The Fourth Industrial Revolution demystified

The High Value Manufacturing Catapult is the go-to place for advanced manufacturing technologies in the UK. Here,we explain how we work with UK businesses to prepare for the many opportunities and challenges arising from the Fourth Industrial Revolution, or Industry 4.0.

What is the Fourth Industrial Revolution (4IR)?

The 4th industrial revolution is the coming together of cyber networks, with physical networks, to create new autonomous systems.
It creates an environment where businesses can give customers exactly what they want when they want it, with all the variations they specify, from the same factory, in a shorter lead time, and more profitably than is possible today.

The key principles of 4IR

1 - Intelligence

Digital factories and digital engineering systems will capture useful data in areas such as:

- how the component is performing in the field; real-time condition monitoring
- the precise position and depth of a machining process to ensure quality control
- the energy the process is consuming
- the wear on a tool or product, and many other metrics

"Much of the high volume of data captured in motorsport is not always relevant to the precise thing you are trying to measure. So we need to be careful to measure the right data at the right time."
Keith Jackson, CTO at Meggit plc and creator of the company's smart factory system, M4.

2 - Connectivity

4IR involves higher levels of industrial communication, including product-to-machine communication. Protocols and standards for machine-to-machine communication and safe product-to-machine communications are being developed so that products can navigate themselves within factories to the places where they are needed, where value needs to be added, and to transfer data 'in the field' through the Internet of Things.

Smart information technology links product characteristics to business-making decisions. Umbrella enterprise platforms will soon be able to send software into a product to track its performance, upgrade its properties and improve product safety and reliability. Already Product Lifecycle Management (PLM) can be linked to Enterprise Resource Planning (ERP) and Manufacturing Execution Systems (MES).

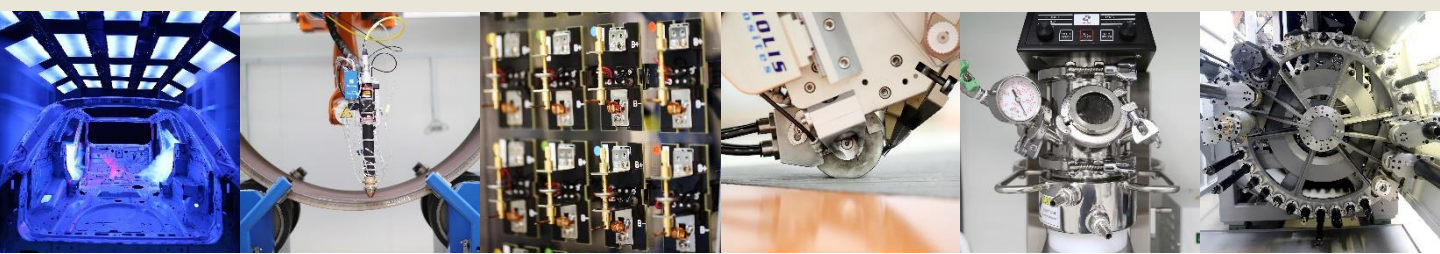
3 – Autonomy

In the future factory, component parts tell digital kanban systems to replenish low stock, and tell a smart tool how much torque to apply to the tightening. Warehousing systems can already be largely autonomous, with automated material handling solutions (inc forklifts and pallet trucks) and Warehouse Management Systems that minimize human intervention.

We already have much of the technology required to operate autonomous, or even driverless, cars. Warwick Manufacturing Group (WMG) conducts specific research into autonomous driving scenarios, drivers' and passengers' interaction with the car, and the implications for urban planning.

4 - Business models

As big data become the hard currency in a software-enabled production environment, 4IR redraws business models and will create new – disruptive – models of providing products and services. The rise of companies combining digital market places, online payment and advanced logistics infrastructure is an early flavour of the hybrid business models that are expected to grow.



The Business Opportunities…

4IR or smart factory technology creates a range of new business opportunities by providing:

Flexibility:
Modernising traditional manufacturing operations to drastically reduce lead times.

Instrumentation manufacturer Rototherm has used a bespoke ERP system with completely re-engineered products to create far greater product variation and better service. The company can now receive orders more quickly, customers can create bespoke orders and lead times have been drastically reduced. In addition staff have been trained to use IT on the shop floor, upskilling and future proofing the workforce.

Customisation:
Offering new manufacturing technologies which enable designs and customisation hitherto unavailable or unaffordable.

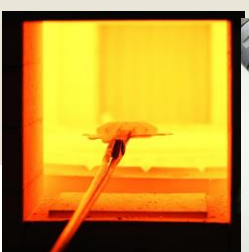
Car companies use Additive Manufacturing to produce 3D printing steering wheels to perfectly fit the hands of the driver. Previously, such customisation would have been costly and prohibitive – now it is bespoke, cheaper and quick.

Productivity:
Creating new technologies and processes which generate step change improvements in productivity.

Aircraft companies can reduce production times on counter-sinking holes in wing sections through automation, in-process metrology and big data capture with no human intervention. An example is the project run for BAE Systems Samlesbury by the AMRC Factory2050.

…and what we need to exploit them

Education:	Businesses need to be made aware of what 4IR means to them.
Skills:	We need enough people with specific skills such as machine programming and M2M (machine to machine) communications; big data analysis and informatics; mechatronics and – crucially – manufacturing management and leadership.
Investment:	Going digital requires real and perceived investment.
Cyber security:	While much industrial internet security is robust and firewalls are reliable, a fear of industrial espionage when machines and processes are connected to the internet could be preventing investment in 4IR. Companies can operate factory equipment while connected to the organisation using a private network, like a VPN, while the machines remain off the world wide web. Far greater advice for preventing and fighting cyber attacks can be provided by the HVM Catapult's network of experts.




Businesses in Britain using 4IR technology

Whilst no company in the UK is yet fully 4IR-enabled (the full suite of technologies is possibly not yet mature enough and investment is a barrier), many companies are already using types of digital manufacturing technology to their benefit.

Siemens Digital Factory, Congleton

A virtual reality CAVE (Computer Aided Virtual Environment) system has saved Siemens Digital Factory's Motion Control facility thousands of pounds in product, factory and tooling development and given customers far higher business value. Siemens was inspired by the CAVE system demonstrated at the Manufacturing Technology Centre (MTC). Scott Haberton, an MTC engineer working with augmented reality, says "CAVE systems and headset mounted devices can make a non-existent environment seem real, allowing natural manipulation of data by non-experts and intuitive communication. This can uncover opportunities quickly and frugally, reducing the gap from digital to final product and the reliance on expensive physical prototypes."
Siemens Congleton is implementing other 4IR technology and is probably the closest the UK has to an operational '4IR factory'.

Meggitt's CLAAW

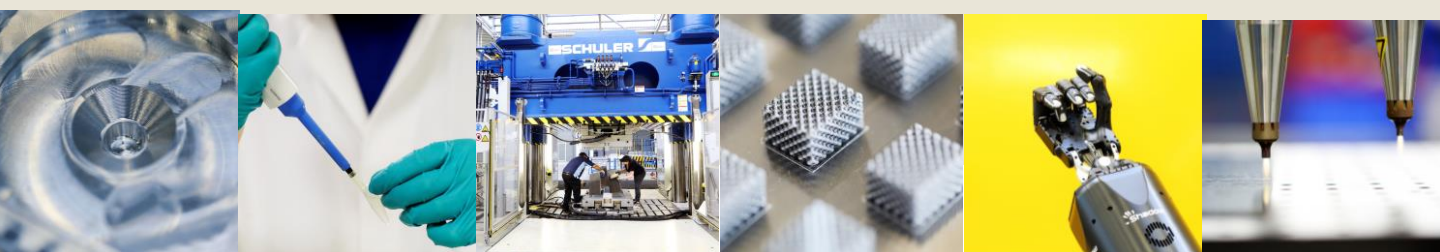
Global engineering group Meggitt has a huge product inventory, producing thousands of certain components as well as one-off spare parts for discontinued aircraft. It has developed a Closed Loop Adaptive Assembly Workbench (CLAAW), which aims to take a big step not only in production output but quality, repeatability and traceability using guidance via lasers, display screens and 'smart' tools.
CLAAW's fixture includes targets to guide the calibration of an overhead laser. A shaft is encoded to enable precise rotation measurements. A power-on brake provides stability for torque operations and product assemblies can be mounted and removed swiftly using a pneumatic easy-click clamp.
The system is part of the M4 production system – Meggitt, Modular, Modifiable, Manufacturing.

INTELLICO

A big part of 4IR is embedding sensors in products to collect data for product traceability. The INTELLICO project set out to realise the opportunities of distributed intelligent components throughout the manufacturing supply chain. The project looked at developing technologies for real-time processing, wireless communications and intelligent components that are embedded within products.
The Centre for Process innovation's role was to utilise printable electronics in the manufacturing of the RFID antennas. Working closely with the University of Loughborough, the CPI has developed sensors that can be printed onto metal and provide excellent read range. This significantly enhances the manufacturer's ability to map stock on a factory floor, increasing productivity and quality assurance.

Lambert Engineering: making personalized machines for the healthcare sector

The products Lambert Engineering's customers make now require more variation in both shape and colour to suit the market. "For one application in the healthcare sector we have developed a new feed system that works in a completely different way using robotics and vision systems," says Lambert Engineering's sales director, Matthew Cox. "While this design is initially more expensive, it allows the system to be flexible in what it can feed. For example, a single part, one of many, can be two different sizes with 30 different colours or patterns and the machine will know which one it is processing at any one time." Matthew adds "The machine is linked to the factory wirelessly into an MES (manufacturing execution system) so it "knows" what it needs to make and tells the factory what it actually has made so everything is connected and far more efficient."



"The companies that will do well out of 4IR will be those that recognize the business opportunities and apply the technologies in a focused way to drive the benefits. The challenge is not which technology to use but what benefits do I need in order to out-compete my rivals"

Professor Ken Young, Technology Director, MTC

"The digital lifecycle of manufactured products will start to get bigger and bigger. The more data you capture the more you can do with it. Technologies are available today like condition monitoring to find a fault before it fails, but Industry 4.0 stitches it all together"

Alan Norbury, CTO, Siemens plc

"Every company is somewhere on the digital spectrum, they just may not know where, or what they need to do, to use digital to realize more value in their business"

Andrew Kinder, VP Industry and Solution Strategy, Infor

"No factory is an island. The most sophisticated algorithms cannot unlock the full potential of a factory without considering suppliers"

Kostas Efthymiou, M4 project architect, Meggitt plc

"When the government is ready to receive it, we are ready to deliver a serious proposal for a digital manufacturing plan"

Dr Lina Huertas, MTC

"We are seeing a definite trend to drive product customization into our automation equipment. What it means is that we have to build machinery that is more flexible"

Matthew Cox, Sales Director, Lambert Engineering

"The secret of mass personalisation is to offer people the ability to change the geometry, performance, the specification of the product, and then feed that into a range of manufacturing techniques to exploit the personalisation. Sometimes you'd only do the customisation to the bit that adds the most value"

Asif Moghal, Manufacturing Industry Manager, Autodesk

HVM Catapult – supporting UK industry to embrace the digital future

The High Value Manufacturing Catapult is the go-to place for manufacturing technology innovation in the UK. Our 7 centres across the country collectively cover the full range of manufacturing technology capabilities, including 4IR technologies such as additive manufacturing, automation, simulation and Virtual and Augmented Reality. Our centres offer open access to the latest industrial scale equipment, world-class expertise and an environment of collaboration between industry, academia and government. We work with businesses of all sizes and all sectors to take risk out of the innovation process, and we help prepare businesses exploit the opportunities and mitigate the risks of 4IR.

VR to optimize factory lay-out

Hayward Tyler, a specialist manufacturer of high-integrity pumps and electric motors, created the world's most advanced facility for specialist fluid-filled motor manufacturing, which was opened in August by the Duke and Duchess of Cambridge. The new "fit-for-nuclear" facility in Luton was designed using new simulation software and modelling technology with support from the Nuclear AMRC. Detailed modelling of product flow has already allowed the company to reduce lead time for its main product by an additional 10-weeks.

Digital Manufacturing and Engineering Leadership Group

The Digital Manufacturing & Engineering Leadership Group is a national executive of engineers, digital manufacturing experts and representatives from the Department for Business, Energy and Industrial Strategy, formed in December 2015. The group intends to push digital manufacturing into the fabric of the Industrial Strategy. Evidence of this is likely to be revealed in the Autumn Statement.

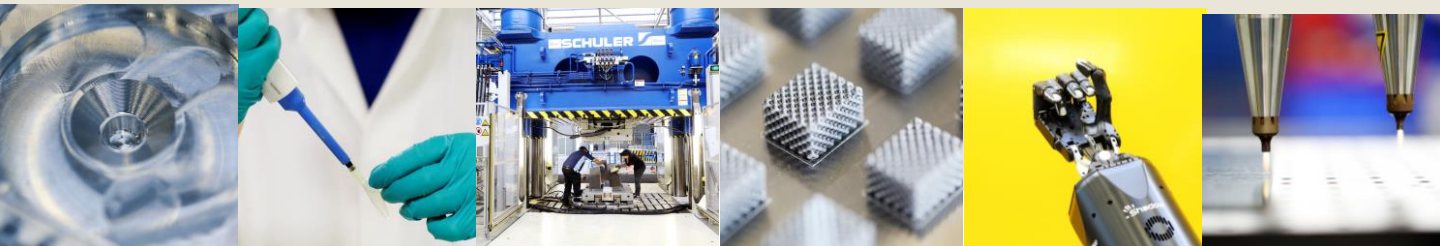
The group has six areas of digital manufacturing to investigate:

- Business models
- Skills, Training and Society
- Cyber security
- Standards
- Innovation and implementation
- Research

Digital Manufacturing in Scotland

Scotland is getting serious about digital. In 2016 a group including Scottish Government, Scottish Enterprise, Scottish Manufacturing Advisory Service and Innovate UK launched '*A Manufacturing Future for Scotland*', an action plan that sets out the country's plans to grow more manufacturing capability, both from inward investment and domestic companies. Implementing digital technology and IT is a big focus.

Dr Michael Ward, technical director of the AFRC at University of Strathclyde, says the make-up of industry in Scotland poses some specific challenges. "Some of Scotland's main industries are very traditional manufacturing activities, such as food and whisky, which rely on craft techniques for their appeal. Digitising the manufacturing would potentially remove that special quality. How do you digitize and retain the brand value?" But Scotland, mindful of the high concentration of inward investment in Scottish industry from foreign companies, needs to develop more indigenous manufacturing capability, and the AFRC with partners is working with companies in different sectors to apply the right digital technology to their process. Automated, sensor-enabled labelling and bottling, for example, can improve the efficiency of whisky manufacturing without interfering with the craft of the product.



Robot laser welding navigator

The RLW Navigator was a 3½ year collaborative programme, led by Prof. D Ceglarek at WMG with 12 industrial and academic partners. Its aim was to configure, optimize and control, in real-time, Remote Laser Welding (RLW) processes for ultra-light automotive structures via merging (1) real-time analytics; (2) in-process sensors; and, (3) multi-physics simulations. It is the first ever fully digitally developed RLW process and was selected by the EU as a success story for outstanding research with industrial relevance. This digital solution developed a broad range of new capabilities including; Jig and fixture design and optimisation, selection and optimisation of welding joining process parameters, Off-line Programming (OLP) of remote welding robots and in-process joint quality monitoring.
Manual programming/set-up for RLW is extremely time-consuming and so has not been adopted by industry previously, but this new digital tool has removed barriers and opened up its use in the market. RLW solutions applied to automotive door assembly resulted in 5x faster processing speed and 60% less floor space than current Resistance Spot Welding (RSW), plus several other improved KPIs.

SCOPE – smart packaging project

CPI leads SCOPE, a Horizon 2020 funded project which plans to build the manufacturing capability, capacity and skills required to commercialise smart packaging and position the UK as a world leader in the production of smart products with printed sensors – a billion dollar global market. “These embedded sensors help pharmaceutical companies with traceability, quality control and supply chain monitoring,” says CPI’s Roosje Watson. “They can check the drugs are being kept or transported within the safe temperature range and that they have not been damaged in transit.”

BAE Systems: Robot counter-sinking cell

A research project to enable robots to accurately machine holes in composite aircraft components has matured into a production system and is on track to save BAE Systems millions of pounds in capital and operational costs over the coming years. The Robotic Countersinking technology was developed through collaborative research, led by the AMRC and involving KUKA Systems UK. The development technology de-risked the process enabling the design of a production system. This production system has now been installed at BAE Systems in the UK, where it will be used to process a wide range of composite components for military aircraft.

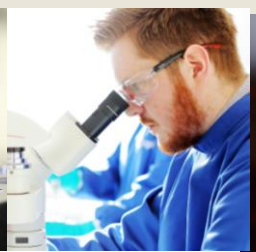
Factory in a Box

The Manufacturing Technology Centre has developed a model that allows companies to deploy pre-packaged, modular factories, potentially transported in shipping container-sized modules, to sites around the world where they are needed. Locations, for example aerospace clusters, which have engineering assembly capability but might be missing a capability to manufacture a specific component, would benefit. The box factories are designed to fill gaps in supply chains, to be portable and easy to operate.

Bringing digital solutions to Composites Manufacturing

The NCC is leading digital manufacturing in composites with a number of industrial sectors, including aerospace and automotive. Working with industrial partners, one key NCC project is investigating Automated Preforming of composites parts. Preforming of fibre reinforced parts is a stage of the manufacturing process that precedes finishing processes such as Resin Infusion or High Pressure Resin Transfer Moulding. The quality and process cycle times of the final component is highly dependent on the quality of the preforming. The NCC has applied 4IR principles, in particular digital in-process verification and machine learning, and is developing solutions to address cycle time and quality improvements that meet the requirements of industry. This approach will ultimately deliver tangible bottom line benefits. The NCC has found that, by applying digital solutions to manufacturing processes, increased efficiencies can be achieved, ultimately realising the potential of data-driven manufacturing.



DID YOU KNOW?

- 56% of a survey of 320 engineers cross-industry had little of no understanding of the term “Industry 4.0”. Just 8% had a significant understanding. Source: IMeche and BDO survey on Industry 4.0, July 2016
- 62% of manufacturers agree that they could be using digital technologies more to boost their productivity. EEF survey of members’ views of 4IR, 2016
- 80% of manufacturers say that 4IR will be a business reality by 2015. EEF survey 2016 (as above)
- 51% of the survey said increased productivity was the top effect of implementing 4IR into their business. Just 22% said the benefit would be lowering staff costs. IMechE and BDO I4.0 survey, July 2016
- 72% of German companies expect to increase their economic success with the transformation to an intelligent factory. ‘German Industry 4.0 Index 2016, Staufen management consultants.
- The digital manufacturing evolution has many names across the world. In Germany it is known as *Industry 4.0*, in Italy *Fabbrica Intelligente*. The UK is gradually adopting the term 4th Industrial Revolution, or 4IR.

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