The Next Industrial Revolution – The Smart Factory
A New Phase in Manufacturing Technology

“ This is a world on fast forward. A world of permanent technological revolution. And in this world, countries like the UK and Germany will only succeed if we have a relentless drive for new ideas and innovations. ”

David Cameron speaking alongside Angela Merkel at the 2014 CeBIT trade show in Hannover.

Context

Material standards of living are dependent on manufacturing. Low cost, high quality manufactured goods are only widely available and affordable because technological advances continue to improve the efficiency with which products are made. Real wealth creation in any modern economy depends on innovation in manufacturing.

The UK government has a strong desire to rebalance the economy by rebuilding the manufacturing base. At the same time the spread of manufacturing technology to developing countries creates a relentless pressure to offshore manufacture once the process becomes mature and easily replicated in lower cost centres.

Retaining manufacturing therefore critically depends on maintaining technology clusters with innovation and investment to deliver new products in plants that have high productivity and a capacity deliver added value products competitively.

British manufacturing has also been beset by long term and persistent problems of low productivity. Though the country is world-class in research in science and technology, this is slow to translate into new and innovative products.

The Industrial Revolution

So far the industrial revolution has had three distinct phases:

Mechanisation – the application of water and later steam power. This made goods like textiles cheaper and widely available from the mid 1700's.

Electrification – in the early 20th century industry became more mobile – no longer was it linked to the river bank or the coal field. Mass production became possible making more complex consumer goods like cars and consumer electrical goods affordable and commonplace.

Digital Automation – with computerised numerical control (CNC) from the 1960's and programmable logic controllers (PLC's) it became possible to store and replicate manufacturing processes. This meant that a sequence of operations could be programed and repeated endlessly, producing a perfect product every time.

It is now entering the fourth phase.

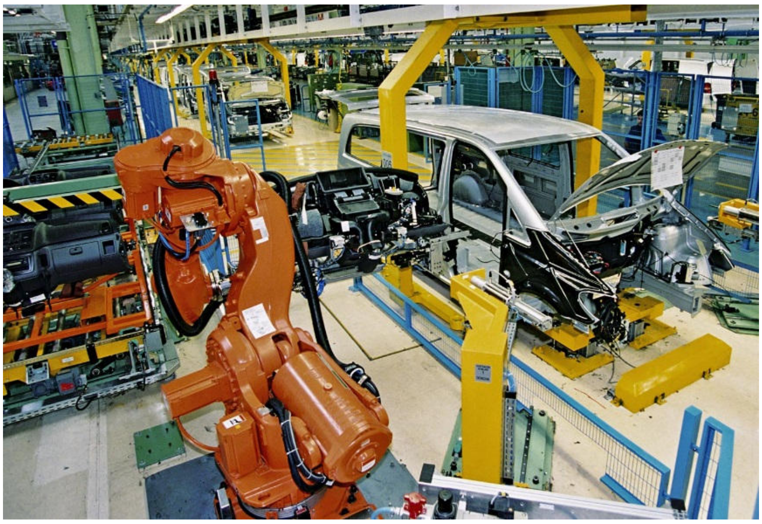
The Paradigm Shift – The Smart Factory

Industry 4

The fourth phase of the industrial revolution – Industry 4 – is about networking shop-floor processes so that digital intelligence is applied to the real world. Linking intelligent machines provides real time production data so that assets are more fully employed and material flows are more efficiently managed.

Consider a practical example. Thirty years ago an engineering machine-shop would have had lathes, drilling machines, saws, milling machines and a host of other equipment dedicated to one process. This was slow, low-tech and labour intensive production with a lot of capital tied up in work in progress as it passed from one machine to the next.

Fast forward. Modern machine shops are fitted with multiple axis machining centres that can turn, bore, drill, plane, saw and perform multiple operations sequentially and quickly. This is high tech, high cost equipment and the engineers that set-up and operate the equipment are highly skilled and paid. A machine shop with say a dozen machines may represent an investment of several million pounds. Achieving a return on this investment is critically dependent on maintaining constant workflow so that the equipment and manpower are as fully employed as possible.



That's just the start, because networking is the core technology in the Smart Factory, the process scales from the workshop to the enterprise and on to the entire supply chain. This creates more than economic advantage. New possibilities for production that are more flexible and responsive to customer demands are also created.

The German government has given official backing to the project behind Smart Factory: Industry 4. As a country with a large manufacturing base and a substantial trade surplus, the Merkel government recognises the need to drive productivity and innovation so that the country retains the core industries that are the foundation for economic success.

Traditional Manufacturing Technology

In traditional manufacturing product design, production planning, order scheduling and production monitoring are separate sequential processes. Once the project gets onto the shop floor then machine outages, material delays, bottlenecks and countless other frustrations make progress a series of stop-start, pause, reschedule and resume events until eventually the finished product emerges from the workshop.

All this is despite the fact that computer technology is widely employed. CAD (computer aided design) technology has been commonplace for more than 30 years, automation more than half a century. Procurement, planning, and back office functions have also been computerised, in even the smallest companies, since the 1980's. Modern plant also has a host of intelligent technology to monitor performance and warn of potential problems. But these processes were, until recently, never comprehensively interlinked, so digital intelligence has operated in a vacuum.

The Smart Factory

The Smart Factory is where real life production data and machine information is processed and analysed in a virtual system, a world of Cyber-physical systems (CPS). This is a deeply enabling technology. No longer is production monitoring a historic process, and learning through feedback a slow and stuttering progression, (assuming error data is captured for action and improvement in the first place).

In the Smart Factory data is constantly available on real-time performance. Material shortages, machine outages, quality issues, longer than expected machine cycle times, any aspect of sub-optimal performance, is immediately apparent. Managers are empowered because they can measure inefficiencies and intervene immediately to rectify them.

Real-time performance information creates an extremely agile and adaptable manufacturing process. Flexible manufacturing, where a particular machine set can produce multiple products and easily and quickly switch from one product to another becomes an economic reality rather than a concept.

Previous norms, like standardised volume and batch production are superseded because a batch size of one is now an economic possibility. The Smart Factory is able to innovate and prototype more readily. It also becomes feasible to produce individually customised products. The Smart Factory facilitates lean production – maximising ROI, by fuller utilisation of capital assets. The Smart factory is compatible with just-in-time programmes – delivering what is required, when it is needed – to minimise capital tied up in work in progress and the supply chain.

It is common for modern machines to have embedded intelligence to monitor condition. These are designed to give early warning and alarm when there are potential abnormalities, a failing motor or bearing for example, or simply tooling that is becoming worn and needs replacing. These machine based systems need individual monitoring, but in the Smart Factory the signal can be networked and included in the shop floor data stream for analysis and action. This means that the system can be programmed to recognise potential problems and order up the spare part for fitting during the next planned maintenance.

The Smart Enterprise and the Smart Supply Chain

Business with multiple sites, operating on Smart Factory principles, gain more. Plant to plant communication is automated so material and component orders cascade down the supply chain from the original end user instruction. Moreover, companies with multiple sites, possibly even operating in different continents, can benchmark performance, share intelligence and become more integrated and responsive to customer needs.

Increasingly businesses have close integration with their external supply chain. The Smart Factory breaks down artificial boundaries permitting even closer integration and coordination between a company and its supply chain.

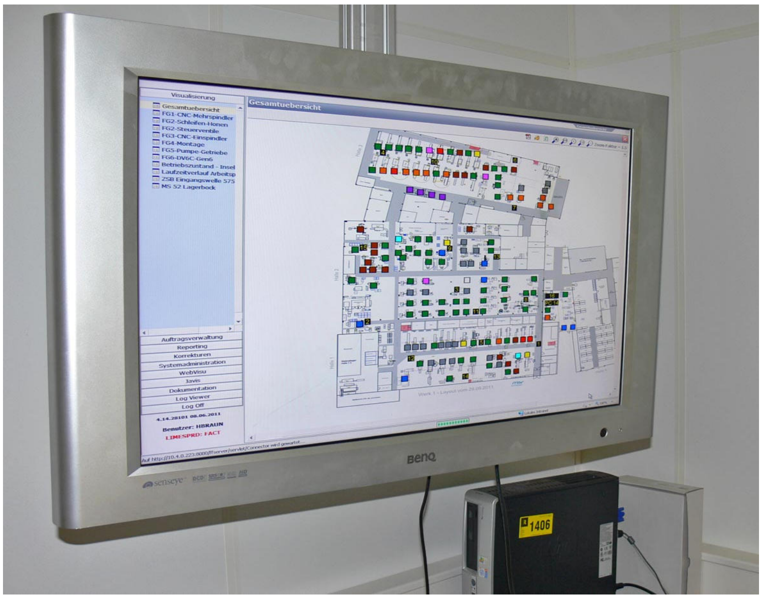
A practical illustration. Aerospace, automotive and rail are all industries dominated by prime manufacturers, but supported by a supply community comprising hundreds of smaller companies supplying materials, sub-systems and components. In this hierarchy, company to company communication is relayed through several tiers of supply. It is a slow, sequential and iterative process. This is an impediment to research, technical innovation and production so development programmes are inevitably long, slow and costly.

Now apply the Smart Factory. When the whole supply chain is networked and communicating in both directions the system becomes more responsive, more agile, better able to adapt, innovate and respond to end user demands. In this environment development cycle times and costs fall, productivity improves, and the whole industry benefits from efficiencies at every level.

Forcam and Industry 4

Smart Factory Pioneers

Former SAP executive Franz Gruber recognised that enterprise resource planning (ERP), though a hugely powerful management tool, was essentially a top-floor system. To compliment this shop-floor planning, data gathering and analysis tools were desperately needed for manufacturers to achieve better overall equipment effectiveness (OEE). Forcam therefore developed Factory Framework, a manufacturing executions system (MES), dedicated to improving shop floor productivity.



Early adopters

German auto manufacturers and component suppliers were among the first to appreciate the potential. Audi, Daimler, Borg Warner and MSR Technologies were early adopters. Increases in output of 20 per cent were achieved by some of these companies in the first year of implementation. Moreover, the improvements have continued and Factory Framework has provided the basis for continual improvement processes (CIP).

In the UK, engineering giant Weir were one of the first companies to see the potential. Weir Minerals was the first factory in the group to install the system, recording a 12 per cent increase in productivity in the first half year. “We now accomplish five days work in four,” confirms Jason Phillips, lean manufacturing manager at Weir. Management were so impressed that they are now looking to introduce the system to other plants, both in the UK and internationally.

World-wide, more than 50,000 machine tools and processes are now monitored by Forcam software.

The Latest Innovation

Development continues. At the 2015 Hannover trade show Forcam will launch further Factory Framework innovations. Gathering, analysing and presenting relevant and customised options, in real time, to mangers, supervisors and shop floor technicians requires masses of data and huge computing power. To achieve this the latest version of Factory Framework embraces big data, using complex event processing, in-memory technology and the power of the cloud to gather and process this information. This is the first shop-floor software to meet all the technical requirements for Industry 4.0 making Factory Framework a world class solution.

Franz Gruber explained, “This is not just a management tool, but a system and a philosophy that the whole team – workers, supervisors and managers – can use to create more productive, competitive and profitable enterprises. Given globalisation of manufacturing this has a crucial role for the viability of factories in advanced economies.”

A practical example. Different team members need different information that is relevant to them and their job. The technician operating the machine needs to know the target time for the job, the specification for the process, quality standards, what the next job to follow and how the machine is performing so that it can be set-up and optimised for best performance. Supervisors may be tracking multiple orders through the shop. They need to know what is completed, in progress and where there are machine outages or bottlenecks to route around. The plant manager may be looking at OEE, current versus historic performance and where there may be gaps in the schedule that permit small orders to be fitted into the programme. The options for data gathering and information display are as varied as the needs of each individual and each factory.

While the Release 5 development is particularly relevant to multinational manufacturers seeking to optimise performance of linked plants around the globe, it is equally relevant to the small machine shop seeking competitive advantage by improving productivity.

Connectivity is a growing trend in the modern world. Linking devices to exchange information, pass instructions and share intelligence via the cloud is known as the 'Internet of Things' (IoT). By intelligently networking manufacturing equipment, plants and supply chains Release 5 is therefore an extension of the IoT on to and beyond the shop floor. To ensure that this can be achieved safely and reliably, the data is entered into a European based company internal cloud, hosted within the company's IT infrastructure.

In keeping with the growing use of portable devices, Release 5 is compatible with a variety of devices from touch screens to mobiles and tablets. UK account manager Charlie Walker explained, "We view this as the fourth phase of the industrial revolution, Industry 4, gathering, interpreting and representing intelligently the key performance information that empowers people to be more productive. Using the power of the cloud we stream data internationally to different plants to create connected and highly transparent manufacturing processes."

Franz Gruber concluded, "Successful manufacturing businesses in the 21st Century need to embrace a manufacturing execution system (MES) that has big data at its core and uses this via the web to give real time transparency and response. This is the route to achieving a continual improvement process (CIP) and sustainable productivity increases."

More Information

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February 23, 2015

Useful Acronyms

MES – Manufacturing execution system

OEE – Overall equipment effectiveness

CPS – Cyber physical systems

IoT – Internet of Things

ERP – Enterprise resource planning

HMI – Human/machine interface

SFM – Shop floor management

CEP – Complex event processing

CAD – Computer aided design

CAM – Computer aided manufacture

Forcam – at a Glance

COMPANY	Headquarters in Friedrichshafen Germany Worldwide over 100 specialists
MARKET	Discrete Manufacturing Industries
PRODUCT	Shop Floor Management System (SaaS)
TECHNOLOGY	Leading Manufacturing Execution System - **Factory Framework™**
CUSTOMERS	Vertical Market Segments (Automotive/Aerospace/Medical) Select Customers include: Audi, BMW, Daimler, BorgWarner, MTU Aero Engines, Mann+Hummel, WEIR Minerals
IMPACT	> Significant improvements in productivity (up to 20%) > Accelerated Return on Investment (ROI 1 Year) > Optimized Return on Capital Employed (ROCE) > Improved transparency leading to lower costs > Higher energy and resource efficiency
GLOBAL PRESENCE	> Friedrichshafen am Bodensee (Headquarters - Germany) > France, Switzerland & Benelux > United Kingdom > United States > South Africa > Poland, Czech Republic, Hungary
MANAGEMENT	> Former SAP Executive founded FORCAM in 2001 > SAP co-founder, Dietmar Hopp is a FORCAM stakeholder
SELECT PARTNERS	> SAP > IBM | TDM Systems | Q-DAS > IMS Center, University of Cincinnati (Prof. Jay Lee) > Massachusetts Institute of Technology - MIT (Prof. Bühler)