The Digital Engineering & Test Centre


# The Distributed Factory & Industry 4.0

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## Executive Summary

This report describes the concepts and the direction with which distributed factories are being setup by small and medium sized businesses across urban areas and larger cities throughout the UK. And to understand how the automotive sectors manufacturing experience can be used to setup new and emerging business models in city hubs to further the UK manufacturing sector.

The automotive industry and large OEMs have been distributing their designs through counties and continents whilst controlling mega factories to serve the local and regional supply chains. The forthcoming industrial revolution 4.0 is utilizing the robotics and automated production systems that have further automated production capabilities through the introduction of cyber-physical systems (CPS)[1].

Germany has been at the forefront of the next industrial revolution; however new business models have been developed that highlight an appetite for the SME sector and the decentralized urban manufacturing markets.

## Background

As Robert J. Shiller quotes "*You cannot wait until a house burns down to buy fire insurance on it. We cannot wait until there are massive dislocations in our society to prepare for the Fourth Industrial Revolution*" [2].

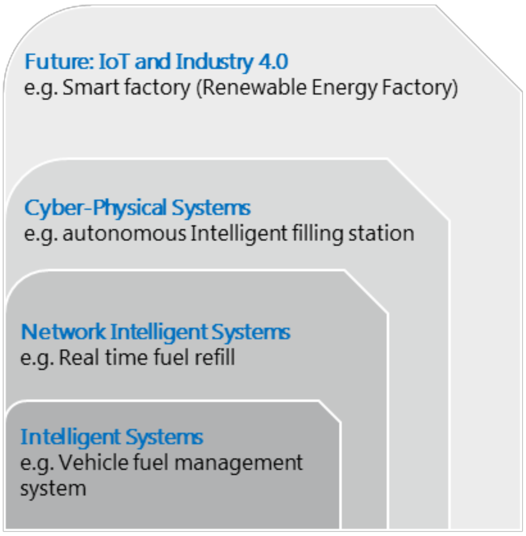
The UK manufacturing arena must become increasingly agile to compete in the global economy. OEMs need to be able to produce premium quality on demand as opposed to traditional manufacturing models which are now based on large production volumes. Ever smaller lot sizes are required to be able to achieve short lead times for an increasing range of products and variants and to enable them to react to customers' demands and the power of ecommerce in placing orders direct to the production lines[3]. High variety and flexibility is traditionally the domain of manual manufacturing systems. This is where the new model of the small medium enterprise (SME) distributing their operations in cities and spreading their footprint is an interesting space.

The demand of having higher quality made by automation on large scales is being distributed to hand finished and bespoke products locally.

## Automotive sector

The automotive sector has already been connected and networked. This has traditionally happened through Product Lifecycle Management (PLM) and Manufacturing Execution Systems (MES) connecting information through to the shop floor. Enterprise Resource Planning (ERP) enables the supply chain of dealers ordering the next fleets of vehicles to factories and production planning resources can be controlled from a centralized location[4]. The use of this 'holy trinity' of manufacturing has enabled the success and management of these mega factories. These megatrends of globalization have been enhanced with Industry 4.0 technology and Cyber Physical Systems (CPS). Connecting virtual and physical worlds with intelligent objects has given the automotive sector more granularity and better decision making perception [5].

The Evolution of intelligent systems into the internet of Things (IoT) and Industry 4.0

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Data from the intelligent objects combined with high performance software systems, creates a new level of functionality[6].

## Small & Medium Industry Movements

Industry 4.0 can be a dominant force in the manufacturing success of small and medium-sized enterprises (SMEs), while the distribution of factories is created through new business models and opportunities. The ability to extend the value chain through industry 4.0 technology will transcend the business and company boundaries[7]. This new network of SMEs can supply their customers extensively and cope with the demands of the client whilst optimizing operations. The distributed factory with 4.0 technologies can challenge the large manufacturers cost models and can compete with the demands of mass production through a single flow item.

Businesses such as Unto This Last (UTL) are creating a web of manufacturing hubs to serve the local community. They are challenging the furniture giants IKEA in creating a product of better value, bespoke by color and dimensions and finish. The furniture manufacturer is creating an ethos of sustainability through distributing the manufacturing methods, designs, business and craftsmanship [8].

## Decision making drivers

The adoption of Industry 4.0 technologies by large scale Automotive manufactures has filtered down to their existing tier 1 partners and large technology vendors who already have a relationship with the automotive manufacturer. Innovation is not only driven through new ideas, but new processes being introduced with long term commitments[9]. The culture is driven into an existing working factory and the people adopt and commit to the new technology roadmap. This also locks out the SME engagement in the sector with new technologies being developed in the bedroom of the next teenage tech guru. The decisions are made on forecast sales of the vehicle and this dominates how technological decisions are driven[10].

The SME looking to distribute and create a smart network of factories will build the technology into their business and will be able to engage with all levels of developers and products from a wider spectrum. This exposes them to newer ideas and developments and the organization can react to changes as expansion is taking place[11].

### Change Management

The large OEMs have very rigid and well-guarded IT systems. This creates security but also adds to the lead time of deploying any changes in the system. Change management is not easy and large consultancies charge large sums to manage the process, whereas the SME will be able to implement and pilot changes sooner and give valuable feedback to the solution providers. Change should be a slow process as with the systems the mindsets will need to adjust and be adopted carefully and incrementally[3].

### Economic Viability

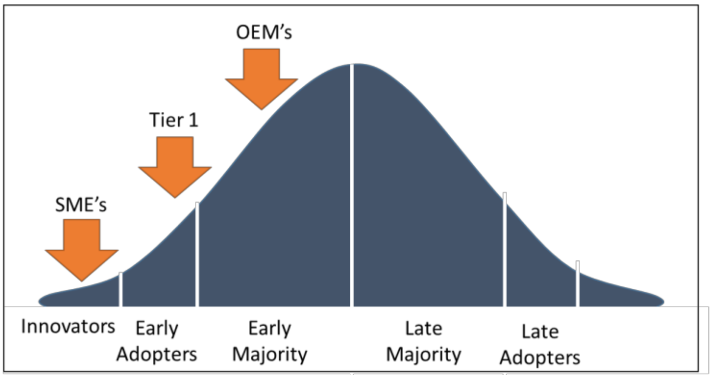
These large systems are very expensive and the 'Return on Investment' (ROI) is a long term calculated business decision. The tier 1 suppliers will be driving the need for the solution and the threats of staying behind and not being able to reach capacities and efficiencies. However, this comes at an extremely high price tag.  There is some validity in these concerns and if a manufacturer does not adopt the smart tech they risk losing their competitive advantage[12].

## Distributed Manufacturing Case Study

**Unto This Last** is a limited company started by Olivier Geoffroy in 2001. The purpose of the company is to develop products, systems and software to make manufacturing furniture on the high street a competitive proposition.[8]

**Product development for distributed manufacturing:** The company has developed hundreds of products within a standard, limited set of materials and tools, required for distributed manufacturing. This enabled the definition of a list of principles, methods and processes, which have been systematically recorded and turned into training programs.

However, this is not the case with the SME manufacturers looking to distribute their operations. Their business is built on a closer network of people and this is driven through the visons of the business founder which encompasses more than just ROI. For instance, at Unto This Last (UTL) the business model is a community model where the people, raw materials, skills and location are sourced from a radius of the range the electric van can deliver to. When they are looking to distribute the business, it is a team effort and people from within the organization will transfer skills, knowledge and business ethics to the new location. The technology is not a driver but an aid to ensure the products are made to the same standard as the store before[8].




Technology adoption of the SME, Tier 1 and automotive manufacturers

## Big Data & Machine Learning

In connected automotive factories, strategic managers quantify big data to enhance supply chain innovation to deliver better fact-based strategic decision making, as the industrial revolution has created large amounts of data. The operational decisions are now leveraged with data analytics[13]. Currently in a smart factory, there are a variety of analytics techniques such as predictive analytics, data mining, case-based reasoning, exploratory data analysis, business intelligence and machine learning techniques that could help manufacturers to mine the unstructured data. These activities are driven through a digital twin to forecast and simulate outcomes.

## Digital Twin

In the cyber manufacturing arena, to mimic what is happening in the real world, there is a Digital Twin[14]. The Digital Twin technologies support the lifecycle of the product and allows the strategic planning to be controlled in a virtual environment. This is a much more complex system that allows the user to comprehend the invisible relationships between data and therefore make optimized decisions.

## Simulation

The Digital Twin makes allowances for simulation models to be run virtually and for the users to predict manufacturing events on a process, cell or manufacturing facility and at an operational level. The simulation analyses the factors and over time how these are effected[15]. It then highlights bottlenecks and material flow, stoppages, blockages and high levels of 'Work-In Progress' (WIP) and Inventory. For data driven efficiency and automated decision making systems to be applied in SMEs for distributed manufacturing, these tools are some of the most powerful, cost effective and risk averse methods to test expansion.

From the comparison of the automotive simulations to the SME and distributed models, we can see vast similarities. The use of the Digital Twin and Simulation could help improve efficiency but also create a continuous improvement culture which is data and fact driven.

# Addressing Cyber and Business Security for Industry 4.0

Cyber security has been one of the major hurdles in implementing any IT system in large OEMs and manufacturers. The data and information flow of the connected machine and systems via cloud environments is the nightmare of the IT strategists. This is creating a bottleneck for the large OEMs in moving forward and prevents them from being at the forefront of new technologies[4]. At one scale innovation teams are developing machine learning algorithms that will empower autonomous adjustment and production, while cyber security teams are protecting the manufactures 'Intellectual Property' (IP) with layers of additional protection. This capability is readily available in large organizations.

SME's will struggle to protect their IP and will risk the business and 'Unique selling point' (USP) being open to duplication, with the cost and infrastructure becoming quite complex and burdening for an SME.

## Industrial Data Security

The data is being continuously monitored through protected networks against potential cyber-attacks with the move to a connected and smart factory. In a paper Grant states "Invention is innovation once it gets commercialized"[16]. With the processes of collecting data from more sensors and devices, it is not innovation until the process is changed. The data interrogation and improving efficiency is part of improving the process. This is critical of the data collected and analyzed and in large OEMs the protection of the data is vital. The IT departments have hurdles of security measures to minimize the integration of any external entity from being able to see the data and therefore without the analysis cannot improve processes. The result is a long lead times for any SME or new vendor being brought onboard. This also brings a reliance on existing Tier 2 suppliers being innovative to drive changes[17].

> *"Invention is innovation once it gets commercialized"*

To tackle hacking issues and any data loss, data encryption and issues associated with connected cars are heavily protected and millions are spent to keep both manufacturer and customer information secure.

The SME manufacturer looking to distribute design, supply chain, strategy and governance to the local community of stores will face similar issues but can learn from the automotive sector about which of these is a hindrance and how they can innovate their timelines to be responsive to customer and market changes[18]. The importance of having data systems which are predictive rather than reactive can give the SME a major advantage. To improve the system, we want the information to flow uninterrupted from customer to machine or robot, without any instances in between. This creates the framework for a 'Distributed Digital Supply Chain'. The digital supply chain has been exploited via the likes of Amazon and eBay for over a decade and is well known, however to distribute and decentralize a supply chain is a new phenomenon.

# Distributed Digital Supply Chain

Large automotive manufacturers such as BMW, have been working on developing a fully digitalized factory[19], using a more dynamic, data analytics driven supply chain. This relies on working with logistics suppliers, going paperless and having the parts being delivered to lines having the capabilities of data recorded via stock movements. A 'Distributed Digital Supply Chain(DDSC)' will work with suppliers in the local vicinity of a decentralized manufacturing facility[20].

To build this model for an SME in the furniture manufacturing business, the new supply chain partners will be selected with a very specific criterion. However, the digital supply chain will comprise of the base of the product design which is key to the manufacturing process and this in turn is key to the assembly and finished product[19]. Within the manufacturing process is the uniqueness of how this furniture is assembled to produce the item in an effective method; which in turn is profitable. So, the DDSC is a two-way communication from shop floor to design and the centralized data. (See figure 1)

**Distributed Digital Supply Chain**

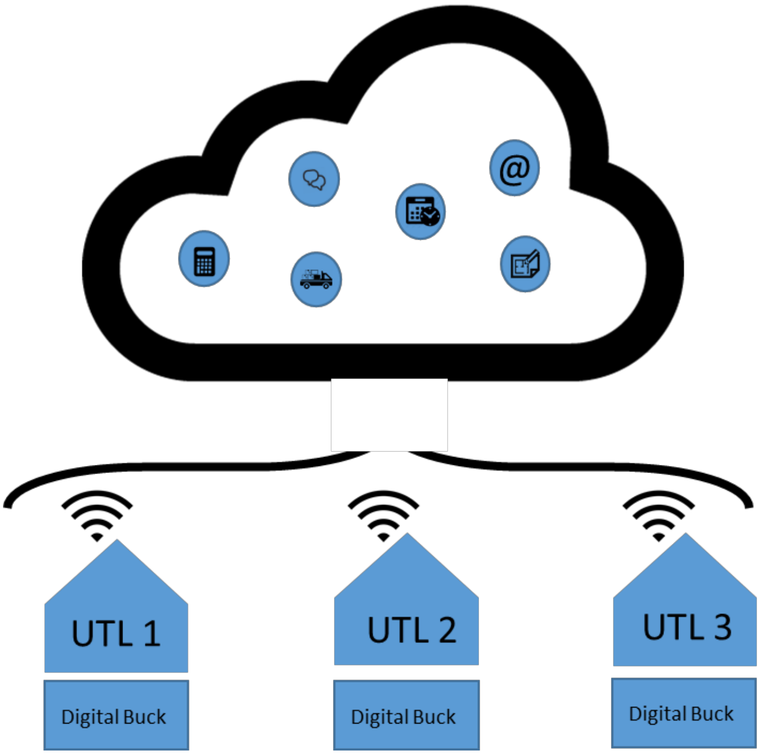



Figure 1 - Distributed Digital Supply Chain

## Business security

The most important asset for UTL is the computer aided designs of the pieces of furniture, while decentralizing and increasing locations the business must share these designs. Although they will be protected by non-disclosure agreements and contracts, the designs are still not considered safe[19].

The duplication of some businesses can be quite fast, although it is more than the product which drives success and this comes in the form of distributing ethics and values. As the DDSC is no longer in a vacuum, they are measured on their success and financials linked to managing a distributed site[20].

The DDSC will allow the information to be shared between each unit and the optimization process will ensure time, cycle times, quality and cost are brought to their true potential. Delivering products to local markets for the cost of large manufacturers such as Ikea, Habitat and Muji. Ultimately reducing risks gives the digital model more strength.

These heavy IT systems take a lot of time and money, so for a fully digitalized function a 3-5-year plan with a return on investment is needed, as the network grows the burden on data is higher and requires management and analysis.

## Conclusions

Taking the information into account we can see the transformation of the SMEs in manufacturing. As the data is more connected, the SMEs can use different sensors during the ramp up, distribution and decentralizing. The goal is to extract big data and to consider the important elements in analyzing it for efficiency and lean practices.

To ensure profit and benefits, the SME will minimize on holding inventory and increase on sharing digital supply chain elements to speed up delivery times with optimum quality. It is also worth recalling that we need to build efficiency for commercial sustainability.

Although digitalization of the supply chain will speed up the pace in growth, this will be industry and sector specific. However, for an SME it's better to make incremental changes, rather than large capital investments into IT systems.

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