AUTODESK

Enabling the Art of the Impossible:
How Britain can lead the 4th Industrial Revolution

FUTURE OF
BRITISH
MANUFACTURING

Contents

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Foreword

Britain was once THE industrial powerhouse, leading the world in scientific advancement, design and innovation. Our appetite to reclaim this position has brought about the recent focus on creating an industrial vision and strategy for the country. In support of this, Autodesk has actively participated in workshops, roundtables and feedback sessions relating to the Industrial Strategy (IS), the Industrial Strategy Challenge Fund (ISCF) and the recently published Industrial Digitalisation Review (IDR), now known as the Made Smarter Review (MSR).

Who is Autodesk?

Autodesk makes software for people who make things. If you've ever driven a high-performance car, admired a towering skyscraper, used a smartphone, or watched a great film, chances are you've experienced what millions of Autodesk customers are doing with our software. We want to give everyone the power to design and make anything. It is this passion that led to the creation of The Future of British Manufacturing Initiative.[1] A collaboration of leading industry partners seeking to go beyond productivity and drive innovation and export levels of UK design and manufacturing.

Globally over 200 million customers use our digital technologies across a broad range of sectors from manufacturing, architecture, engineering & construction to media & entertainment. In addition, our global education programme provides these technologies free of charge to schools, colleges & universities. In the UK alone, this exceeds 2,600 institutions, equating to over 5.4 million students with access to our software.

As an organisation at the forefront of digitising industry, Autodesk continually engages with customers of all sizes across the design and manufacturing sector.

Why this document?

The prospect of a UK Industrial Strategy is an exciting one, which we are wholly committed to making a success.

Following the release of the MSR, the recent budget announcement and the Industrial Strategy White Paper (ISWP), it is clear that we have begun the task of reclaiming Britain's industrial greatness.

However, we see a number of issues that, in our opinion, still require further emphasis in order to better align with the needs of UK manufacturing, and capitalise on the convergence of once separate industries.

Our knowledge of these markets, combined with our experience of helping the UK Government to transform the construction industry through the mass adoption of Business Information Modelling (BIM), has led us to develop a series of recommendations in partnership with industry, that we believe would drive a similar transformation for UK design and manufacturing.

We feel these recommendations will accelerate Britain's progress in becoming the driving force of the 4th Industrial Revolution, and complement the work of the MSR and ultimately the IS.

> **"We want to give everyone the power to design and make anything."**

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[1]autodesk.co.uk/fobmi

Executive summary

In general, the MSR certainly confirms what industry lacks, particularly in the SME space. However, we suggest the recommendations be prioritised as follows:

1. **Leadership:** Which, coupled with awareness, is lacking, particularly in the SME space.

2. **Adoption:** Which we suggest is a function of the leadership issue.

3. **Skills:** Which we suggest is a function of whichever specific technologies are adopted.

Whilst we recognise the ISWP is much wider than one industry, we welcome the five foundations, particularly through the lens of UK manufacturing. However, the paper does not appear to fully reflect the work of the MSR, particularly in the areas of leadership and adoption, which our own findings, referenced later in this document show to be significant barriers to progress.

But more fundamentally to this, we believe a sustainable strategy for UK manufacturing must be based upon two core principles, which we do not feel are adequately recognised in either the MSR or the ISWP. These core principles are:

1. **Thinking beyond productivity**

2. **Embracing design & manufacturing as a single, connected discipline**

We therefore call for greater recognition of these core principles, and for specific consideration around the following strategies that we feel would support them:

1. **Developing home grown leadership**

2. **Enabling full spectrum innovation**

3. **Simplifying the skills issue**

4. **Connecting everyone**

This document describes these core principles and strategies in further detail, outlining why we believe greater progress can be achieved through higher levels of simplicity and alignment.

> "Simple can be harder than complex: You have to work hard to get your thinking clean to make it simple. But it's worth it in the end because once you get there you can move mountains."
>
> - Steve Jobs

Thinking beyond productivity

We need to think much bigger than productivity. Increasing it is clearly one crucial measure of UK success, but alone, will it lead to the sustained, profitable growth that industry needs?

Productivity does of course help reduce cost and drive efficiency in business, but by focusing on it in isolation, are we sending a message to industry that enabling higher volume, lower cost mass production and automation are the only routes to economic growth?

This is the reality of how the term is being interpreted by the industry, particularly in the SME space. Whilst we can certainly close the productivity gap, the UK is unlikely to compete with nations like China and India in this area alone. Research by Deloitte[2] indicates that the market is moving towards increasingly smarter, personalised premium products, which will in turn require greater flexibility in both design and production methods.

Productivity does generate short term competitive advantage, but ultimately keeps a business focused on selling fixed value products. That type of business model is becoming less and less relevant to our future.

Greater potential exists in developing personalised products, which are designed collaboratively, and produced flexibly using a hybrid of techniques. This creates a step change in a customer's experience and a springboard to a range of connected, insight-based services.

How might this work in practice? Imagine engineers of multiple disciplines, converging digitally from all over the country, to develop new, groundbreaking products, which could be easily tailored to a specific customer need before being produced, perhaps locally at an advanced manufacturing facility. The value of such a model goes way beyond productivity as it allows innovation to be personalised and delivered faster than ever before.

We must therefore balance the focus on raising productivity with an equal focus on creating new opportunities and value added earlier in the business cycle. This can be achieved by making the complete concept to manufacture process faster, more seamless and intelligent through radical collaboration.

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[2] The Future of Manufacturing – Making Things in a Changing Word, Deloitte University Press 2015

Opportunity creation & value-add through radical collaboration

Driving a radical step change in collaboration between organisations within the same or traditionally different sectors, has the potential to unlock significant innovation and economic growth.

The UK design and manufacturing sector is hugely diverse, but, as yet, not very connected. A recent report by Hennik Research[3] revealed that while 62 per cent of respondents were planning to undertake some form of move to 'Industry 4.0', only 23 per cent of them were actively doing something about it.

Accelerating the rate and scale at which companies of any size or sector could connect and collaborate would create value in the form of new, smarter products and business models that generate income and employment through insight-based, value-add services, known as servitisation. Uber and Airbnb are perfect examples of what can happen by enabling traditional industries to connect and collaborate in new ways.

> **"The agility of an industry driven on opportunity creation and value-add would be significant, driving innovation, growth and of course productivity."**

Huddersfield-based safety barrier manufacturer A-Safe has disrupted its own industry by developing a range of innovative safety barriers and connected monitors for use in environments where people, products and profits need to be protected.

[3]UK Manufacturing Statistics, The Manufacturer, www.themanufacturer.com/uk-manufacturing-statistics/ (accessed on 24th August 2017)

Opportunity creation & value-add through radical collaboration

The value created could be measured in terms of company profitability and growth, but we need to enable more business owners to take a greater proportion of their employees on a journey into the future of work. As organisations are exposed to new opportunities, a range of 'next generation' jobs will emerge that would represent an attainable next level, depending on the willingness and ability of the employee. This could range from servicing or maintaining automation to far more advanced design and manufacturing roles. Considering the urgency with which industry is attempting to up skill its workforce, we believe this approach to the future of work represents a scalable way forward that addresses many of the 'lights out' concerns around mass automation of the production environment.

This type of radical collaboration would allow more companies of all sizes to connect and work on specific projects operating as if they were, for that project, one single organisation. They could of course continue these collaborations or choose to move on to other opportunities if they saw potential. The agility of an industry driven on opportunity creation and value-add would be significant, driving innovation, growth and of course, productivity.

> "We need to enable more business owners to take a greater proportion of their employees on a journey into the future of work."

Embracing design & manufacturing as a single discipline

Since everything that is manufactured must first be designed, design has to exist in total balance with manufacturing. Can we afford to separate these skills any longer?

In addition, everything that is made needs to be sold, creating a very different type of product lifecycle to manage. Our experience shows that industry is clearly moving towards a model where the design, manufacture and sale of products is becoming one single, connected discipline, not separate silos within a business. The engineers of tomorrow will create digital threads that seamlessly connect how products are designed, made and sold, and there will be no separate design and manufacturing thinking.

> **"The engineers of tomorrow will create digital threads that seamlessly connect how products are designed, made and sold, and there will be no separate design and manufacturing thinking."**

Technologies such as generative design, artificial intelligence and machine learning, offer the possibility of 'push button' workflows. These have the potential to disrupt and grow the industry in the same way that the print industry ultimately grew through the introduction of desktop publishing, eventually creating greater wealth and opportunity for more people when compared to the pre-desktop publishing era.

Generative design mimics nature's evolutionary approach to design. By specifying design goals and parameters such as materials, manufacturing methods, and cost constraints, the work of an engineer is enhanced through the rapid exploration of all possible permutations of a solution, quickly generating alternatives which are tested, taking what works forwards into the next iteration.

We must therefore expand our view of the opportunity from 'advanced manufacturing' to one that embraces design and manufacturing as a single connected discipline. With 2.7 million individuals employed in manufacturing[4] and over 1.5 million people working in the design sector in design roles[5], connecting these groups will strengthen our industry, accelerate innovation and of course, drive productivity. Digital technologies and the skills to use them will play a significant role in enabling this new era of agile design and manufacturing.

[4] www.eef.org.uk/campaigning/campaigns-and-issues/manufacturing-facts-and-figures
[5] www.designcouncil.org.uk/resources/report/design-economy-report

US-based Hack Rod is using generative design, virtual reality (VR), 3D printing, and a cloud-based supply chain, to challenge the traditional approach to manufacturing, allowing almost anyone to design and build a custom car.

Agile design & manufacturing for the SME

Agile design & manufacturing seamlessly connects the way any product is designed, made and used. This is made possible by having a single digital thread that captures all key information of that product, making the relevant information available at every stage of its lifecycle.

It holds the key to the rapid generation of intelligent, connected products, such as Tesla cars, which will increasingly require the design phase to be seamlessly linked to manufacturing techniques from subtractive to additive and a hybrid of the two. Focusing only on advanced manufacturing overlooks the UK's pedigree in design and innovation and prevents the 1.5 million people working in design, from adding value much earlier in the process.

Agile design and manufacturing technologies free engineers from mundane, repetitive tasks, empowering them to innovate and connect the way they design, make and sell their products. It is also highly scalable, depending on the digital maturity of the business.

UK-based Advanced Oncotherapy, a leading force in proton therapy treatment uses business automation to connect and manage key workflows in its business to its outsourced manufacturing including audit management, goods receiving, change control and intellectual property management.
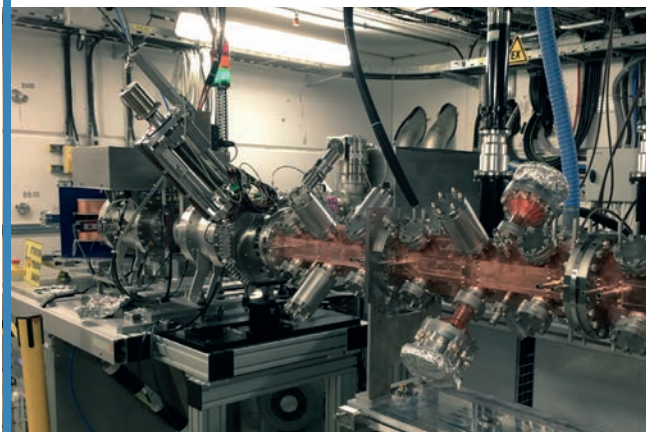
Chesterfield-based manufacturer, Penny Hydraulics, is using engineering automation to reduce the creation of lifting equipment designs from weeks to hours. In doing this, it has increased its manufacturing capacity and grown its revenues significantly without increasing headcount.

Airbus uses generative design to enhance the work of its engineers. Using the power of the cloud, the software creates thousands of potential solutions to a single design problem such as making aircraft fixtures lighter, and combines this with the latest additive manufacturing processes for production, to ensure parts are not just designed more efficiently, but designed for manufacture too.

These types of agile technologies, if applied at the pre-production / manufacture stage of a process would deliver a significant increase in productivity and innovation, by helping engineers solve more complex problems and select the most relevant manufacturing process. Research by Autodesk suggests that the average non-value add time per engineer per week is as high as 21.5 hours.[6]

Indeed, there are many additional benefits arising from such agile design and manufacturing approaches, such as increased capacity to sell, innovate and produce higher quality products.

We believe agile design and manufacturing goes to the heart of a joined-up industrial strategy. If a greater number of SMEs achieved such gains, faster through significantly lower levels of up-front investment, the returns would be significant. This would generate revenues that could ultimately be re-invested in the continued business model transformation, including downstream automation. The reality is that such technologies are now accessible to anyone from start-ups to established design or manufacturing business.

The issue seems to be a general lack of awareness of what's actually possible, coupled with a belief that such technologies are beyond their SME capabilities and budgets.

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[6]Based on the Autodesk Non Value Add Survey, conducted with over 80 companies across Northern Europe.

Recommendations

We feel the following steps would have a significant and hugely beneficial impact on the UK's design and manufacturing sector, bringing these disciplines together as one and driving unprecedented levels of collaboration, innovation and value creation, thereby encouraging British businesses to strive for and achieve the Art of the Impossible.
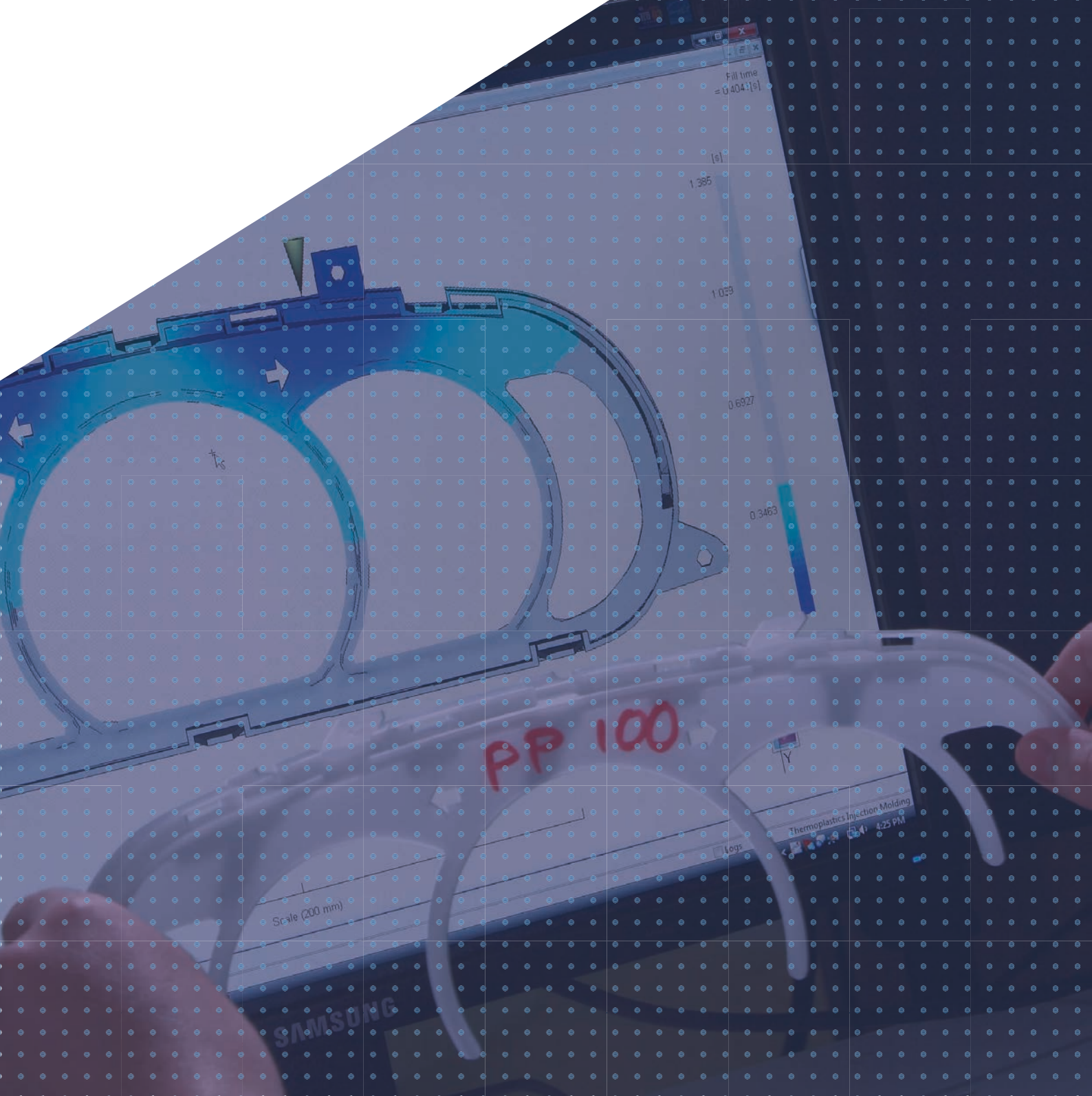
Developing home-grown leadership

The UK needs new breed of design and manufacturing role models from inside industry, who can inspire others to adopt agile design and manufacturing technologies, develop leadership skills and ensure their business continues to grow and thrive through strong succession planning.

These industry champions can help to fundamentally change the perception of:

· What it means to get into engineering.

· What it means to run and own a design or manufacturing business.

· Careers in engineering not being "cool", being confined to the factory floor, or limited to men only.

The approach needed to achieve this is multifaceted, with the objective of encouraging a greater diversity of individuals to engage in STEM-related subjects, and make STEM-related career choices. There are numerous organisations already working on this, including the WISE campaign and Engineering UK. But these efforts tend to exist in silos and potentially re-enforce the current misconceptions of STEM-related careers.

We welcome the Government's announcement to invest an additional £406 million to help address the shortage in STEM skills, however, what is needed is a "pull" from the industry.

Government and industry must collaborate more effectively to provide a joined-up approach that begins with the creation of prominent, entrepreneurial role models who create that pull by increasing awareness of the exciting nature of careers in this field. What's needed is a holistic journey from school, to training, to the work place and beyond.

Some additional steps have also been taken, such as the creation of Institutes of Technology and the introduction of T-levels: which an Autodesk employee has been asked by the Department for Education to act as chair on for Engineering & Manufacturing but greater steps must be taken in order to develop this home-grown leadership.

We agree with the MSR's recommendation for a national campaign, however, our recommendations of its scope would be to:

· Co-ordinate National Design & Manufacturing Days where business leaders around the country pledge to open their facilities to schools and colleges on one single day. A model that is gaining traction in the USA - mfgday.com

· Target SMEs to demystify the 4th Industrial Revolution and help business leaders to translate such terminology into growth, profitability and competitive advantage, thereby stimulating engagement and adoption from this critical sector

· Highlight entrepreneurial role models in manufacturing, engineering and other STEM careers, the emphasis here being on the people and the problems their companies solve as opposed to the products or the technologies

· Development of a leadership curriculum for design and manufacturing businesses, supported by industry, local growth hubs and Local Enterprise Partnerships (LEPs) who might offer development and Continuing Professional Development (CPD)

Enabling full spectrum innovation

By developing stronger home-grown leadership, we could accelerate innovation at all levels. Public and private sector investment in innovation has certainly seen a welcome boost over recent years. More than £1.6 billion has gone into the Catapult network of technology and innovation centres, and the 2016 Autumn Statement announced a 20 per cent increase of public investment in research and development – equivalent to an additional £4.7 billion – by 2020-21.[7] The 2017 Budget also committed to a further increase in funding and programmes to support research and development and the commercialisation of these innovations.

Unfortunately, many of the UK funds are focused on early stage research and development. What's needed is a balance of measures to take great ideas from research and development through to commercialisation, adoption and business model transformation.

Research by Harvard Business Review[8] shows that top performing organisations have a blend of innovation activities from incremental through to transformative.

SMEs find navigating and engaging with the current network of business support organisations and funding streams a challenge. Many would like to see a better balance of practical business support versus long term research and development.

We welcome the Government's recent increase of funding to these programmes and agree with the House of Commons Science and Technology Committee[9] that commercialisation should be a key priority for the newly created body, UK Research and Innovation. In addition, we recommend:

- Expanding the funding scope further to enable UK companies to develop and commercialise a broader range of product and business model innovations such as:

  - **Smarter, connected products.**

  - **Smarter, connected factories to produce these products.**

  - **Smarter businesses that generate growth through connected services.**

  - **Smarter connected workers with the skill set to thrive in these new business models.**

- Greater awareness of the research and development Tax Credit scheme which has recently seen an increase to 12 per cent but sadly seems poorly utilised by SMEs.

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[7]*Autumn Statement* – Boosting UK Research & Innovation; GOV.UK; 16 December 2016
www.gov.uk/government/news/autumn-statement-boosting-uk-research-innovation
[8]*Managing Your Innovation Portfolio – Harvard Business Review, May 2012*
[9]*Improvements needed to the commercialisation of university research;* Commons Science and Technology Committee; 13 March 2017; www.parliament.uk/business/committees/committees-a-z/commons-select/science-and-technology-committee/news-parliament-2015/managing-intellectual-property-report-published-16-17

Simplifying the skills issue

Employers are hungry for engineers with the skills to satisfy current requirements, often citing examples of university graduates or apprentices that come to them, unable to perform certain essential tasks. We recognise the importance of meeting this demand, but perhaps this is yet another symptom of leaders trying harder to meet demand as opposed to trying to be 'smarter'? We'd also question the long-term viability of a workforce trained to only solve yesterday's problems.

Britain must equip its workforce with a broader range of skills earlier and empower them to identify and add to their skills as their careers develop. For example:

·   Applying 'design thinking' and greater interpersonal skills to traditional problems

·   Identifying and using the right digital tools to research and collaboratively design smart, connected products that can be made using a hybrid of manufacturing techniques

·   Leveraging social platforms and coding skills to connect with customers directly and change the experience of buying, owning and operating products

The majority of the current apprenticeship frameworks reference out of date skills and lack the real-world experience that employers seek. Thankfully, these are now under reform by the Institute for Apprenticeships (IfA) but this needs to be looked at in terms of skills of the future as well as the skills required now.

However, a number of universities and apprentice centres such as Imperial College London and the Institute for Advanced Manufacturing and Engineering at Coventry University (IfAME)[10] produce high calibre, industry-ready graduates that possess the right blend of skills with real world experience. Such lighthouse models need to be studied and replicated.

An Imperial College London student recently supported an SME in reducing a traditional process down from two weeks to 240 minutes by improving the production of custom foam inserts for bespoke protective cases.

When placed inside traditional environments, such graduates establish co-mentoring relationships with existing staff, absorbing their experience, but also challenging tradition. This establishes a natural up-skilling environment at significantly lower levels of investment than current alternatives.

For mid to longer term skills issues we do not agree with the creation of yet another institution such as the Skills Strategy and Implementation Group (SSIG). Simplification is needed, as referenced by Lord Sainsbury in his 'Post-16 Skills plan and independent report on technical education'[11]. Also creating the SSIG goes against the Government response to Lord Sainsbury's report, which recommends that the IfA will look after all technical education.

We also question the costs to create, market and effectively manage a national learning platform, and its relevance in the world of established open source learning platforms, such as YouTube, and LinkedIn.

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[10]www.coventry.ac.uk/ame
[11]www.gov.uk/government/publications/post-16-skills-plan-and-independent-report-on-technical-education

Simplifying the skills issue

We therefore recommend:

- Greater focus and support for the IfA, who is responsible for all technical education in the UK, including up-skilling and the new T-level qualifications

- A 'digital catalyst' programme such as Autodesk's 'Fast Track' or the IfAME's apprenticeship scheme which connects skilled student experts with experienced engineers at SMEs to collaborate and drive innovation through the adoption of new technologies and workflows

- Revisiting the recommendations made in the EEF report 'Lifting the lid on the Levy'[12] and the recent skills paper by Cranfield University.[13] This would make the Apprenticeship Levy system easier to navigate and accommodate more up-skilling, T-levels and CPD

- Reviewing and uprating the current maximum funding bands to take account of the high cost of delivering a degree-level apprenticeship in advanced manufacturing and engineering, and encourage greater collaboration between employers, schools and universities in designing curricula and ensuring the skills that industry really needs are delivered

- Exploring other tax and financial incentives, such as the R&D tax credits to support Apprenticeships, up-skilling and CPD

[12]Lifting the Lid on the Levy: Making the Apprenticeship Levy work for Industry; EEF; 3 March 2017
www.eef.org.uk/resources-and-knowledge/research-and-intelligence/industry-reports/lifting-the-lid-on-the-levy-making-the-apprenticeship-levy-work-for-industry
[13]UK manufacturing skills shortage creates future industry concerns; 24 May 2017; Cranfield University; www.cranfield.ac.uk/press/news-2017/uk-manufacturing-skills-shortage-creates-future-industry-concerns

Connecting everyone

The Government has already taken significant steps towards improving digital connectivity across the country, noting in its March 2017 Connectivity Paper that improved connectivity leads to innovation, better productivity and brings 'significant economic rewards'. Therefore, the recent announcement to invest further in full fibre broadband and 5G are welcomed, particularly in light of the current position of the UK.

The Government and Ofcom committed in 2015 to introduce by 2020 a broadband Universal Service Obligation (USO), with the ambition to give people the legal right to request a connection to broadband with speeds of 10Mbps. But this ambition falls significantly behind other countries with whom the UK needs to compete. A report in August 2017 suggested that the UK's average broadband speed was just 16.5Mbps, placing it 31st in the world. Residents of Singapore enjoy speeds three times as fast at 55Mbps, while European competitors such as Germany, Denmark, the Netherlands, Latvia, Norway, Belgium, Spain, Sweden and Hungary all beat the UK for broadband speed, as do the United States, Canada and New Zealand[14].

We therefore support any acceleration of investments in the UK's digital infrastructure, such as the full fibre broadband trials announced recently, to bridge the connectivity gap that we face compared to competitor nations. It should be our ambition to make the UK the fastest, most connected nation by 2025. This should include:

· Financial support for companies and regions to upgrade their connections and connection speeds

· Developing some form of "Digital Connectivity" rating to promote the UK's investment in digital

Alongside this, it is crucial that businesses have faith in the security of their connectivity. The UK must lead with world-class cloud and cybersecurity systems to make it one of the safest countries in which to run a business. The Government's Cyber Essentials scheme is a great step in this direction, but uptake has been slow, as noted by GCHQ director Robert Hannigan in 2015.
To provide greater reassurance, the Government should consider:

· Better publicising the Cyber Essentials scheme to the public and business, to improve awareness and hence the value to companies of being accredited

· Offering free training to organisations via the LEP network on cyber security

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[14]Average UK broadband speed slower than most of Europe, report finds, The Guardian, 8th August 2017, www.theguardian.com/money/2017/aug/08/average-uk-broadband-speed-europe-germany-spain-singapore (accessed 24th August 2017)

Conclusion

> **"If we are to accelerate our journey to the Art of the Impossible, and truly lead this 4th Industrial Revolution, our misconceptions around productivity, design and manufacturing need to be addressed through the principle of 'show, not tell'."**

Based on a future readiness assessment[15] conducted by Autodesk, business leaders feel unable to move forward with digitisation due to a lack of up-to-date design and manufacturing capabilities, and more worryingly, are too busy to find out what's realistically possible. They therefore remain unaware of the possibilities or worse still, assume their challenge is impossible to solve, creating a significant barrier to progress.

Our experience, some of which is referenced previously, shows the reality to be very different. Many of the productivity and innovation challenges the UK faces can be significantly impacted by better use of digital technologies that exist today, much earlier in their value chain, to create opportunity and add value, plus the integration of smart design and manufacturing as one discipline.

If we are to accelerate our journey to the Art of the Impossible, and truly lead this 4th Industrial Revolution, our misconceptions around productivity, design and manufacturing need to be addressed through the principle of 'show, not tell'.

We must therefore begin by inspiring business owners and leaders through effective demonstration of value, which we believe will prove to business owners that many of the challenges they face are far easier to resolve than first thought. The remainder will either require some help from the network of digital support organisations, or could form the basis of research and development projects. But we see the entry point clearly being a demonstrator as follows:

National Demonstrators

Support Organisations

Research & Development Institutes

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[15]Future of making Things Readiness Assessment – Autodesk fomt.autodesk.co.uk

There are numerous organisations in the UK designed to connect industry to the support they need, such as Research Councils, Catapult Centres, and well-established trade bodies such as EEF. They do tremendous work but often operate under different business models, and in some cases, overlap with one another. This landscape can be confusing and even demotivating for the SME sector, which is where we feel growth potential for UK design and manufacturing lies. Connecting these organisations together through a clearer and simpler engagement model, which begins with a demonstrator would strengthen their ability to engage with SME's in greater volume.

We strongly believe the feedback set out in this paper would create an environment for UK design and manufacturing companies to explore the Art of the Impossible, identify the most appropriate technologies and implement them at a rapid pace.

We therefore welcome a conversation with BEIS, the MSR board and the wider design and manufacturing industry in the UK about the views expressed in this document.

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How Britain can lead the 4th Industrial Revolution