Contents

Summary ......................................................... 3
A Bit of History .................................................. 4
  The 4th Industrial Revolution ............................... 4
A Fusion of Technologies ....................................... 6
  IoT ............................................................... 6
  Big Data and AI ............................................. 7
  Robotics ....................................................... 8
  AR, VR and Wearables .................................... 10
What Will 4IR Enable? ......................................... 11
What’s Next? .................................................... 12
  Start Small ................................................... 12
  Don’t Go It Alone .......................................... 12
  Don’t Get Left Behind ..................................... 14
Conclusion ....................................................... 15
Opinion piece ..................................................... 16
  Seeing the Context ......................................... 16
  How Should Manufacturers Look at IoT? ................. 16
  How manufacturers and construction companies look at IOT today . . . 17
  How to get started .......................................... 18
  About the Author ............................................ 19
The 4th Industrial Revolution (4IR, aka Industry 4.0) is exactly what the name implies: the fourth wave of technology-fuelled change that will revolutionise industry. Like its predecessors, the technological transformation will also usher in social, economic and cultural change. Unlike its predecessors, it will happen pretty quickly.

4IR has the power to reshape production, consumption, transportation and delivery systems across every industry and service imaginable. The Internet of Things (IoT) is just one facet of this revolution, which will see a confluence of technologies encompassing big data analytics, artificial intelligence (AI), robotics, augmented and virtual reality (AR and VR), blockchain and more, in addition to IoT. It will be underpinned and enabled by cloud computing and a new next-generation (5G) network comprising fixed and wireless technologies, some already available and others still under development, that will power lightning fast communications in real time with unimaginable capacity.

**4IR is about multiple technologies coming together to create a time of unprecedented change, opportunity and potential.**

David Kelnar, Investment Director and Head of Research, MMC Ventures

This may all sound terribly complicated and horribly expensive, but 4IR need not be either. Think of 4IR as a long journey with plenty of stop-offs. The ultimate destination is improved competitive advantage through better operational efficiency and lower operational costs. Every manufacturer, as well as those in the manufacturing supply chain, will need to take that journey eventually, and those that start sooner will reap the benefits more quickly. And help is at hand to help you plan the destination, the route and the modes of transport that are the most appropriate for your specific business.

This Insight Report will describe the nuts and bolts of 4IR and what role specific technologies will play, with real-world examples of what 4IR can achieve. It will also provide information and guidance about the help that is available to UK manufacturers to get them started and enable them to achieve their goals, and demonstrate the significant opportunities that exist for UK tech companies to lead the way with innovative new 4IR products and solutions.

**Technology is an evolution. The revolution is what the technology enables in reducing costs and improving productivity, quality, performance, agility and lead times, especially in terms of new business models and opportunities.**

Professor Sam Turner, Chief Technology Officer, HVM Catapult

**4IR is the future of manufacturing, and it is happening now.**
A Bit of History

In order to put 4IR into context, it’s helpful to track back the preceding industrial revolutions to understand just how revolutionary each was. 4IR is no exception: in a world where new technologies rarely justify the hype, 4IR has the potential to be truly transformational. It’s also happening quickly compared to previous industrial revolutions, which were decades in the making.

**THE FIRST INDUSTRIAL REVOLUTION** began in Great Britain around 1760 and was the transition from hand production to the use of machines. It involved the mechanisation of production through the use of water and steam power and it marked a major turning point in history.

**THE SECOND INDUSTRIAL REVOLUTION** is generally accepted to have begun around 1870, led by Great Britain, Germany and the United States, and continued until the start of the First World War. Earlier developments (railways, shipping, telegraph, the machine tool industry and steel production) became more widely available and new technologies (notably electricity and telephones) were developed, culminating in a period of rapid industrialisation, mass production and globalisation.

**THE THIRD INDUSTRIAL REVOLUTION** is commonly known as the Digital Revolution as it involved the conversion of analogue technologies into digital through electronics. It started taking shape in the mid 1950s with the emergence of the first digital computers, and started to take off from the late 1970s as mass production of circuits brought down the cost of computers. The rise of computing enabled more sophisticated automation of production, while digital communications resulted in global information networks such as the internet, increasingly sophisticated mobile phones and a whole host of technologies we take for granted today.

**The 4th Industrial Revolution**

**THE 4TH (OR FOURTH) INDUSTRIAL REVOLUTION**, shortened to 4IR, is the preferred designation in the UK. It’s a global movement that has various names depending on the country in question, but they all mean the same. It’s synonymous with Industry 4.0 (I4.0), a term coined (as Industrie 4.0) in 2011 as a German government initiative to ensure the future competitiveness of the country’s manufacturing sector. 4IR is largely focused on the manufacturing industry, but its potential goes far beyond manufacturing.

The term 4IR is often used interchangeably with the Industrial Internet of Things (IIoT) but, although the two refer to similar technologies and applications, they are not the same.
IIoT, also known as the Industrial Internet, applies IoT concepts to industry, encompassing manufacturing, energy, transportation, public safety and defence. It uses IoT to connect and manage all the elements in a given supply chain. IIoT is a big part of 4IR – indeed 4IR will not be achievable without IIoT – but is by no means the whole story.

4IR is all about data and communication: using the data collected by physical things – be they built products or components in a machine in a factory – to inform and impact the manufacturing process and build ever smarter products. It is not an off-the-shelf product or even a specific technology, but a combination of technologies that create cyber-physical systems (CPS), which represent the fusion of advanced digital technology and AI with both people and machines.

IIoT is creating new sources of data and in huge quantities. Robotics supplemented by AR is taking automation of manufacturing processes to a new level, and in turn creating more data. All this data can be mined through analytics and machine learning to deliver actionable insight. Add in autonomous vehicles, drones, 3D printing, nanotechnology, biotechnology, quantum computing and more, and the sky is the limit.

And that limit will not just be the domain of large manufacturers. Many of the solutions coming to market are being developed by SMEs, for SMEs, to provide advanced capabilities that would previously have been beyond their means. These include low cost sensors, cloud computing and 3D printing enable solutions that are affordable for even the smallest manufacturer.

**SMEs WILL PLAY A CRUCIAL ROLE IN PROVIDING SOLUTIONS THAT WILL LEVERAGE CLOUD AND IIOT TECHNOLOGIES TO DELIVER SOLUTIONS WHICH CAN BE USED BY THE MANY RATHER THAN A HANDFUL OF BIG MANUFACTURING COMPANIES.**

Aman Gupta, Co-founder and Head of Devices, ThingTrax
IoT is the cornerstone of 4IR – without it, and the data collected through it, 4IR would simply not be possible. The dramatic reduction in the cost of sensors means that data can be collected at every stage of the manufacturing process: from every component in a machine part, from robots, the factory floor, the machine operators and the end products themselves. Data can also be gathered at the product design stage, throughout the supply chain, and during the lifetime of the product’s use. Analysing and deploying that data delivers a wealth of opportunities to hone and optimise the entire manufacturing cycle.

For example, retail information can give real-time insight into what products or features of a product are selling best, so that manufacturing can be stepped up or scaled back to meet demand. Data on how the products are used can be fed back into product design. Data on the product itself can tell the user or service provider when it needs repairing, enabling remote diagnostics and predictive maintenance. Intelligence from the factory floor, the plant and manufacturing processes helps manufacturers optimise every stage of the process and enables the cost-effective supply of custom products.

IIoT will be the main driver pushing adoption of 4IR. Unlike old SCADA systems, which were difficult and costly to install, smart IIoT devices make installation easy and provide strong edge processing capabilities. Thus the payback time is greatly reduced.

Aman Gupta, Co-founder and Head of Devices, ThingTrax

Blockchain is only just beginning to emerge as a commercially available technology, and early use cases are predominantly in the financial services sector. Blockchain enables new ways to manage and distribute data, and to create new relationships between data sets and the stakeholders. Blockchain is the underlying technology behind cryptocurrencies like bitcoin and it can be applied to not just bitcoin, but to any “asset” that can be stored, distributed or transacted, such as property titles, music, insurance, physical goods and assets, and data. The scale of and opportunities for blockchain in manufacturing are not yet obvious, but it’s clear that there is scope for it to play a role in 4IR, such as in using blockchain to track problems through supply chains.

Use case: London-based startup ThingTrax was founded in 2015 and took part in Startupbootcamp’s IoT programme the following year. It launched its first pilot in December 2016 and within a month had two further pilots underway. In May 2017 the company raised over £250,000 in seed funding led by Technology Venture Capital Investments.

The ThingTrax device can be attached to any machine on the factory floor to turn it into a smart, connected machine. The data captured by the devices, from machines, motors and operators, is analysed in the ThingTrax cloud platform and presented to shop floor managers via a personalised dashboard which enables real-time tracking, remote configuration and optimisation of machine parameters. A real-time alert is sent if an anomaly is detected, enabling unused machines to be shut down and preventative maintenance undertaken to reduce downtime and extend machine life. ThingTrax’s early focus has been on injection moulding machines, but the device could potentially be used on any machine in a factory or
warehousing. ThingTrax claims it takes just two hours to set up and configure, and thereafter customers pay a monthly subscription of £45. ThingTrax now has customers in five countries with a typical solution payback time of less than two months. Its first pilot customer, a factory in India, paid for its subscription within the first day of installing ThingTrax, having increased operations efficiency by 5% and identified cost savings on unproductive machines and staffing processes.

Big Data and AI

Manufacturing has long been a data-rich industry and with IoT more and more data is being collected on a daily, hourly or even per-second basis. However, all the data in the world is meaningless unless it is mined to derive value and intelligence that can be put to good use. Cloud computing means that advanced data analytics are now available at relatively low cost and quick turnaround, while AI enables more value to be obtained from data so that intelligence can be embedded in manufacturing processes.

WE LIVE IN A DATA ECONOMY AND MANUFACTURING IS FUNDAMENTALLY A DATA-DRIVEN BUSINESS. THE OPPORTUNITY TO CAPTURE, MANAGE, UTILISE AND DERIVE VALUE FROM DATA TO DRIVE REVENUE AND REDUCE COSTS IS CENTRAL TO ANY COMPANY TODAY.

David Kelnar, Investment Director & Head of Research, MMC Ventures

‘Big data’ is a buzzword that’s been bandied about for a while, but don’t let the term put you off. It simply refers to the extremely large data sets that are collected via the IoT and which can be analysed (through big data analytics) to reveal patterns, trends and associations. The resulting insight can be used to inform business decisions, strategy and future direction.

Analysing it quickly and efficiently is impossible without computers, and the extraction of useful insight is where AI comes to play in 4IR.

MANUFACTURERS RECORD A LOT OF DATA ABOUT THEIR OPERATIONS BUT USING IT TO DO ANYTHING MEANINGFUL IS STILL A MAJOR CHALLENGE. THE DATASETS CAN BE SO LARGE AND SO COMPLICATED THAT IT IS QUITE SIMPLY IMPOSSIBLE FOR A HUMAN TO MAKE ANY SENSE OF IT WITHOUT SOME SOPHISTICATED TECHNOLOGY.

Jamie Potter, Co-founder and CEO, Flexciton

Basic AI has been around since the 1950s but, because the algorithms are too complex to be programmed manually, it is only recently that real progress in AI has been made. So, in the context of 4IR, when we talk about AI we really mean machine learning, which is a subset of AI. Machine learning allows us to tackle problems that are too complex for humans to solve, where the algorithms learn through training so that the quality of their predictions improves with experience.
To complete the AI picture, deep learning is a subset of machine learning that mimics the activity of the human brain. Perhaps the most well-known example is UK company DeepMind, which was acquired by Google in 2014 and was behind the recent defeats of leading players of Chinese board game Go. Google retired AlphaGo in May 2017 in order to focus on solving real-world problems, with early areas of interest likely to be healthcare and energy.

It is machine learning where considerable progress has been made in recent years and where there is excitement around real world deployments, not least in the manufacturing sector. Solutions are already available and, while predictive maintenance is a key area of focus now, the opportunities in manufacturing and beyond are huge.

4IR generates a huge volume of data; with even the current levels of information capture being too great for effective human digestion, smarter and more automated methods are needed. This is where machine learning can help – by intelligently distilling huge volumes of information into key facts that humans are able to make effective decisions upon, helping things like improved quality control and predictive maintenance to become a reality.

Alex Hill, Co-founder and Chief Operating Officer, Senseye

Use cases

Sensors in the factory gather real-time data about environmental conditions like temperature, humidity and acoustics, which can be analysed and alert to a safety or performance issue. But human intervention is required to respond to that alert and, while there are advantages to shutting down systems before safety or product quality is compromised, the cost implications of idle machinery can be high. Enter IIoT, through which sensors are not just on the factory floor but on the equipment and the products themselves, as well as data analytics and machine learning.

Southampton-based Senseye has developed a cloud-based predictive maintenance system designed for industrial companies, which uses in-house data analytics and machine learning to monitor and assess the current condition of the equipment. The system predicts when a fault is likely to occur and what that fault will be, and constantly learns and adapts to deliver continuous ‘prognostics’ to cut unplanned downtime from machine failure. In just six months, Senseye saved a global auto manufacturer £8m in avoided downtime.

London-based Flexciton is using machine learning to improve manufacturing scheduling, which is currently done either manually (a time-consuming process that is subject to human error) or by scheduling software that does not ‘understand’ the complexities of a specific manufacturing process. Its algorithms use the data recorded about a manufacturing process to identify scheduling inefficiencies and suggest improvements with the aim of minimising operational costs, reducing production cycle times and increasing production levels.

Robotics

Industrial automation has of course been around for decades and, while there have been significant improvements in robotics in recent years, the UK manufacturing industry has been slow to invest in robotics in comparison with its international peers. With 4IR, sensors and intelligence are embedded in robotics, and 3D printing is bringing the cost of robotics down to a cost-effective price point. 4IR is also ushering in a new breed of multi-functional and collaborative robots (cobots) which work alongside existing machines.

1 For more detailed insight into AI, machine learning and deep learning, read David Kelner from MMC Ventures’ primer on AI and 4IR. https://medium.com/mmc-writes/the-fourth-industrial-revolution-a-primer-on-artificial-intelligence-ai-ff5e7ffcaee1
human operatives with programming done on site. Thus, the line between manual and automated tasks is becoming increasingly blurred.

**COST EFFECTIVE AND EASY TO USE ROBOTICS WILL ENABLE MANUFACTURERS OF ALL SIZES AND EXPERIENCE TO AUGMENT THEIR WORKFLOWS AND HARNESS THE BENEFITS OF AUTOMATION USUALLY RESERVED FOR LARGER BUSINESSES OR THOSE WITH EXTENSIVE TECHNICAL KNOWLEDGE.**

Mostafa Elsayed, Co-founder, Automata

Unlike traditional industrial robots, which perform their work in physically isolated units, cobots come into direct contact with their human colleagues. They do not just follow pre-programmed commands but are capable of reacting to people. They use sensors and cameras to observe the movements and positions of their co-workers so it is safe for them to directly assist the human team members. Cobots are flexible, easy to programme and are generally lightweight so they are easy to move and put into action where they are needed.

There are many scenarios where a fully automated process is not possible because certain tasks require human input. Instead, many tasks could be performed by a cobot. Cobots will therefore undertake tasks that are difficult or dangerous for humans to do, such as heavy lifting, as well as repetitive tasks that could be subject to human error through boredom or those requiring very specific dextrous ability. The human team member is freed up from monotonous or physically tiring work so they can focus on the installation itself.

**ONE OF THE GREAT THINGS ABOUT USING “INTELLIGENT” ROBOTS WITH SENSING IN MANUFACTURING IS THAT THEY CAN PERFORM QUALITY ASSURANCE ON THE TASK AT THE SAME TIME AS EXECUTING THE TASK. SO, FOR example, A VISION SYSTEM USED TO CONTROL GRASPING CAN CONFIRM THAT YOU PUT THE PART IN THE RIGHT PLACE AT THE END OF THE PROCESS. WE’RE ALSO SEEING A LOT OF INTEREST IN USING INTELLIGENT ROBOTICS IN TEST LABS TO AUTOMATE SOME OF THE MORE TEDIOUS PROCESSES NECESSARY TO ASSURE COMPLIANCE.**

Rich Walker, Managing Director, Shadow Robot Company

**Use case:** London-based Automata suggests that less than 10% of manufacturing tasks that can be automated with industrial robotics have been, blaming the poor takeup on expensive, complicated and time consuming products that do not meet the needs of many manufacturers, such as those with seasonal requirements or unskilled workers. It is aiming to revolutionise robotics with Eva, a robotic arm that can be pre-ordered for under £5,000. It is set to start shipping in June 2018, and will weight in at just 8kg and (so the company claims) can be set up in 15 minutes. It has ready-made widgets for common tasks and can be programmed by guiding it through a task by hand, which it will then repeat. Automata promises a variety of uses for Eva, from product testing, to loading and unloading parts into machines, and surface spraying of paint or toxic chemicals.
Developing 4IR solution is not just for start-ups. London-based Shadow Robot Company has been designing and manufacturing anthropomorphic robot hands and related systems for 20 years. Its Shadow Dextrous Hand and Hand-Lite (a smaller, lighter and cheaper version) can be used as a tele-operation tool or mounted on a range of robot arms as part of a robot system, but is also designed for nimble work. In 2017, the company began testing components for its Shadow Smart Grasping System, which has been specifically designed for manufacturing to provide an alternative to traditional industrial ‘grippers’ which can only perform a single function. The aim is to reduce costs for manufacturers and free up factory space through the use of fewer robots. It has an easy user interface and setup, with built-in intelligence so that it can sense the appropriate object, interpret what it needs to grasp, and then select the correct grasp for the object before acting. It is modular so it can fit onto existing robotic arms and platforms, and parts can easily be swapped and replaced.

**AR, VR and Wearables**

Wearables such as smart glasses or hard hats with embedded sensors enable more data to be gathered from the factory floor and through supply chains, but they have a much wider role to play in 4IR. They can stream live images for scenarios such as remote diagnostics and maintenance and, when combined with AR and VR, open up a raft of opportunities for simulation and visualisation. Projection technologies such as VR suites and holographic computers herald still more opportunities to speed up and optimise the entire production process, from product design through manufacturing to delivery.

To illustrate the huge potential and disparate use cases, below are a handful of examples that are already in deployment:

- **PRODUCT DESIGN**: A holo computer enables the designer to perfect the design and create a 3D prototype to be approved by the customer, before production begins.

- **CUSTOMISATION**: AR reduces the need for niche technical knowledge and enables the production of more customised products, for example by projecting where parts need to be fitted during manufacturing so that products can be tailored at each stage of the production process.

- **PRODUCTION LAYOUT**: A VR suite enables the most efficient factory layout to be established and tested in order to meet new demand or manufacture new products, before any physical changes are made. Any problems are identified before production begins.

- **WAREHOUSING**: AR glasses help warehouse workers navigate their way through the warehouse to speed up product dispatch.

**Use case**: The replacement of paper working instructions through visualisation may sound like a mundane use case but it can lead to significant benefits in terms of shorter lead times and improved quality. Sam Turner, CTO at HVM Catapult, uses the analogy of Google Maps replacing a traditional paper map. Beforehand, the driver had some knowledge of where he was going before starting out, supplemented by a paper map. Now, Google Maps works out the best route based on current conditions and gives the driver the instructions he needs when he needs them. In the factory, the operator would have a good idea of the tasks that needed to be done but could make mistakes, and would refer to paper working instructions that had been printed and were therefore not up-to-date. With wearables and AR, the operator receives the information he needs when he needs it with no distractions, and those instructions are continually updated as the system evolves and are based on real-time data around customer orders, machine uptime and a host of other relevant data.
**What Will 4IR Enable?**

The endgame of 4IR is smarter product design; agile factories that can support mass customisation of products with no unplanned machine downtime; and efficient supply chains, logistics and transportation. Material waste and defective products will be reduced, if not eliminated. Idle equipment will be a thing of the past. New products will ship to market more quickly.

Ultimately 4IR could lead to ‘manufacturing as a service’, whereby a completely customised product can be ordered by the customer, manufactured in an automated factory, tracked as it and every component in it progress through the supply chain to delivery, and then serviced/ maintained according to the specifics of the product.

### Products
- Incorporates intelligence from existing products
- Targeted products for different customer segments
- Greater customisation

### Agile factories
- Streamlined and optimised production processes
- Increased machine uptime and usage
- Reduced capacity constraints
- Better quality products
- Less waste, reduced inventory levels
- More efficient energy usage
- Predictive maintenance and servicing
- Remote diagnostics and maintenance
- Safer working environment
- Mass customisation
- Quicker time to market
- Robots perform difficult or onerous tasks

### Supply chains
- Automation to integrate manufacturers with customers and suppliers
- Greater visibility reduces risk and improves flexibility
- Real-time tracking of assets, inventory and components
- Integrated business planning and production
- Products get to customers more quickly and cheaply

What does all this mean for the manufacturer? Ultimately, a more efficient and cost effective operation, higher profits, greater customer satisfaction and – potentially – a happier workforce. Manufacturers embracing 4IR will be more competitive than their less innovative rivals, and will be able to use technology to unlock new business opportunities.

*IF YOU CAN DESIGN, EXECUTE AND TURN AROUND ROBUST PROCESSES EXTREMELY QUICKLY, THERE IS HUGE OPPORTUNITY IN HORIZONTAL MARKETS AND MOVING INTO OTHER VERTICAL SECTORS. AND ONCE WE GET BEYOND THE FACTORY INTO THE SUPPLY CHAIN THE OPPORTUNITIES ARE VAST IN TERMS OF HAVING FLEXIBLE, AGILE AND RESPONSIVE SUPPLY CHAINS.*

Professor Sam Turner,
Chief Technology Officer, HVM Catapult
What’s Next?

As outlined in the summary of this report, it is best to think of 4IR as a journey that will take time and careful planning, and will solve current business challenges while preparing for the future.

Sources interviewed for this report agree on three key pieces of advice for any manufacturer embarking on its 4IR journey:

1. Start small
2. Don’t go it alone
3. Don’t get left behind

Start Small

4IR is not an off-the-shelf product but a combination of tools, technologies and capabilities that perform the actions and services required for a particular business. Rushing headlong into adopting 4IR technologies could be an expensive waste of time with little or no material benefit.

TO TAKE ADVANTAGE OF 4IR, COMPANIES MUST WORK BY DEGREE. IT IS NOT A SUDDEN SHIFT BUT A SET OF EXPERIMENTS, PROOFS OF CONCEPT, SMALL DEPLOYMENTS AND THEN LARGER DEPLOYMENTS AROUND SUCCESSFUL USE CASES. COMPANIES SHOULD FOCUS ON INITIATIVES THAT WILL DELIVER TANGIBLE BENEFITS IN THE SHORT TERM COMBINED WITH MORE RESEARCH-LED INITIATIVES THAT CAN INFORM THE COMPANY’S DIRECTION IN THE LONGER TERM.

David Kelnar, Investment Director & Head of Research, MMC Ventures

Instead, take a more measured approach. First take the time to evaluate and understand your business, and identify small-scale projects where technology can be used to solve current business challenges. This might be to reduce lead times or control stock flow through the factory. Whatever the project, the aim must be to deliver a measurable short-term benefit. A successful implementation will have secondary benefits in proving the business case for larger projects and identifying any problems and challenges that can be ironed out to enable larger projects to go more smoothly.

Furthermore, individual projects will generate more data that can give better insight into the operations not only of your own business, but also those of your customers and supply chains. That intelligence can be used to inform future projects and priorities.

Starting small will also minimise the capital outlay, which could be under £1,000 for an analytics or application deployment. And 4IR is not about forklift upgrades with completely new machinery and systems; many solutions available on the market add new capabilities to existing plant.

A LARGE PART OF 4IR SUPPORTS THE RETROFIT OF MACHINES, ALLOWING OLDER ASSETS TO BE ‘SMARTER’ AND COMPETE WITH NEWER ONES. THIS ALLOWS FOR MORE EFFICIENT OPERATION OF EXISTING MACHINERY WITH THINGS LIKE PREDICTIVE MAINTENANCE, BUT ALSO ALLOWS MANUFACTURERS TO EXTEND THE LIFE OF THEIR OLDER ASSETS. IN ESSENCE, IT WILL ALLOW UK MANUFACTURING TO IMPROVE QUALITY, EFFICIENCY AND UPTIME WITHOUT THE HEAVY COSTS OF NEW MACHINERY.

Alex Hill, Co-founder and Chief Operating Officer, Senseye

All that said, don’t be overly cautious. You must be willing to experiment if you are to get the maximum benefit further down the line. And, as is outlined in the following section, help and advice is at hand to minimise the risk.

Don’t Go It Alone

You do not need to go it alone, as there is plenty of advice out there to help get started and guide you on the way, from government initiatives such as the High Value Manufacturing (HVM) Catapult and Innovate UK (more below) as well as private sector companies developing 4IR solutions.

Manufacturers are not technology companies, and manufacturing engineers are not IT specialists, although the lines between them will continue to blur. It’s highly unlikely that any manufacturer will have the necessary in-house skills in machine learning, robotics and AR, so those interested in 4IR, particularly SMEs, will need to use external suppliers
and experts. Over time, they may adopt a hybrid approach to 4IR by using third-party specialists alongside the development of internal expertise, where appropriate.

**WE APPLY OUR AI TECHNOLOGY TO UNLOCK THE TRUE POTENTIAL OF DATA. MOST MANUFACTURERS DON’T HAVE THE SKILLS IN HOUSE THAT ARE REQUIRED TO BUILD THE TECHNOLOGY WHICH CAN MAKE SENSE OF THIS DATA.**

*Jamie Potter, Co-founder and CEO, Flexciton*

The High Value Manufacturing (HVM) Catapult’s remit is to help drive the future growth and success of advanced manufacturing in the UK. It helps companies of all sizes understand what technologies are out there that can meet the needs of their particular business. It can then signpost them to relevant recommended companies. For more sophisticated requirements it can test, prove and de-risk the technology in the demonstrator facilities at its seven Technology and Innovation centres across the UK. Each centre is focused on a particular technology area: the Manufacturing Technology Centre in Coventry specialises in intelligent automation, manufacturing simulations and informatics.

**WE HELP COMPANIES UNDERSTAND IN REAL TERMS WHAT THE TECHNOLOGY IS, WHERE IT IS GOING AND HOW IT CAN BE APPLIED BY THEM TO SOLVE REAL PROBLEMS. THEN WE HELP THEM TAKE THE FIRST STEPS IN IDENTIFYING THE BEST OPPORTUNITIES TO APPLY THAT TECHNOLOGY IN THEIR OWN FACILITIES.**

*Professor Sam Turner, Chief Technology Officer, HVM Catapult*

HVM Catapult is seeing huge opportunities for UK businesses, and is working on a national strategy in order to scale up its activities. It collaborates with Digital Catapult, which brings skills and expertise in the areas of data science and cybersecurity, particularly around sharing and accessing data. The two work to connect the UK’s manufacturing and technology communities, by bringing technology companies into HVM Catapult facilities and running pitstops and other events to challenge technology SMEs to come up with innovative solutions for the manufacturing industry.

**Use case:** Worcester-based Smethwick Drop Forge turned to the Manufacturing Technology Centre (MTC) and its CASiM2 collaboration with the University of Birmingham and Rolls-Royce, which provides virtual simulation technology for manufacturing SMEs to test and trial new products and ideas. Smethwick Drop Forge, which manufactures highly engineered connecting rods for major truck and automotive OEMs, received a large project for a potential customer that required it to start working with a new material. MTC and CASiM2 provided technical support that allowed the company to visualise and test the manufacturing process of the new material before investing and changing its existing processes.

It was therefore able to fulfil the customer requirement, efficiently and profitably, and has opened up a new market opportunity.

The two Catapults also work with Innovate UK and its network partner, Knowledge Transfer Network (KTN). KTN developed the 4Manufacturing programme in 2016 to help smaller UK manufacturers embrace 4IR. It started quietly but early success encouraged Innovate UK to commit funding to help it grow. Some 170 companies have now signed up. The manufacturing team at KTN has been approached to help tweak the programme for other industries, with food and drink as well as the energy sector showing early interest.

The programme identifies 22 areas of interest in four categories (business integration, supply chain integration, customer integration and product innovation) so that a company can get started on its 4IR journey in one or two areas, which are broken down into manageable bite-sized projects that deliver
tangible benefits in a relatively short timeframe, typically under a year. Malcolm Harold, KT Manager for Manufacturing at KTN, explains: “We could see that a lot of companies would find 4IR a real challenge so we worked out how we could help them. With 4Manufacturing, companies create a roadmap that can be developed into a business strategy.”

KTN aims to work with companies as a long-term partner as they build up their confidence and competence in 4IR, and plans to introduce other areas of interest to the framework as the programme unfolds.

Harold is delighted with the takeup. He believes that the success of the project is that it delivers something businesses really need, and does so in an easily digestible way. Communication is key. Meetings are held in person rather than online, so KTN can fully understand the individual business and its requirements. The programme deliberately shies away from jargon, techno-speak or soundbites that could put a company off before it’s even begun, so the company immediately understands what the programme is about and how it can help them.

4IR SOUNDS BIG AND SCARY BUT IT CAN INVOLVE SMALL, DISCRETE, PRACTICAL PROJECTS THAT REALLY MAKE A DIFFERENCE. IT IS ABSOLUTELY IMPERATIVE THAT THE UK EMBRACES THIS BECAUSE IT WILL REDUCE COSTS FOR COMPANIES AND IMPROVE THEIR PRODUCTIVITY AND RESILIENCE. THIS IS PARTICULARLY IMPORTANT WITH BREXIT COMING UP.

Malcolm Harold, KT Manager for Manufacturing, KTN

Use case: An early adopter of KTN’s 4Manufacturing programme was Hyde Aero Products, a division of Hyde Group based in greater Manchester with less than 500 employees across one design and nine manufacturing companies. Its first goal was to improve schedule adherence and, instead of hiring several new employees with project, schedule, tracking, reporting and capacity planning expertise, it implemented middleware to integrate the various manufacturing and ERP systems. It can now run manufacturing planning scenarios and accurately predict delivery so that delivery schedules to customers are met, and machine utilisation has increased by an average of 10%. It is now working on developing and integrating other business critical systems to ensure the right data is delivered to the right people at the right time.

Don’t Get Left Behind

4IR is already happening, and quickly. Those that ignore 4IR do so at their peril; they risk being left behind by their more innovative and forward-thinking competitors. UK manufacturers need to embrace 4IR in order to maintain/gain competitive advantage, and they need to start now.

4IR is not just for big manufacturers or those with large budgets. 4IR need not cost the earth and there are many low-cost solutions out there that have been specifically designed for smaller companies. Smaller manufacturers have as much to gain as their larger competitors and, with leaner hierarchies and decision-making processes, are able to move more quickly. They are also likely to have more tightly knit operations that can, if they haven’t already, more readily pull together data from different sources than their more sprawling larger rivals.

Particularly in the area of robotics, investment in the UK manufacturing sector has lagged behind its international competitors. That must change if the UK is to maintain, let alone grow, its position on the global manufacturing stage. In fact, 4IR presents an opportunity to leapfrog the older technologies some manufacturers have invested in and deploy the more advanced solutions that are now available.

THE UK MANUFACTURING SECTOR HAS SUFFERED FROM A LACK OF INVESTMENT. 4IR IS AN EXCITING AND NECESSARY SHIFT; FOR UK MANUFACTURING IT’S A CHANCE TO CLAW BACK GROUND LOST TO OTHER COUNTRIES. TECHNOLOGY-DRIVEN SOLUTIONS ARE NEEDED TO FURTHER IMPROVE QUALITY AND REDUCE UNPLANNED DOWNTIME.

Alex Hill, Co-founder and Chief Operating Officer, Senseye
Conclusion

Technology is a key enabler to improve performance and competitive advantage at the same time as reducing costs, and there is plenty that manufacturers can do now to take a lead in 4IR and plan for the future. Indeed, UK manufacturers cannot afford to rest on their laurels if they are to compete globally, especially in a post-Brexit world. 4IR will create adaptive, agile manufacturing processes that will boost innovation, quality and efficiency.

In order to stay competitive and profitable, manufacturers will need to harness the intelligence produced by their products, and by the processes that manufacture the products. As such, IoT is the driving force behind 4IR, complemented by a raft of technologies, notably AI and robotics. These have been around for years, if not decades, but it is only now that real progress is being made in developing cost-effective solutions to real-world challenges in the manufacturing sector. Newer technologies such as VR and AR add a new dimension to manufacturing, while the likes of cloud computing and 3D printing are driving down costs so that innovative solutions are available for even the smallest manufacturer.

4IR does not need to be a complete overhaul but can build on machines and processes already in place. It can be deployed in stages, as the technology becomes available and in line with the long-term requirements and future operating model of the individual business. It does not need to represent a large capital investment; indeed the first steps should be around planning and laying the foundations for the future in order to deliver enterprise-wide value.

There are numerous opportunities for UK companies to contribute to 4IR through innovative new products and services to drive the vision into reality. And because the field is so wide, there is scope for SMEs to develop niche products, even for niche sectors.

FOR SMES, CERTAINLY FOR US, 4IR GIVES THE OPPORTUNITY TO BE PART OF SOMETHING HUGE AND EXCITING. THERE IS GOING TO BE COMPLETE CHANGE IN HOW MANUFACTURERS WILL WORK, AND WE’VE GOT THE CHANCE TO INFLUENCE THESE CHANGES.

Rich Walker, Managing Director, Shadow Robot Company

I WOULD SAY TO SMALLER MANUFACTURERS, DON’T THINK THIS TECHNOLOGY IS FOR SOMEBODY ELSE AND THAT IT’S FOR THE FUTURE. THE OPPORTUNITY IS HERE, NOW, TO TAKE THE INITIATIVE AND THE LEAD. THAT MESSAGE APPLIES EQUALLY TO TECHNOLOGY COMPANIES: THERE ARE HUGE OPPORTUNITIES IN MANUFACTURING TO CREATE A NEW DIGITAL MANUFACTURING ECOSYSTEM THAT COULD START TO LEAD THE WORLD.

Professor Sam Turner, Chief Technology Officer, HVM Catapult
Opinion piece

BY DR ROY WOODHEAD, MANAGING DIRECTOR OF IOT TRANSFORMS LTD AND SENIOR LECTURER AT SHEFFIELD HALLAM UNIVERSITY

For many, the Internet of Things (IoT) boils down to millions of sensors sending data from ‘things’ at the edge of a network to a cloud in the core of the network for analysis and insight production – big data, machine learning, artificial intelligence (AI). Where connectivity to a cloud is problematic, some IoT solutions push compute power out to the edge (note that there are numerous IoT architectures). However, these infrastructure views often overshadow the priority of business value. For me, IoT is like a central nervous system for your business, sensing what is going on in and around a living company. As such, IoT unlocks more value by reducing uncertainties and improving decision quality.

IoT can be transformational – for example, knowing that a chemical pump is behaving strangely could be a warning of trouble that can be avoided. IoT moves us from reactive management to proactive management as we swap out dumb products for their smart counterparts. It can also be transformational for a business as it stops selling a product in a transactional way and starts to sell outcomes as a service. For example, a manufacturer selling compressors today could start selling ‘compression by the hour’. Such a move is good for customers as it pushes maintenance risks on to the service provider. It can also be good for the service provider if it has an agile R&D process that can improve reliability through innovation, real time monitoring and an active approach to condition based maintenance. It will be able to do what its competitors cannot, especially low-cost rivals from the Far East.

Manufacturers and construction companies that do not move in this direction will suffer in the medium and long term as rivals offer more value to customers and convert the customer’s capital expenditure (capex) to operational expenditure (opex).

Seeing the Context

The changes that ripple out from 4IR can be both threats and opportunities for manufacturers and the construction industry. We will see new products that connect to the internet and use information to tell us more about what is going on in the bigger picture, such as asset tracking and location-based services linked to handheld devices. Similarly, we will see new services arise that cut the ground from under the established transactional thinkers, much like Uber did in the taxi industry by reworking information flows between customers, taxis and payment mechanisms. Supply chains will also adapt as demand forecasting becomes less random and suppliers start to prefer one manufacturer or construction company to another, because they help them manage their own business more efficiently. The move from transactional business to relational business will also mark the start of new customer relationships. For example, where does someone’s journey to work actually start and end? What data services can be developed to make that journey faster, better, cheaper and more reliable for a customer thinking of buying a new car, or a train company selling new augmented-journey tickets? This could be a mobile phone app linked to the car’s satnav that wakes the traveller up 20 minutes early to avoid getting stuck in congestion due to a burst water main – simple yet efficient changes through smart, joined up sensors.

The creative thinkers will learn from Netflix, AirBnB, Uber et al and invent new business models that take revenue away from sleeping rivals.

How Should Manufacturers Look at IoT?

IoT is essentially a marketing term that covers many different use cases of relevance to manufacturers and construction companies alike. It is an evolution of the internet itself and that means it typically leans to the OSI (Open Systems Interconnection) seven-layer model, for example protocols such as TCP and HTTP we often use when we browse the Internet.
However, many manufacturers have air gapped Process Control Domains (PCDs) which use different protocols, such as SCADA (supervisory control and data acquisition) and Modbus to name two of the many. This world with actuators, computer numerical controls (CNCs) and programmable logic controllers (PLCs) is collectively called operational technology (OT). Lots of devices in the OT space have no IP address, an essential requirement for many internet-based protocols in IT. In the here and now, there are very serious security concerns around blindly allowing some IP addressable devices in to the PCD as they can bridge air gaps and circumvent firewalls. Security is a major issue that must be taken seriously or risk major incidents that destroy the trust customers have in your company.

One of the first things manufacturers and construction companies need to do is acknowledge the need for an IT and OT convergence strategy so things unfold in a controlled way.
and the downside risks start to look very ominous. My advice is, don’t be left behind.

Many manufacturers and construction companies will adopt IoT but within existing paradigms. That is, they will try to do what they do today but faster, better, cheaper. Whilst this approach will lead to benefits it misses what could be achieved if leaders were more creative and entrepreneurial.

Some will step back and reinvent ways to deliver outcomes customers are willing and able to pay for. For example, a pipe manufacturer in the fluid transportation business could build sensors into its products and start selling data services to end customers who are more concerned with what passes through a pipe, such as an oil company worried about wax build-up and blockages. Who the pipe manufacturer sees as the significant customer moves from the immediate transactional hierarchy (the sub-contractor installing a purchased pipe) to a relational network of actors able to optimise their own operational costs through better information flows. It is a subtle but profound business opportunity.

Right now, leaders of manufacturing and construction companies should be developing a strategic digital vision with a linked benefit realisation plan that later helps steer incremental investment in the right direction. It needs thinking through at the strategic, tactical and operational levels in an integrated and optimised way.

How to get started

Getting started will follow a typical journey from overly optimistic to the complex challenges and frustrations of transformational change. Know this mood journey before starting so when feedback arrives you can either see it as a natural part of the process or as an unforeseen facet that needs a managerial intervention.

Understand the motivation of others. The IT industry typically sees IoT as a way to sell cloud workloads. Given that most clouds are implementations of the open source Cloud Foundry, assume that they are all commodity and ask for clarity on why prices differ so widely. Some do give more value than others so find the one that best fits with your long-term plans.

Understand your data velocity requirements and link your benefits realisation plan to decision making. Be very clear on which decisions really do need to be real time and which do not, because the closer to real time, the more expensive the IoT solution. Make sure your organisational needs drive the conversation rather than external salespeople. Think about data volume and plan the storage costs. Some IT firms make extra profit when data volume thresholds are exceeded. Also, think very carefully about who owns your data. Be creative and consider whether there are potential new revenue streams staring you in the face. If you pay to install a sensor which communicates to the
internet, could you offer the same communication pathway as a service, reducing the installation costs for other companies you don’t even think of as rivals?

Be wary of public clouds in which your secret sauce might become visible to others including rivals. Be very clear on your Intellectual Property (IP) strategy and how you will protect it and what is not actually differentiating IP. Be willing to use lower cost public clouds for non-differentiating data as part of your long-term cost optimisation planning.

For small and medium sized manufacturers and construction companies, seek out local talent in meetups and hackers from the maker movement as they often have lots of retired experts who can help you out.

Adopt an experimental attitude and encourage capability to grow rather than looking for big bang solutions that make you overly dependent on third-party experts. Start with small and simple IoT projects and add complexity as you prove one version at a time. I do this with AI and it is a faster way to get to where you need to be. Bring your employees on a transformational journey, accepting that some will not get it and others won’t really care. Such are the workplace realities so accept them and crack on regardless.

Plan how to be able to switch from one provider to another. Building your secret sauce in applications that run in containers like Docker means it should be easy to withdraw from one cloud provider and deploy in to another. Don’t get locked into an exploitative relationship.

In closing, 4IR is here but it is still early days. You have time to grow internal capability and new customer relationships. Move with 4IR rather than resist it. Finally, plan how to create sustainable strategic value before investing; identify the long-term objectives linked to short-term business cases before spending starts!

**About the Author**

Over a career spanning nearly three decades Dr Roy Woodhead has helped companies large and small improve ROI through innovation practices in manufacturing, chemicals, refining, oil & gas, construction, logistics and new product development. In 2016 he took voluntary severance from HP where he had worked for over a decade, most recently in HP Enterprise’s Industry Solutions & Industrial Internet of Things business. He subsequently set up IoT Transforms Ltd with the aim of helping organisations define their IoT strategy and select the technologies and suppliers that will open up new business opportunities. In 2017 he became a senior lecturer at Sheffield Hallam University’s Department of the Natural and Built Environment. He is a strong supporter of open source communities and explores digital innovation that combines theory and practice.