

A practical roadmap for the implementation of **Industry 4.0**





About the Authors

Andrew Minturn

As Business Development and Strategic Product Manager for Bosch Rexroth, Andrew Minturn supports the implementation of Industry 4.0 for businesses across the UK. Now established as one of the key experts on the subject, Andrew has given a number of talks at leading industry events demonstrating the benefits and best practice of creating an Industry 4.0-enabled facility.

Andrew's career in engineering spans over 25 years, during which time he has worked across industries such as aerospace, general automation, food & packaging and medical. He began working as an engineering toolmaker for BMW Manufacturing, formerly known as The Rover Group, in 1991, where he was responsible for the manufacture of car body presses and tooling.

Andrew remained at this company for ten years before going on to study for his ONC and HNC qualifications. He subsequently joined Bosch Rexroth as a Technical Support Engineer in 2002. While working at Bosch Rexroth, Andrew continued his formal education in engineering, graduating from the University of Bath with a First-Class degree in Engineering Systems in 2010.

He went on to specialise in assembly technology and system sales, before moving on to his current role of Business Development and Strategic Product Manager in 2016. "Industry 4.0 isn't going to be a sudden change – it's gradual and it's happening now. The ultimate step will be the complete evolution of the supply chain, from the subcontractor to the end user. Everyone will need to get involved."

Andrew Minturn

Strategic Product Manager, Bosch Rexroth



Mike Lomax

Since joining Bosch Rexroth in 1979, Mike has been one of the leading experts in electrification and factory automation. His current role of Electrification Manager sees him provide automation and Industry 4.0 solutions to clients across a range of industries.

Mike has worked as part of Bosch Rexroth for more than 38 years, following his graduation from the University of Sheffield in 1977 with a degree in Control Engineering. During this time, Mike has has held roles as an Electrification Manager and Head of Product Management for the UK, for which he has overseen a range of projects, from major automotive developments to the implementation of pick and place systems.

Mike's in-depth knowledge of servo control systems, PLCs and SCADA has seen him assist major OEM machine makers with their own implementation of Open Core and Industry 4.0. He has also been involved in the retrofit of Industry 4.0-compatible devices to hydraulic packs, and is now a key source of advice and support for anyone wishing to move into the Industry 4.0 space.

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"Machine automation has been a passion of mine throughout my career. Industry 4.0 is the next logical step. It may seem daunting, but no-one needs to be left behind."

> **Mike Lomax** Electrification Manager, Bosch Rexroth



Paul Streatfield

Paul has been working at Bosch Rexroth for almost 30 years, and is highly experienced in his field and specialises in Factory Automation. Areas of expertise include, Automation, Drives and Controls, motion control PLCs Factory Automation, Printing and Converting, Energy Efficiency, Assembly and Test.

Paul's passion lies in the area of Industry 4.0, with supporting the formulation of the UK Industrial Strategy. Paul is hoping to demystify Industry 4.0 for SME's by enabling their first steps towards connected industry.

In Pauls early career he has worked in various UK manufacturing companies involved in factory automation focusing on production engineering on the shop floor. Pioneer of 3D CAD/ CAM/ CAPPS, he worked in several engineering companies and in the early days of CAD/CAM he worked in numerous engineering companies and further developing his skills in shop floor communications. Paul then joined Indramat in sales and applications engineering which later became known as Rexroth Drives and Controls.

"I'm proud to support The IET each year with their annual Faraday Challenge – an engineering based competition for school children between the ages of 12-13 looking to put their skills to the test. Teams compete against each other with a genuine engineering challenge."

Paul Streatfield

Product Manager for Electric Drives, Bosch Rexroth



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Overview – is it just hype, or is it actually happening?

The phrase "Industry 4.0" has proliferated across trade, business and national press in recent years, and is largely hailed as the next industrial "revolution" of the 21st Century. There is currently a general understanding that Industry 4.0 refers to the "digitalisation" of a business's infrastructure, but there has yet to be any consistent standards or definitions applied to what remains an arguably vague concept for businesses worldwide. For these reasons, one could be forgiven for dismissing Industry 4.0 as a confusing mess of technological jargon, digital bandwagons and futuristic hyperbole.

Yet, for all the noise, what is becoming clear is that Industry 4.0 will fundamentally define how a country such as the UK does business within the next five to ten years.

The expression "Industrie 4.0" was first coined in Germany in 2010, and it is here that the concept is spreading its wings. The notion of digitalisation has made its way – albeit slowly – to the UK, and we are starting to see some indications of its use in various parts of the supply chain – particularly within the automotive industry.

Nevertheless, Industry 4.0 is encountering hurdles here in the UK, and numerous studies and surveys are indicating a reluctance, and even suspicion, towards implementation. All-too-often, any successful penetration points within the UK are largely as a result of a UK subsidiary being influenced by its German or Japanese-based head office. In a general sense, the difficulty lies in the UK's understanding of what Industry 4.0 actually is. Even its epithet – the Fourth Industrial Revolution – is provoking serious debate, with many arguing that it is not a "revolution", but a logical evolution from the implementation of electronics-led automation, which largely defined the third industrial revolution.

A white paper released by The Manufacturer has discussed Industry 4.0 in three terms: smart manufacturing, connected products, and a connected supply chain.

In the long term, Industry 4.0 will require the integration of all three of these aspects into a strategy, in order to guarantee future competitiveness and growth. This white paper will neither deviate from, nor focus on, one particular aspect of Industry 4.0, and the guidance contained in the following pages can be applied to manufacturing, products or the supply chain, depending on which areas a business may wish to prioritise.

This white paper does not seek to define what Industry 4.0 is. Nor does it aim to propose a set of standards for industry to use in its digital adoption. Instead, its objective is to offer practical guidance to businesses that want to implement some aspects of Industry 4.0, without committing a large amount of capital or time. It also seeks to assuage any doubts about the suitability of Industry 4.0 for certain businesses, by emphasising the benefits of a step-by-step approach.

All manufacturing companies, whether large or small, are under constant pressure from their customers for their products to be better quality, lower cost and available quicker. Industry 4.0 should be seen by manufactures as an umbrella term for a toolkit of available technology to enable them to deliver these customer requirements.

The real-time gathering and processing of data from sensors will enable quality checks at the point of manufacture, economical batch sizes to be reduced (making production far more flexible) and machine and process health to be monitored, allowing maintenance to be predicted and scheduled in to natural breaks, rather than breakdown repairs. Lower cost to the customer is one possible outcome of improved productivty by the manufacturer.

Ultimately, it is our hope that businesses will be gently encouraged to move forwards in their Industry 4.0 implementation in a way that best suits their business model, if necessary one step at a time, with a limited budget, without becoming distracted by the noise and the over-excitement about a concept that, for the most part, has yet to be formally defined.

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Barriers to Industry 4.0 white paper

Governments around the world are creating strategies and policies to encourage the adoption of digitalised manufacturing, from the USA's Advanced Manufacturing Partnership, to Germany's High-Tech Strategy 2020 Action Plan. The real indicator of Industry 4.0 success, however, is the rate at which individual companies embrace a digital, software-based framework as part of their own strategy. Despite the excitement and increased press coverage, this is progressing more slowly than hoped.

Manufacturing, finance and economic organisations across the UK have conducted surveys to understand the current sentiment towards Industry 4.0. For the most part, these surveys have demonstrated a distinct lack of understanding and investment from both OEMs and their suppliers across various sectors, including those that we would perhaps have associated with a more forwardthinking attitude towards digitalisation, such as automotive and aerospace.

An Industry 4.0 report conducted by BDO highlights that 56 per cent of its respondents admitted to possessing little to no understanding of Industry 4.0. A further 48 per cent stated that they had no strategy in place to implement, or cope with the demands of, Industry 4.0 over the next few years. Furthermore, of the 20 per cent that did have some form of strategy in place, 2 per cent had acknowledged that their strategy was developed and implemented by their foreign parent companies. The conclusion to be drawn from this is that UK industry remains reticent towards Industry 4.0, often relying on foreign intervention or support to achieve any meaningful digital growth. There are various reasons for this, with concerns over scale, cost and skills all acting as barriers to the digitalisation of our manufacturing infrastructure Let us analyse a few of these in more detail:

1. "The Big Bang": is it too much, too soon?

The media hype around Industry 4.0 has certainly helped to disseminate the message across UK industry, but this has also created a sense of urgency and panic. This is, of course, necessary in order to galvanise industry into action, with companies such as PwC stressing that Industry 4.0 capabilities will soon become a "qualifier to compete" for businesses worldwide. It has, however, also had the somewhat unintended effect of an all-or-nothing mentality among businesses, particularly SMEs. In other words, many are coming to the conclusion that they must shift their production over in its entirety to an Industry 4.0based system.

This mindset is unhelpful. A complete digital overhaul, no matter the size of the business, is a gargantuan task that would prove difficult for even the most resourced businesses to undertake. As well as involving a sizeable upfront investment, such an endeavour would also place great strain on the workforce and the efficiency of that business, to such an extent that it may need to bring in external help or shut down production while the project is completed. It is vital that businesses understand such an approach is unnecessary, and may actually be hampering any possibility of moving forwards with an Industry 4.0 strategy. Strategies for implementation will be discussed later in this white paper.

2. Too big to scale?

Whether businesses are looking to take a granular approach to Industry 4.0 implementation, or considering switching over to the digital space entirely, a concern for many will be the feasibility of scaling digital technologies to match that of their current operations. Larger manufacturers in particular will perhaps find the task of digitalising their production environment daunting, particularly those that operate from large, ageing facilities. Many will also employ legacy machinery equipment that, at first glance, may not lend itself well to machine communication and data sharing.

The suitability of one's manufacturing environment to Industry 4.0 will certainly vary from business to business, but many manufacturers remain unaware that a range of technologies exist to support the digitalisation of their infrastructure, without the need to replace existing equipment. This "one-size-fits-all" mentality is another reason behind UK industry's reticence.

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3. The cost of implementation

Whether the business holds an "all-or-nothing" or "onesize-fits-all" mentality, cost will remain a primary concern. While several reports have highlighted a willingness in industry to invest, there remain some doubts over the affordability of certain Industry 4.0-based technologies, as well as the cost of training and/or hiring staff.

PwC's Global Industry Survey, for example, states that 20 per cent of its respondents planned to invest more than 10 per cent of their annual revenues in Industry 4.0 within the next five years. Is this enough to achieve a fully digitalised UK industry? Certainly, in the UK, we have yet to see many businesses publicising such a commitment.

A reason for this may not just be an unwillingness to invest on the part of the business itself. Some must also convince their stakeholders, such as their shareholders, investors or customers, of the validity of such an investment. This is currently difficult: little data exist to demonstrate the return on investment of Industry 4.0.

4. Is the workforce ready?

It is important to remember that Industry 4.0 does not just refer to technologies within automation, cloud or edge computing and data sharing. It also encapsulates organisational restructuring – moving from a physical to a digital infrastructure within a more collaborative, datareliant environment.

This, therefore, requires each employee at an individual level to change their mindset and adopt one that is, not only open to change, but open to the concepts that Industry 4.0 embodies, such as using data to improve processes, or collaborating more openly with partners across the supply chain.

The UK is currently experiencing a skills gap, which is felt most keenly across manufacturing and engineering. It has an existing workforce that perhaps may not be familiar with a digital infrastructure, and which will need sufficient training in order to adapt. It also has an upcoming workforce that understands the digital space, but that does not have the requisite skills needed for a career in engineering or manufacturing.

This is also hampering the UK's adoption of Industry 4.0. After all, we cannot invest in the latest technologies if we do not have the skills or knowledge to fully exploit them.





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The Solution

As previously mentioned, this white paper is not offering a sweeping solution to these barriers. Instead, it is advising businesses to implement Industry 4.0 through a step-bystep approach. This means prioritising the areas in which digitalisation would offer the most benefit. One can then expand Industry 4.0 capabilities by building on the business's initial digitalised capabilities. The advantage of this approach is that the solid foundations of technology, infrastructure and skills can be laid, facilitating the final move into the so-called "Factory of the Future".

The areas on which a business chooses to focus will vary depending on its priorities – whether the business is looking to troubleshoot problematic areas, or improve performance to meet increasing customer demands or improve levels of quality and consistency, for example. This may range from a manufacturing cell or an individual tool, both of which could offer valuable insight into process efficiency, equipment performance and energy usage. We will provide a case study of how this can be applied in further detail later.

No matter which area is identified, we recommend a threestep approach for Industry 4.0 integration:

- 1. The implementation of sensors and controls;
- 2. Enhancing the capabilities of these sensors;
- 3. Full implementation, in which Industry 4.0 capabilities are rolled out at plant-level.

In order to demonstrate how these steps can be achieved, we will focus largely on Bosch Rexroth's IoT Gateway technology. This enables businesses to digitalise their production machinery, without the need for extensive re-wiring, re-tooling or replacement of existing assets. It is therefore a suitable starting point for any business undertaking Industry 4.0 implementation.

The IoT Gateway - which is named for the Internet of Things, is a key aspect of Industry 4.0's functionality – providing a cost-effective and scalable way for businesses to network new and existing machines in order to optimise production processes and improve product quality.

A key differentiator of the IoT Gateway from similar products on the market is its capacity to be retrofitted to machinery without interfering with any existing automation logic. The modularity of its software also makes it highly flexible, and highly scalable. Essentially, the IoT Gateway provides just that – a "gateway" to machine-to-machine communication, which can be attached to existing assets easily and quickly.

The IoT Gateway, when combined with its various service apps, cloud-based software and support, can be applied to all three stages mentioned above. Let us examine these in more detail.

1. The implementation of sensors and controls.

The IoT Gateway combines hardware (i.e. the sensors that are fitted onto a cell, machine or tool), and software, which is based on Linux operating systems, as well as several Java applications and other open interfaces. Before installing this into a plant, however, it is important to analyse and clarify the requirements or objectives that must be realised through the use of the IoT Gateway. This will ultimately dictate where the sensors should be placed in order to realise their full potential.

Once the sensors have been installed correctly, a business can begin collecting the process data. Again, the data collected will depend on the type and level of insight required by the business. Examples include: temperature, pressure, vibration and power consumption.

The IoT Gateway works by gathering the data through the configured sensors, which cover both digital and analogue interfaces, as well as connections such as Bluetooth, USB and RFID. Data is then pre-processed by Bosch Rexroth's app named Devises App, which converts data into readable information using logical and mathematical operations.

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2. Enhancing the capabilities of these sensors.

Once a business has configured the sensors and connections to gather the data it desires, it can then build on these capabilities through the integration of "higherlevel systems". This not only allows businesses to collate and display the data in real-time, but it also enhances the IoT Gateway's functionality beyond a simple "plug-and-play" device, to something that is more integral to the business's overall infrastructure and processes.

This can be achieved through the IoT Gateway Starter Kit. The kit includes the Production Performance Manager from Bosch Software Innovations, which is an example of the afore-mentioned "higher systems". This technology acts as an interpreter, gathering and converting data into information that is transparent, accessible and thus actionable.

An added advantage of employing such software is that one can immediately gain an idea of how ready a business is to implement Industry 4.0 and identify what, if any, changes will need to be made to make the transition as smooth as possible. At this stage, it is also possible to begin training the team in the skills necessary to fully exploit Industry 4.0, without the need to rely on an external agency for the dayto-day management of production machinery, or systems and lines.

3. Full implementation, in which Industry 4.0 capabilities are rolled-out at plant level.

Once a business has successfully completed steps one and two – and this may be at multiple cells or locations around a site – it can then consider working towards fully implementing Industry 4.0. Through this approach, the digitalisation of a plant can be achieved as a natural

evolution of separate, connected cells into one fullyconnected, functioning plant.

Before this can be achieved, however, a business's infrastructure must be able to support a wider scale of digitalisation. Following on from the Starter Kit, the Software Development Kit can combine multiple data sources into one analytical platform. Described as an open, future-orientated software architecture, the Development Kit provides full documentation and library integration through an Open Service Gateway Initiative (OSGI). This is a Java framework for developing and deploying modular software programs and libraries.

The key word to remember is "open". Without it, it is not possible to harness Industry 4.0 or its benefits. Furthermore, without following this three-step approach, businesses will find the task of digitalising their assets both complex and time-consuming. Businesses must, therefore, develop a strategy of starting small and scaling, while building up the infrastructure as they go.

We have focused on the IoT Gateway and its relevant products here because we firmly believe that it is an effective tool for businesses that, for one reason or another, may simply not know where to start. Bosch Rexroth has used this technology for its plant in Homburg, and is already seeing improvements in product quality, productivity and energy efficiency. Downtime costs, for example, have been reduced by 25 per cent, with a return on investment achieved in less than 18 months.

In the following section, we will provide an example of how the IoT Gateway can be employed to monitor and improve the functionality of a simple treadle lathe, which we hope will demonstrate the numerous applications that could benefit from Industry 4.0 functionality.



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Case Study: Modernising century-old machinery for the Factory of the Future

Robert Bosch's 300kg, cast-iron lathe dates back to 1887, when it was purchased for the equivalent of around €30,000. Powered manually by a foot treadle, the lathe was initially used to manufacture parts for magneto ignition devices. It has taken pride of place as a key Bosch tool for many years, and was an integral part of the company's first technical breakthroughs at the end of the 19th Century. The lathe was even used by Bosch's founder, Robert Bosch, in the early years following its purchase.

The financial and sentimental value of the lathe are not to be underestimated, which is why, when Industry 4.0 capability was first developed at Bosch Rexroth, the treadle lathe was one of the first pieces of legacy machinery to be upgraded. The resulting construction was the first of its kind in the world.

We began by mounting sensors on the machine that, when linked to the IoT Gateway, collected data on performance parameters such as: temperature, pressure, vibration, power consumption, angle inclination and rotational speed. The IoT Gateway could then transmit this data to a monitor, which displayed the results to the treadle lathe's operators in a way that was both comprehensible and actionable. Two significant outcomes were achieved. First, the surface finish of a turned part is governed by a combination of rotational speed and traverse speed of the cutting tool. The monitor was programmed to show the minimum and maximum speed windows. The operator can then adjust their pedalling speed of the treadle to keep within the window thus garanteeing a quality surface finish. It would also protect the lathe tool from damage or wear.

Second, operators could now pick up on changes to the belt drive that may previously have been missed. As the belt grows older, it begins to slip between the drive wheel and the spindle that carries the workpiece. The sensors would be able to recognise deviations and notify a maintenance worker once the pre-defined threshold had been reached.

The treadle lathe is a good example of how legacy machinery – even that which dates back to the first Industrial Revolution – can become part of a connected, digitalised infrastructure. Furthermore, it demonstrates how Industry 4.0 capability can continue to achieve a return on investment from machinery that is over a century-old.



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Final Thoughts

Perhaps, then, Industry 4.0 is not a revolution, but an evolution after all. As the treadle lathe case study demonstrates, we are not required to replace machinery outright, but rather adapt our existing assets to a new way of working.

The challenge, as we see it, lies in how one can do this. Evolutionary theory dictates that only the strongest or most adaptive species can survive. For manufacturers, however, this does not mean that the lucky, gifted or wealthy will be blessed with an unfair advantage. Rather, it is those prepared to learn, develop and create that will be the frontrunners of our technological evolution. The task may seem daunting now, but it is also an exciting one, capable of changing our lives for the better. We at Bosch Rexroth are looking forward to witnessing the results of this transformative epoch.

To this end, perhaps it is fitting to end with the words of Charles Darwin from his seminal work, The Origin of Species:

"There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved."

