

# The Future of Manufacturing in the Digital Age

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# Project Overview

As part of development of the Digital Manufacturing strand of the Digital Catapult, James Devitt of the University of Huddersfield, Centre for Industrial Analytics was commissioned to coordinate a piece of work to better understand Digital Manufacturing readiness, capability and capacity across the Yorkshire Region.

The aim of the study was to gain insight into the current state of digital manufacturing in the region and the appetite and barriers to digitalisation. Specifically the study was designed to contribute towards:

- Supporting the Digital Catapult in understanding how it can underpin innovation efforts and accelerate productivity growth in relation to the application of digital technologies to innovation in manufacturing (Often known as 'Digital Manufacturing and/ or 'Industry 4.0').
- Developing a deeper and broad understanding of what the opportunities and challenges are for manufacturing sectors in the application digital technologies and the perceived benefits of innovating in this area.
- Understanding how UK manufacturing businesses can benefit from the application of digital technologies across the value chain and through the supply chain, describing the barriers to achieving this.

Colleagues from the University of Huddersfield, the Digital Catapult Yorkshire and Connect & Create reached out to a number of manufacturers across the Region, during the Spring of 2017, to engage them in conversation about the digitalisation of their business to help assess business readiness levels and capacity for implementing digital manufacturing applications. A questionnaire was developed to aid discussion, help collate key lines of enquiry identify common themes and challenges. A series of events were held across the region aimed at demonstrating the potential of digital innovation across the Yorkshire manufacturing value chain.

The University of Huddersfield would like to thank the Digital Catapult London and Digital Catapult Yorkshire and, in particular, David Laycock and Janine Hamilton for their support and collaboration throughout this project.

Particular thanks are due to Ceri Batchelder (Connect&Create) and Tracey Johnson (Digital Media Centre/ Enterprising Barnsley) for their work in leading the "Connected Manufacturing" Project focused on South Yorkshire.

Finally the University would like to sincerely thank all the companies consulted and the national/ regional agencies organisations that contributed to this Project.

Note: Digital Manufacturing or Industry 4.0 can be characterised as the application of digital and automation technologies to innovation in manufacturing processes and systems.

Note: Value Chain defined as R&D; Design; Production; Supply; Sales & Marketing; Services; Reuse/ Disposal.

# Context

The nature of manufacturing is fundamentally changing, due to the digitalisation of the industry, to the point that physical production processes are simply one element of much wider value chain activities, generating new and additional revenue from pre and post production activities. Traditional delineations in aspects of the design, sourcing, production and delivery of goods and services to market are being eroded. Future trends will require manufacturers to improve collaboration and investment across the whole value ecosystem.

McKinsey (2015) described the scale of the opportunity as “an explosion in data and new computing capabilities, along with advances in other areas such as artificial intelligence, automation and robotics, additive technology, and human-machine interaction are unleashing innovations that will change the nature of manufacturing”.

Regional (Region Economic Plans) and National (Northern Powerhouse, UK) industrial and innovation strategies all recognise the critical role our manufacturing industry plays in a successful and balanced economy; and national and regional research has identified England’s northern industrial corridor as being in many ways the heart and brains of the UK manufacturing ecosystem/ value chain. Yorkshire is uniquely placed at the centre of that wealth of expertise and capability. Leeds City Region, for example, has the biggest concentration of jobs and companies in manufacturing in the UK and Sheffield has specific strengths in advanced manufacturing.

There is an opportunity for the UK to take centre stage in driving forward a smart manufacturing revolution based on knowledge, technology and innovation, enabling firms to become faster, more responsive and closer to customers. The opportunity for Yorkshire and the North of England is to be at the forefront of this connected and intelligent age of digital manufacturing, by harnessing the economic value of aspects such as novel software, high performance computing, the Internet of Things and Big Data (creating new revenue streams from manufacturing services, capitalising upon data generated by sensors embedded in products, for example).

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# Executive Summary



**A total, 51 organisations were consulted (26 manufacturers, 6 digital services to manufacturing and 19 regional/ national bodies). From the initial cohort of companies, six firms agreed to explore the topic in more detail. Three targeted events were also held in the Region attracting over 200 delegates. The objective was to uncover the challenges and opportunities facing the region's manufacturers in the context of digitalisation.**

The digitalisation agenda is a high priority for a sizable percentage (roughly 40%) of firms in the region. It is also apparent from the interviews that there is a contingent of SME manufacturers who are less disposed to fundamental digital innovation. Paradoxically these companies are often highly capable and profitable businesses including many craft engineering manufacturers who are the lifeblood of the regional economy.

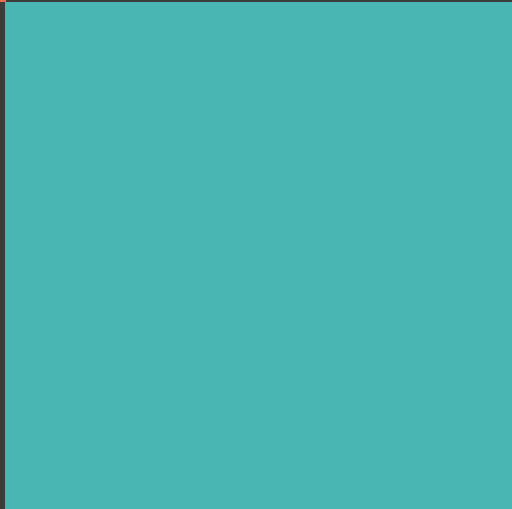
A number of themes emerged from the study including; the critical importance of the human factors related to the adoption of Digital Manufacturing; the need to understand and find ways of supporting the region's "craft" manufacturers in more detail; and the shortage of data analytical skills.

The Report concludes with a number of recommendations including:

- An acknowledgement that the Digital Catapult has a pivotal role to play in driving forward the Digital Manufacturing agenda in the UK and in particular in supporting adoption of new and innovative digital technologies and the transfer into manufacturing of technologies developed in other sectors.
- There is a need for manufacturers in the region to have access to a technology and knowledge brokerage service through trusted bodies and initiatives designed to broker and facilitate partnerships between manufacturers, universities and innovative digital technology companies.
- The need to generate a range of persuasive use cases and case studies, together with a cohort of business champions willing to demonstrate and promote the uptake of Digital Manufacturing in the region.
- The creation of a grant funding opportunity specifically designed to support manufacturers to help de-risk digital investments in their workplace.
- The Region's LEPs, working with partners in the development of a network of regional (connected) Digital Manufacturing Demonstrators.
- The Digital Catapult and other national bodies need to invest resources and priority in understanding the human factors (including user acceptance/ change adoption) relating to the digital transformation of manufacturing.
- There should be a national drive to help stimulate data analytical talent in UK industry.

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## The Study



Between February and July 2017 colleagues, led by James Devitt from the University of Huddersfield, undertook a convening project on behalf of the Digital Catapult centre, London. The objective of this project was to uncover the challenges and opportunities facing the Yorkshire Region's manufacturers in the context of digitalisation. Colleagues from Enterprising Barnsley and Connect&Create were asked to undertake an exercise focused on the South Yorkshire area, referred to as the "Connected Manufacturing" Project. In total including the Connected Manufacturing Project, 51 organisations were consulted (26 manufacturers, 6 digital services to manufacturing and 19 regional/ national bodies). From the initial cohort of companies, six firms agreed to explore the topic in more detail, and a further meetings were held with these companies. In addition, a further three targeted events were held in the Region attracting over 200 delegates.

The Connected Manufacturing programme in South Yorkshire focused on starting a dialogue with local manufacturers about their challenges and opportunities in embracing digitalisation, and the Industry 4.0. The programme also offered the chance for digital technology companies to make new contacts and understand the growing need for their skills. To build on this initial phase, the following recommendations have emerged from meetings with local businesses and running the first Connected Manufacturing event in May 2017, was initiated by Ceri Batchelder (Connect&Create) and Tracey Johnson (Digital Media Centre/ Enterprising Barnsley). The first phase was delivered with the support of Digital Catapult Centre London and Digital Catapult Centre Yorkshire, Sheffield Digital and the Sheffield Innovation Programme (involving both Sheffield universities).

The South Yorkshire team met with 9 manufacturers and 1 software company between February and April 2017. The meetings informed the theme of a very successful "Connected Manufacturing: Transformation through technology" event held on 17th May 2017 at the Digital Media Centre in Barnsley, which highlighted how digital technology can have an impact on operational efficiency and productivity in manufacturing.

A total of 113 delegates attended the Connected Manufacturing Event, from a broad spectrum of organisations. These included manufacturers, digital companies, service businesses, large corporates, investors, universities and those in enabling/ support roles. Over 50 companies were represented and fairly evenly split between SME manufacturers, SME digital tech businesses, SME service businesses and large companies (including manufacturers and digital technology companies. The University of Huddersfield

(including the Northern Productivity Hub), Sheffield Hallam University and the University of Sheffield (including the AMRC) all played an active role and the following government support agencies were also highly involved: Digital Catapult London, Digital Catapult Centre Yorkshire, the Knowledge Transfer Network (KTN) and Tech North.

#### A summary of the Challenges identified in the South Yorkshire cohort:

##### **Business owners**

Busy and stretched; Hard to find the time to think about new technology; Driving change is very challenging; Succession planning is a big issue in family-owned and other businesses; Tender writing for new contracts; Need to improve their digital marketing presence and activities.

##### **Equipment**

Old, inefficient, traditional machinery (e.g. needs to be left on all day and night in case it can't be re-started, leading to unnecessary energy usage and costs); Use of old software, including back up on floppy discs; Lack of digitalisation across the board, including shop floor, admin and business information systems, which are often not joined up.

##### **Staff**

Traditional outlook, reluctant to change; Don't have the skills to use digital technologies; Hard to find people with the digital skills that are needed (from marketing to operations); Need to transfer experience and knowledge in people's heads to new colleagues/ next generation.

##### **New technology**

Attempts to integrate digital technology with existing operations and staff activities have sometimes been unsuccessful; Some confidence/ trust issues with suppliers of digital solutions; Data collection and use of real-time insights aren't being used by most; Once you have data, you need to know what to do with it.

##### **Operations**

Job scheduling (particularly for companies who make bespoke products); Seasonal demand; Operational efficiency and productivity are the most critical areas

##### **Clients**

Managing clients' expectations on timings of jobs (particularly jobbing-shop type companies); Hard to recoup the cost of changing client briefs and upfront design work; Keeping up to date with upgrades to software packages demanded by clients.

### A number of high level themes emerged from the South Yorkshire Study:

- There is a big opportunity for improvements in manufacturing through digital interventions.
- Adapt or die – digitalisation is coming and firms that do not embrace it run the risk of getting left behind, becoming increasingly uncompetitive and ultimately going under.
- Digitalisation is coming and the manufacturing industry in the UK needs to be aware, as the UK as a whole is getting left behind. The manufacturing sector in other countries such as France and Germany has been quicker to adopt digital technologies and in Germany at least there is massive investment.
- Manufacturers like to see examples of how other companies have dealt with the practical implications of digital transformation, including how they demonstrate a measurable impact.
- Digital adoption involves change management and ensuring the staff and their views are highly integrated in the process so they engage.
- Start small and run pilot projects before making investments.

A team consisting of James Devitt from the University of Huddersfield and David Laycock from the Digital Catapult, London, supported by Janine Hamilton from the Digital Catapult Centre Yorkshire, were tasked with engaging manufacturers and agencies from the rest of the Yorkshire Region (West, East and North Yorkshire). The team visited and discussed digital manufacturing with 17 manufacturers, a further 5 digital technology companies and a wide range of regional/national agencies. The collective findings of this study and the Connected Manufacturing Project are summarised in the following sections.

At the culmination of the project, manufacturers and digital technology businesses were invited to a Digital Manufacturing: Industrial IoT and Analytics Event which took place at the 3M Buckley Innovation Centre, Huddersfield on 12 July 2017. A number of presentations highlighted how digital innovation is transforming our manufacturing sector for the 60 delegates in attendance. The event focused on the use of the Internet of Things and big data analytics to improve operational efficiencies and productivity in manufacturing.

Presentations from Leeds City Region manufacturers including Surfachem (a global distributor of surfactant and speciality chemicals), Camira Fabrics (a large textile manufacturing company) and Daletech (a leading provider of electronic product design and manufacturing) outlined their approach to enabling uptake of new digital technologies in their companies. The event also gave an opportunity for innovative digital technology companies to showcase their capabilities to the audience.

In conjunction with the event, Digital Catapult London and the University of Huddersfield also hosted a workshop on Gateways for Internet of Things: LPWAN (Low-Power Wide-Area Networks). The workshop was well attended with a further 30 delegates attending.



Photography by Timm Cleasby



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# Findings

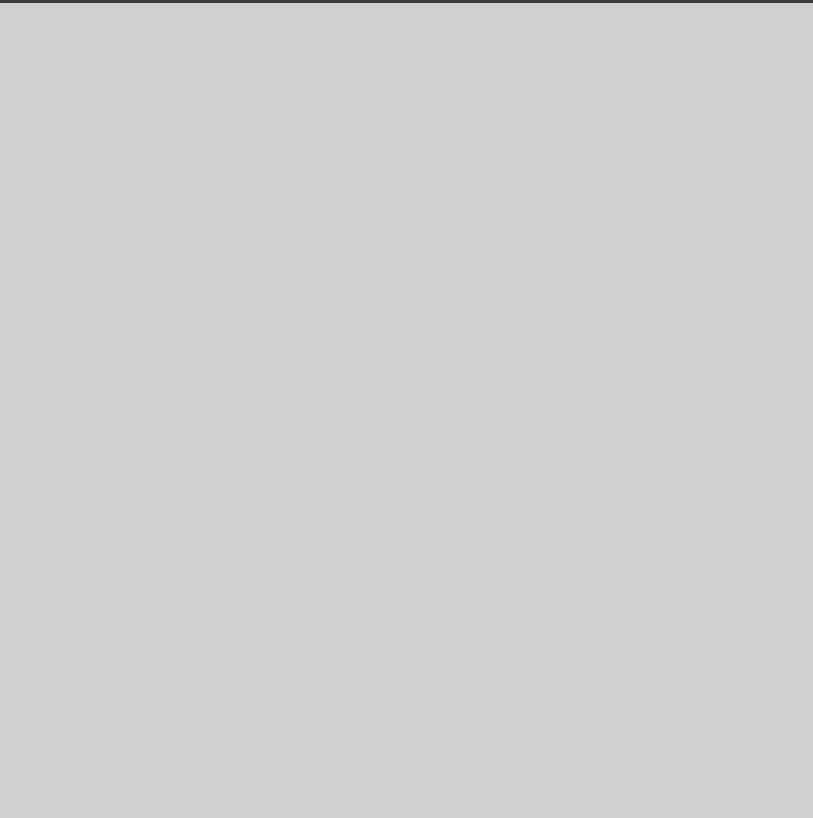


Figure 1



Source: Digital Catapult Analysis

## Adopters and Sceptics

The companies interviewed covered a range of size, location and activity types. With regard to the digitalisation agenda, companies fell into three broad categories: - first adopters, sceptics and a middle group of companies neither true innovators nor laggards. A useful way of characterising this middle group came from one of the companies interviewed who referred to themselves as “cautious innovators” (Figure 1). The sample of this study was too small to draw any conclusions, however studies elsewhere, including one in the Netherlands, would suggest that the ratio of companies fitting into these three categories are, 5 to 10% 1st Adopters; 40% Cautious Innovators and 50% Sceptics and Laggards.

The 1st adopter group tended to be, either very large corporates/OEMs, or highly specialised SMEs producing ‘smart’/ digitally enabled products and/ or operating in Fast Moving Customer Goods

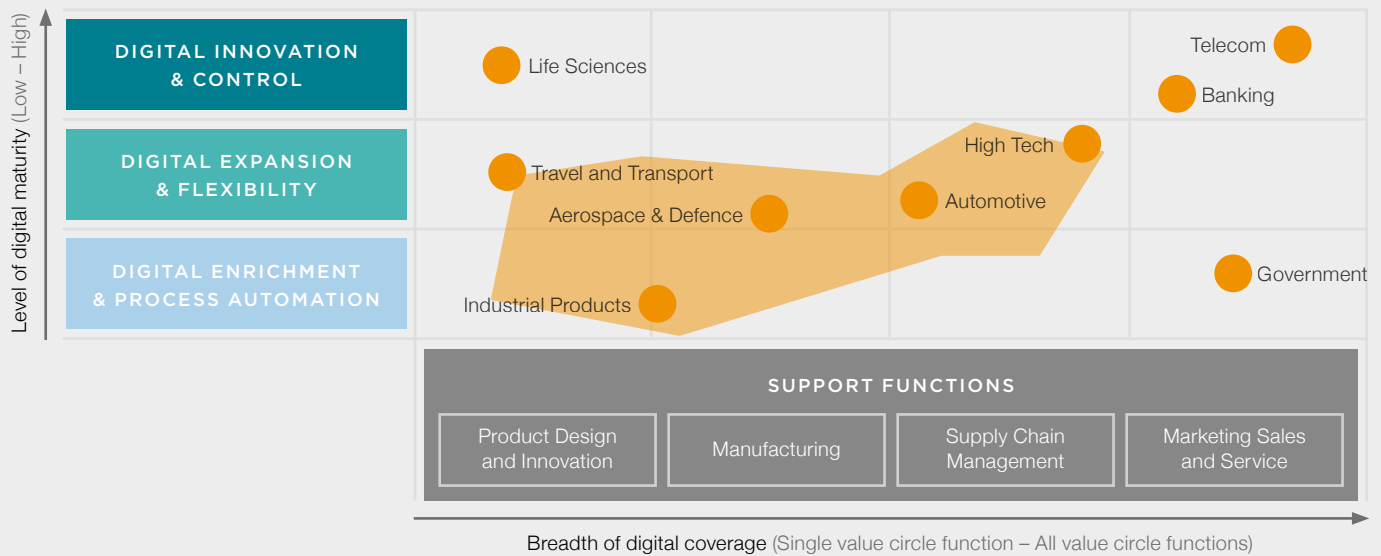
(FMCG) supply chains. These companies are front runners and are already reaping the benefits of digital transformation. They could be role models for other manufacturers to follow and this is no doubt already happening. However, they are also non typical and given their large/ specialist nature they may not resonate with the majority.

On the other end of the spectrum is a large proportion of companies who either don’t see the benefits of further digital transformation, or who don’t see it as a priority for their business, at this time. These companies are often extremely busy and focused on short term business goals.

Broadly speaking, the findings of this study are consistent with other pieces of work exploring the same topic area. In terms of the digital maturity of the companies interviewed, an illustrative guide was produced by Cap Gemini (see figure 2 below) which does seem to be borne out in this study.

Figure 2  
Digital maturity of the manufacturing industry

■ Digital footprint of the manufacturing sector



Source: Capgemini Consulting Analysis

It is important not to generalise, however from the limited sample of this study, it would suggest that the “Sceptic/ Laggard” Group of companies are quite commonplace in the Yorkshire Region. One could almost suggest they represent the heartland of traditional manufacturing in the UK. Typically these firms are SME’s, often some way down the supply chain (i.e. further from the end customer), operating in non-Fast Moving Customer Goods (FMCG) sectors and/ or are craft engineers operating in specialist sectors, producing one off/ limited volume products.

Investment in digital transformation for this group is often seen as a costly distraction from the immediate and pressing activity of running a manufacturing company and business leaders often don’t feel they have the luxury of time or “headroom” to contemplate major innovation of this nature. There is also a sense of a lack of understanding about digital manufacturing/ Industry 4.0 and its implications for their business. Added to that, is a good dose of “Yorkshire” scepticism from companies about, what one firm described as, “Industry 4.0 hype”. For some businesses, talk of artificial intelligence, robotics and autonomous production is farfetched and has been over-exaggerated by the vendors of large hardware solutions.

The reality is that a large proportion (possibly a majority) of the region’s manufacturers fall into the Laggard category. This is not to say that these companies are not good at what they do nor that are they somehow unsuccessful. In the main, traditional manufacturing in Yorkshire is currently buoyant and the digital agenda has not yet disrupted that.

Nonetheless, the danger is that when Industry 4.0 does start to have an impact, these companies will be ill-prepared and slow to adapt. Change for this group of companies may only come about as and when they are forced to innovate; either because they are required to by their OEM; or when they start losing ground to more digitally enabled competitors.

## The Cautious Innovators

On a more positive note it is clear that the digitalisation agenda is a high priority for a sizable percentage of firms. This mid group of “cautious innovator” companies vary by sector, size and location, but all share a common thread of being well connected to wider national and global networks/ supply chains. They often have an open, enquiring and strategic culture in place, with at least one senior leader with an eye beyond the day to day operation of the business (looking beyond the horizon). Many of these companies are not 1st adopters but have the will to adapt and grow. However, they are also cautious and confused by much of the white noise and hyperbole surrounding the Industry 4.0, Digital Manufacturing, Big Data, and the Internet of Things agendas and are wary of the hard sales pitches and claims of the large digital manufacturing service companies in the marketplace currently.

There was a sense of reaction from the companies against what they described as the heavy push of hardware and technology on them. Many companies had already invested heavily in a variety of enterprise software products to manage business operations, resource planning and customer relations and so on. Manufacturers didn't feel that they were lacking in data, on the contrary they were, as one company put it, “awash with data”. What they universally agreed was that they were not fully exploiting the data they had.

It was quite apparent that the cautious innovator group had an appetite for practical support to help them. Several return meetings were held with a number of these companies to explore this topic in more detail. The findings of these conversations added depth to this report.

There was general agreement amongst the cautious innovator companies of the relevance and potential impact of digital transformation for their business and the wider economy. These companies also understood how improved digital technologies could have a positive impact on their most pressing business challenges. The five most common and pressing challenges expressed by those interviewed is summarised below:

1. Reducing time to market (demand for shorter innovation cycle)
1. Increasing efficiency/ reduced cost of operations (waster/ energy/ operating costs)
3. Productivity gains
4. Increasing quality (closed loop quality processes, traceability)
5. Recruiting/ retaining talent/ knowhow
5. Technology push (smarter products/ processes)

In discussion, companies felt that adopting new digital technologies, but, more importantly and far more commonly, making more of the data they were already collecting could have a measurable impact on increasing efficiency, productivity gains and increasing quality.

Firms did, in general, see how the application of digital and digitally enhanced automation technologies would improve their productivity but this would not be easy to achieve. One small manufacturer summed this up by conceding that whilst productivity gains could be made “we are not very digitally advanced. We have traditional machinery with traditional outlooks from shop floor workers”.

An indication of the pressure firms are under was illustrated well by one firm when referring to the need to increase efficiency by suggesting that they “must continuously improve to stand still in the current climate”. A smaller but significant proportion also recognised that digital technologies were part of the solution to help them reduce time to market and innovation. For example, one firm felt that reducing time for market was “critical in providing us with differentiation”.

Interestingly, apart from the obvious efficiency/ productivity benefits of digital technologies, a number of the firms interviewed were eager to explore how the development of smart IoT enabled products, for example, could be the catalyst for new business models for the company. A number of companies wanted to have follow on discussions relating to this topic. Some of these companies clearly saw the potential for servitisation (firms developing the capabilities they need to provide services and solutions that supplement their traditional product offerings, classically illustrated by Rolls Royce and their ‘power by the hour’ concept) by embedding sensors and other smart devices into their existing products. The new business model argument for digital transformation would seem to be a topic which has not been fully exploited by those promoting Industry 4.0 as yet and may be a useful mechanism for greater engagement with the cautious innovator group.

The challenge of mass customisation and flexible manufacturing was also seen as a major priority for at least one firm “the seasonality of our business demands flexibility, forecasting challenges”. Likewise there were a number of firms who expressed an interest into the future use of additive layer manufacturing (3d printing) processes in the future, but were unsure about the full scope and benefit of adopting these technologies. There would seem to be merit in agencies providing helpful and honest brokerage and awareness raising through practical demonstration in relation to technologies, such as Additive Layer Manufacturing and Virtual/ Augmented Reality.

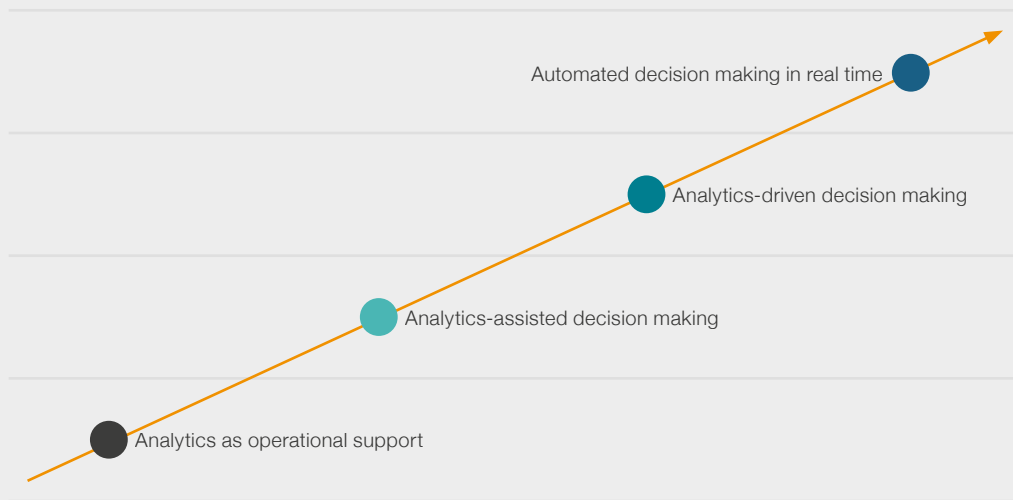
## Data Analytics

The greatest interest and follow on discussion with companies related, less to do with the large scale implementation of cyber physical systems, but rather to the more prosaic, immediate and practical opportunities in making more of the data they were already collecting. All the firms interviewed recognised that they had very limited capabilities to do more with the large quantities of data they were collecting. Many of the firms had complex big data systems in place, however they also recognised that these were not been fully exploited. Many companies admitted the systems they had in place were being employed to simply track and monitor on going factory processes and production outputs.

It was commonplace to see the use of computerised but often, one dimensional dashboards doing little more than monitoring output. The graphics and visualisation often appeared cumbersome and antiquated. There was the impression in some quarters that these systems had been designed to look more complex and technical than they needed to be. The suggestion being that these processes were the preserve of a small group of skilled personnel with a vested interest in maintaining a veneer or mystique about data monitoring. It would appear that there is a need to democratise data in workplaces, making it easier for the widest possible number of people within the firm to see and understand and thus take informed decisions.

When asked where they would place their firm on a continuum (below) illustrating the level of application of analytics in their business ranging from analytics as operational support through to fully automated decision making in real time (prescriptive AI), it was telling that the vast majority of companies saw themselves very much at the foundational level of data informing operational support. A number of the larger firms placed themselves into the 'analytics assisted decision-making' bracket. Only a couple of high advanced companies recognised their firm to be in the 'analytics driven' bracket, and only the very large corporates and specialist automation/ robotics manufacturers claimed to fit into the 'automated decision-making in real time' category. The diagram below is an illustration of the spread, as seen within this sample. The diagram has discounted the very small automated decision making as they are very untypical of the totality of the Region's manufacturers.

Figure 3



Source: Digital Catapult Analysis

Senior executives in some of the larger firms interviewed saw the need to invest in more sophisticated analytical and Artificial Intelligence (AI) mechanisms to address predictive maintenance, real time condition monitoring and the introduction of integrated production planning/scheduling systems vertically throughout their supply chain. However, there wasn't much evidence that this was more than an aspiration at the moment. The enlightened, could conceive of the potential benefits of investing in advanced analytical/ AI systems, but were reluctant to invest in what they felt was relatively untested technologies in their industry. There is clearly a pressing need to have a range of proven success stories/ case studies in place (preferably at a local level and across a broad range of business types and sectors).

Scheduling and production planning were major challenges for a number of firms. One company, for example, said "it's very hard to get accurate estimates on production timings (and therefore pricing)". "It is difficult to predict what jobs will be going through in 4 weeks' time". They went on to say "improvements to planning our very complex workload would make a significant impact for both us and our customers"

Another company saw the need for improvements in work planning as being essential for customer service, "It's really hard to plan as the jobs are bespoke for each customer – the machines get tied up and then it's difficult to fit in work for regular customers but we need to be seen to be responsive and deliver an efficient service"

Another business saw scope in the introduction of "remote digital monitoring of all systems that help assess speed, heat and other parameters and identify areas that need maintenance". They saw this as having the potential to reduce the need for staff on site and reduce risk and health and safety issues.

It is useful to note that, as part of this project, researchers from the University of Huddersfield initiated a series of practical introductions and ongoing dialogues between the manufacturers, the university and innovative digital technology providers (or 'digital enablers' as they are referred to). These dialogues with the digital enablers have resulted, in a number of cases, to a commitment to develop further proof of concept activities. The University has subsequently established the Digital Enablers Network (the DEN)

The DEN model offers SME's access to small scale proof of concept type projects, often on a pro bono basis) as a pre cursor for more substantial investments over time. This incremental approach allows companies to dip their toes into the digitalisation agenda, on a low or no cost basis, and are designed to build trust and confidence as well as show the potential for a return on investment. This then leads to larger investments, which typically takes the form of the development of full scale digital solutions to one part of a production process (the introduction of advanced data analytical capabilities connected to an existing ERP system for example), or possibly a multi-faceted, enterprise wide, digital strategy for a small company. It is hoped

that this three way partnership between the manufacturer, the digital enabler and academia will continue to flourish and lead to further innovations in time. All the indications are that this approach is having a measurable impact. At the time of this report going live, there were a total of five companies engaged in active projects with digital enabling companies, with a pipeline of funding applications in development.

## Human Factors

It would be easy in the excitement generated by the 4th Industrial Revolution, the age of automation; robotics; and super-efficient and productive cyber physical systems, to overlook the importance that human factors will play in its success or failure.

One of the corporates interviewed had a particularly interesting insight into this. This company operates in a highly advanced manufacturing environment and is in many ways at the forefront of digital technology in manufacturing, but it was revealing to learn that even though the company had a history of digital enablement and automation dating back for some decades, it hadn't been without pain. Perfectly workable solutions had, in the past, been adopted only to be found mysteriously unworkable a few months later. This was, in the view of the person interviewed, the work of modern day "luddites". One of the most important lessons they had learnt was to place considerable effort and investment into bringing the workforce along with them. Often, this would involve retraining and demonstrating how these adaptations would be of direct benefit to them as well as allaying workers natural fears in relation to automation and job security.

It was also interesting to observe (particularly, where the research team were asked to return for follow on discussions) the often conflicting internal dynamics and tensions within a workplace in relation to the adoption of transformative digital technologies. It is quite easy to see how, for some, the introduction of automation or machine learning/ AI can be seen as posing an existential threat to a person's job. However, a more common issue was that these new technologies were more likely to challenge the established working processes and internal hierarchies of the company, than to make staff redundant. What was also apparent from at least one of the companies, which the research team worked with more intensively, was the real possibility that these perceived threats could, by sensitive, informed and more sophisticated methods of change acceptance/ adoption, be turned around and used as energy to engage in new roles.

Some would argue that new digital technologies (AI in particular) have the potential to effectively liberate or democratise knowledge within a business, offering an opportunity for wider decision-making and challenging existing practices. Given that, it is also understandable

that this can be seen as, as much a challenge as an opportunity in some circumstances. Indeed on a couple of occasions, the researchers experienced the tensions and conflict this can cause, first hand. It would seem to be very important that considerable effort is placed in bringing as many people as possible, along (sense of ownership) with the process of automation/ digitalisation at an early stage. More research is needed to understand how companies can respond to this very real challenge, and it would seem to be useful for an agency/ service to develop a range of practical tools including some form of business coaching/ mentoring for businesses to help manufacturers successfully navigate through what is in reality a major exercise in change management.

The question of talent and skills was never too far from the minds of those interviewed. In particular, companies expressed concern that they may not have the level of skills and talent needed to implement digital transformation strategies in their company. Many of the more traditional manufacturing/ engineering companies had a mature and highly expert workforce with substantial levels of tacit knowledge and skills in industry, but they recognised that they may lack some of the skills needed to run a business in a highly digital and connected world. The more enlightened business leaders, who were interviewed, placed a high priority on the need to attract younger, more "digital native" talent.

One firm, when asked about the application of lean tools in a digital environment, said that "our processes are becoming more restrictive and challenging conventional process development skills".

It is perhaps a truism to say that a firm's business strategy reflects the knowledge and perception of its owner or CEO. It could be argued that this is even more apparent amongst manufacturing SMEs. It would be tempting to cite the age and background of an executive as being the most important determinants of whether or not a company embraces a digital transformation agenda, but what was clear, from those interviewed at least, was that it was the person's outlook which was the most telling factor. This was less about simple open-mindedness and more a very obvious sense of enquiry and thirst for knowledge from the individuals concerned. In addition, it was noticeable that company executives who were exposed to fast moving consumer led markets tended to be more receptive to digital transformation and change in general.

One of the CEOs interviewed epitomised these attributes. An avid ingester of knowledge, he had made it his business to understand how digital technologies might impact on his business and, as a result, could clearly see over the horizon at the competition his firm may face in the future from global online retail giants, driving their

highly automated and efficient processes down the supply chain into manufacturing and production. His conclusion was that he must “beat them at their own game”. This CEO referred to the need for his firm to replace its existing traditional business strategy with one that puts digital at the heart of everything. To paraphrase him “we need a digital strategy not a business plan”.

This idea that companies are now looking for a more comprehensive digital strategy (once the preserve of marketing) to run like a golden thread through every aspect of business and production was echoed by a number of the cautious innovator companies. The concept of investing in a holistic view of the digital architecture of the business, ensuring all the aspects are fully connected and complementary, certainly had a positive reception from a number of companies.

In terms of the company’s existing digital footprint, not unsurprisingly, almost all had invested in some form of factory floor and production systems, and web-based customer order tracking systems. Simulation and product innovation applications also featured strongly. Interestingly a few of the more advanced companies were actively looking to develop their predictive maintenance capabilities. See below for a list of the most common business functions to have been ‘digitalised’ (those highlighted in red being the most often quoted);

### **Factory floor and production systems**

**Sensors**

**Simulation**

**Supply chain integration & mapping**

**Web-based customer order tracking**

**Product innovation: new product development**

**Product innovation: improvement of an existing product**

Many companies expressed a frustration that they had invested heavily in the past in various enterprise IT solutions only to find their business process/ ERP systems could not interface with the sales/ marketing teams and their CRM applications or financial packages. Some felt aggrieved that they had been sold expensive IT solutions from major vendors only to find in practice they had serious limitations for in their business and that they were effectively short-changed. This had made them wary and cautious. A number of businesses went further, realising that they were only deriving a fraction of the value of the data being generated by their own internal systems. When asked more about this aspect, many of the firms recognised they simply didn’t have the digital and in particular the analytical skills in house to interrogate the data they produce. The shortage of data analytics skills in the workforce and the need for new skill sets to reflect the digital age was clearly a major issue for some of the companies interviewed.

Another less obvious but still significant impact of the explosion of new high tech digital technologies and capabilities, in areas such as Big Data, Artificial Intelligence and the Internet of Things (IoT), is that the sheer pace of change is causing many of the Cautious Innovator Group companies to delay investment. Companies are unsure whether the innovations they may make today will be outdated or overtaken by others before they can see a return on investment. To quote one business “The field is disruptive, with new technology presenting opportunities that delay customer purchase decisions, deciding when is the “right” time to invest!”. The Digital Catapult is perfectly placed to provide an objective view on this, through its region spokes (the Digital Catapult Yorkshire for example).

One firm suggested it is “it’s too costly to develop alone (as an SME) – but too fast moving to ignore”. This company called for creation what it referred to as localised knowledge, development and network sharing centres, where SME’s can get an unbiased, honest broker assessment of a company’s digital needs, a forum for other SME’s to share experience and good practice and a place where companies can go to view a range of Industry 4.0 applications in process (Demonstrators). The development of the Digital Readiness Level (DRL), if coupled with localised centres could be a model which works well in this context.

The introduction of smaller scale ‘Pitstop’ type competitions for regional SME’s also resonated with a number of companies. Some of the companies suggested that they might collaborate on shared topics to host a Digital Catapult Pitstop events in the region, which would attract a good quality of digital technology companies from the region and further afield.



## Craft Manufacturers

From the interviews carried out there would appear to be a contingent of SME manufacturers who are less disposed to fundamental digital innovation. Paradoxically, these companies are often highly capable and profitable businesses. The West Yorkshire area, for example, has a high proportion of companies which can be characterised as being niche or 'craft' manufacturers (predominantly engineers), operating in tightly defined supply chains, producing highly specialised and often precision 'one off' products. From the interviews carried out there would seem to be a trend amongst these companies to be less inclined to see the opportunities that the full scope of Industry 4.0/ digital manufacturing can offer.

The reasoning is understandable; if you are making specialist, one off components at some distance (in terms of the supply chain) from the end consumer, there would seem less imperative to automate. On the other hand, there is a considerable need to invest in digital technologies which result in improved quality control, measurement and traceability, for example. It would seem that one useful course of action would be to focus initial conversations with craft engineers on the way digital technologies can impact on quality related dynamics. It would perhaps be worth exploring how the existing agencies with a focus on quality and measurement, in particular the National Physical Laboratory (NPL), could look at further ways to digitalise product verification processes and look at ways to connect these into advances in IIoT/ and Artificial Intelligence capabilities in production.

Given that precision/ craft engineering is at the very 'heartbeat' or 'DNA' of Yorkshire manufacturing, it is essential that more work is undertaken to understand whether this phenomenon is accurate to gauge what the risks are for these companies moving forward.

## Agencies

The team involved in the project also reached out to a good cross section of stakeholder agencies and regional/ national bodies involved in manufacturing and economic development. On a positive note there is a substantial amount of interest in Digital Manufacturing/ Industry 4.0 from all quarters, and the agenda is now seen by most as a priority, even if this has also resulted in a certain amount of jockeying and competition amongst agencies looking to 'capture the agenda'. However, it would seem that there is sufficiently wide enough scope for most of these agencies to see reasons to collaborate in time. From discussions two distinct strands of activity are emerging, each with a subtle yet equally important roles to play in the digital manufacturing agenda.

On one hand, there is the powerful and influential voice of the traditional engineering-led lobby who tend to be focused on the capital investments companies can make on the factory floor into hardware and kit. It would appear that much of the emphasis of the Digital Manufacturing agenda in the UK has been, to date, on driving forward these large scale production line/ engineering efficiencies through automation and robotics as seen in advanced sectors such as the automotive and aerospace industries. There are great productivity gains to be made here and the focus is, and clearly should remain, a priority.

On the other hand, the less physical aspect of transformation-potential relating to the introduction of digital technologies, such as industrial analytics, predictive monitoring/ maintenance and the adoption of Artificial Intelligence (AI) and machine learning techniques, is not nearly as well articulated or promoted. However, the immediate and more affordable impacts that these technologies can offer to companies should not be underestimated. It would seem there is a unique opportunity the Digital Catapult has to offer a complementary focus based on the adoption of these digital technologies. An area where the Catapult has a very important role to facilitate the transfer into manufacturing of digital technologies developed in other sectors such as Finance, Health and Retail.

It may be obvious, yet still important to note that agencies wishing to support the Digital Manufacturing agenda should first try to identify with the needs of the business find out their pain and speak their language, before introducing new innovations. There was little interest in simply talking about disruptive digital technologies without being able to connect their relevance to the day to day pains and priorities of the business and without being able to describe the value that digitalisation can bring to the table.

Companies in general seemed to appreciate the principle of starting small when it came to digital transformation. They felt they needed to be able to build trusting partnerships and relationships with digital technologies companies through the development of small practical proof of concept applications. They felt that in this way highly innovative digital enabling technology companies would also have the opportunity to gain valuable market exposure in manufacturing. In addition, they felt that they would appreciate the involvement of an honest broker such as the Digital Catapult, or a university, for example, in facilitating and supporting them through their journey into digitalisation. As one company put it “we have ideas related to digitalisation that we would like to discuss (what’s currently possible, what’s not) with trusted contacts”

When asked, companies generally agreed that there was a role for the public sector, universities and organisations such as the Catapults/ Innovate UK to help manufacturers make digital technology investment decisions. Having easy access to grant funding to help de-risk investment was predictably high on their wish list.

A large proportion of firms felt that they would consider making investments in potentially transformative digital technologies, but would like help to de-risk or get these past a proof of concept/ pilot stage. Currently in the Region, there would seem to be opportunities for SME’s to access innovation funds, with a number of the sub-regions offering ‘innovation voucher’ type products. This could prove extremely helpful to get over some of the initial barriers and should be promoted strongly to the ‘Cautious Innovator’ Manufacturing SME’s. However, it is also worth noting that a good percentage of the companies interviewed were technically too large to be categorised as SME’s (sometimes part of a larger group) and therefore ineligible but in practice still small in comparison to large corporates. They felt that options for them were limited. The Innovate UK path was seen as an option, but the time and competition involved in these bidding rounds was seen as being a potential hurdle. The larger firms made a strong argument to suggest that they were the ones most likely to accrue the biggest benefits from Industry 4.0 and provide the SME’s with the much needed ‘use cases’ currently in short supply.

There is clearly a need for national and regional bodies to do more to highlight and support companies to understand the opportunities and challenges relating to digital manufacturing and to find and promote useful case studies of local companies who have benefitted from digital transformation, physical demonstrators of IIoT/ automation in action for companies to see first-hand how this may work (The HVM Catapult Factory 2050 at AMRC in Rotherham is a good example of this <http://www.amrc.co.uk/facilities/factory-2050>).

## Conclusion

This project set out to gain insight into the current state of digital manufacturing in the Yorkshire Region and better understand the appetite and readiness of firms to digital transformation (Industry 4.0/ Digital Manufacturing). In that respect it achieved its brief.

The project served to underline much of the generally accepted insight relating to the adoption and readiness of digital manufacturing by industry. What emerges is a mixed picture ranging from examples of great strides of innovation and productivity by some, alongside a common-placed sense of ignorance, denial and confusion, from others. For manufacturing SMEs in particular, it would seem that the value proposition for Industry 4.0 has, not yet, been fully transferred into a compelling case for adoption.

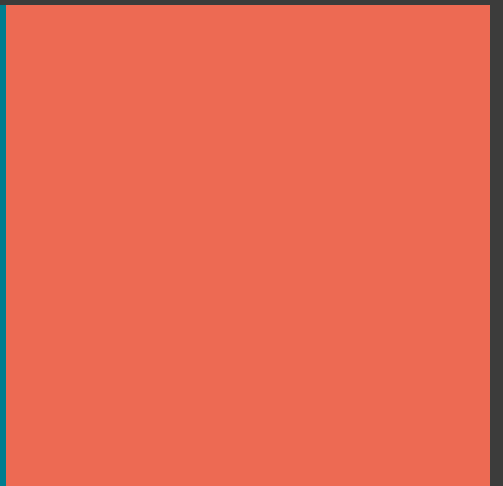
In addition, some important new lines of enquiry and topics for further exploration and action were uncovered by this project. Not least the critical need to address the human factors relating to the adoption of Industry 4.0 and lack of data analytical capabilities within manufacturing in the region.

The Report also serves as an important evidence base for regional policy makers to assist them in the development of new business support and innovation packages for the manufacturing sector. From the success that this project had, in terms of follow up action, focus should be placed on identifying and engaging with the ‘cautious innovator’ cohort of businesses, from which there would seem to be the greatest traction and return on investment (in terms of public funds) potential. The approach, as developed by this project, by incrementally building trust with the cautious innovators and by introducing specialist digital technology companies as required (as illustrated by the Digital Enablers Network) is a formula that would seem to work for SME manufacturers, in this context.

Yorkshire, being such a large and diverse manufacturing region, is in many ways a microcosm of the nation’s manufacturing industry, and as such, the findings and recommendations of this Report should resonate across the UK. This Project therefore also contributes depth and granularity to the knowledge base, currently being gathered, to inform the development of UK policy, including the Industrial Strategy.

4

# Recommendations



- Digital Catapult has a pivotal role to play, alongside traditional manufacturing agencies, in driving forward the Digital Manufacturing agenda in the UK. The Digital Catapult should focus on the adoption of new and innovative digital technologies and the transfer into manufacturing of these technologies from applications in other sectors.
- Given its importance to the regional economy, further work needs to be carried out to gain a clearer understanding of 'craft' manufacturers and their potential risk exposure to competition should they fail to digitally innovate. The Catapult and partners should explore whether there is scope to build on these companies interest in quality whether there is scope for developing further digitalisation of product verification processes, for example.
- There is a need for manufacturers in the region to have access to technology and knowledge brokerage services through trusted bodies. Manufacturers require practical and impartial advice to help them navigate through the bewildering array of new technological innovations, helping them to make informed decisions regarding the right investments to make. The Digital Catapult is well placed to support the development of this, through its region centres (the Digital Catapult Yorkshire, for example).
- There is a pressing need for a range of use cases and case studies to be developed and a group of business champions identified, willing to demonstrate and promote the uptake of Digital Manufacturing in the region. These case studies should clearly set out the journey taken and the range of return on investment benefits which can be accrued.
- Regional and national agencies should consider the creation of a grant funding opportunity to help manufacturers de-risk digital investments in their workplace. A Digital Manufacturing Proof of Concept Fund could be developed for manufacturers to fast track the process of embedding Digital Manufacturing approaches in businesses. The work of developing the Digital Readiness Level Assessment could be used for baselining and eligibility purposes. The fund should be connected to supporting partnerships between innovative digital technology companies and manufacturers.
- The Digital Catapult is well placed to support the development of the Digital Enablers Network and other similar initiatives designed to broker and facilitate three way partnerships between manufacturers, universities and innovative digital technology companies.
- The Digital Catapult should introduce a series of Pitstop competitions in the region and look to develop a variant of the Pitstop to allow for a collection of smaller firms with a shared challenge to come together.
- The Regional LEP's working with partners (including the Digital and HVM Catapults and NPL) should consider the development of a series of regional (but connected) Digital Manufacturing Demonstration sites where manufacturers can see first-hand the application of innovative digital technologies. The focus should be on aspects such as AI and other forms data analytics and visualisation (including virtual/ augmented reality), Internet of Things systems and devices, robotics and automation,
- The Digital Catapult and other national bodies need to invest resources and priority in understanding and harnessing the human factors (including user acceptance/ change adoption) relating to the digital transformation of manufacturing. Further research is required to better understand and respond to the perceptions of workers impacted by the prospect of digital manufacturing in their workplace and a range of workable change management and other techniques need to be readily available for manufacturers to access. It would seem useful for the Digital Catapult to sponsor the development a range of practical tools, case studies and good practice guides, alongside some form of business coaching/ mentoring to help companies with their digital transformation.
- The adoption of digital technologies will be greatly enhanced and accelerated if the Digital Catapult places a strong emphasis on the importance of data analytics and in particular on the intersection between analytics and understanding and the critical role that visualisation can play in this process.
- There should be a national drive to help generate a pool of data analytical talent in UK industry. Universities should be encouraged to increase their intake of students in these key subject areas and new curricula should be developed where appropriate to reflect the needs of manufacturers in particular.
- The new business model argument (servitisation etc.) for digital transformation would seem to be a topic which has not been fully exploited by those promoting Industry 4.0 as yet and may be a useful mechanism for greater engagement.
- Further research should be carried out to better characterise the 40% of manufacturers who can be described as being the cautious innovators. The cohort where the greatest benefit and return on public sector investment should accrue.

## Manufacturing companies consulted

Location	Size	Industrial focus	Specific markets
West Yorkshire	Medium	Lighting	Industrial lighting products,
West Yorkshire	Medium	Engineering	OEM machines, Aero, General
West Yorkshire	Medium (part of multinational)	Engineering	Lab equipment manufacturer
West Yorkshire	Small	Medical	Dental
West Yorkshire	Medium/ Large	Chemical	Formulation and distribution
West Yorkshire	Medium/ Large	Textiles	Furnishing upholstery
West Yorkshire	Small/ Medium	Glass	Construction
West Yorkshire	Medium	Engineering	Aero, Medical
North Yorkshire	Small/ Medium	Printing	Horticulture
North Yorkshire	Medium	Automotive	Haulage equipment
North Yorkshire	Medium	Engineering	Automation
West Yorkshire	Small	Engineering	Specialist lab equipment
West Yorkshire	Small	Engineering	Robotics
West Yorkshire	Part of larger group	Engineering	Distributor electronics
West Yorkshire	Small	Engineering	General
United Kingdom	Corporate	Engineering	Aerospace
Global	Corporate	Engineering	Multiple sectors; materials
South Yorkshire	Medium (part of multinational)	Automotive	Tyre management systems
South Yorkshire	Small	Engineering	Steel structures
South Yorkshire	Small	Engineering	Jobbing engineers
South Yorkshire	Small	Engineering	Structural engineers
South Yorkshire	Small	Furniture	School furniture
South Yorkshire	Small	Process	Conveying
South Yorkshire	Large	Construction	Drainage solutions
South Yorkshire	Small	Engineering	Specialty wire manufacturer
South Yorkshire	Medium	Engineering	Big structural; mining

## Digital services to manufacturing companies

South Yorkshire	Small	Data Science	Data management
South Yorkshire	Small	Data Science	All data analytics
West Yorkshire	Small	Data Science	All data analytics
West Yorkshire	Small	Data Science	All data analytics
West Yorkshire	Small	Data Science	All data analytics
London	Small	Data Science	All data analytics

## National/ regional agencies consulted

Digital Engineering Technology Centre

Knowledge Transfer Network

Digital Catapult

High Value Manufacturing Catapult

EEF

Leeds City Region

Sheffield City Region

Humber City Region

York and N Yorks LEP

NPL

Barnsley DMC

Hull CC

Kirklees Council

Bradford Council

Leeds CC

Digital Sheffield

The Manufacturer

BSI

Institute for Manufacturing

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