Factory Efficiency

5G Era IoT Use Cases and Benefits

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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 manufacturing growth has been consistent globally, 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.

Across manufacturing operations, technology plays an increasingly important role in maintaining margins, competitiveness and meeting transformational goals. Research has

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

shown that manufacturers adopting Industry 4.0 technologies and introducing innovative new processes to the production environment can reap significant benefits:

- ABI 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.

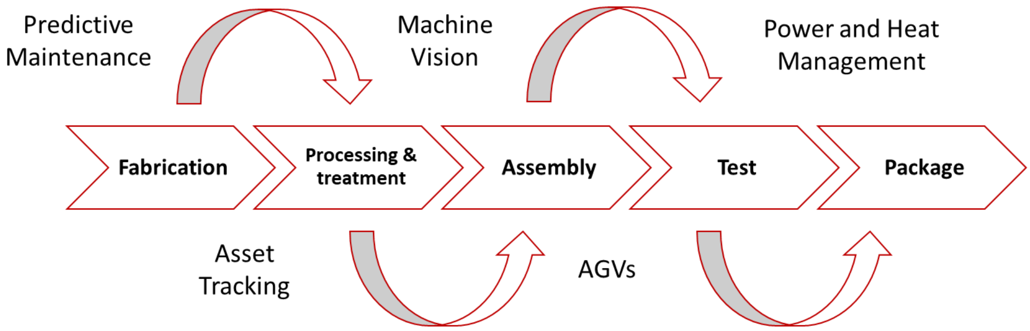
Digital Innovation for Factory Efficiency

Mobile networks are by their nature flexible, secure, and scalable. All generations of mobile networks are able to drive significant improvements in manufacturing and supply chain operations by offering a consistent user experience across multiple locations and use cases. The latest mobile generation, 5G, supports improved efficiency of the production environment by being able to connect even more assets and collect even more data throughout a manufacturing plant than previous mobile generations. Data such as temperature, power fluctuations, and wear on mechanical apparatus, can be collected at high granularity in near real-time to be used in immediate decision making. This drives

[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

new efficiencies such as faster asset location enabled through better tracking, timely workstation replenishment, and production line downtime avoidance through predictive maintenance. 5G IoT improves manufacturing performance and thus efficiency by enabling ongoing optimisation of the production process at all times. 5G networks can also be configured to utilize dedicated infrastructure and network resources in the form of a private network or network slice.

5G IoT creates a return on investment for manufacturing performance. Case examples have shown that performance improves by 2% over non-5G connected equipment[5]. Taking an auto manufacturer as an example, an increase in productivity of around 2% would mean additional vehicles being produced from each shift, which has clear financial benefits. Seen as a whole system, the use cases described in this document all add to these performance improvements. Improved performance means a higher yield from the production line, which again in turn lowers the total cost of ownership (TCO) of mobile enabled IoT in Manufacturing.



Predictive Maintenance can create a cost saving of up to 1.65% across the whole manufacturing operation.[6] In order to achieve this saving, manufacturers must embrace the use case and technology completely, as savings can be maximized with economies of scale and full end-to-end automation. The savings come in several forms. Workforce savings can be considerable, and the total asset cost or ownership can also be reduced, with a significant reduction in the costs associated with equipment operation, testing and spares being cut by at least 50%. The reduction in the cost of downtime, estimated at up to $260,000 per hour by Aberdeen Group[7], also goes towards creating an attractive business model for manufacturers to adopt this use case.

Asset tracking can have similar returns, with a total cost saving of up to 1.05% across the whole manufacturing operation. [8] This cost saving is made of a number of individual elements, including missing inventory value, errors, cost of substitutions, cost of searching, depreciation costs, cost of production idling and so on. Having an effective asset tracking solution inside the plant allows manufacturers to realize significant cost saving and create a more sustainable, efficient business. In one case example, an engineering company

[5] https://uk5g.org/5g-updates/read-articles/uks-first-5g-industrial-trial-suggests-new-technol/
[6] https://www.ericsson.com/en/internet-of-things/trending/abi-research-industry-40-roi
[7] https://www.aberdeen.com/techpro-essentials/stat-of-the-week-the-rising-cost-of-downtime/
[8] https://www.ericsson.com/en/internet-of-things/trending/abi-research-industry-40-roi

implementing an IoT asset tracking solution realized a return on investment in just 4 months.[9]

When it comes to plant management, electricity consumption is a major cost, with many manufacturing businesses discussing it at board level. Automating the management of heating, ventilation, and air conditioning systems (HVAC) for maximum energy efficiency can lead to significant cost savings, with up to 15% demonstrated in some facilities. [10]

Analysis of Manufacturer Needs

Customer needs for factory efficiency revolve around a few key issues that can dramatically affect the operation and output of an industrial environment, and these issues lead to a range of use cases that can be resolved with 5G IoT to improve overall factory efficiency.

A few key themes have emerged to support the drive for factory efficiency:

- Digital transformation of the factory floor
- A much better view of the whole factory environment
- Making better use of high value skills that can be deployed more precisely

Additionally, the outbreak of Covid-19 is driving more organizations to focus increasingly on collecting data from the factory floor in order to minimize both human interactions to ensure social distancing and also to ensure that specialists can have effective impact whilst working remotely.

Decision making driven by the need for a clear return on investment is creating momentum for digital transformation along these key themes. Faster payback is possible with better intelligence derived from IoT sensors, in turn creating better opportunities to save costs and time. To many manufacturing organizations, reducing downtime and increasing yield are as important as saving costs, and often the two are intrinsically linked. Therefore, the better the quality of data gathered, the better the view of the factory floor, the earlier any interventions can be made to prevent issues, and the better the return on investment that can be made.

5G IoT offers a clear route to fast, detailed data gathering. Alternative technologies can collect the data but are limited by either available bandwidth in some wireless networks or lack of flexibility in monitoring equipment, assets, or workers from fixed networks. 5G IoT technologies offer the best route to gathering large amounts of data in as close to real-time as possible whilst introducing a level of flexibility in its deployment that allows

[9] https://www.digicatapult.org.uk/news-and-insights/blog/asset-tracking-for-manufacturers-and-industrial-supply-chains-iot
[10] https://www.iotworldtoday.com/2020/02/14/smart-building-energy-management-systems-yield-cost-savings/

manufacturers to design the factory floor to ensure they both utilise their workforce most efficiently and meet their customer needs in an increasingly more dynamic way.

In line with this, security and reliability of any communications technology is crucial. Loss of data or control has a large impact on the production line and so it is imperative that all aspects of the technology work securely and seamlessly, without interruption, to ensure that efficiency is maintained or improved. Mobile networks are designed with this in mind.

The final aspect of note is around simplification of technology. Manufacturers do not want to manage hugely complex systems, and where they can be simplified, they should. Network management skills rarely exist inside manufacturing companies, and so new operational models, such as outsourcing and servitisation of networks are all on the table for discussion.

USE CASES

Several use cases are identified in this document as being able to bring considerable efficiency improvements to manufacturing operations through the use of mobile networks and platforms:

- Predictive Maintenance
- Asset Tracking
- Power and Heat Management
- Machine Vision for Plant Management
- Replenishment of Machines and Workstations with AGVs

Use Case: Predictive Maintenance

Balancing the maintenance needs of a production line with the need to minimise downtime is a complex problem to solve. Using connectivity, IoT capabilities and data analytics to predict maintenance requirements needs means that downtime and maintenance windows can be effectively planned, and the risk of unplanned downtime due to machinery breakdown is minimised. In turn this means that factory productivity and performance can be optimised.

Current situation

- Lack of detailed data on production line performance means maintenance needs are hard to predict
- Downtime directly impacts the bottom line, with downtime costing manufacturers in the UK three days production per year on average[11]
- Root Cause Analysis is complex when legacy equipment is involved
- Real-time analysis of whole production line down to component level is not available in all scenarios due to cost and complexity
- Scalability and integration of legacy Operation Technology (OT) analytics systems is troublesome
- Unplanned maintenance costs a significant amount in terms of lost production and management overheads
- Lots of effort is needed to manually monitor the production line for faults, and this resource could be better utilized on other production line management tasks.

Solution Needed

For effective predictive maintenance, several things must be in place. Firstly, accurate granular real-time and historic data gathered by IoT sensors supporting condition-based monitoring of machine and production line performance. Secondly, data analytics or AI designed to predict where issues on the production line might be about to occur, including for legacy equipment. Finally, an effective scheduling and resource management system to ensure any downtime is managed as efficiently as possible. Any maintenance solution needs to ensure that it is able to minimise downtime throughout the production line. The ultimate goal of predictive maintenance is not only to improve maintenance processes, but to optimise availability of the production line, ensuring that yield and margins can be maintained or improved.

Mobile enabled IoT support for the Use Case

- Wireless coverage from mobile networks allow every part of the production facility to be monitored so that even macro factors, such as building temperature, can be analysed to predict issues with the production line.

[11] https://www.themanufacturer.com/articles/machine-downtime-costs-uk-manufacturers-180bn-year/

- 5G era mobile network support for Massive IoT (Massive Machine Type Communications (mMTC))[12] makes it more economical and less complex to connect machinery down to component level
- NB-IoT[13] allows components to be connected for low cost with long battery life so their status can be assured. This creates capacity to take data readings from even the smallest components meaning that much more detailed data analytics can be completed to better train predictive maintenance algorithms.
- Low latency and improved bandwidth, enabled by 5G, mean real-time data sets can be collected and analysed against historic data to highlight trends which may impact production efficiency.

[12] https://enterpriseiotinsights.com/20191016/channels/fundamentals/what-is-mmtc-in-5g-nr-and-how-does-it-impact-nb-iot-and-lte-m
[13] https://www.gsma.com/iot/narrow-band-internet-of-things-nb-iot/

Use Case: Asset Tracking

Knowing where all the assets, inventory and equipment are in a factory environment is one of the fastest routes to achieving efficiency gains. Too often, factories hold stock of supplies without knowing precisely where they are stored or do not track the flow of components through the factory, perhaps only recording when they enter a factory or warehouse but not when they leave again. Having complete visibility over where assets are located can cut time, and costs significantly.

Current Situation

- Assets, particularly low-cost assets, often remain untracked once they enter the factory gates, meaning they often get lost and need to be re-ordered.
- Inability to find correct assets in a timely manner can increase downtime of production line.
- Warehouse space is not effectively organised in many situations resulting in costly and timely stock audits needing to be undertaken regularly.
- The provenance of every part and component flowing through the factory is not always recorded.
- Asset Tracking solutions in place today often rely on manual operation – e.g. use of QR codes and scanners and manual requests for re-supplies at each station.
- Leadtime to find assets and equipment in warehouses can be lengthy and would benefit from automation.
- More expensive equipment and machinery can also be tracked to assist the production process and prevent theft or misuse.

Solution Needed

An effective asset tracking solution can increase efficiency significantly by automating the recording, location and eventual use of any asset, part or component entering into the factory. There is also value in extending this tracking upstream into the supply chain to ensure that quality control can be monitored. The IoT technology needed to track an asset needs to be able to both identify it and its location, whilst being linked to consumption data at workstations to ensure that adequate re-supply and re-ordering can be undertaken. Automated recording, positioning, status and destination of assets and components in the production environment needs to readily available to production managers and other systems. Having a broad ranging, dedicated, and connected asset tracking system is a guaranteed way to improve factory efficiency.

Mobile enabled IoT support for the Use Case

- The flexibility of mobile networks means that even low cost assets and equipment can be connected with low cost connectivity, with the latest generations of mobile networks supporting long battery life so that devices can be connected and tracked over a long period.
- Significant increases in data bandwidth supports new, innovative ways of tracking assets. Use of cameras to identify and track assets through the factory can be

achieved, removing the need for some manual tracking systems even on the lowest cost items.

- Support for dense connections means that an almost unlimited number of assets inside and outside the factory wall can be connected to the mobile network at any one time.
- 5G's native location support means that 5G supports location tracking in building with a good accuracy range. This is planned to become more accurate as the 5G standard matures.

Use Case: Power and Heat Management

The factory environment is crucial to the efficient running of the production line, with the factory needing to be kept at an appropriate ambient temperature. This often requires a range of HVAC (heating, ventilation, and air conditioning) systems, but even so specific pieces of equipment can give off high levels of heat during their operation and so need focused management. Likewise, power requirements will need to be managed to ensure machinery always has the power it needs available to it.

Current Situation

- Power and HVAC are not linked to production operations in many cases, meaning operations can be impeded if effective monitoring and management is not in place
- Cost of HVAC and power can be significant OPEX considerations in manufacturing
- Flexible factory floors require flexible power and HVAC supply
- Power and HVAC are often outsourced to power companies and building management services, and not under the control of the manufacturer, meaning supply could be interrupted or excessively costly
- At certain times of year, to aid power grid load, intensive industrial sites such as chemical manufacturing are incentivised by power companies to shut down when necessary so as to prevent grid blackouts and brownouts
- Heat output from machinery is not generally linked to HVAC and power management systems, meaning control is completed on a macro level only

Solution Needed

Power and HVAC management systems need to be closely aligned with production operations to maintain overall efficiency and reduce the risk of unplanned downtime. Use of IoT sensors to monitor heat output of individual pieces of machinery as well as their power consumption means that a building management system will be able to create more flexible controls over power and heat. Use of off-grid power generation and storage to create a virtual power plant for use by the production facility would give a huge amount of flexibility to production operations as well as reducing the risk from external generation and distribution factors. Reductions in the cost of HVAC and power supply can be achieved through the use of enhanced data analytics, automation and AI to ensure that operations are as efficient as possible and potentially some processes only run when environmental conditions and power costs are at an optimal level.

Mobile enabled IoT support for the Use Case

- Creation of a virtual power plant to control energy consumption and storage, as well as connections to the power grid requires a range of IoT sensors and data analytics to control. Mobile networks offer the flexibility, coverage and low latency required to effectively link these systems together to offer near real-time control
- Massive IoT support means that a broad range of IoT sensors for measuring heat output and power consumption can be used throughout the factory. Change can then

be automated through mobile connections to production machinery and building management systems

- Links to the power grid enable a wider view of the power demands across a region, meaning that better planning for energy consumption can be made. Linking manufacturing consumption to grid operators demand response platforms could mean that certain machinery is only used when energy costs fall below a certain level. Using mobile enabled IoT to connect these machines gives a finer level of control to the overall system.

Use Case: Machine Vision for Plant Management

Machine vision, and the use of cameras as sensors, is widely enabled by the adoption of 5G. This use case focuses on the application of machine vision for plant management. High resolution cameras offer a low-cost and reliable route to monitoring broad areas of a manufacturing site's operation. From security through to monitoring complete production cycles, cameras are a flexible and good general purpose sensor with many applications that complement and enhance the data derived from 'traditional' IoT sensors.

Current Situation

- Monitoring of factories and warehouses is often a labour intensive task especially if IoT sensors cannot be used extensively. Low cost, flexible methods are needed for monitoring a wide range of parameters associated with efficient manufacturing operations. Examples include worker safety, production line performance, and monitoring the completion of production equipment cycles
- Repeatable patterns are commonplace across a manufacturing environment, making them suitable for automated monitoring, and allowing fast highlighting of any production or safety issues
- Although IoT sensors are good at monitoring specific processes or parameters, the wider environment is harder to monitor and benefits from a generic class of sensor to provide full coverage of an area or situation, allowing advanced decision making.
- Camera technology has advanced to a point where a high-resolution camera suitable for industrial settings has dropped to a low price point, however the method for analysing the image data is still proprietary in many instances, which has a higher cost

Solution Needed

A broad machine vision solution that captures not only specific tasks being completed, but also highlights unpredictable events can be deployed to fully automate some aspects of manufacturing plant management. The solution should offer precise analysis of both moving and still images, converting image data into actionable intelligence. Management of these sensors and data needs to be through existing dedicated IoT platforms to allow integration of data with other sensors. Data management at the edge allows for faster response times. The image analysis algorithm is one of the key areas that efficiencies can be made. Using a robust, well trained algorithm will give confidence in the response being generated, ensures similar data sets can be compared, and will dictate the areas where machine vision will give the greatest advantage in combination with other IoT sensors.

Mobile network support for the Use Case

- 5G networks offer enhanced bandwidth, massively increased over previous generations. This is needed to collect the huge amount of data generated from cameras capturing both still and moving images
- Enhanced bandwidth means that image transfer can be completed quickly. What is more, where local infrastructure such as edge compute is used to conduct image analytics, low latency alerts and remedial commands can be generated if issues are identified.
- Data from camera sensors can be combined with data from more traditional IoT sensors to create a truly in-depth view of the manufacturing environment at any point in time. The use of 5G IoT to enable this means that more data can be processed in a shorter period of time, leading to improved response times to problems and improved overall factory efficiency.
- Where machine vision identifies an issue there is the ability to route the real-time image feed to plant management staff for further analysis or action – using 5G's high bandwidth to deliver this wherever required across the manufacturing plant.

Use Case: Replenishment of Machines and Workstations with AGVs and AMRs

AGVs (Autonomous Guided Vehicles) and AMRs (Automated Mobile Robots) are increasingly common in modern manufacturing settings and are increasingly used to automate a number of tasks that involve moving items from one location to another. In the case of replenishment of machines and workstations this is usually to support JIT (Just In Time) manufacturing models. 5G IoT provides much improved, higher bandwidth and reliability communications, to support greater reliability of AGVs and greater sophistication of AGVs resulting in higher efficiency and safety.

Current Situation

- Manual replenishment processes are time consuming and need detailed planning to ensure effectiveness. Timely, zero-error replenishment of automated machinery and manual workstations must be completed to ensure the elimination of production stops if required components and parts run out
- Factories are dynamic workplaces with a constantly changing environment. The ability to navigate around obstacles and find new routes is a must for any technological solution
- The "flexible factory floor" means that replenishment needs will change over time, increasing the possibility that mistakes are more likely to occur, resulting in increased downtime.
- Location of parts in warehouse is also likely to change as new deliveries accepted, and keeping track of their location is difficult to do without a level of automation
- If different products are being produced, then parts and replenishment needs will change on a sometime daily basis, which would need a complex manual process to support without automated replenishment
- Without efficient and reliable replenishment processes there may need to be increased inventory holding which ties up additional working capital
- Movement of heavy/ dangerous items around a factory can create a risk for human operatives leading to health & safety issues

Solution Needed

The objective that AGVs (and AMRs) need to support is continuous operation of the production line with zero downtime. Flexibility and ability to cope with changes in environment and manufacturing process is absolutely critical to achieving this. Therefore AGVs on the production line need to be connected at all times to report progress and highlight any issues that may need intervention, they also need to be smart enough to find their way to and from component stores and workstations without interruption, record assets they interact with, as well as maintain and re-charge themselves. Additionally, the return on investment for an AGV system needs to be enough to warrant the replacement of more manually led processes and allow human capital to be used for more highly skilled tasks. AGVs are also part of a whole automated system and should be linked into other systems and processes such as stock control and asset tracking to ensure optimal performance and control.

Mobile network support for the use case

- Mobile networks are able to support deployment of AMRs across a factory floor. The high bandwidth and low latency native to 5G networks is perhaps better able to support the operation and monitoring of intelligent AMRs in near real-time to enable more sophisticated operation better suited to a changing, flexible factory environment. In addition, all mobile networks are able to support data transfer to and from AGVs to allow improved operations.
- AGVs can be equipped with more advanced sensors e.g. 360 degree cameras and LIDAR to improve safety for human operatives working in the factory, eliminate collisions and ensure the safety of products being transported
- Location services within mobile networks allow an AGV or AMR to both know its location at any given time, the location of other AGVs and also know the location of storage and workstations and obstacles to effectively plan and execute optimised routes around the factory floor
- Use of connected workstations and warehouses through the use of enhanced bandwidth means that all parts of the operational chain can be connected. Then a full end-to-end view of AGV & AMR function and its impact on overall production performance can be understood.

Recommended Approach for Mobile Operators

With potential for improved factory efficiency, an attractive return on investment and benefits across use cases for factory efficiency and 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 AGVs and AMRs, introducing predictive maintenance and asset tracking platforms and building more effective controls over power and heating management 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.

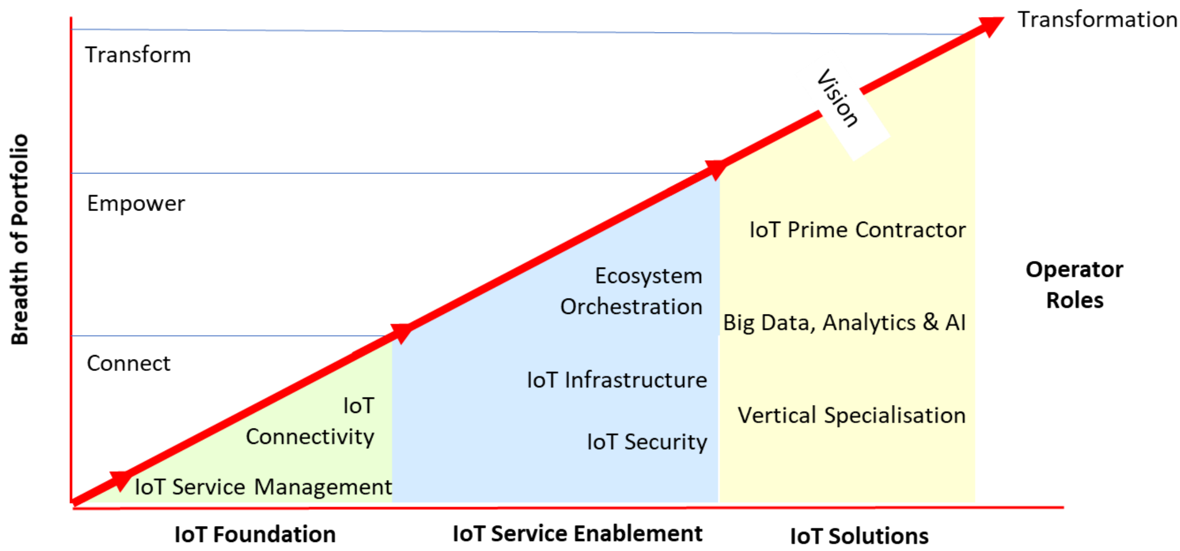
Another aspect of note is the separation of data and network, required by some companies for security reasons. Different data types may have different security classifications, and this will impact the appropriate network and infrastructure deployment model, with some data having to remain on premises and encrypted at all times.

Key measures that operators will need to meet in their factory efficiency 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 efficiency. 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 five 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 must be. This vision must then be used to inform all value propositions, partnerships, and development activities. The vision maybe 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 IoT 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 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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