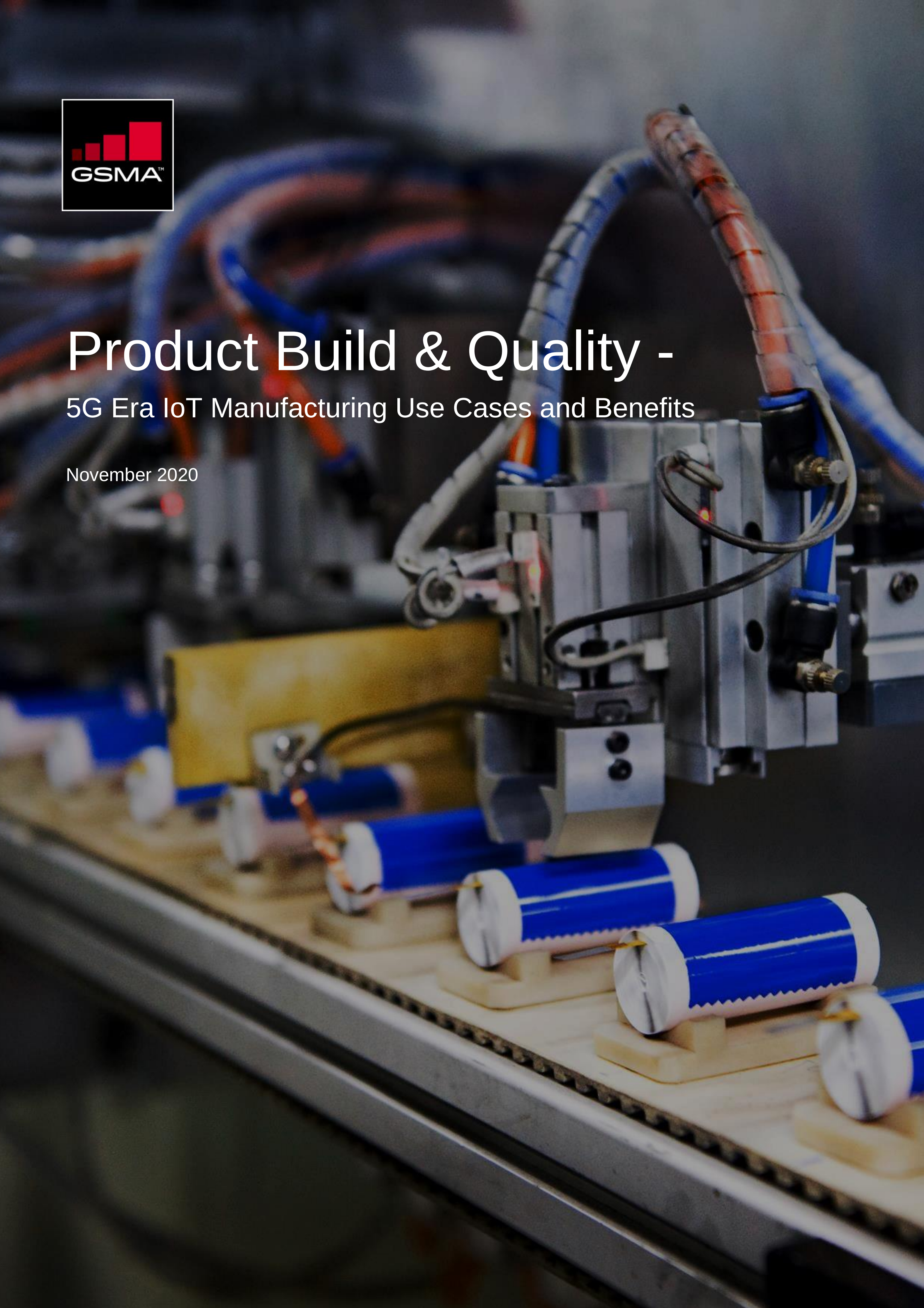

GSMA

Product Build & Quality -

5G Era IoT Manufacturing Use Cases and Benefits

November 2020

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Introduction

Manufacturing is essential to the global economy, and its outputs can be worth well over 10% of GDP in advanced economies such as Germany and the USA, increasing to 40% in countries with very large manufacturing bases such as China. Being such a large industry in its own right and global in nature, the manufacturing sector is naturally competitive, with participants seeking competitive advantage across their operations and supply chains. Over past decades manufacturing has seen a substantial shift from being almost entirely based on manual operations to the increasing use of automation both in the manufacturing facility as well as the associated supply chain. This increased use of connectivity to create more intelligence on manufacturing and supply chain operations and in turn make them more efficient, flexible and sustainable drives what we call 'Industry 4.0'.

New technologies being adopted in the move to Industry 4.0 including IoT, edge and cloud computing, big data and analytics, blockchain, artificial intelligence (AI), virtual and augmented reality (VR and AR), additive manufacturing (the industrial name for 3D printing), energy storage and robotic process automation (RPA) are driving the digitization and transformation of manufacturing operations. This in turn drives improved operational efficiency, faster time to market, better product quality and production line performance.

Whilst globally manufacturing growth has been consistent at roughly 3% per annum over the past 40 years[1] there can be short term shifts in manufacturing between countries and companies depending on economic and political factors. The recent Coronavirus pandemic, whilst affecting short-term output, has highlighted new areas for transformation, with manufacturing flexibility and supply chain diversity to avoid disruption areas of particular new focus. In these areas, 5G Era IoT offers notable benefits over legacy fixed and Wi-Fi communications technologies.

5G Era networks are a key enabler of Industry 4.0. The mobile industry has demonstrated its ability to connect and transform society through its 2G, 3G and 4G networks over the last 30 years. The 5G Era will build on these successes by delivering a platform that enhances existing services, and enables new business models and use cases. Mobile networks create flexible, reliable and secure connectivity services with additional benefits compared to other options such as fixed connectivity or Wi-Fi. Mobile networks can provide the connectivity for a whole range of technologies and use cases, not just across the factory floor, but also through the supply chain and customer engagement. Whether satisfying high performance requirements, such as low latency and high bandwidth, or monitoring and controlling connected IoT assets, mobile networks are designed to meet industrial requirements and lower the barriers to their adoption. 5G can also be configured to utilise dedicated infrastructure and network resources in the form of a private network or network slice.

[1] https://data.worldbank.org/indicator/NV.IND.MANF.KD.ZG

Across manufacturing operations, technology plays an increasingly important role in maintaining margins, competitiveness and meeting transformational goals. Research has shown that manufacturers adopting Industry 4.0 technologies and introducing innovative new processes to the production environment can reap significant benefits:

- ABI Research estimate that across all manufacturing use cases, the introduction of cellular IoT to the factory floor will result in 8.5% operational cost savings, with a return on investment of over 9x over 5 years for some use cases[2].
- McKinsey have reported that manufacturers undertaking digital transformation have realised a reduction in machine downtime of between 30 and 50%, a 15% to 30% improvement in productivity and a 10 and 20% decrease in costs[3].
- Deloitte report that manufacturers undergoing digital transformation driven by innovation alone are currently gaining as much return on investment as those organisations driven by productivity or operational goals[4], whilst achieving a much better foundation for future growth.

Innovation is at the heart of manufacturing digital transformation, and can impact every aspect of factory operations. Additionally, the pace of change in manufacturing is accelerating as new technological solutions become available and manufacturers are increasingly open to the opportunities that they can bring. Certainly, it seems likely that those manufacturers who are not innovating will be overtaken by those that are. Mobile networks coupled with IoT capabilities offer not just the reliability and security that manufacturing companies require, but also the flexibility that enables efficiency gains to be accrued by improving every part of the production process, and enabling a range of completely new data-driven use cases.

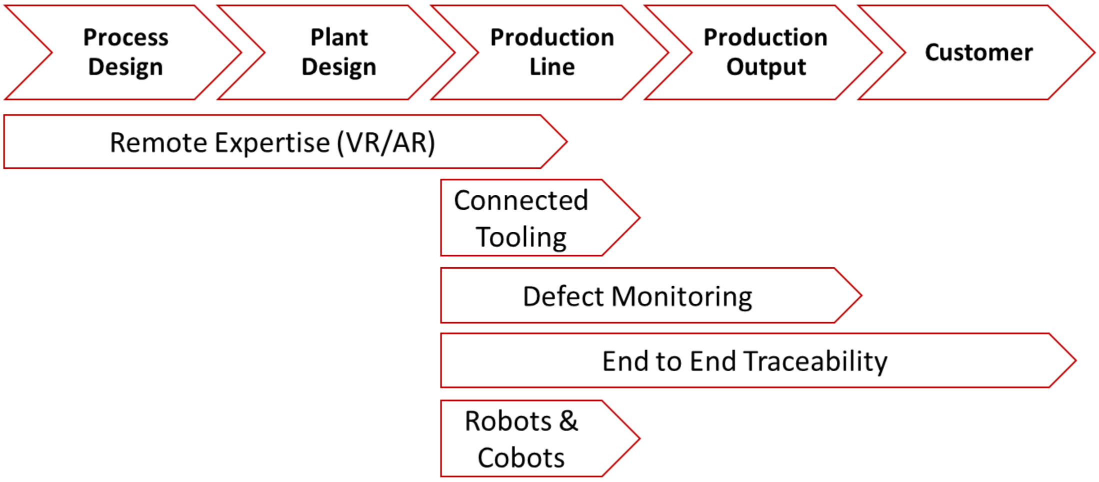
For mobile network operators the manufacturing and supply chain sectors represent attractive markets. However, the use cases this document introduces demonstrate that the opportunity must be focused on supporting value beyond connectivity, with a range of specialist skills and partners needed to successfully implement Industry 4.0 solutions. Solutions such as edge computing, data analytics and AI, network slicing and private/hybrid networks are compelling value-added capabilities for Industry 4.0.

Digital Innovation for Product Build and Quality

Quality assurance and quality control are disciplines that stretch across the manufacturing value chain. IoT enhances product quality by introducing digital transformation of numerous processes leading to business benefits across the value chain from product design through materials supply, manufacturing and ultimately to the customer.

[2] https://www.ericsson.com/en/internet-of-things/trending/abi-research-industry-40-roi
[3] https://www.manufacturingglobal.com/technology/mckinsey-digital-manufacturing-preparing-new-normal
[4] https://www2.deloitte.com/content/dam/Deloitte/cn/Documents/energy-resources/deloitte-cn-er-industry-4.0-paradox-overcoming-disconnects-en-full-report-190225.pdf

The diagram below maps key Product Build & Quality use cases across the value chain and each of these use cases is described in detail further in this document.



There are several points along the production process where automation of quality control can be effectively applied through the use of IoT. These include monitoring of the supply chain to ensure components arriving at the factory are of the desired quality, monitoring to ensure production and assembly are completed properly with bad parts rejected, and finally during post-production testing and re-work. This final step could be removed completely with an appropriate solution, creating a significant cost saving. Quality control is important across both discrete and process[5] industries, but there are distinct differences between them, where the quality drivers in process industry maybe much stricter to avoid spoiling large, costly batches of product.

Each use case highlighted in this document in isolation can improve product build quality but taken together the entire production process can be optimised by a more holistic approach. IoT is at the heart of this. From reducing error rates in repetitive tasks, to tracing components through the supply chain to better planning and reconfiguration of the production process, mobile networks are able to support quality improvements throughout the whole production process. Tying mobile networks and IoT into existing quality processes such as ISO 9000 or Six Sigma means that these quality improvements can be realized through methodical approaches to managing quality. OEE (overall equipment effectiveness) scoring, widely used in the manufacturing industry to measure factory performance, availability, and quality, is a good overall measure of the effectiveness of quality control processes.

[5] Discrete manufacturing = manufacturing of distinct items. (e.g. white goods)
Process manufacturing = manufacturing of recipes and formulas. (e.g. food and beverage)

Generating Value from Product Build and Quality

The American Society for Quality found that for every dollar spent on a quality management programme, there was a return of $6 in revenue, $16 in cost reduction and $3 in profit[6]. There are several areas where quality costs can be saved through the implementation of IoT services, including:

- Planning costs:
  Preventing quality issues through better planning, and using improved data quality provided by IoT to improve the planning, production and product design process
- Internal costs:
  Costs incurred before the product leaves the factory, such as wastage, reworking and rejections
- External costs:
  Quality costs incurred after the product has left the factory, such as repairs, warranty claims and returns.

The macro-economic drivers for investment in Quality Assurance and Quality Control are best illustrated by "Demings Chain Reaction", where the drive to improve quality ultimately results in not just cost savings, but productivity enhancements and ultimately growth of the business and job creation. The use of mobile networks and IoT technologies to improve quality means that the "chain reaction" is not just a one-off event but is a continuous cycle of improvement as refinements and enhancements are made based on ever more accurate and granular data.

Research around this model has shown that Quality Management across the UK's manufacturing base has been driving approximately 5.8% of the UK's GDP. Annual GDP would increase by 3.37% or $48bn, if Quality Management savings and systems were to be fully realized, a figure greatly driven by technology adoption.[7]

The benefits of improved quality assurance and quality control on the manufacturing line are clear. Fewer errors mean a higher yield and better quality products, which in turn increases margin and accelerates return on investment on IoT investments. Combined with the other OEE factors of Availability and Performance, mobile networks can improve scores in all three areas, providing comprehensive improvements to overall production management and control.

[6] http://asq.org/economic-case/
[7] https://www.managers.org.uk/~/media/Files/PDF/Quality_Management_CQI_CMI_June2012.pdf p.48

Analysis of Manufacturer Needs

Product Quality is vital to the survival and success of manufacturing operations with every manufacturer striving to reduce their defect and rejection rates. Good quality products result in more satisfied customers and fewer returns. In turn this leads to higher margins and faster returns on investments. There are a range of use cases supported by mobile networks and IoT solutions which support the achievement of higher product build and quality levels.

A number of key themes have emerged to support the need for IoT to drive better product build and quality

- Quality at speed and scale
- Accurate reporting and inspection
- Trend towards new revenue from "servitisation" of products and ecosystem services

Data is absolutely critical to increasing product quality and reducing rejection and defect rates. Accurate data on manufacturing operations, gives confidence in product quality, leading to the need for reduced physical inspections. Granular data about quality and production not only allows for more effective operations but when shared with suppliers and sometimes even customers, manufacturers can ensure there is confidence in their products and ability to make them, solidifying these relationships.

Reducing the defect and rejection rates in manufacturing operations through the use of technology is also seen as being one of the crucial ways to improve product quality and improve performance margins. Automation of many processes leaves a data trail that gives accurate reporting to reduce defect and rejection rates through continuous process improvement. It also leads to improved understanding of the reasons for product defects, and whether fault lies at the door of the supplier, producer or equipment provider. Outside of the factory, this data can be used to apply quality and service levels to products deployed in the field with customers, leading to improved customer relationships and new servitisation business models.

Solutions such as Digital Twin (a virtual model of a manufacturing process or product) are something that many manufacturers see as a logical next step in their operations, and where they can take the next shift in improving product quality whilst improving the production margins at the same time. These solutions allow change to be effectively planned and tested without disrupting the production line. The use of analytics technologies such as artificial intelligence and machine learning provide a way to automate many of the decisions that need to be made on the production line so that process management can move beyond using data from IoT sensors for simple status reporting to using it to inform sophisticated automated decision making.

One of the fundamental measures for implementing any change is Return on Investment (RoI). When examining RoI on product build and quality multiple measures can be applied into that return. Rework on manufacturing output and processing returns from customers is a heavy burden that some manufacturers bear, and, reducing this effort can go a long way towards building the business case for using technology more readily. Using OEE as a measure for RoI of any digital transformation of manufacturing operations allows the precise comparison on product quality throughout a project.

Measures to monitor RoI in manufacturing product build and quality could include:

- Manufacturing throughput and yield
- Product defect and rejection rates
- Supply chain diversity and performance
- Stock levels and turnover rates
- Waste generated
- Customer returns and contacts

Mobile networks and IoT technology are well placed to support improved processes that lead to better product build and quality. The technology can also be linked up and down the value chain so that quality controls can be applied upstream to supply chain partners, ensuring that component and materials quality is at the required level to start with, and downstream all the way to customers themselves who are able to provide better usage reports for products so that the manufacturing process can be refined even further in the future.

USE CASES

A number of use cases are identified in this document as being able to bring considerable improvements to product build and quality processes through the use of mobile networks and platforms:

- Remote Expertise (AR/VR)
- Automation with Robots and Cobots
- Smart, Connected Tooling
- Defect Monitoring with Machine Vision
- End-to-End Traceability

Use Case: Remote Expertise & Collaboration (AR/VR)

Augmented and Virtual Reality (AR and VR) technologies help a manufacturing company collaborate with expertise either from their suppliers or different parts of their own organisation. Such expertise can be used in the design, test, build or operation of a product and production process and could be for a physically realised production process or provided virtually, ahead of investment in actual physical infrastructure. Not only that, collaborating on product and production processes is something that has traditionally been expensive to achieve and often involves travel, often internationally, to inspect and collaborate on complex tasks. This is likely to decrease organisational efficiency as expertise is more difficult to bring in as and when required. Today, remote access to product design is available through the use of VR and AR technologies. These technologies can also be extended to the factory floor to aid worker training and performance and remote diagnostics and maintenance of machinery.

Current Situation

- Complex machinery and production processes need specialist assistance to design, operate and maintain, sometimes at short notice.
- Some machinery is very specialised and there are only a small number of trained experts to commission and maintain them around the world.
- Significant costs can result from flying specialist engineers around the world to resolve issues at short notice. Any maintenance issues with production machinery that require a specialist engineer to visit the site, will often have a notice period of several days, resulting in lengthy downtime or reduced yield.
- Some machinery once installed is hard to access due to its location or presence of hazardous materials, and making an area safe for maintenance visits is expensive
- Staff training on complex machinery can be difficult as it would require production downtime, whereas a virtual model of the machinery allows hands on training with no impact to the production line.

Solution

To maintain quality, VR and AR systems combined with digital twin analytics technologies can provide a comprehensive virtual or augmented system. This system can then be used for planning changes to products and processes, prototyping and testing of production runs, training staff and augmenting their actions on the production line to minimise errors and bringing in remote expertise or providing complex data to production and maintenance engineers on the factory floor. On the factory floor, engineers can need access to large amounts of information. AR allows the directly relevant information to be overlaid on the physical environment and immediately displayed to the engineer. Remote assistance from other experts in remote locations can be provided to guide staff through the identification and resolution of complex issues.

Mobile network support for this use case

- VR and AR technologies use a large amount of bandwidth, which 5G IoT can support both indoors and outdoors. Giving engineers access to complex data sets and virtual or augmented environments on site requires massive volumes of data, and the 5G network can support this need.
- When deploying AR and VR, latency is critical to ensure the virtual world is synchronised with the real-world. 5G IoT offers ultra low latency, and so data uploads and downloads can occur in near real-time ensuring that the correct information, is always available.

Use Case: Automation with Robots and Cobots

Robotics technology has advanced to such a point now that it is possible to have robots automate all kinds of tasks along the production line. Robots are able to repeat programmed cycles or tasks on a seeming never-ending loop. Cobots are able to alter their work patterns based on the actions of, normally, a human co-worker, and able to undertake new tasks each day without detailed re-programming. Robots and cobots have the benefit of performing each task to precise standards, so that product build quality can be tightly controlled.

Current Situation

- Many non-automated tasks directly affect the ability to control quality in final assembly and distribution of products, with repetitive tasks creating opportunities for human error.
- A large number of repetitive tasks are in use across manufacturing - assembly, welding, finishing, transport, testing and packaging are just a few examples
- Human labour needs breaks and cannot be utilised 24/7, meaning that production line will inevitably experience significant periods of downtime
- Assistance is often needed on the production line to hold heavy equipment in place or picking from assorted components.
- Complex products with sometimes hundreds of components for assembly require complex labour intensive processes which are ripe for automation
- Health and safety in manufacturing can be compromised through injuries resulting from repetitive strain, working with dangerous equipment or materials and lifting heavy loads

Solution Needed

Robotics solutions need to support some factory floor flexibility. Although often designed to perform highly repetitive tasks, robots will also likely be moved and/or re-programmed during their lifespan, and this process should be straightforward with minimal outage time. Cobots often offer much more flexibility in terms of control and location, and so the data management and connectivity needs must reflect that. Use of robotics brings a range of positive business benefits, not least improved build quality, that allow costs to be saved elsewhere from reducing factory lighting to reducing defect rates or improving worker safety.

5G era support for the use case

- The wireless flexibility of mobile networks means that a robot or cobot does not have to be fixed in one location throughout its lifetime, it can move or be moved and this opens up a range of new use cases in the factory.
- 5G's enhanced bandwidth compared with other wireless communications technologies means that robots and cobots can really be monitored and updated in real-time as the environment changes. Where, for example, customisations to

specific products are needed 5G IoT can be used to feed precise requirements for each product through to the robot or cobot to create personalised products

- 5G's low latency allows for actions to be monitored in near to real-time. Cobots, especially, will alter their actions second by second depending on the human co-worker and the environment around them, and this can be monitored and automated interventions made if there is an issue

Use Case: Smart, Connected Tooling

Connected tooling offers various benefits covering tooling setup, assurance of quality and data about production performance and product build quality.   Connected tools can generate data on the number of times the tool is used, it's location, the pressure and torque applied, the type of bit or accessory attached and the time between uses. Together these contribute to an extremely comprehensive picture of production, workstation performance and quality control.

Current Situation

- Non-connected tooling cannot validate usage, meaning issues with product quality may arise
- Misplaced or lost tools in the factory can result in long delays whilst they are located
- Quality control issues can arise from improperly installed components during the assembly process
- Quality assurance in complex production processes can be harder to achieve if tools are not setup correctly, with appropriate torque and pressure settings needed to minimize defect rates.
- Confidence in meeting quality control thresholds can be gained when individual workstations can report successful completion of jobs and processes
- Tool maintenance and replacement is difficult to optimize when usage data is not collected.
- Health and Safety concerns such as repetitive strain injuries are often linked to the usage of tooling for repetitive tasks
- No way of telling who has used tools at specific times and locations.

Solution Needed

Tooling is and will remain a core requirement in the factory. However, tooling is typically linked with manual processes, and for full digitisation of the production line, tools can be connected and tied into data analytics and reporting platforms. As each tool is likely to be used for different processes and in different locations during its lifetime, wireless connectivity is a sensible way to ensure continuous connectivity, no matter the process being supported by the tooling and whether this connectivity is for tool setup or monitoring. Tools can also be digitally tied to their users, so users' performance can be monitored and training used if some quality issues are tied to specific employees. Additionally, Health and Safety of workers can be extended to the tools they use and the way in which they use them.

Mobile network support for this use case

- Coverage inside a manufacturing plant will need to be extensive to connect tools wherever they are used. Mobile connectivity is able to be deployed at a range of frequencies with dedicated in-building infrastructure so that coverage of every corner of a factory can be assured.

- There may be a dense volume of tools inside the factory that need to be connected. Mobile networks offer support for dense connectivity, which means that all tools can be securely connected
- The use of NB-IoT or LTE-M[8] networks means that connected tools can be communicated with in a power efficient manner, meaning that battery lifespan can be maximized.

[8] https://www.gsma.com/iot/mobile-iot/

Use Case: Defect Monitoring with Machine Vision

The ability to monitor product quality at scale is a complex task that has often relied on manual processes and extensive testing before shipping to the customer. The use of cameras as an IoT sensor has the ability to transform this process through reducing the occurrence of defects by ensuring automated processes are completed in full, and allows product to be inspected quickly both on the production line and before shipping to customers

Current Situation

- Monitoring and improving product build and quality can be a difficult and costly task, especially with processes that use human capital, which carry a risk of product defects through human error and inconsistency
- Existing non-optical sensors for checking product build are typically bespoke and can be expensive to design and install, increasing the cost of improving product quality.
- It can be very difficult to monitor the entire end-to-end production process
- There is often not enough data to make a quick pass / fail decision for each product or component passing through the production line
- Thorough post-production quality testing is commonplace and add costs to the overall production process
- The lack of complete end to end defect detection can result in customers rejecting products at delivery, or warranty failures

Solution

The use of IoT-enabled cameras, coupled with Machine Vision analytical capabilities, can be used to monitor for visual defects on the production line. This solution enables the manufacturer to monitor for a broad range of defects and conditions that may cause a quality test fail or service life failure. Following the capture of images by the camera, machine vision algorithm or application can then process the images and make a decision to accept or reject the product. This decision can be made in near real-time so that a product can be identified and removed from the production line as needed. Therefore, the use of localised image processing, which can be performed with edge computing, combined with local manufacturing management applications can use the data feed from one or more cameras to create an effective quality assessment / defect monitoring solution. Furthermore, the use of advanced analytics can further process the machine vision results to perform root cause analysis, allowing the reason for a defect occurring to be identified and remedied.

Mobile network support for the use case

- Cameras produce large amounts of data whether they are producing still or moving images. The enhanced bandwidth native to 5G allows even faster data uploads from the factory floor, meaning that image analysis can be completed in close to real-time if data analytics are conducted close to the source
- 5G networks mean the position of cameras is fully flexible – they can be placed precisely where needed and connected wirelessly over the mobile network to the data analytics application
- 5G's ultra-reliable low latency communications means that control actions resulting from the processing of images can occur in near real-time and with guaranteed delivery. This means production line actions such as rejecting a product with poor quality can be achieved without causing delay to the production process.

Use Case: End-to-End traceability

Product assemblies are typically made up of numerous components, each of which may come from a separate supplier within the supply chain. The quality of each of these components is directly relatable to the quality of the finished product. When there is any form of quality issue, being able to trace the source of all components or supplies, and the journey of products through the production environment to the customer is invaluable to ensure a holistic view of quality across the production environment.

Current Situation

- Lack of traceability of components and limited supply chain integration into the production process means that product failures in the field may rest at the door of the manufacturer, rather than a supplier whose components may have failed, and may be difficult to pass related costs on
- Quality Assurance relies on traceability of product and component through an end-to-end process. There is often little linkage between the supplier obligations around quality delivery and the quality assurance process.
- Data capture of component usage is often unavailable or not detailed enough to go beyond estimates related to the dates of using a batch of components
- There are limited automated tools in many factories that are able to track individual components across the factory floor, so that validation of components in the final assembled product can be completed.
- In some industries, e.g. pharmaceuticals, full end-to-end traceability is a regulatory requirement and requires significant and often costly manual supervision

Solution

In order to trace and identify every component, its source and its contractual performance requirements, significant investment in asset tracking is required. Traceability adds the capability to link components and assets back to the supplier, and obligations should be placed on the supplier to provide origination data and other data such as production date or environmental conditions of storage. A comprehensive database that combines asset tracking through the factory with supplier data can lead to reduce manufacturer risk, improve quality control, and improve compliance with relevant regulations. A continually updated database with the full end-to-end history of a component can be tied into other systems to better understand overall product and production performance, and ensure that contractual renegotiations with suppliers and distributors focus on the important areas for improvement.

Mobile network support for this use case

- Coverage in-building and outdoors means that full, uninterrupted tracing both within and upstream and downstream of the factory can be undertaken. For example, the temperature of refrigerated goods can be recorded at all times, no matter where in the value chain the product is held.

- Even components not connected to a power supply can be tracked through the use of mobile IoT networks. NB-IoT, for example, is a low power network technology which supports small data volumes and long battery life, meaning that even assets stored on the shelf for several months can still be located and tracked.

Recommended Approach for Mobile Operators

With potential for improved RoI and lower TCO for mobile driven improvements in product build and quality, there exists a significant business opportunity for mobile operators.

The value for operators is not just in connectivity, but also in IoT solution provision, data analytics and additional integrations between production environment systems and wider connectivity, data and management platforms. Therefore, operators should focus on creating specialist partnerships to enable end to end value propositions. Further, creating an integration across several use cases improves the overall attractiveness of operator offerings considerably. For example, enabling the deployment of robotics, combining connected tooling with production line management platforms and creating a platform for storing supply chain data and using this to improve quality creates an extremely attractive value proposition. Building a wider ecosystem around these solutions makes the operator value propositions more than simple connectivity or product propositions, putting the operator at the heart of manufacturing operations.

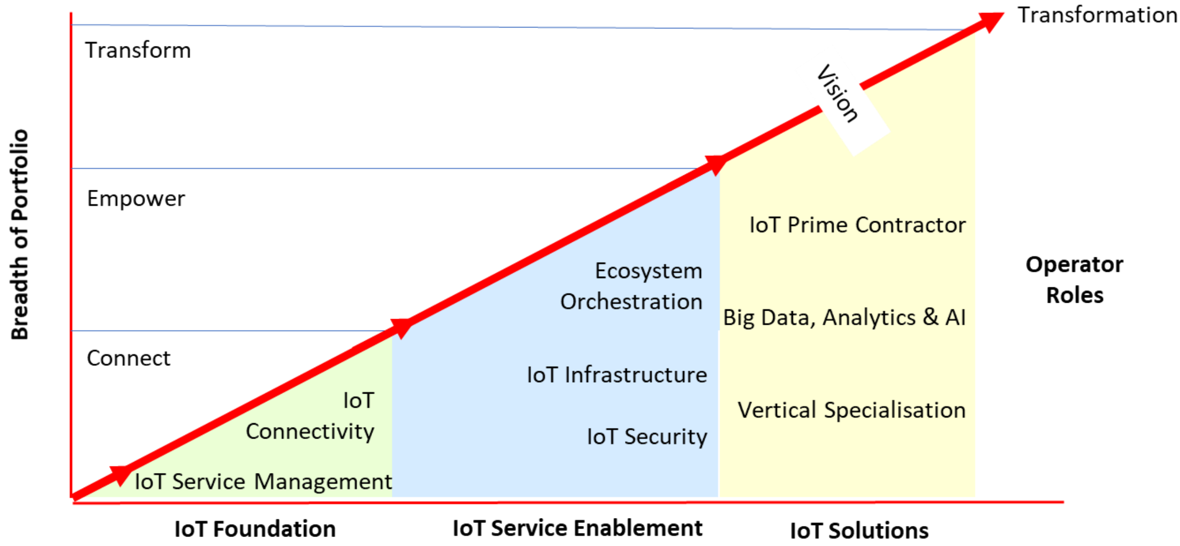
Key measures that operators will need to meet in their product build and quality propositions for manufacturing and industrial customers include: reliability (including service level agreements), total cost of ownership, return on investment and estimated or guaranteed degrees of improvement in production availability and performance. Completing pilots and proof of concepts will yield some of this data and remove any potential perceived risk of using new technologies in manufacturing environments. The key advice to mobile operators remains to orchestrate an ecosystem around the operator that can both meet specific manufacturing requirements and build a significant economic change over existing production solutions and networks.

Pathway to success

Previously, GSMA has defined a pathway for operator transformation beyond connectivity, in the document *Beyond Connectivity: New Roles for Operators in the IoT*. This pathway is adaptable to success in the manufacturing vertical. The pathway encompassed three sets of defined roles:

- **Foundation IoT Roles to *Connect*:** including the provision of IoT connectivity and IoT service management. These roles support connecting devices and are, therefore, the bedrock of operator IoT services.
- **IoT Service Enabler Roles to *Empower*:** including ecosystem orchestration, delivering IoT infrastructure (cloud and edge) and becoming an IoT security provider; these roles are about providing essential tools and capabilities to ecosystem partners and supporting monetisation and interoperability between IoT solutions.

- **IoT Solution Roles to *Transform*:** such as becoming a manufacturing sector specialised IoT prime contractor, a big data analytics and artificial intelligence (AI) provider and delivering vertical specialisation capabilities; these roles cover end-to-end services where operators take the lead in transforming vertical industries and their customers' businesses.



Each step in the pathway allows operators to serve customers in increasingly sophisticated ways and thus increase their value in the ecosystem. Some of the roles are already familiar to operators. For example, IoT connectivity is the starting point for mobile operators, and many operators already provide some cloud computing infrastructure or serve as prime contractors in IoT services. By contrast, other roles will be new for many operators, such as ecosystem orchestration and vertical specialisation.

In the manufacturing vertical, it is critical that the operator establishes themselves at the heart of an ecosystem, rather than being drawn into projects on an ad-hoc basis. Lack of an ecosystem is a sure-fire way for continuous positioning as a connectivity provider only. To move up the pathway and create more value, and operator must undertake 5 key activities:

1. **Build a vision and a focus:** The operator must have a clear view of what their vision and role within the manufacturing vertical is to be. This vision must then be used to inform all value propositions, partnerships and development activities. The vision may be to focus on one or two of the use cases described in this document, or a full end-to-end service. Whatever it is, it is critical to ensure that the vision and area of focus is clear
2. **Develop capabilities quickly:** The manufacturing sector is evolving rapidly, particularly in light of the disruption caused by Covid-19. Operators should build short-term capabilities quickly if they want to gain market share. In practice this

means a strict focus on use cases that can be supported as quickly as possible. Knowing the next steps and progressions from that starting point are also essential.

3. **Establishing standards and norms:** Manufacturing companies have a very clear view of what works for them and what doesn't. They are generally risk averse. Working to establish proven deployment models and business cases through alliances, standards and certification schemes in functional areas such as private networks, security and AI will help operators get manufacturers to accept the adoption of 5G technology within the vertical.
4. **Building technical supporting infrastructure:** For the ecosystem to work efficiently, it needs to be pre-integrated through some supporting infrastructure. That can include the operator's service management tools and billing systems; edge and cloud integrations; data analytics models and algorithms, and mechanisms for handling data authentication and security.
5. **Build a collaborative culture:** Ecosystem is key to success in smart manufacturing. To stimulate specialist partnerships in the manufacturing vertical, operators must build a collaborative IoT culture. Holding workshops, networking events, initiating labs and pilots, casual meet-ups, and hackathons will all assist in creating ecosystems that specialise in the manufacturing vertical and position the operator as a go-to partner for vertical collaborations.

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