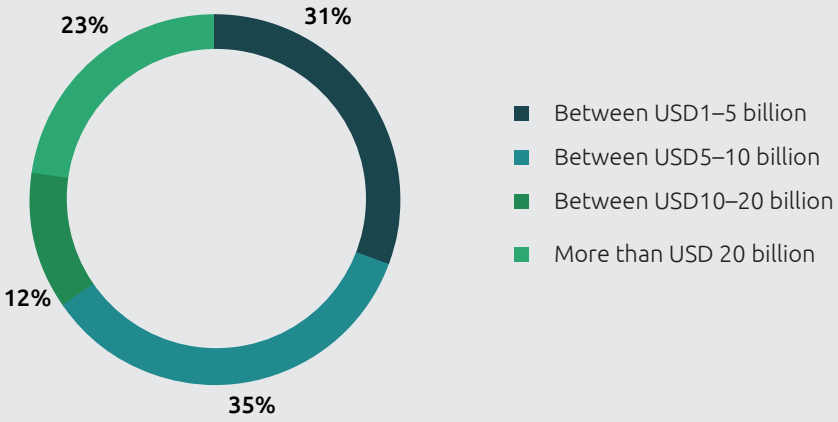

**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=1,000 industrial organizations that have adopted or are planning to adopt 5G.

**Distribution of telcos**



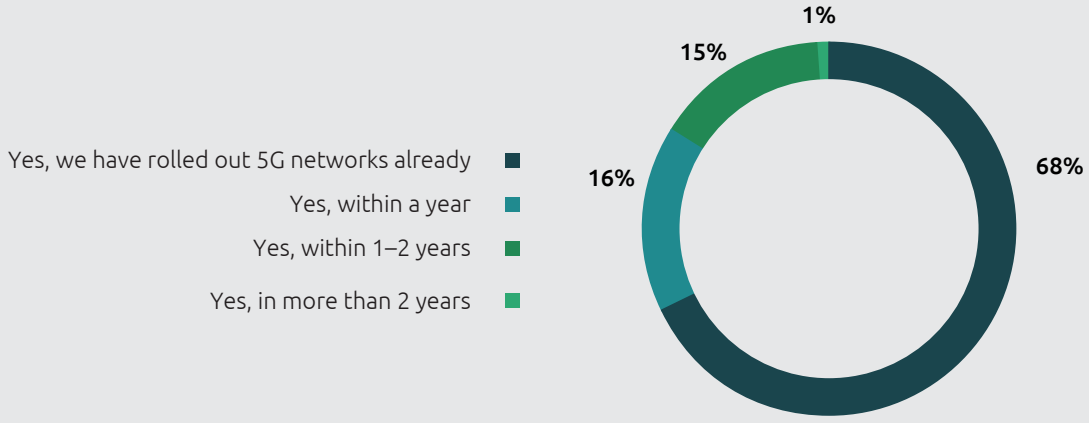

**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=75 telcos that have rolled out or plan to roll out 5G networks.

## Telcos by annual revenue




**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=75 telcos that have rolled out or plan to roll out 5G networks.

## Has your organization rolled out 5G networks/does your organization plan to rollout 5G networks in the future?

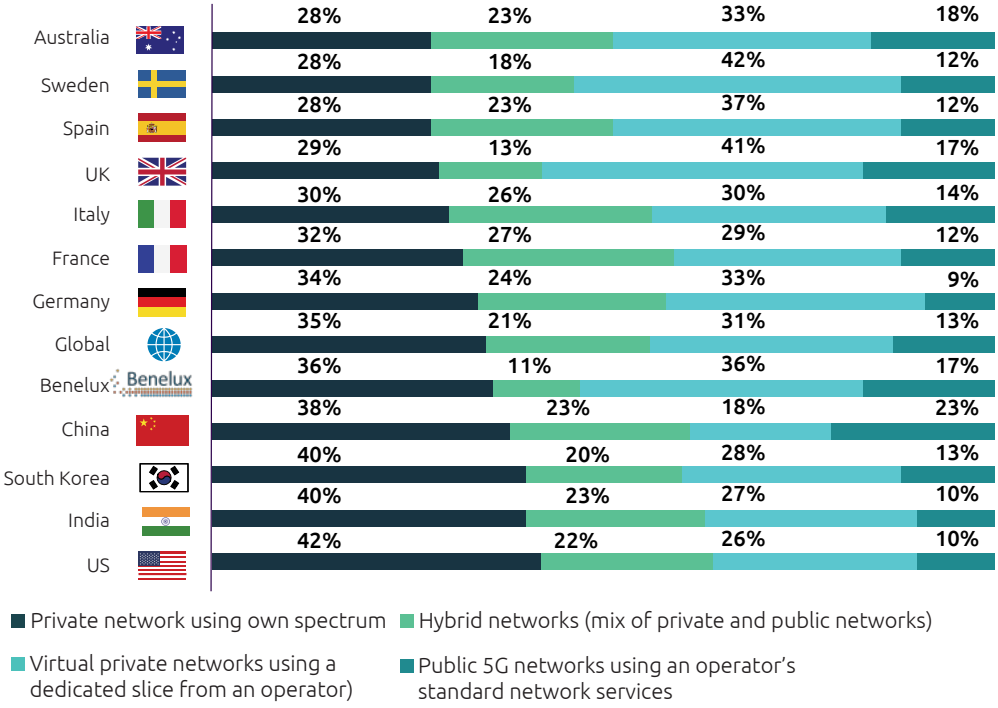



**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=75 telcos that have rolled out or plan to roll out 5G networks.

# Appendix

**Preference for 5G implementation models by country**

## Which of the following is your organization's preferred model for 5G implementation?

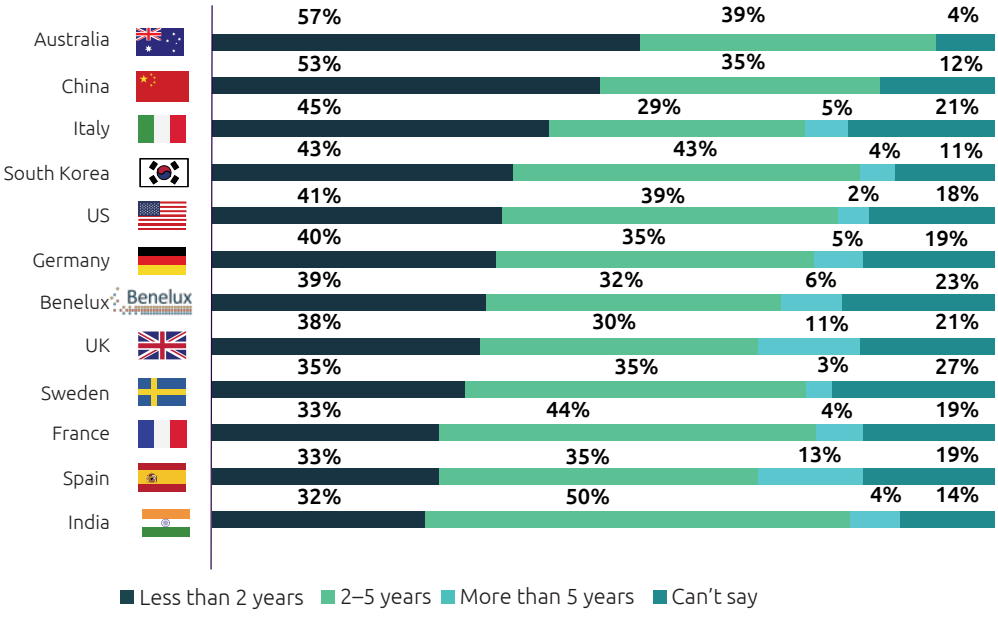



**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=1,000 industrial organizations that have adopted or are planning to adopt 5G.

**Timelines for 5G implementation at a single site**

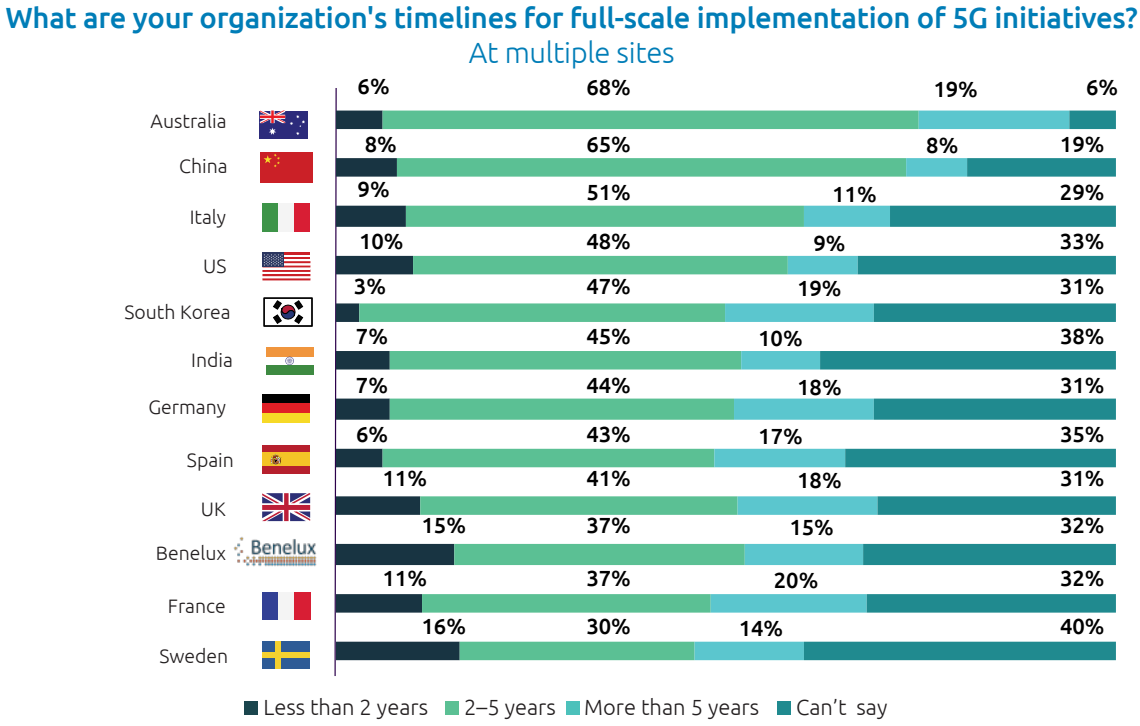
## What are your organization's timelines for full-scale implementation of 5G initiatives?

At a single site



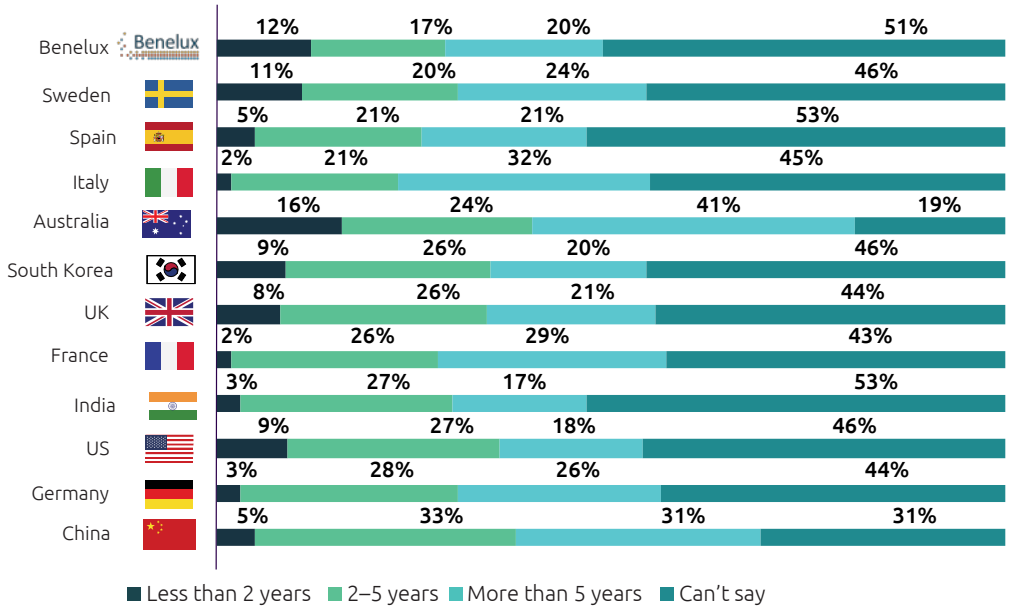

**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=789 industrial organizations that are at the pilot or earlier stages of 5G adoption.

**Timelines for 5G implementation at multiple sites**



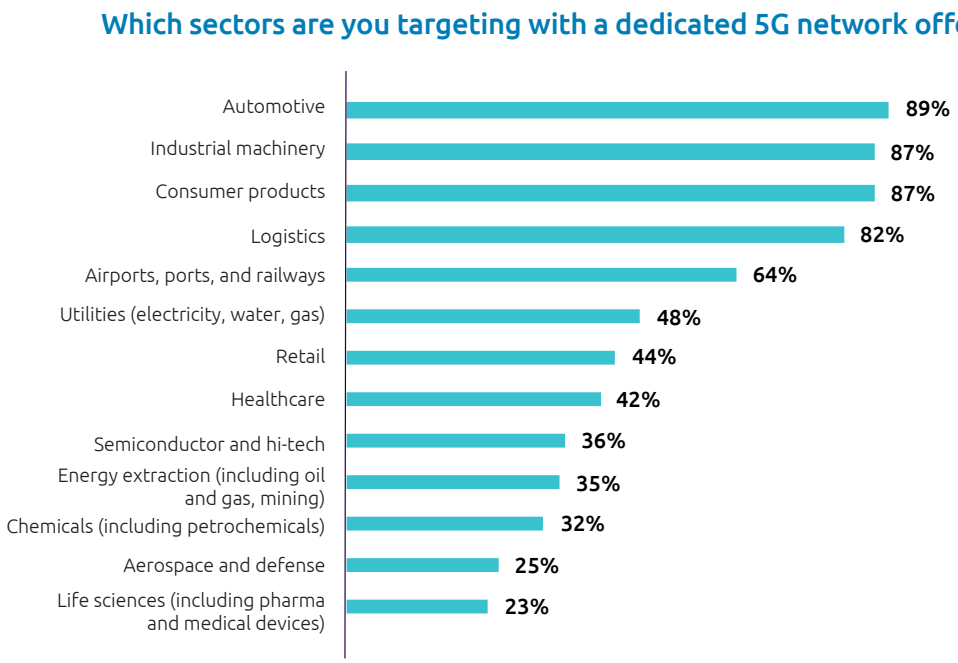

**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=875 industrial organizations that have implemented 5G at a single site, or are at the pilot or earlier stages of 5G adoption.

**Timelines for 5G implementation at most/all sites**




**Source:** Capgemini Research Institute, 5G and edge in industrial operations survey, February–March 2021, N=946 industrial organizations that have implemented 5G at scale at multiple sites, single site or are at the pilot or earlier stages of 5G adoption.

**Sectors that telcos are targeting with their private network offers**

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The Capgemini Research Institute is Capgemini's in-house think tank on all things digital. The Institute publishes research on the impact of digital technologies on large traditional businesses. The team draws on the worldwide network of Capgemini experts and works closely with academic and technology partners. The Institute has dedicated research centers in India, Singapore, the United Kingdom, and the United States. It was recently ranked number one in the world for the quality of its research by independent analysts.

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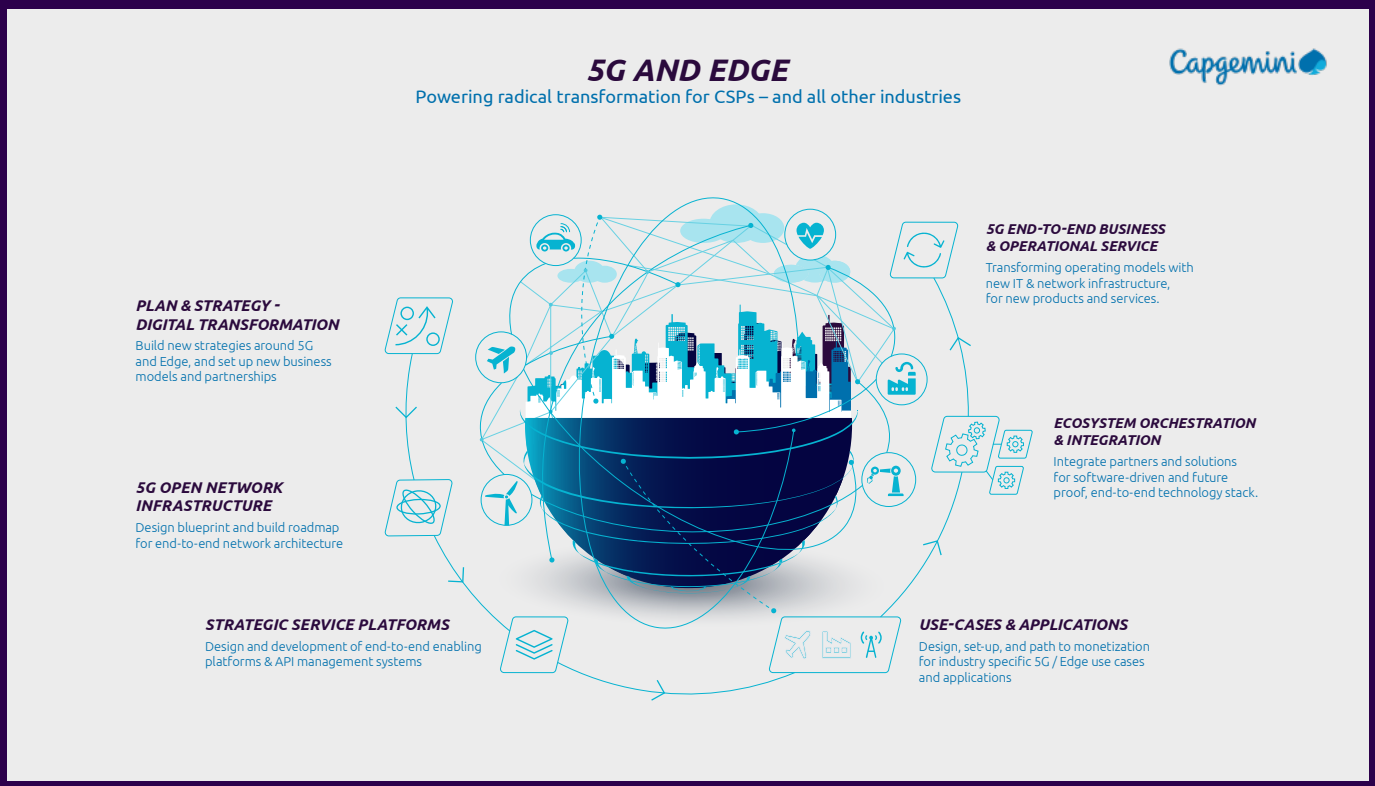

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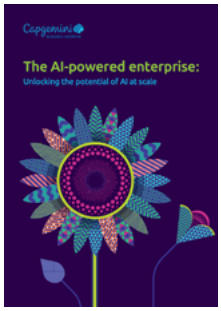


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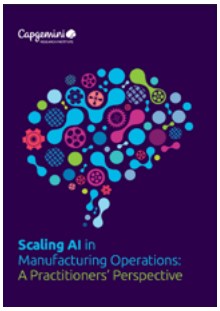


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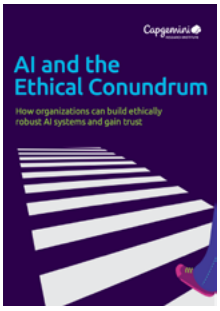


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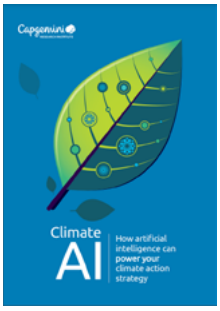


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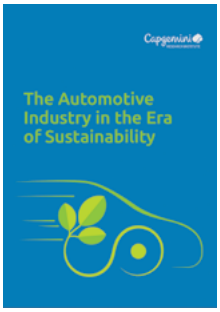


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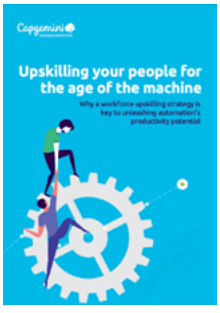


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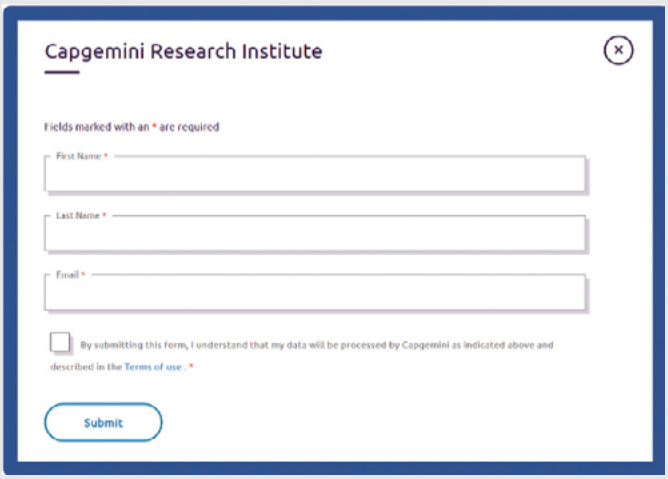

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