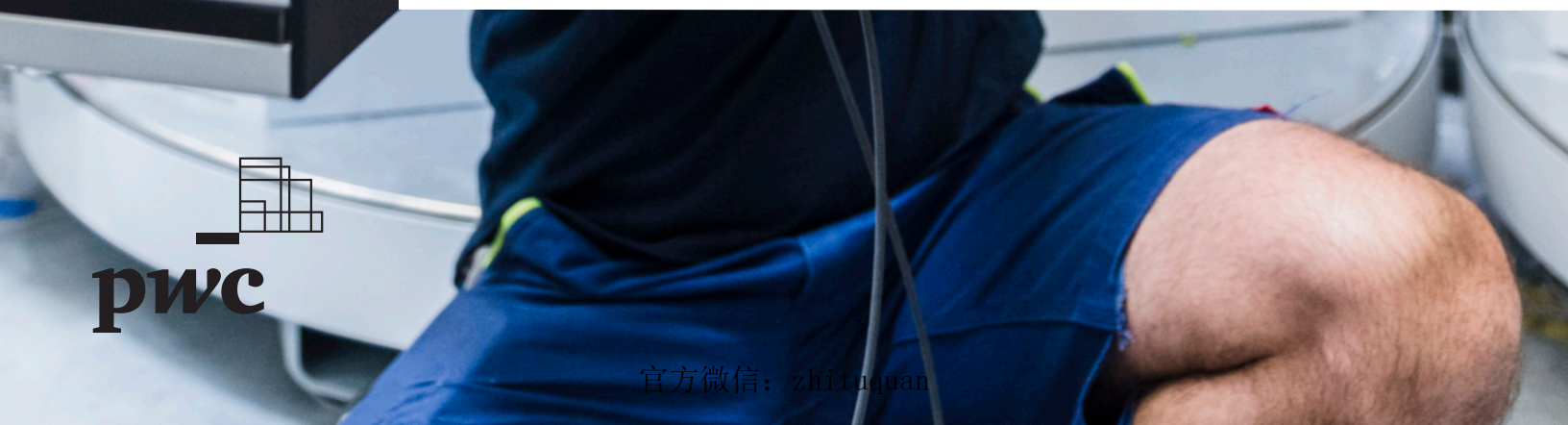
# 5G in manufacturing

**How the new wireless standard can accelerate automation**



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# Executive summary

Most of the technologies on which the Fourth Industrial Revolution (4IR) depends are in place — at least in theory. Advanced robotics and 3D printing, artificial intelligence (AI) and machine learning, sophisticated sensors and the Internet of Things (IoT), cloud computing, virtual and augmented reality, advanced data analytics — most manufacturing companies understand the value of these technologies whether they are in the supply chain, in production processes or incorporated into the products and services sold to customers. But few manufacturers have made the big bets necessary to implement these technologies throughout their operations.

According to a 2019 study by PwC and the Manufacturing Institute, more than half of manufacturers are either just beginning to experiment with emerging technologies or haven't even started. Now comes 5G, the super-fast, super-flexible wireless communications technology that is already being implemented in neighbourhoods around the world. It promises highly reliable, near-instantaneous data connectivity — a critical part of the vision of smart factories, connected supply chains and IoT-enabled products.

5G may not be the missing piece that will generate the immediate gains in productivity inherent in the promise of 4IR. But no manufacturer can ignore its potential in realising many of the technologies and processes coming to the factory in the near future.

## Imagining smart manufacturing

The modern factory is already a highly complex environment. The promise — if not the full reality — of 4IR has pushed organisations to digitise virtually every aspect of manufacturing. Advanced machines and robots are equipped with a wide array of sensors connected to high-powered analytics engines in the cloud that assess performance, manage production schedules, maintain supplies and orchestrate all the activities on the factory floor.

Now imagine that factory transformed by the implementation of 5G networking. The significantly greater speeds of 5G — up to 10 Gbps, far faster than wi-fi — and its near-zero latency should alleviate concerns about the speed and reliability of earlier wireless protocols. By eliminating the need for wired connectivity, 5G will supplement the high-speed manufacturing environment with a far greater degree of flexibility. And the sheer richness of the 5G-enabled factory, which will have the capacity to maintain connections among far more sensors than either wired or previous wireless facilities, offers the potential to connect just about anything (see Exhibit 1).

**Exhibit 1. 5G's technology specs far surpass those of other wireless protocols**

| | | Real-time high-capacity, low-latency applications | | |
|---|---|---|---|---|
| **Feature** | **Description** | **Wi-Fi6** | **4G** | **5G** |
| Latency | Delay between the sender and receiver of the data — the lower the latency, the more 'real time' the experience of the event | 20 milliseconds (ms) | 30–50 ms | 1–10 ms |
| Reliability/availability | How efficient the network is in transporting data between the source and destination without packet loss | 99.99% | 99.99% | 99.99% |
| Throughput | Theoretical maximum amount of data moved from one place to another in a given period | 9.6 Gbps | 300 Mbps–1 Gbps | 10 Gbps |
| Speed (project driven) | Expected practical speeds per user or device | 1 Gbps | 20–50 Mbps | Up to 1 Gbps |
| Connection density | Number of connected devices per unit area | 8 per part | 12 per part | 100 per part |
| Energy | Comparative power consumption levels | Medium | High | Medium |

Source: PwC

What will 5G enable? Processes with the greatest potential for productivity gains include:

- **Production optimisation.** Capturing real-time data on machines, inventory and production will let companies analyse production patterns in far greater detail. With this information in hand, they can identify the proper sequencing of factory activities and maximise flow, helping smooth production cycles and reduce waste.
- **The modular factory.** 5G's potential density, speed, wide bandwidth and low latency will enable considerable flexibility. Tools and robots can be repurposed quickly, improving efficiency and creating an environment in which mass customisation and manufacturing on demand will be possible.
- **Enterprise connectivity.** 5G will enable the integration of factory infrastructure, operational technology and resources with enterprise IT systems, enabling further optimisation and remote control of factory processes.
- **Human–machine interface.** The speed and density of 5G will free staff from fixed computer terminals, providing the means to equip them with mobile data and visualisation solutions, such as tablets and augmented reality gear, enabling visual interaction with machines and products.
- **Supply chain integration.** As transparency into the supply chain increases, having 5G networking integrated into factory tools will enable fast, automatic replenishment of parts and supplies, minimising delays and boosting efficiency.
- **Preventive maintenance.** Denser arrays of sensors will allow companies to monitor the status of equipment far more closely. This in turn will enable them to conduct scheduled maintenance when needed, predict the need for unscheduled maintenance before problems arise and enhance remote diagnostics performed by suppliers of complex equipment.
- **Safety.** The wide range of sensors available and 5G's near-instantaneous response time will create a considerably safer manufacturing environment, with fewer people needed on the floor and more responsive emergency shut-off signals.

Consider the experience of a German manufacturer of metal-bladed disks for jet engines. The long and complex process of making the disks was causing an error rate of up to 25%, and a faulty disk couldn't be identified until after manufacturing was finished. By installing sensors capable of detecting potential faults in real time and connecting them through a 5G network, the manufacturer was able to stop the machines before the manufacturing fault actually occurred. The result: a significant decline in the error rate and a savings of several thousand euros in the average production cost of each disk.

**The sheer richness of the 5G-enabled factory, which will have the capacity to maintain connections among far more sensors than either wired or previous wireless facilities, offers the potential to connect just about anything.**

# Assessing the challenges

As compelling as it is to imagine the factory of the future, achieving it is no easy task. It is helpful to divide the challenges of 5G-enabled automation into two general areas: the technological and the financial.

## Technological challenges

The sheer complexity of automation technology is a major limiting factor. A recent PwC survey of manufacturers shows that the majority of industrial companies have yet to implement many of the technologies associated with 4IR (see Exhibit 2, next page).

Moreover, even those companies that have made progress in implementing these new technologies remain concerned about converting their plants to a fully wireless environment. Manufacturers have long depended on closed, hardwired factory systems, in which neither reliability nor security was a significant concern. But a fully wireless environment brings both of these concerns to the fore. Although 5G promises high levels of reliability, the factory floor is a notoriously difficult, noisy environment for any wireless system. And no wireless system that's dependent on open connectivity to the cloud can be 100% secure. It is possible to implement 5G as an entirely closed system, but that would likely mean losing the speed and flexibility gained by maintaining critical computing processes in the cloud.

Finally, 5G presents (as does the entire suite of technologies that make up 4IR) another iteration of a long-standing problem for manufacturers: how can they be sure that these new technologies won't be superseded by something even better in the next few years? No technology is fully future-proof, of course, but a singular virtue of the digitised factory is that the critical underlying software on which the factory depends can be updated regularly, assuaging concerns that entire systems will quickly become obsolete. Indeed, factories may soon be governed entirely by fully integrated, software-based platforms, with features that can be quickly implemented and modified as needs change.

## Financial challenges

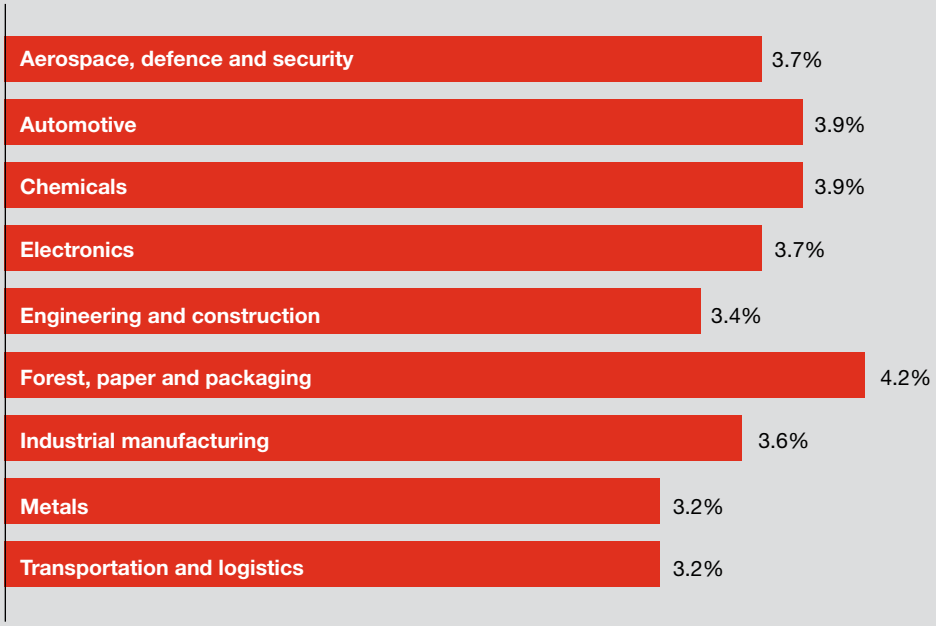
Unsurprisingly, the most critical factor in whether or not to implement 5G, or any of the technologies associated with 4IR, is often the cost. Put bluntly, will a company's investment in 5G networking create sufficient value for the manufacturer to move forward?

The decision to implement 5G on the factory floor will depend on three related factors.

- **Cost.** The absolute cost of any 5G implementation will depend on the size of the factory and the scope of the task. This includes not only the 5G networking capability itself, but also the extent of the array of sensors to be networked and the corresponding complexity of integrating technologies into the base architecture.
- **Efficiency.** A significant portion of the financial benefits of 5G will come from the anticipated gains in efficiency. PwC recently surveyed executives in a variety of industries to assess their expectations for the effects of 4IR on their operational efficiency. (The survey was conducted in 2018, but the findings are just as valid today.) The overall effect, they believed, will be significant (see Exhibit 3).
- **Productivity.** Our studies show that productivity in many manufacturing sectors remains considerably below the mean. Boosting factory output is key to the promise of 4IR, and 5G will be critical to that effort. When integrated into smart factory solutions, 5G's far faster speeds, lower latency and greater bandwidth should, in theory, enable companies to increase their factories' throughput, by minimising the downtime required for maintenance and by enabling faster changes to the production line. And greater integration with supply chains will reduce delays in replenishing parts inventories.

The question is whether the gains in productivity and efficiency will significantly offset the cost of implementing and maintaining the 5G-enabled factory. The answer, we believe, depends largely on how companies perceive the tradeoffs, and ultimately the business value they can expect to gain from the effort.

**Exhibit 3. Expected cost reductions per year through 4IR**




Source: PwC's Strategy& Global Digital Operations Study 2018

# The 5G value proposition

Like more fully developed technologies associated with 4IR, 5G presents manufacturers with a challenge. They understand its technical superiority over 4G, wi-fi and other wireless protocols. And they concede its ability to transform their business, boosting efficiency and productivity and giving them a competitive advantage over rivals.

But questions invariably arise: What will implementation mean for their current IT systems, in which they've invested millions? How difficult and disruptive will it be to implement 5G, and how should they go about it? And the most important question of all: will the implementation of 5G provide enough business value to justify the effort?

It is very difficult to answer this last question using a standard, case-by-case calculation of return on investment. Few manufacturing companies are likely to implement 5G if leaders think in terms of its effect on individual machines, or even factories. Instead, companies need to take a longer, more strategic view of the problems 5G can solve and the overall productivity gains that will result. For leaders who think this way, value isn't calculated on a machine-by-machine basis, but rather in terms of overall strategy: what does this new technology mean for our productivity or growth strategy, or our plans to reduce or expand the factory footprint?

There are, of course, forward-looking companies that have begun implementing 5G, in conjunction with other 4IR technologies. These companies haven't necessarily resolved the question of value. Instead, they tend to have a greater inherent cultural and strategic commitment to innovation, and they believe that their innovation efforts will eventually lead to growth, even if they can't yet reduce that calculation to a spreadsheet.

But such companies don't implement new technologies blindly. These companies approach the innovation challenge with considerable discipline — typically maintaining substantial control over the testing and scaling up of new technologies and thus improving the odds that the choices they make will eventually deliver value.

### The role of the telecom service provider

No matter how culturally inclined they are towards experimenting with and scaling up new technologies, most companies will find that the complex demands of a 5G implementation will require collaboration with telecom service providers. Those entities have the experience and wide-angle lens needed to enable the full networking ecosystem the digital factory requires. This is where telecom companies can most profitably play in the 4IR market.

In doing so, they must make sure to avoid the risk of becoming merely the pipes through which the data generated and captured in the 5G network flows to customers. This means delivering the most business value to their manufacturing customers and ensuring that their efforts are aligned with the manufacturer's business strategy. To that end, telecom companies can no longer simply offer manufacturers the 5G network

### 5G and 4IR in a post-COVID-19 world

5G will play an instrumental role within the industrial manufacturing sector in accelerating the implementation and impact of 4IR technologies — and it is likely that the COVID-19 pandemic will only highlight the value to be gained through greater automation and smarter, more resilient supply chains. The unique advantages of 5G-enabled 4IR in further automating the factory floor and incorporating new services into all kinds of products will make it a must-have in the post-COVID-19 era.

The pandemic is primarily a public healthcare problem, but one with immense immediate implications for businesses and for economic, fiscal and monetary policy. The health threats could disappear within months — or persist for years. This virus is both accelerating powerful existing trends (such as automation and inequality) and slamming the brakes on trends that had, until very recently, possessed tremendous momentum (such as globalisation). By recognising the challenges confronting the world, internalising the lessons of the pandemic and deploying the tools and technologies at hand, we can chart a new, more adaptive course. PwC has organised the most disruptive trends that companies face into an ADAPT framework. The five forces that comprise the framework are: asymmetry (increasing wealth disparity); disruption (changes wrought by technology); age (demographic shifts); polarisation (increased nationalism and populism) and trust (declining confidence in institutions).

However, deploying these technologies in what looks to be a challenging economic environment will require a different mindset — one that fully takes into account the key role of technology in unlocking value. Companies can focus on several key advantages to get the most out of 5G investments and 4IR technologies in a challenging economy.

- **Greater automation.** The advent of 5G has ushered in many more options for businesses that want to automate their operations, boost productivity and increase agility. Optimally, every aspect of 4IR should be employed: robotics, predictive maintenance, advanced analytics, artificial intelligence and robotic process automation.
- **Increased M&A activity.** Businesses planning strategic acquisitions to boost their 4IR capabilities may find that the coming slowdown will lead to lower valuations on acquisition targets.
- **Smarter supply chains.** US CEOs concerned about trade conflicts are changing their supply chain and sourcing strategies. 4IR technologies combined with 5G networking will enable companies not just to shift or shorten supply chains but to make them smarter and faster. Consider what's possible with connected information from the IoT, real-time shared blockchain ledger records and AI-powered analytics: a more agile and transparent global footprint and swifter customisation, innovation and response times.
- **Higher revenues and customer loyalty.** Businesses are increasingly using 5G services to develop new 4IR-driven products and services — and embed 4IR technologies into legacy analogue offerings — to create new revenue streams.

capacity and connectivity hardware they need. Instead, they must develop and offer full solutions and services across the operator's entire factory footprint, while managing the costs of providing the necessary infrastructure and provisioning requirements, especially for factories located far from population centres.

Such solutions must be worked out in collaboration with the manufacturer, ensuring that the business interests of each are kept in mind. Deutsche Telekom, for example, is working with manufacturing partners on a 5G trial to equip robotic vehicles with 3D cameras in order to integrate dynamic route planning, with the analytics taking place in the cloud. Thanks to 5G, the vehicle can upload the 3D images to the cloud at a rate of 1Gbps to help the vehicle avoid obstacles in its path.

Telecom operators should also consider partnering with other service providers that already have considerable experience in factory management and automation. The virtue of this B2B2C relationship lies in the synergies generated by combining the capabilities of each player — expertise in 5G networking, on the one hand, and an understanding of and experience with managing factory operations, on the other (see "5G in the real world," next page).

Regardless of which approach telecom operators take in providing manufacturers the 5G services they need, these operators, like their manufacturer customers, must develop a strong innovation mindset and the willingness to experiment if they are to develop end-to-end solutions to the challenge of 5G implementation. Doing so is the only way to overcome the reluctance on the part of manufacturers to take on the challenge, and meet it profitably.

### The five key steps to an effective pandemic response

The scope of the problems from COVID-19 may seem daunting, particularly for industrial manufacturers with integrated global supply chains and complex operating environments. But that's no excuse for inaction. For governments, businesses and institutions, the essential elements of a high-level response are quite similar.

**Repair.** First, stakeholders need to fix the economic damage of the crisis. Governments must address increased national debt, a reduced tax base, and higher short-term spending. Businesses will need to address vastly weaker balance sheets, steep revenue declines and, in many cases, weakened supply chains and stressed or depleted employee bases.

**Rethink.** Both governments and businesses need to review their response to the pandemic, understand best practices, and prepare for the next inevitable crisis. Companies must rethink their operating model, supply chain and business model. Countries need to consider what is essential to localise for reasons of security, economy and crisis management. More broadly, both nations and organisations need to rethink what success means, identifying new measures of material, social and environmental progress that can guide our efforts.

**Reconfigure.** Organizations must make the systemic rethinking concrete by reconfiguring public and business institutions. This represents a much more fundamental redesign of organisations than the repair process entails. The crisis has put into strong relief the uncomfortable truth that a host of institutions around the world are simply not ready for the 21st century. It's essential that systems including healthcare, legal, education and taxation be reconfigured to become more efficient, effective and resilient.

**Report.** In a period of great uncertainty, people will call for more transparent information on a broader range of issues. Investors, regulators and stakeholders will demand more disclosure and information in real time on everything from cash flow to the health of employees.

**Restart.** A host of organisations — in both the public and private sectors — will need to restart in a changed world, because they were either shut down owing to government fiat or forced to for financial reasons. The need to restart can happen at any point in the repair-rethink-reconfigure process. As uncertainty grows around the world, this process becomes the new normal: the next crisis will occur, and organisations that have not learnt the lessons of this experience will be back in repair mode.

## 5G in the real world

*Ansgar Bergmann is project manager in the technology and innovation division of the Frankfurt-based Kion Group, a major supplier of factory automation and communications systems. Bergmann is responsible for data and mobile networking, and leads various research projects on the issues of data analysis and communication. He recently spoke to PwC about the challenges his manufacturing customers face as they consider implementing 5G networking on their factory floors, and how his firm hopes to help them overcome those challenges.*

**PwC: What is the level of interest among your customers regarding 5G's potential for manufacturers?**

Bergmann: We are seeing increasing interest among manufacturers, but many are still taking a careful, wait-and-see approach, as the latest release of 5G has not yet been completely implemented. Much also depends on the kind and size of of the company. Companies that expect to benefit in their processes, along with large tech-oriented companies (such as automotive manufacturers), are expressing greater interest and have already entered a dialogue with suppliers like us. But there are also companies that are currently not starting any 5G activities. Clearly, 5G networking may not be for everybody yet.

**What do you think is holding companies back?**

We see three main factors. The first is reliability and security. Many companies currently have a partially hardwired infrastructure. Confidence in mobile connectivity, especially 5G, has yet to be established, as there is a lack of experience. With today's time-critical process chains in companies, a loss of connectivity would have a serious impact on throughput in factories. Only when the technical benefits and cost advantages are obvious and risks are minimised will the need for mobile networking beyond wi-fi start to increase.

The second problem is the cost structure. Although the costs of the necessary radio frequencies are transparent, there still is a lack of experience regarding the costs of implementation and the necessary components due to the current low level of coverage. In addition, there is also a lack of experience regarding the final operation and possible follow-up costs of such systems.

The third factor is simply availability. At present, there are no real standalone, industrial 5G infrastructures that have stood the test of time and still not enough industry-compatible communication components available. So far, only a handful of module manufacturers have started to produce 5G modules for the industry that can be implemented in modems.

**Given these concerns, how do you think manufacturers will proceed with the adoption of 5G?**

Various implementation guidelines, which the Kion Group is contributing to, will support the introduction of 5G. These provide companies with increased clarity about necessary internal efforts and opportunities. Some companies are already testing the possibilities of 5G and are looking for the right business models. However, as the industry-relevant releases are still missing, it might take several years before 5G is widely deployed in industrial applications. It is to be rather expected that many hybrid systems will prevail at companies early on — old technology will exist alongside 5G. Without sufficient experience, customers will be unwilling to completely shut down their existing communication infrastructure and replace it with 5G. It is unrealistic to expect that any manufacturer will rely entirely on a single non-redundant 5G system directly now.

# Conclusion

Few manufacturers doubt that 5G networking can bring major operational benefits to their factory floors. But concerns about the costs involved, the potential business value and the security of fully wireless systems will likely slow implementation for some time.

These concerns should not prevent company leaders from developing proofs of concept for the operational value of 5G, and starting pilot programmes to better understand the technical challenges involved. And service providers such as telecom companies that hope to participate in the effort should invest in developing complete ecosystems of offerings that can help manufacturers capture the most value from their 5G implementations. This will also allow telecom companies to distribute their upfront development costs across manufacturing customers in multiple sectors.

Finally, companies looking to adopt 5G technologies sooner rather than later should take a strategic view of 5G's value, looking at the productivity gains and greater competitive advantage on a company-wide basis. As with any other truly new technology, many of 5G's benefits will be revealed only as companies gain experience with it.

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