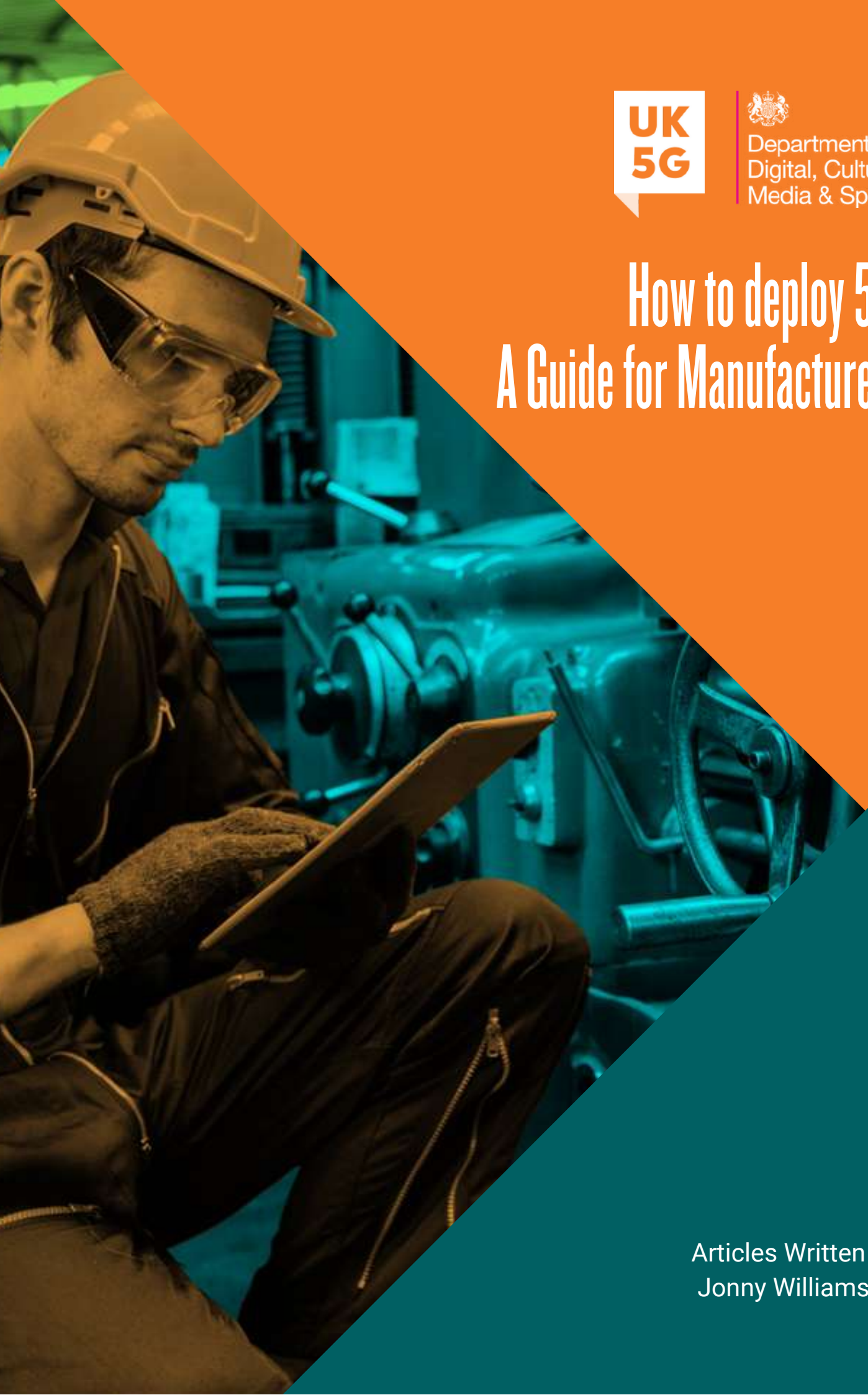

UK 5G

Department for Digital, Culture, Media & Sport

How to deploy 5G: A Guide for Manufacturers

Articles Written by
Jonny Williamson

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"IF YOU THINK OF 1G AS VINYL RECORDS, 2G AS CDS, 3G AS DVDS AND 4G AS BLU-RAY, THEN 5G IS LIKE THE INTERNET – AN ENTIRELY NEW VALUE PROPOSITION."

This series of articles was commissioned to answer the key questions many industrial business leaders are still wrestling with.

Foreword

Imagine a management team who believed the internet and the myriad opportunities it enables was nothing more than a fad. How much of a disadvantage would their company be against competitors who had all embraced eCommerce, digital marketing and cloud-based software systems. The same will soon be said about 5G connectivity, according to one expert.

That analogy chimes with that of mobile tech expert, Simon Rockman, who says that if you think of 1G as vinyl records, 2G as CDs, 3G as DVDs and 4G as Blu-Ray, then 5G is like the internet – an entirely new value proposition.

Comparisons between 5G and the internet aren't surprising. Both have connectivity at their core, both offer unparalleled business growth opportunities and both are valued not for what they are but for what they enable. Where the two differ is in how quickly they transform every aspect of trade and commerce.

Today, an internet connection is as crucial to a manufacturer as a CNC turning centre or CAD software. Yet, it took decades for the internet to ascend from arrival to ubiquity. Most commentators agree that 5G will achieve the same feat within the next five years.

So, why should 5G be on boardroom agendas today? Manufacturing businesses face an abundance of challenges – internal and external, domestic and international. Many of these are made more acute by the rigidity of traditional production processes and assembly lines.

The majority of factory assets are fixed and have wired connectivity. Enacting change within such environments is often arduous and time-consuming. A wireless network allows equipment to be reconfigured quickly and easily. As a result, factory floors become more flexible, agile and responsive – capabilities synonymous with increased productivity and profitability.

Short term, you could achieve this with a Wi-Fi network. Before long, however, the constraints of Wi-Fi, i.e. a limited number of connections over a limited area, will hinder progress.

According to Ericsson, the digitalisation of factory equipment, workers, vehicles and processes means the number of connected devices will exponentially increase. Such connectivity demand, combined with manufacturing's need for reliability, low latency and security, means 5G will swiftly move from nice-to-have to business imperative.

Foreword Continued

Indeed, the revolution has already begun. Real-world trials and testbeds are currently demonstrating the productivity, efficiency and innovation improvements 5G unlocks. A small sample of these are explored in this eBook, including:

- BAE System's Factory of the Future in Lancashire
- The Ericsson USA 5G Smart Factory in Lewisville, Texas
- Birmingham-based AE Aerospace's Glass Factory
- Connected Automotive Logistics at Nissan Sunderland
- 5G Enabled Manufacturing at Ford's Electrified Powertrain campus in Essex

Elsewhere, there are interviews with Ericsson North America's Paul Chan Tse and Rab Scott, Professor of Industrial Digitalisation at the University of Sheffield Advanced Manufacturing Research Centre.

This series of articles was commissioned to answer the key questions many industrial business leaders are still wrestling with, including:

- What is 5G?
- What economic impact have early adopters experienced?
- How do I build a business case for investing in 5G?
- How does 5G integrate with my legacy IT systems?
- How do I choose the right 5G network for my business?
- What steps can I take to make my business 5G ready?

It's been a pleasure researching and producing this series. Thank you to all those who provided their insights and direction, particularly Vicki DeBlasi and the UK5G team.

Jonny Williamson
Editor of the UK Manufacturing Outlook and former Editorial Director of The Manufacturer

"Real-world trials & testbeds are currently demonstrating the productivity, efficiency & innovation improvements 5G unlocks"

Measuring the financial gains

5G has the potential to add £126 billion to the UK economy between 2021 and 2025, and create or transform up to 2.7 million jobs.

More specifically, the adoption of 5G could add as much as £6.3 billion to the value of the UK manufacturing industry. That's more than the total manufacturing output of Northern Ireland.

Crucially, that £6.3 billion isn't a one-off cash injection. It's every year. Money that could be spent on building new facilities, upgrading equipment, creating jobs and developing the future.

Big numbers have become part and parcel of every 5G conversation; the only thing that seems to change are the figures themselves. Some estimates put the added value to industry closer to £6.1 billion, other say £5.2 billion.

Accounting semantics aside, it's clear that 5G represents a significant economic opportunity. But where will this additional value actually come from? How does a manufacturer go from investing in a new mobile connectivity to seeing a sizeable uptick in its bottom line?

The short answer is speed. The faster goods can be designed, made and shipped, the faster they can be sold.

The more complex and nuanced answer is that every stage of manufacturing is ripe for improvement:

- New product development
- Prototyping
- Sourcing raw materials and components
- Production (scheduling, processing, assembling, finishing)
- Inspection and quality control
- Packing
- Distribution
- Maintenance and servicing

Each of these areas will benefit greatly from the introduction of 5G, both as individual processes and as part of a connected operation. But don't just take my word for it.

Businesses across all four nations of the UK are currently involved in projects focused on making the benefits of 5G technology a reality.

Over the past five years, the Department for Digital, Culture, Media & Sport (DCMS) has part-funded 34 Testbeds and Trials projects with more than 200 delivery partners.

These projects span sectors where the UK already has a competitive advantage, including high-value manufacturing, scientific research, healthcare and the creative industries.

The three industrial case studies below illustrate just some of the ways in which 5G will generate a balance sheet boost for manufacturers and the wider UK economy.

Discover more via UK5G's dedicated 5G and Manufacturing resource hub.

CASE STUDY 1: SMART, CONNECTED, COLLABORATIVE AUTOMATION

The village of Warton in Lancashire probably isn't where you'd expect to find a futuristic manufacturing facility, yet BAE System's Factory of the Future is truly a first-of-its-kind facility.

Inside this fully connected digital factory, current and emerging technologies are working in partnership with an adaptable and digitally minded workforce to demonstrate the future of military aircraft production.

This experimental hub is the result of a multi-million-pound investment and collaboration with more than 60 blue chip and SME companies, along with academic institutions.

The goal is to create a truly flexible production environment capable of switching between building a new fighter jet one day to small volume unmanned vehicles the next.

Numerous systems have been incorporated to realise this goal, from artificial intelligence and 3D printing to smart sensors and augmented reality. However, the factory has been designed to be more than just the sum of its parts.

The connectivity between these systems, machines, robots and human operators is ultimately what will create a new and revolutionary approach that will drive additional productivity, pace and affordability into the manufacture of next-generation combat aircraft.

5G is providing the connectivity that links each asset and system in the factory together, offering the ability to capture manufacturing data from the start of the process right the way through to completion.

This provides myriad benefits, but something sure to be of interest to all manufacturers is how it has led to the development of Intelligent Work Stations and Robot Assisted Assembly techniques.

Off-the-shelf automotive robots typically work to an accuracy of about half a millimetre. Military aircraft demand much tighter tolerances, less than a third of the width of a human hair in some cases.

Robots have been paired with a precise system which monitors the processes being performed in real-time and makes the minute adjustments in position when needed. This has resulted in a more efficient, cost effective and flexible operation.

Manufacturing agility is further increased by replacing traditional fixed cells with robots that can be reprogrammed to perform different tasks on different aircraft as required.

BAE Systems' Intelligent Work Station has been developed in collaboration with The University of Sheffield's Advanced Manufacturing Research Centre (AMRC) and Fairfield Control Systems.

The digital work bench features 'pick by light' technology which recognises operators and automatically delivers tailored instructions during the sub-assembly build process. This helps to make learning faster and more effective, and minimises process deviations.

The work station also has a sensor-enabled collaborative robotic arm. This allows a worker to make strategic decisions while delegating repetitive driven tasks which require consistency to the cobotic arm. This allows engineers to focus on highly-skilled tasks, adding greater value to the operation.

KEY TAKEAWAY: Greater adoption of Robotics and Autonomous Systems (RAS) could raise productivity in the UK manufacturing sector by up to 22%

– Department for Business, Energy & Industrial Strategy

CASE STUDY 2: REAL-TIME PERFORMANCE MONITORING

The trail-blazing work being undertaken at Warton is part of the £9.5m 5G Factory of the Future programme. The two-year initiative aims to demystify 5G and overcome the barriers associated with deploying the technology in industry.

The project draws on the expertise of manufacturing, telecommunications and academic leaders including the AMRC (project lead); BAE Systems; Digital Catapult; IBM; telecoms provider AQ Limited; logistics specialist Miralis Data, and Machine Tool Technologies (MTT).

5G Factory of the Future is investigating five industrial applications, each of which could be applied to almost any high-technology manufacturing environment. I won't explain them all, you can read more about them on www.5gfof.co.uk, but I will highlight one area.

What if the health and performance of every component in a machine could be monitored in real-time?

Most maintenance performed on industrial equipment is either reactive (carried out after a breakdown has already occurred) or preventative (after "X" number of days, weeks or months).

The cost of having a machine down can quickly become eye-watering. Unsurprisingly, many businesses have adopted a preventative approach, despite its tendency to cause lengthy and unnecessary maintenance or functional parts being replaced prematurely.

Anther downside to preventative maintenance is that parts are only identified as needing replacement on inspection. Unless a replacement is immediately available, the result is further downtime and cost.

Predictive maintenance, or condition-based monitoring, uses data analytics and machine learning to pinpoint when a piece of equipment might fail so that corrective action can be taken before the point of failure.

Predictive maintenance has been around for several decades, but the concept has always had limitations. These include the number of sensors, machines and assets that can be connected, how reliable that connection is, and how quickly information can be processed and acted upon.

5G provides the increased capacity, greater reliability, ultra-low latency and enhanced security required to realise factory-wide condition-based monitoring in real-time.

To demonstrate this, the 5G Factory of the Future project is monitoring high speed manufacturing processes by placing sensors on high-throughput equipment such as CNC machines.

Data from these sensors is being used to improve problem detection, insight and efficiencies and reduce operational cost and quality defects. In some cases, it can also trigger automatic remediation in a form of 'closed-loop' system.

KEY TAKEAWAY: Unplanned machine downtime is costing the UK manufacturing sector more than £180 billion every year, an average of £31,000 per company

– The Manufacturer

CASE STUDY 3: MACHINING BY THE HOUR

Small and medium-sized enterprises make up around 99% of all UK businesses, and more than half of UK business turnover. As such, they play a vital role in accelerating the uptake of 5G technologies. The 5G Testbeds and Trials programme recognises this and many of the projects are led by or involve SMEs.

AE Aerospace is a high precision engineering business with an ambitious growth strategy. In 2021, it became the first UK SME to deploy a 5G private network, supported by government-backed initiatives West Midlands 5G (WM5G) and Worcestershire 5G (W5G), and technology partners BT and Ericsson.

AE Aerospace is trialling 5G in three areas, one of which is helping the business to unlock new business models and revenue opportunities through its vision of a 'Glass Factory.'

More and more manufacturers are branching into selling services as well as products. The concept, pioneered several decades ago by Rolls-Royce with its 'Power by the Hour' business model, is seen as a way of climbing the value chain and forging deeper customer relationships.

Traditionally, AE Aerospace sold components, but its USP lies in how those components are machined. That realisation led to a shift from selling finished parts to selling the means of manufacturing.

High-quality wireless 5G and sensors have been installed across the factory floor to enable wireless connectivity between machines, allowing high volume data capture. The ability to understand production flows and machine time utilisation is what is enabling AE Aerospace to sell machine time to customers.

Its Glass Factory has three stages:

- Enabling a customer to view where their parts are in the manufacturing process via an online portal.
- Enabling a customer to influence the order of operation. If their orderbook suddenly changes, for example, they can independently change which parts are produced first.
- Enabling a customer to be in complete control of 'their' cell on the shopfloor – an extension of their own facility, effectively.

Additionally, the data capture provides real-time condition monitoring for each machine, meaning the business can very accurately project when parts will be finished and where there is available capacity or a bottleneck.

As Peter Bruch, managing director of AE Aerospace, explains;

"Having long-term relationships with customers and knowing how many machining hours they require means we can reduce the price per hour, and therefore the price per component. The customer benefits and we have stability in terms of our cash flow and margins, it's a win-win."

KEY TAKEAWAY: Manufacturers that offer services alongside their existing products are realising business growth of up to 10% a year

– Aston University

How to build your 5G business case

TRULY EVALUATE THE IMPORTANCE OF CONNECTIVITY.

Discussions of 5G technology almost always refer to its hyperconnectivity – its ability to connect large numbers of devices to the internet at the same time. The most widely cited stat is that 5G can support upwards of 1 million devices per square kilometre (roughly equivalent to two London City Airports).

Such a capability should be high on the wish list of any manufacturer given that the number of industrial IoT connections is set to more than double to 36.8 billion by 2025. Yet that isn't the case.

"There is a lack of attention to connectivity at a strategic level within manufacturing companies," according to Digital Catapult's Made in 5G report. Several companies Digital Catapult interviewed said their current connectivity covers their present needs. Yet, they also noted that the wired connectivity they typically use is inflexible and costly to expand to provide additional capabilities.
A manufacturer looking to expand from their current 1,000 factory sensors to 100,000 would find it "challenging, complex and possibly even physically impossible to do with wired connectivity due to the cost of wiring, tray installations and disruption of production," the report explains.

In viewing connectivity as simply a business expense, manufacturers overlook the opportunity cost of not replacing their current methods. Addressing this myopia will only become more urgent as the number of devices on shop floors continues to rise and companies attempt to scale up siloed IoT test cases to the rest of the organisation and beyond.

Are you reading this thinking, Is 5G really that different from 4G? Maybe you're asking yourself, What even is 5G?

Get up to speed with this easy-to-understand breakdown that answers these questions and more – How 5G will power the Fourth Industrial Revolution

TAKE AN OUTCOME-BASED RATHER THAN TECH-BASED APPROACH

A staggering 70% of digital transformations fall short of their intended objectives. Reasons for this include unrealistic expectations, low levels of user adoption, ill-defined success measures and attempting to do too much too fast. Another common cause is placing too much emphasis on technology and too little on the desired outcome.

It's easy to become awestruck by technology. Artificial intelligence, augmented reality, additive manufacturing, smart robotics, virtual twins – all exciting developments that promise to bring myriad benefits to any organisation. Who wouldn't want to have them at their disposal?

The most successful digital transformation projects lean heavily towards the transformational aspects rather than the digital. The same principle applies to 5G.

Start with the need. What is it you want to achieve? It might be optimising your current processes to become better, faster, cheaper, more flexible. It might be introducing new value-added customer services such as order tracking, automated stock replenishment and preventative maintenance.

You may be doing it in response to being disrupted or you may want to become the disruptor. Whatever the strategic goals might be, deciding what they are should be the priority. Only then can you best determine what technologies will help you achieve them, where you should start, the skills required and what success looks like.

USE THE MULTIPLIER EFFECT TO STRENGTHEN YOUR BUSINESS CASE

Convincing an unenthusiastic CEO, board of directors or Chief Financial Officer to invest in new network infrastructure and equipment can be a tough sell. We know 5G is a highly capable, ground-breaking technology but it is also multifaceted, complex and still in its infancy.

This makes quantifying the return-on-investment problematic. A task made harder by the multitude of potential applications and the almost infinite number of ways these can be combined.

Exploiting this versatility holds the key to creating a robust business case, says Rab Scott, Professor of Industrial Digitalisation at the University of Sheffield Advanced Manufacturing Research Centre (AMRC).
"Building a business case for 5G to solve one challenge and one alone might not stack up. Deploying several

“We have seen that the greatest opportunities are unlocked by combining 5G with other technologies”

Rab Scott, Professor of Industrial Digitalisation, University of Sheffield AMRC

use cases together, however, will bring greater gains because you’ll have a multiplier effect.

“We have seen that the greatest opportunities are unlocked by combining 5G with other technologies, the most common being artificial intelligence, big data analytics, IoT, autonomous robot, augmented reality and digital twins.”

Deciding which use cases your organisations should focus on requires much greater collaboration across departments, but especially between IT and OT functions, Rab advises.

CONSIDER HOW 5G WILL BRING NEW LEVELS OF WORKER SAFETY

When considering the benefits of 5G, minds usually turn to operational gains and revenue opportunities such as increased profitability, process efficiency, flexibility, quality, resilience, network security and competitiveness.

In times of economic uncertainty, it’s understandable for executive teams to focus on the financials. But 5G provides multiple soft benefits that manufacturers, in particular, shouldn't ignore.

Take worker safety as an example. Manufacturing is a heavily regulated industry where safety, security, and standards are non-negotiable. Factories around the world are leveraging the reliability and low latency of 5G networks to power a range of solutions to ensure workers can safely operate tools and machines and navigate their surrounding environment.

Examples include:

- 5G-enabled video surveillance to identify in real-time any incorrect operation of machinery, dangerous working conditions or predictors of danger such as operator fatigue
- Protecting a robot arm with a laser curtain which, if broken by a worker reaching into the cell, would stop the machine instantly to prevent injury
- Having remotely-operated drones and robots enter hazardous environments rather than human workers
- AI-assisted computer vision to detect a human presence in restricted areas, enabling action to be taken before an incident occurs
- Using IoT to monitor and track the unauthorised movement of safety equipment such as fire extinguishers
- Fitting smart sensors to personal protective equipment (PPE) to ensure it is being used and to automatically notify supervisors in the event of an accident such as a fall or gas leak
- These applications not only provide a boost to worker safety and reduce the presence of humans in high-risk areas, but they also deliver quantifiable operational efficiencies.

5G CAN HELP YOU REACH YOUR SUSTAINABILITY GOALS

The accelerated roll-out of 5G connectivity across Europe and the UK will have “an immediate and catalysing impact” in reducing CO2 emissions, according to a 2021 study by Ericsson.

The report highlights 5G’s potential for much more efficient use of energy as a key opportunity, stating that sensor-driven efficiency improvements in factories alone could save up to 35 metric tons of carbon dioxide equivalent (MtCO2e) by 2030.

Manufacturers are already leveraging greater connectivity to provide more efficient temperature and humidity control in factories and warehouses to reduce electricity consumption, lessen inventory wastage, and extend the shelf life of time-sensitive materials.

Material reuse and recycling could also have a dramatic impact on carbon emissions reduction in manufacturing, says Ericsson, and could potentially account for nearly half of emissions reductions by 2030.

The work underway at the National Composites Centre (NCC) shows how the application of 5G is helping make production processes more sustainable and reliable.

The unique properties of composite materials enable the design and manufacture of better lighter, stronger products with less waste that last longer. But making composite materials is far from easy, says Jonathan Butt, Chief Engineer of the NCC's Digital Business Unit.

The raw materials are energy-intensive, manufacturing processes carry significant risk, defects are both common and hard to detect and the finished composites are difficult if not impossible to recycle.

"A digitally enabled or connected production environment provides a clearer understanding of what interventions need to take place in order to improve a production line; it enables more targeted and better process improvement of our processes," Jonathan explains.

"5G allows for a more flexible data infrastructure than traditional networking and has given our engineers better access to and faster deployment of digital tools. That again helps you to improve on and iterate your continuous improvement much more readily from a business perspective. Ultimately, driving efficient manufacturing will deliver against sustainability targets."

DON'T BE AFRAID TO ADMIT THAT YOU DON'T KNOW WHAT YOU DON'T KNOW

The most crucial factor in building your 5G business case is to speak to those already familiar with the technology – users, network providers, technology specialists, researchers.

These early adopters will have done quite a bit of the heavy-lifting and de-risking for you, so make use of their experiences. Visit their sites, talk through their adoption journeys, what would they do differently, what benefits are they seeing, have they seen any positive unintended impacts?

Also, consider how other industries are using the technology. Looking beyond your normal field of view can often be a source of great inspiration and spark novel use cases.

This is just part of what makes the UK's 5G national innovation network invaluable. This 'network of networks' facilitates collaboration between organisations working on 5G activities across the UK and further afield.

Its constantly updated resource library allows you to discover related funding competitions, insights from live and past projects, technology updates and government announcements, alongside upcoming events and workshops and a supplier directory.

How 5G integrates with legacy IT systems

Jonny Williamson discusses 5G interoperability and compatibility with Rab Scott, Professor of Industrial Digitalisation at the University of Sheffield Advanced Manufacturing Research Centre (AMRC) and spokesperson for the 5G Factory of the Future project.

How does 5G technology underpin the Fourth Industrial Revolution or Industry 4.0?

Industry 4.0 is about the removal of non-value-added activity. Anytime a worker or a business has got to go to the data, that is non-value-added activity. Instead, bring the data to the worker and enable them to make better decisions more quickly by centralising the information.

The heart of Industry 4.0 is connecting currently isolated equipment and departments together. The enabler for that is the communications layer, of which 5G is one option. It's as fundamental as that. Except 5G overcomes some of the constraints that previous communication layers have provided.

5G provides you with mobility because it's a wireless protocol and it provides mass connectivity. As the number of devices on the shop floor dramatically increases, from smart tools or devices worn by workers to large-scale equipment and AGVs, we'll start to hit the limits of existing connectivity solutions. They certainly can't handle the bandwidth or the latency that will soon be required.

These limitations are all overcome by 5G while also providing previously unattainable levels of security and configurability.

For now, 5G will predominantly be used as a traditional communication layer until the demand for its additional capabilities arises. The Department for Digital, Culture, Media and Sport's national 5G Testbeds & Trials Programme is helping to build that demand by showing the art of the possible and that the benefits outweigh any risks.

It appears that 5G is not currently a priority for most small and medium-sized businesses. How do we change that?

Most SMEs we talk to are still just looking to survive the pandemic and its fallout. They're not exploring what I'd call next-generation activities.

In a way, it's good that large players have seen the opportunity and are starting to undertake implementations. As demand rises, the prices should come down, the skills should become more common, and the capabilities and benefits will become more known.

That will all help bring 5G to a price and availability point for the SME base. But we can only do that through investment and demonstration.

How much of the 5G opportunity is about better connectivity within your own factory versus creating stronger connections between your operation and those of your partners?

The place to start is in the factory. But, remember, your factory is someone else's customer point. Their products sit on your shop floor. If they're connected to that piece of equipment, then so should you because you can be looking at the data slightly differently.

The equipment manufacturer will want to aggregate data from their entire install base and use it to drive next-generation products and possibly to introduce new services around product optimisation and predictive maintenance.

As the equipment user, you're only interested in improving your own productivity and in doing so, reducing your energy consumption, reducing waste, etc. That makes it quite hard to put a solid boundary around the potential impact that this connectivity layer can have.

Most production environments contain equipment from multiple manufacturers, all of which will be drawing data from their machines for the reasons you describe. Is there a way for a factory manager to see everything that's happening in one master overview via a single portal?

That sort of interoperability is one of the largest barriers that we see in Industry 4.0; getting different systems to talk to each other because every OEM wants their system or standard to be the global standard.

This is where the cloud comes into play because we can use it as the aggregating area and start dashboarding things from the cloud. Doing so circumvents the challenge of having propriety systems talk to each other.

The Catapults, alongside organisations such as the BSI, have a key role to play in this. We've got to show end-customers the value of being able to access the data from their different vendors and protocols all in one place. Because it's the buyers and users who have the leverage over the equipment providers.

The other issue, particularly in the UK, is that most modern equipment is 5G-enabled or soon will be. That's great if you're in the market for some new equipment but we're very proud of keeping 100-year-old machines running. Compare that to Germany, where businesses are proud of having new machinery.

The UK's productivity challenge stems from this 'make do and mend' mentality. This is why we need to start engaging with financial institutions because, in a lot of cases, it would make more sense to take out a loan and invest in new machines that do exactly what old equipment does but so much more effectively and efficiently.

It sounds like industrial IT architectures are going to become increasingly more complex with wired and wireless connections, 4G and 5G networks, all stacked on top of each other.

I think so. Architectures will have multiple communication layers, depending on what the purpose is, and this is where we're beginning to see real challenges around where the boundary lies between IoT and OT.

Who is responsible for managing that boundary? Who is responsible for managing the embedded IT systems in the OT environment? Who is responsible for patching a particular piece of software? IT views it as being vulnerable to cyberattack but doesn't want to risk interrupting production, and OT doesn't want any work to be carried out because it's currently operating perfectly.

There needs to be a much better understanding of the ecosystem as a whole and greater integration of IT and OT teams.

The issue is made more difficult because of legacy IT systems and a lack of modern enterprise architectures within manufacturing facilities. Changing one piece of equipment can often cause a knock-on effect and require multiple other machines to be recalibrated. So, changes aren't made and we're back to this 'make do and mend' mentality.

Modern enterprise architecture has almost an information bus that runs across the whole organisation which you just hook into. An Amazon webpage has multiple different

microservices running on it such as dynamic pricing, real-time delivery schedules and personalised recommendations.

Any one of which can be reconfigured individually without having a dependency on anything else. That's one of the key benefits of a modern IT system.

Untangling your legacy IT system to get data from the shop floor to the top floor more effectively will only benefit your business in the long term. This could be achieved using existing connectivity layers and solutions not necessarily 5G.

How long will it take for 5G adoption to become mainstream and what can a manufacturing business do today to prepare for that?

Within the next five years, definitely. The pandemic has both helped and hindered adoption. Working remotely and the need to socially distance have driven the uptake of digitalisation and helped to emphasise the importance of connectivity. On the other hand, factory closures, supplier bottlenecks and an international shortage of semiconductor chips have slowed the development of various 5G devices.

Today, businesses should be identifying the challenges they want to overcome and the capabilities they want access to, and then work to determine whether 5G is the best solution to achieving that. It might not be. 5G isn't a silver bullet, it's just part of the armoury at our disposal.

If 5G is the right solution, then engage with UK5G and speak to other businesses already making use of it. They will have already done a lot of the heavy lifting and de-risking for you in terms of building the business case, integrating the technology and testing its capabilities.

Don't be afraid to admit that you don't know what you don't know. But also look outside your normal field of view. What's crucial is that if you're going to invest, do so with future-proofing in mind. Don't just think about this month or this year, consider what's coming down the road in the next five, 10, 20 years and how your business will respond.

How companies are deploying 5G in their factories

In the choice of public or private, manufacturers strongly favour deploying a private 5G network.

Three in four manufacturers intend to adopt private 5G networks by 2024. So says an international study by network management company Accedian. By comparison, 92% of manufacturing facilities today use Wi-Fi for local networks.

Explaining why interest in private 5G is at an all-time high, Accedian's Jay Stewart says that manufacturers clearly understand the impact it can have on their businesses. "Private 5G supports a wide variety of existing manufacturing applications while enabling new ones that aren't practical with Wi-Fi, Ethernet, and other technologies," he adds.

5G for Manufacturing: How companies are deploying 5G in their factories Continued

The research, which canvassed the connectivity ambitions of manufacturers in the UK, Germany, the US and Japan, identified five key factors influencing 5G deployment model decisions:

- 63% – Network Security
- 49% – Network Performance
- 49% – Speed / Simplicity of Deployment
- 45% – Application Performance
- 43% – Data Sovereignty / Privacy

For Verizon, it's easy to see why private 5G networks are emerging as the 'connectivity technology of choice' – "A private 5G network gives companies the ability to customise the network according to specific organisational needs and locations, securely, and on their timetable."

A manufacturer's 'specific organisational needs' demand the highest level of security and consistency of performance. Exactly what private 5G delivers.

A preference toward deploying private 5G rather than public offerings also reflects where manufacturers are in their adoption journey and the current level of national coverage.

KEY TERMS TO KNOW:

Private Network, sometimes referred to as a Local Network – A dedicated network that provides unified connectivity and optimised services within a specific area (ranging from a single building up to an entire campus), with restrictions to effectively lock out external access or devices. Access to a private network is typically provided to members.

Public Network – An open network that provides substantial coverage accessible by anyone, i.e. the general public. Those with access to a public network are typically subscribers or customers.

5G Network Slicing – The ability to create multiple independent virtual networks from a single physical network infrastructure, delivering improved flexibility and agility. This is a key differentiating feature of 5G technology.

For more info, head to **UK5G's glossary of useful technical terms.**

Public 5G is available, but cities are at the front of the queue

Mobile network operators have been steadily rolling out localised public 5G networks in recent years, with South Korea, China and the US leading the charge. All four of the major operators in the UK (EE, Virgin Media O2, Three and Vodafone) have now launched 5G networks and have announced plans to expand their coverage.

However, these public network deployments are currently focused on serving densely populated urban areas. Typically, not somewhere manufacturers choose to establish themselves.

Forecasts vary for when we can expect a much broader national coverage. Most predictions lie somewhere between five and ten years. EE, for example, has the ambition to offer 5G "anywhere in the UK" by 2028.
5G adoption will "definitely" go mainstream within the next five years, says Rab Scott, Professor of Industrial Digitalisation at the University of Sheffield Advanced Manufacturing Research Centre (AMRC).

"The pandemic has both helped and hindered adoption," Rab notes. "Working remotely and the need to socially distance have driven the uptake of digitalisation and helped to emphasise the importance of connectivity. On the other hand, factory closures, supplier bottlenecks and an international shortage of semiconductor chips have slowed the development of various 5G devices."
In the meantime, those manufacturers keen to be among the early adopters are taking deployment into their own hands.

A winning strategy – test, assess, scale

If you look at where manufacturers are choosing to trial 5G, the most common applications today typically fall into one of five areas:

- Design & Planning – data-driven decision-making, digital twins, real-time mixed reality collaboration, VR and AR prototypes.
- Production – Real-time monitoring, quality control, intelligent automation, enhanced human-machine collaboration, training and upskilling, improved worker safety.
- Operations – A fully connected factory, worker support, autonomous guided vehicles and mobile robots.
- Maintenance & Support – Condition-based monitoring, predictive maintenance, VR and AR-facilitated guidance.
- Supply Chain – Automating processes, asset location tracking, connected goods, inbound and outbound confirmation, and customs process management.

The majority of these use cases occur within a manufacturer's own four walls, broadly speaking. That makes sense. With 5G still in its relative infancy, decision-makers understandably want to run and closely observe proof-of-concepts internally first before scaling proven use cases out to their wider value chain. Therefore, it makes equal sense that manufacturers are opting to deploy private 5G networks.

Incidentally, Digital Catapult and several industry partners recently put five of the most widely accepted manufacturing use cases to the test: condition-based monitoring, predictive maintenance, wireless robotics, asset and tool tracking, and AR-enabled training.

The analysis showed a payback time of between 12 and 24 months and a five to 10-times return on investment over five years. On top of the financial gains, the tests also helped to provide the knowledge and experience to scale projects, both internally and externally. They also helped lay the foundations to unlock new use cases and, in some cases, lucrative new business models such as selling specialist services (servitization).

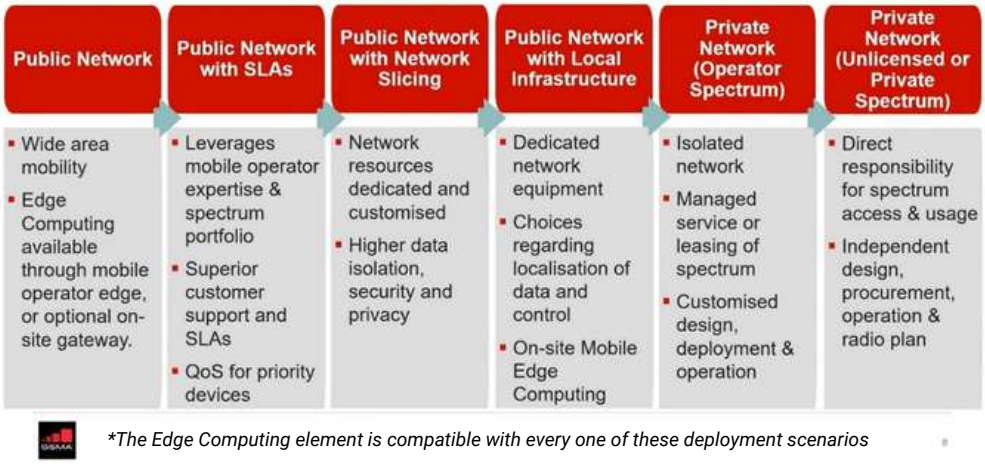
So, manufacturers are being driven to deploy private 5G networks because of currently patchy public coverage, an immediate focus on internal use cases, and their need for high levels of security, reliability and control. However, a fully private network isn't the only option.

A growing list of deployment models

The choice of private or public isn't as binary as it first appears, or may have appeared historically. 5G introduces a range of possibilities between a public network and a standalone fully-private network, including:

- Public network
- Public network with a service-level agreement (SLA)
- Public network with network slicing
- Public network with local infrastructure
- Private network (operator spectrum)
- Private network (unlicensed or private spectrum)

Each deployment scenario has its own set of characteristics, as outlined by Jo Gilbert on a recent webinar hosted by KTN and delivered in partnership with UK5G and Digital Catapult.



**The Edge Computing element is compatible with every one of these deployment scenarios*

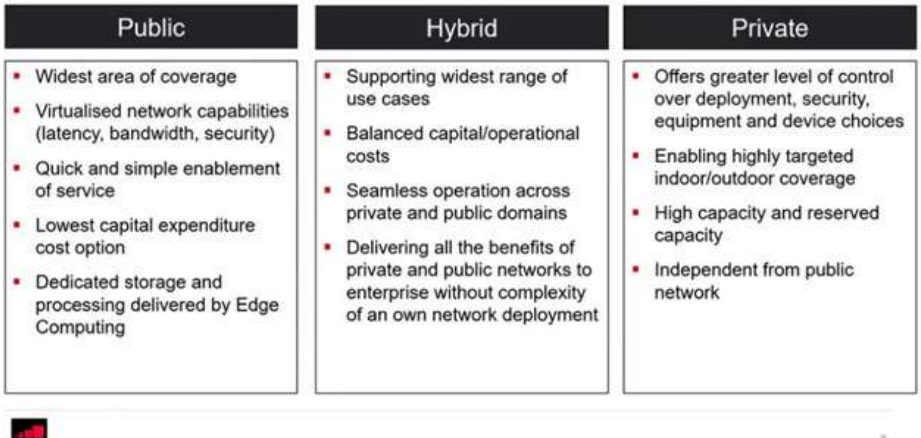
"Network Slicing is where we begin to create a virtualised private mobile network," explained Jo, who is Technical Director and Manufacturing Lead at GSMA, which represents the interests of mobile network operators and the broader mobile ecosystem.

"Public network with local infrastructure can be thought of as a managed service solution where the operator or a third-party partner can install and manage dedicated network equipment with an SLA, for example," she continued.

Mobile network operators are increasingly offering a range of solutions that, in some cases, includes a hybrid solution. These deliver "a private mobile network with seamless interoperability into the national or regional public networks," Jo commented.

Such hybrid models, which bridge both private and public networks, could offer a viable means for manufacturers to embrace 5G, especially small businesses that may not have the resources to manage deployments themselves.

The ability to move effortlessly across private and public domains makes hybrid models an attractive proposition for manufacturers keen to expand their



use of 5G beyond the factory (or warehouse) gates and out into their wider value chains.

But would doing so mean having to wait for a universal public 5G coverage across land, sea and air? Not necessarily thanks to a pioneering project on a different kind of network.

Laying the tracks to extend 5G beyond the factory gates

Manufacturers don't operate in isolation. They exist in diverse ecosystems of suppliers, partners, distributors, customers and other stakeholders which often span the globe. How do businesses track, monitor and remotely control assets that are travelling through or are operating in locations where existing mobile networks don't reach?

The answer is satellite technology, according to IT services provider CGI UK. Satellites can help bridge the gaps where terrestrial connectivity has yet to go or just can't go, or deliver a resilient second strand of connectivity.

"Satellites are an ideal way to serve areas with a population density too low to justify a cellular service because the constellation coverage is available immediately without the need to deploy terrestrial infrastructure," says CGI UK.

The biggest challenge in realising this vision of seamless connectivity, where the switch between terrestrial and non-terrestrial networks goes unnoticed, is the complex calculations involved with ensuring the moving antenna is pointed at the right satellite at the right time.

To help develop the technology involved, CGI UK is working with the Department for Digital, Culture, Media and Sport (DCMS), the UK Space Agency (UKSA) and the European Space Agency (ESA), with support from National Rail and other train operators, to create a hybrid 5G network for use on trains.

The aim is to enable trains to flag issues to central managers immediately – from life-critical information, like derailments to more mundane matters, like notifications of track conditions and their impact on the train's maintenance requirements. As an additional bonus, passengers won't experience coverage black spots.

If successful, the knowledge transfer between this project and numerous industrial applications is clear. One more solution in a manufacturer's rapidly growing connectivity toolbox.

The key learnings from this project are available on UK5G's Transport & Logistics resource hub.

How 5G is enabling autonomous last-mile logistics

A pioneering live trial is currently underway at the Nissan factory in Sunderland, testing 5G's ability to boost productivity through the use of autonomous trucks to move parts and assemblies across the plant.

Manufacturing is a carefully choreographed dance that requires many multiples of people and parts to precisely hit their mark at exactly the right time. It's an analogy that applies to most mass-volume production but is especially apt for how cars are made.

An automotive assembly line produces hundreds of finished cars a day, each containing tens of thousands of parts. The supply of these parts is in perfect synch with the production schedule. Stock is replenished 'just in time'. Any later would interrupt production; any earlier would require buffer storage areas and goods to be double-handled (moved and then retrieved).

This impressive feat is made easier by key suppliers locating their operations nearby, some even occupy a building on-site. Although convenient, this results in numerous journeys being made every day, often over very short distances, between nearside suppliers and the factory.

The Nissan Motor Manufacturing plant in Sunderland is a prime example. The largest car factory in the UK is adjacent to the UK Nissan Distribution Centre and has several on-site suppliers.

Several thousand HGV movements a day service the plant. Some from very close by, some from much further afield. All arriving at drop-off points strategically located along Nissan's 7km long production line. In short, it provides an ideal environment to test whether an autonomous capability can boost productivity and efficiencies, safely and securely.

The ground-breaking 5G-enabled Connected Automotive Logistics (CAL) project is doing exactly that. The £4.9m operation, part-funded by the Department for Digital, Culture, Media and Sport's £200m 5G Testbeds and Trials Programme, is investigating the practicalities of taking remote control (teleoperation) of an autonomous electric HGV in a live industrial setting.

Nissan's Sunderland manufacturing plant is the size of 50 football pitches and two cars roll off its production line every minute.

Since opening in 1986, the site has produced more than 10 million cars.

Nissan Motor Manufacturing UK

5G-CAL project partners and expertise:

- **North East Automotive Alliance**: Project lead
- **Sunderland City Council**: Project management and regional coordination
- **Newcastle University**: Research and dissemination
- **StreetDrone**: CAV provision and build
- **Vantec**: Logistics expertise
- **Nissan**: Site coordination and operational needs
- **Coventry University**: CAV cybersecurity
- **Perform Green**: Technical and quality assurance, collaboration lead
- **Connected Places Catapult**: Impact assessment, evaluation and dissemination

Less monotony, greater productivity

Autonomous driving is frequently in the headlines, driven in large part by Tesla and its controversial CEO and co-founder. This level of autonomy typically has a driver present. If the vehicle stops for whatever reason, someone is physically there to take control and continue the journey, either to completion or until safe to hand back control.

This level of autonomous capability doesn't overcome two serious issues affecting the logistics industry – a shortage of HGV drivers (in the region of 70,000) and spiralling wage bills. It also doesn't address the monotony of travelling backwards and forwards along the same short route day in and day out. The use case at Nissan Sunderland, for example, is less than 2km.

By combining teleoperation with autonomous technology, 5G-CAL is helping to overcome all these issues. It's also helping to improve operational efficiency, driver satisfaction and safety, reduce costs and potentially increase the driver: vehicle ratio from 1:1 to 1: many.

I sat down with Richard Barrington, principal consultant and head of business development for Perform Green, to discuss the lessons learnt and forward opportunities.

How does your set-up differ from Automated Guided Vehicles, which have become common in factories and distribution centres?

When our vehicle encounters something it doesn't understand or hasn't encountered before, it stops and triggers an alarm. In a lot of operating environments, if an AGV stops someone has to physically go and restart it. That doesn't present much of an issue within a confined space but our use case is a 2km stretch of road. Having to trek out to the vehicle costs time and money. That's where remote control comes in.

Our teleoperator rig is an exact replica of the in-vehicle driving station and three screens display a direct camera feed from the left, right and straight ahead of the vehicle. The user experience is the same as if they were sitting in the cab and the sensory information is the same. With a sub-10 millisecond latency, the information is also being presented in what is effectively real-time.

When the vehicle stops and triggers an alarm, the teleoperator sits down in the rig and makes an informed decision as to how to proceed until they feel comfortable passing control of the vehicle back to the autonomous software.

Why is 5G so crucial to 5G-CAL?

Many manufacturing sites have strict speed limits of 5 or 10kmph. In theory, 4G could be used but as soon as you travel beyond the confines of the facility, you'll want to go a lot faster. Higher speeds mean longer stopping distances and that's where the ultra-low latency of 5G becomes very important. We need to know we can stop the vehicle on a dime to ensure the whole operation is safe and secure.

Additionally, the HGV has been fitted with multiple cameras and LiDAR units and lots of sensors. These produce lots of data, around 100Mbps, that has to be taken off the vehicle and presented to the teleoperator who, in our case, is sitting in the Vantec building. That's very hard to do with any technology other than 5G. It is also very different to a Tesla, for example, where all the decisions by the autonomous software happen locally.

The reliability of 5G is another major factor. The performance of our private network, using Ofcom Shared Access spectrum n77, is consistent from end to end. You don't get that with 4G. 5G is also very secure, particularly with a private network. The only devices that can talk to our network are those we've authorised and issued sims to.

New project partner, Dutch vehicle manufacturer Terberg, has taken one of its tractor units, often seen operating in airports and ports, and retrofitted it to be electrically powered and drive by wire.

StreetDrone has installed its autonomous software on that vehicle and it has been fitted with a wide array of sensors, LiDAR and cameras

What stage has the project reached?

StreetDrone has finished the engineering on the vehicle and it's at Nissan Sunderland. We're very fortunate that Nissan has not only a private road network but also a skid pan and a test track on-site.

Currently, we are practising all the basic manoeuvres on the skid pan, with a particular emphasis on the handover between the autonomous software and the teleoperator and back again. Our focus is on making sure that it works under all circumstances and demonstrating that our system is more responsive and therefore safer than having someone sat in the cab.

Tests have been ongoing since April and we expect to progress onto the private road network in June. From there we'll be looking at two things. The first is scale up. We've proved it works with one vehicle, what happens when we have six? How does the network stand up? Do we have one-person teleoperating six vehicles or is 1:6 too high a ratio?

The second is negotiating a more complicated route but still within a private road network. We can go to another distribution point which means having to go through two sets of traffic lights, a roundabout, security gates and a humpback bridge

The route has traffic from multiple distributors going to and from the plant so it's a far more real-world operating environment.

Are you able to quantify any of the expected efficiency improvements?

From what the project has achieved so far, a plant similar in scale to Nissan should be able to see a £2.5m to £3m efficiency saving per annum.

We are also looking at creating efficiencies at the other end of the process. Nissan Sunderland produces around 3,000 cars a day, 80% of which are exported through the Port of Tyne. That means hundreds of car transporters carrying thousands of cars, not to mention the containers full of parts arriving at the port each day.

Once we have proven our system works across multiple vehicles and that it can work across a much more complicated road network, which will likely take 24 – 36 months, the next step could be overseeing transport between Nissan and the port.

That would likely involve having to move between private networks and potentially the public network. How would those handovers work? Would the private network provide our required performance characteristics? Your standard MNO network is designed to deliver data down to

devices not for bringing data up from them.

Does your system have applications beyond automotive and other large discrete manufacturing plants?

We've been working with Connected Places Catapult and Newcastle University to explore the potential for 5G enabled autonomous vehicles to be deployed more widely in other industrial and social settings.

Other use cases include airports, ports, public transport services, and campuses. Most supermarkets, for example, operate in much the same way that a car plant does with hundreds of trailers getting dropped off and picked up every day.

There are significant costs associated with delaying an aircraft, much like with an assembly line. Holding up a flight because the baggage isn't at the right place at the right time does more than frustrate passengers. These areas all present massive opportunities to become more efficient and more use cases will emerge as we continue to refine this technology.

How 5G connectivity is underpinning best-in-class factories

The Ericsson USA 5G Smart Factory sets a precedent for how humans, robots and data can combine to deliver unprecedented levels of efficiency and productivity. Jonny Williamson reveals how the factories of the future are already here.

There are millions of factories operating around the world but just 103 are classed as 'Lighthouses'. Each of these sites is leading the way in demonstrating how Industry 4.0 technologies can increase productivity and profitability, while having a positive impact on the environment.

The World Economic Forum's Global Lighthouse Network spans more than 75 regions and a diverse range of industries including healthcare, electronics, pharmaceuticals, automotive, and more.

Becoming part of the network means truly being a front-runner in advanced manufacturing, yet the network contains an even more elite subset. Six factories have gained the additional designation of being 'Sustainability Lighthouses'. These sites are accelerating technological innovation to achieve their environmental pledges toward both people and the planet.

Ericsson's first fully-automated USA 5G Smart Factory is one of these prestigious six. The site in Lewisville, Texas, is powered by 100% renewable electricity. Integrated environmental systems have been designed to reduce energy consumption by 24% and indoor water usage by 75% when compared to a similar building.

The $100m factory opened in Spring 2020 and produces Advanced Antenna System radios to help meet the rising demand for rapid 5G deployments. But the plant isn't just manufacturing the latest 5G equipment; it is also equipped with the same 5G-enabled technology.

Ericsson's fast and secure 5G connectivity enables agile operations and flexible production. This is being achieved through use-cases including automated warehouses, connected logistics, automated assembly, packing and product handling, and autonomous carts.

"The future belongs to those companies willing to embrace disruption and capture new opportunities. The lighthouses are illuminating the future of manufacturing and the future of the industry."

Francisco Betti, Head of Shaping the Future of Advanced Manufacturing, World Economic Forum

It is a genuine 'Smart Factory' and provides a working demonstration of what 5G can deliver.

To learn more, I sat down with Paul Chan Tse, a 5G Solutions Engineer for Ericsson North America and part of the team working on applying 5G innovation to industrial use-cases.

Why is 5G so important to Ericsson and the future of manufacturing?

We wanted to manufacture in the US but we needed to do that competitively. Labour costs are higher in the US than elsewhere in the world, for example. We needed to embrace Industry 4.0 thinking and technologies to ensure the factory operated in the most productive and therefore the most competitive way.

Industry 4.0 encompasses technologies such as smart automation, artificial intelligence, machine learning, virtual and augmented reality and the internet of things (IoT). 5G allows manufacturers to truly start taking advantage of these advancements and combine them to build more efficient and sustainable factories.

A key part of that is helping solution providers to embrace 5G more quickly. We are working with suppliers and technology vendors and showing them how 5G connectivity means their equipment can deliver even greater benefits.

A really positive example of that has been our autonomous mobile robots. AMRs are already smart machines but are somewhat limited in their capability, such as needing to be guided by magnetic strips fixed to the floor.

AMRs could move more efficiently if they had free movement around a production environment to conduct inspections or move material but that requires managing a large amount of data and highly reliable, low-latency connectivity. Equipping them with 5G modems that connect to our 5G network delivers this level of connectivity.

We believe in the power of collaboration so strongly that we've established an open ecosystem testbed within the factory. This provides vendors with access to spectrum and an innovation space that is as close to real-world as possible in which to experiment.

"When compared to a similar site without its automation and Industry 4.0 improvements, Ericsson's USA 5G Smart Factory delivers an impressive 2.2 times improved output per employee."

Since the factory commenced operations, your team has developed 25 different 5G-enabled use-cases capable of being deployed at scale in less than 12 months. You've already mentioned AMRs. What others are you working on?

Augmented and virtual reality are two really exciting areas. When the Lewisville factory opened, our engineers were trained with almost no face-to-face interaction. It was all done through virtual collaboration and knowledge sharing in the months before opening.

VR-enabled onboarding allowed new team members to sit in a classroom in Dallas to learn directly from their peers 8,000km away in Ericsson's Tallinn Smart Factory in Estonia.

An area where augmented reality is delivering significant tangible benefits is maintenance. Every manufacturer understands the importance of maintaining machines and equipment. But maintenance is difficult due to a lack of expertise in industry and the time and costs associated with the process itself as well as the engineer travelling to the job site.

5G-enabled AR provides factory teams with virtual guidance from experts to troubleshoot and repair equipment. With both parties wearing a headset, the expert can share audio, visuals and annotations in real-time for quicker, more precise support from anywhere in the world. This helps increase efficiency, reduce cost and minimise equipment downtime.

What's crucial is that we don't underestimate the human factors. We know augmented technology works, for example, but is it comfortable to wear a headset for extended periods? What's the user interface like? Does the annotated image obstruct their view? You have to consider the users and not just focus on the technology.

What challenges are involved in deploying 5G in manufacturing today?

Interoperability, certainly. Within a particular process or assembly line, equipment vendors are typically quite collaborative or at least understand the need for their solutions to work with those of others. But when you as a factory manager try to connect various parts of your operation, that vendor integration can be lacking.

"Industry can't embrace 5G at scale without 5G-enabled devices supplied via the vendor community. Vendors can't provide such devices without somebody stepping up and giving them the connectivity and space in which to develop and test them. We are providing exactly that at the Ericsson USA 5G Smart Factory and other locations."

Industry 4.0 is all about extracting and analysing all the data from across the organisation to optimise and increase throughput. Today, that's a challenge. 5G doesn't automatically make that easier but we're hoping that 5G will stimulate greater vendor willingness to be more open and share capabilities.

"Hopefully, with 5G, everyone sees enough possibility that it lifts all boats."

A good analogy would be how Apple CarPlay or Android Auto makes a car suddenly so much smarter. The automotive manufacturer didn't have to create a mapping solution and figure out traffic flow, they didn't have to do anything at all.

The driver just connects their phone and can then make better decisions because they have access to the data. Imagine an entire factory benefitting similarly from that level of service from a third party.

Most agree that mainstream 5G won't happen for 5 to 10 years. What can decision-makers do today to prepare their operation?

It's a longer and tougher journey than you probably think, so start now. Otherwise, in the next future, when 5G-enabled devices are more widely available, you won't be ready.

Experiment and start small through proof of concepts. Scaling these POCs may not be possible now as the equipment isn't commercially available and supported, but it's a valuable exercise nonetheless. You will learn what is and isn't useful and which use cases you need to push vendors to support.

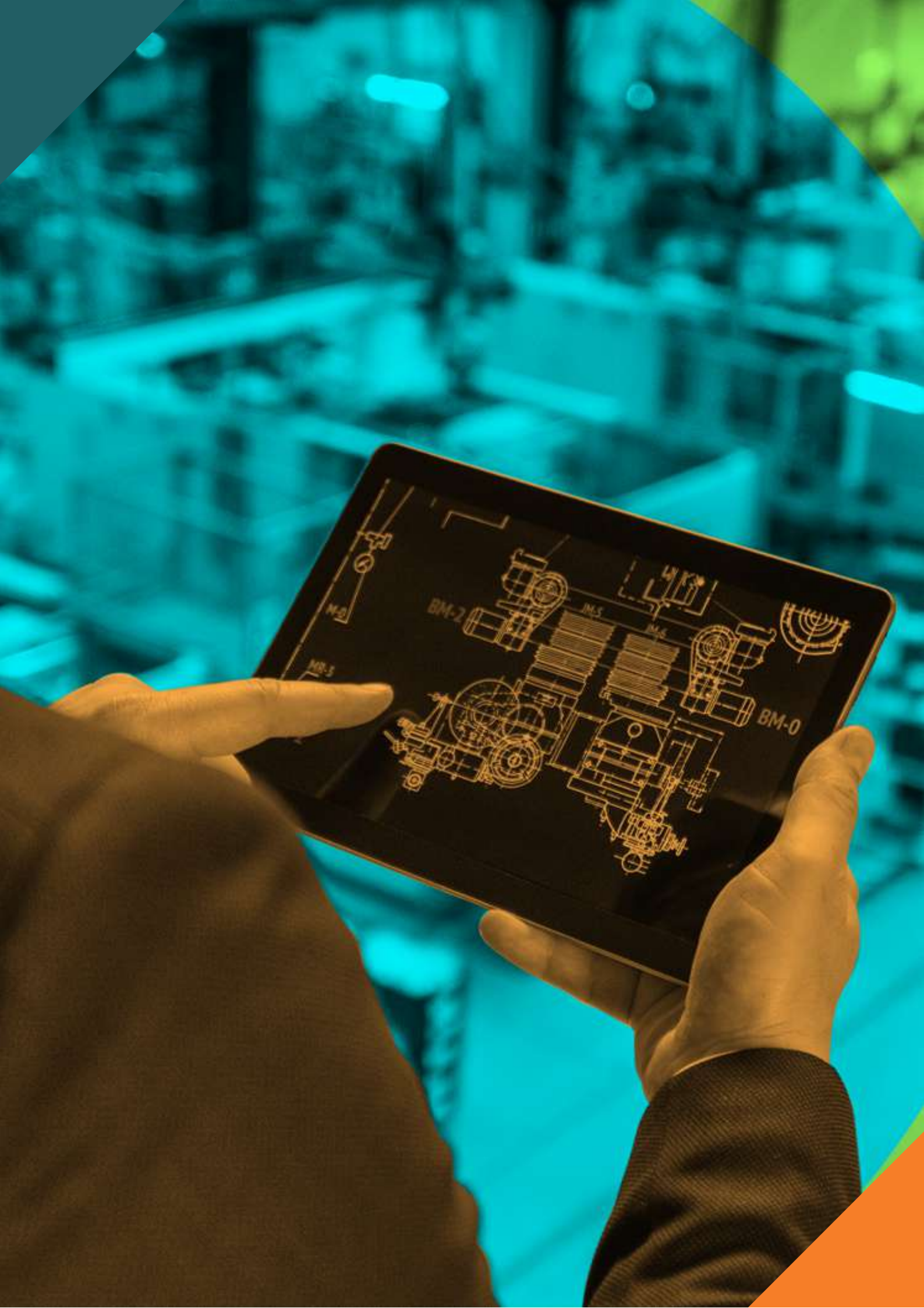
It's also perfectly okay to do a POC on Wi-Fi knowing that you'll need 5G to scale it. Yes, you'll need 5G eventually, but it's fine to experiment on Wi-Fi first. The important thing is to start. POCs will also help your IT teams to get ready in terms of providing reliable, secure connections and orchestrating cloud services.

"5G is one way of getting data and asserting control. Whether Wi-Fi, 5G or wired, make sure you have a very strong IT and OT data architecture so that you can take advantage of connectivity."

I'm particularly conscious of not using 5G like a hammer in search of nails. It's a toolkit item. The focus shouldn't be on 'how can I use 5G' but on 'what keeps us up at night?', 'what are our key problems?'

Forget your current limitations and draw up a use-case wish list. Whittle that down by determining the expected return for each. What do you hope to achieve and how likely is that outcome? Then create a minimum viable project to test that. If it doesn't work, then pivot.

Challenge yourself to understand the changes that are coming but also recognise that a lot of this is new so partnering with external experts and collaborating with others is probably going to help.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