

RACONTEUR

Future of Industrial Machinery Manufacturing





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.

Autodesk is leading the way to the future of making, allowing manufacturers to meet growing market demands by delivering better products faster, at lower cost and with less waste. With a comprehensive design and manufacturing portfolio, Autodesk provides advanced technology that automates and connects workflows for end-to-end product development.

As design and manufacturing converge, we equip companies with an integrated set of desktop and cloud-based tools that brings together everything from design, engineering and simulation to collaboration, CAM, additive manufacturing and factory floor management. This unified platform breaks down the silos between disciplines, enabling more agile work among engineering teams and empowering manufacturers to become more competitive.

To find out more visit autodesk.com/fom

RACONTEUR

Publication sponsored by



Publisher Flavia Brown

Project manager Georgie Cauthery

Editor Peter Archer

Designers Elisabetta Calabritto, Grant Chapman, Celina Lucey

Head of production Justyna O'Connell

Digital marketing manager Kyri Rousou

Contributors

Rich McEachran

Freelance journalist and copywriter, covering start-ups, technology and innovation. His work has appeared in *The Guardian*, *The Telegraph* and *Professional Engineering* magazine.

Ben Rossi

Formerly editorial director at *Vitesse Media* and editor of *Information Age* and *Computer News Middle East*, he writes for national newspapers and business publications.

Contents

This report explores how industrial machinery manufacturers can harness the convergence of design and manufacturing, to unlock new levels of creativity and gain a competitive edge

04

Future of product design
How manufacturers are unlocking new possibilities

06

Digitising your workforce
Preparing your talent for Industry 4.0

08

How manufacturers can achieve built-in agility
Adapting operating models for better CX

10

Upskilling to fill the manufacturing skills gap
Could the solution lie in your existing workforce?

12

Automating to upskill your workforce
The opportunities created by automation

14

Servitisation gives manufacturers breathing space to grow
New revenue streams to drive growth

DESIGN

Future of product design

Whether it's drilling equipment on a construction site, combine harvesters gathering crops or an offshore turbine harvesting wind energy, gearboxes are the important component that helps deliver torque and increases the rotational speed of industrial machinery

Rich McEachran

The more precisely designed a gearbox is, the greater its operational efficiency and the better it will perform.

Thanks to Industry 4.0 and the technological advances that this digital transformation has brought with it, the designing and manufacturing of gearboxes and other machinery parts can now be improved by digital twinning. The process involves mapping a physical asset to a digital platform and using sensors to monitor the efficiency, condition and real-time status of the asset.

In turn, this can inform manufacturers on what design decisions to take, enhancing future product development and extending product life cycle of existing products.

"Digital twinning promotes many things, but one of the most important is collaboration," says Ben Salama, industry X.0 lead for UK and Ireland at Accenture.

"Manufacturers can now simulate the behaviour of components, while co-ordination with engineers means designers can improve production and streamline work processes. They can collaborate, regardless of location, to find the small things that have a big impact. And as a result, savings in production costs, lower maintenance on more



durable products and higher customer satisfaction are likely to follow."

Optimising design of assets' life cycle

Industries heavily reliant on equipment and machinery require assets to be able to work at full capacity and, sometimes, around the clock; any faults or breakdowns can affect operational output and quality. Through digital twinning, manufacturers can both tweak designs and monitor assets so they can predict when any parts, such as the gearbox, might need replacing. Thus, engineers

can carry out proactive, rather than reactive, repair work.

Norway-based DNV GL, a world-leading energy certification body, has recently developed WindGEMINI. The wind turbine digital twin analyses vast amounts of data to provide prognostic analytics and remaining life estimates of both the turbine as a whole and its various components.

“The advantage of the data gathered is two-fold,” says Francesco Vanni, head of WindGEMINI. “Firstly, it allows operators of wind farms to make informed operating decisions and optimise their fleet.

“Secondly, as the information from a digital twin can be fed back into a turbine’s operational strategy, it can then feed directly into the design process of new wind turbine types. The development process can take into account the optimal operation and the design objectives can shift from individual targets, such as the amount of energy to be captured in a given period, to optimising the overall cost of energy throughout the life cycle of the turbine.”



Through digital twinning, manufacturers can both tweak designs and monitor assets so they can predict when any parts, such as the gearbox, might need replacing

Importance of parts management

The cost of maintaining and replacing components of large industrial machinery, and the operational losses associated with the inevitable downtime, can be compounded by delays in acquiring the spare parts needed.

A key part of future product design will be servicing and parts management. According to Andrew Edman, industry manager for product design, engineering and manufacturing at Formlabs, digital twinning may be able to accelerate prototyping and cut lead times, but it won't be able to bridge the physical-digital divide unless it's used in conjunction with responsive and intuitive fabrication technologies.

“Additive manufacturing enables manufacturers and front-line assembly workers to provide feedback on the ergonomics of a component and then have an improved 3D-printed part in service the same or next day,” says Mr Edman. “The time saved in delivering a component to a customer means manufacturers can respond to emerging trends and customer needs more quickly.”

What this also means is that manufacturers can continuously introduce incremental improvements to the design of assets, based on the information fed back to them by the digital twin, and address any issues in the process at speed.

With increasing competition, especially from companies in Asia that can manufacture at a much lower cost, manufacturers in the UK, Europe and United States need to be able to get products to market quickly. Digital twinning enables them to do this, while tailoring products to specific requirements and achieving competitive differentiation. ●



Digitising your workforce

Manufacturing is on the cusp of a revolution that will be vital for its future success

Rich McEachran

To take advantage of the opportunities the fourth industrial revolution (4IR) presents, manufacturers will need to ensure their future workforce has the skills and expertise required.

The problem is many younger workers may view manufacturing as a dying industry that is low paid, offers little career progression and they may be put off from entering it.

Despite the negative impression some may hold, the sector can actually offer an abundance of opportunities.

"Manufacturing needs a rebrand. The future of the sector is dependent on getting the younger generation engaged at an earlier stage," says Alan Sheppard, managing director

of LCA Group, which manufactures control panel boxes for various sectors, including the pharmaceutical and nuclear industries.

"Young people are full of ideas on how to do things differently and much more open to change by embracing new technology."

LCA Group is currently preparing its own workforce for the digitisation and automation of manufacturing.

Young people's appetite for digital and their tech-savvy skills, compared with previous generations, are clearly needed. A study by Deloitte and the Manufacturing Institute found that 4.6 million new jobs will be created in the United States alone by 2028 through digitisation and automation. Yet, as it stands, 2.4 million of these jobs will go unfilled because of a skills shortage.

"We, as a sector, need to raise the profile and image of engineering and manufacturing, and companies need to step up and make them accessible," says Mr Sheppard. "We've almost become scared of taking on school-leavers and apprentices, but to safeguard the sector's future, we need to demonstrate the many career opportunities that can branch out from manufacturing."

Staying ahead of the curve

As 4IR helps the sector to become more connected, manufacturers will be able to use technology to be more efficient and speed up production by connecting the design and manufacture of machinery, allowing product development data to flow seamlessly up and down the process.



Claudius Peters

Key takeaways

The fourth industrial revolution (4IR) will mean the digitisation of manufacturing supply chains, connecting design and manufacturing workflows, and speeding up product development.

Data captured can be fed back to business dashboards and tools, where it can be analysed and used to make informed decisions on manufacturing strategies.

Software will be able to support manufacturers to design more efficiently. For example, by working with Autodesk and using generative design, Claudius Peters has made part of its clinker coolers 30 to 40 per cent lighter and at a reduced cost, with savings of €100 (\$123/£97) per part.

To make sense of the data flowing from the various technologies, however, manufacturers need to ensure their workforce has the relevant technical skills and expertise.

Young people are digitally savvy and can help the manufacturing sector take advantage of the opportunities 4IR presents.



Young people are digitally savvy and can help the manufacturing sector take advantage of the opportunities 4IR presents

A success story is Claudius Peters, which manufactures heavy equipment for cement and coal plants, and is headquartered near Hamburg in Germany. With the help of technology partners, such as Autodesk, the company has been able to connect and optimise processes across its departments, and capture data to make better decisions faster.

It has also turned to generative design to reduce material usage when designing and manufacturing its clinker cooler, a machine that cools down molten rock.

According to Thomas Nagel, Claudius Peters' operations director and chief digital officer, the long-established business needed to embrace digitisation to remain competitive.

To stay ahead of the curve, the company has also been looking to utilise the ingenuity of younger workers, particularly graduates, by partnering with technical universities in the region. "Interns can be change agents," says Mr Nagel.

With digitisation enabling manufacturing operations to be integrated with intelligent systems, there is a continuous and seamless flow of data that needs to be analysed to glean insights and then used to make strategic decisions.

Young people entering the workforce are digital natives and well suited to apply appropriate analytical techniques to work through this real-time data. Thus they can support manufacturers in becoming more productive and efficient. ●



Young people are full of ideas on how to do things differently and much more open to change by embracing new technology

PERSONALISATION

How manufacturers can achieve built-in agility

Customers are demanding a personalised experience, but traditional operating models make it difficult and costly to scale production of such products, so with new technologies available, manufacturers must bake more agility into their business

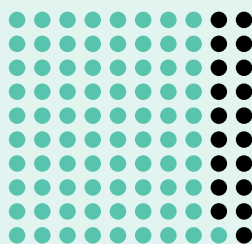
Ben Rossi

Agility has always been important, but has never been higher up the agenda for manufacturers. Consumers no longer accept that a product will be available soon. Customer expectations have changed and consumers want to feel they can have what they want, when they want it and in the format they expect.

Successful manufacturers understand the need for a good customer experience, but they risk losing this as they develop. The trouble is many evolve to be big more than they evolve to be smart. The result is a system constrained by immense supply chains and distribution networks, as well as fixed equipment and personnel costs that necessitate large production minimums. The transition from prototype to full scale in traditional manufacturing is a costly commitment and refinements are difficult to make.

Manufacturers are also held back by legacy systems and organisational structures. Many are countering this by building in agility through small, autonomous functions which they can swap out and replace as needed, making them leaner and more flexible by optimising the end-to-end orchestration of the business and individual functions.

“There are new ways to engage the customer, particularly when there is a complex supply chain between the manufacturer and



81%

of organisations
expect to compete
based mainly on
CX in 2019

Gartner, 2019

the customer,” says Graeme Wright, UK and Ireland chief technology officer for manufacturing at Fujitsu. “But having the right infrastructure to be agile and implement new ways of working is the key to delivering on this engagement.”

3D printing

Meanwhile, traditional norms around production minimums, supply chains and time to market are being upended by new additive manufacturing capabilities. “How products are conceived and designed can now link almost seamlessly with an individual customer experience, with hundreds of thousands of components produced every day to different customer specifications,” says George Brasher, UK and Ireland managing director at HP.

Long gone are the days of just mass products; companies offering a more personalised customer experience are growing faster and achieving greater profitability. This level of diversity, agility and specificity in manufacturing is unprecedented and the line between prototyping and full-scale production is becoming less distinct. The design process can now be seamlessly integrated rather than precede a long procurement and manufacturing process, allowing companies confidently to modify production at scale.

Increasing return on investment will require a renewed focus among manufacturers on



Westend61/Getty Images

improving customer satisfaction, reducing churn and increasing brand loyalty. Failing to respond to market changes, by not adapting fast enough if a competitor introduces a more popular variation of a product, for example, is sure to lose customers.

Incremental changes

To build agility into their existing business models, manufacturers need to focus on promoting incremental changes, whether on a brownfield production line, physical plant or around supervising IT and operational technology systems. Responding quickly to changing demands requires production lines that can be configured rapidly.

“The simplest way to do this is by introducing flexible robots on existing lines rather than fixed machines, changing manual adjusters, deploying smart sensors on to lines, and introducing manufacturing execution and manufacturing operations management



Those that survive and thrive in the future of manufacturing won't be the largest, the fastest or the strongest, they'll be the organisations that adapted best to change

systems,” says Martin Walder, vice president of industry at Schneider Electric.

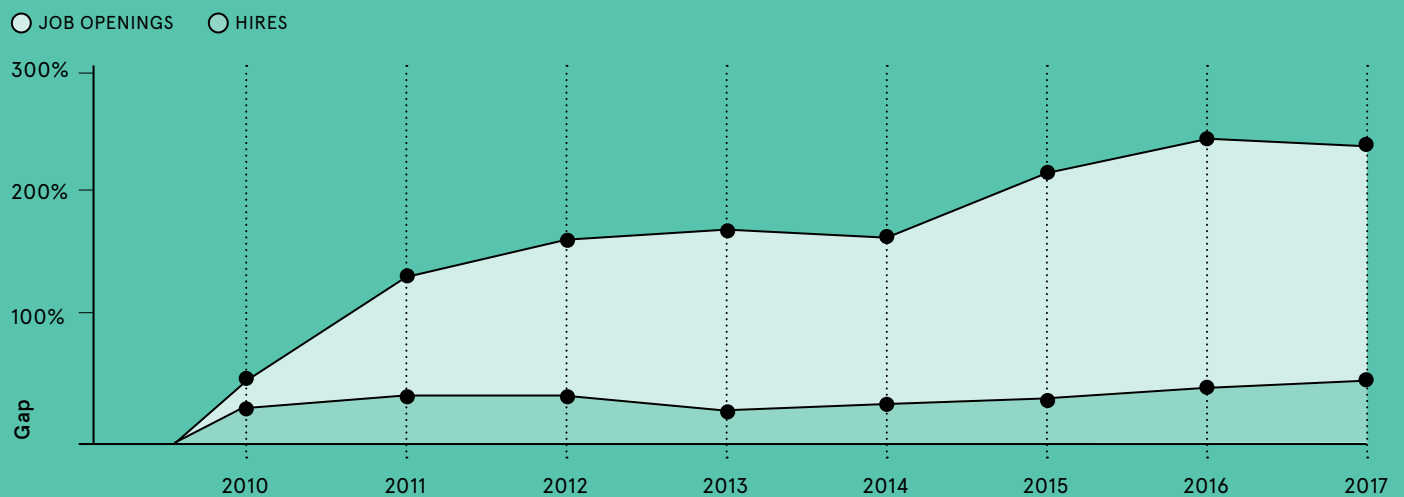
Agility has always been a differentiator in the manufacturing sector and that will only become more apparent as technology continues to move and evolve at a rapid pace. Those that survive and thrive in the future of manufacturing won't be the largest, the fastest or the strongest, they'll be the organisations that adapted best to change. ●

UPSKILLING TO FILL THE MANUFACTURING SKILLS GAP

Despite a widely reported manufacturing skills gap, the answer may lie in the existing workforce

① THE MANUFACTURING SKILLS OUTLOOK MAY SEEM BLEAK...

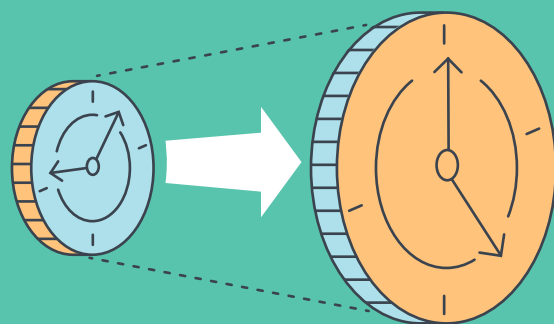
Growing shortage of skilled manufacturing workers



Microsoft, 2019

② ...WITH MANUFACTURING JOBS REMAINING UNFILLED FOR LONGER

Average time to fill an open manufacturing job



70 days
2015

93 days
2018

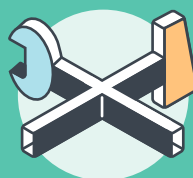
Deloitte/Manufacturing Institute, 2018



2.69m

manufacturing jobs left open from retirements

Deloitte/Manufacturing Institute, 2018



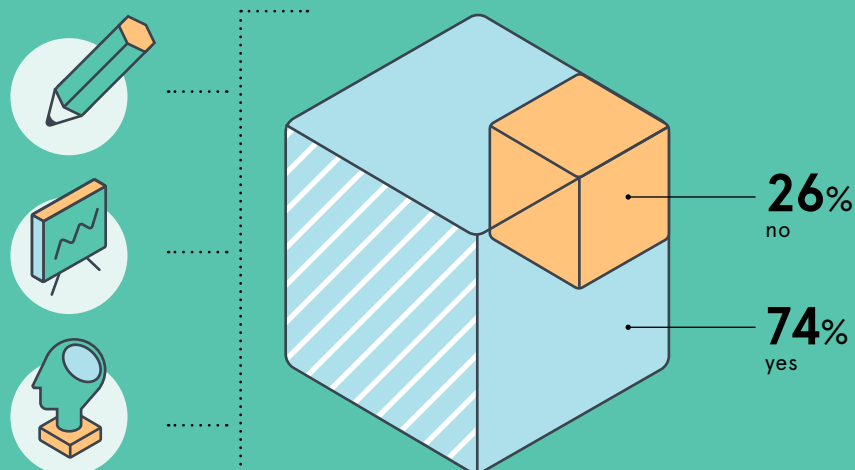
1.96m

additional workers may be needed from 2017 to 2028 to meet the growing consumer goods demand

Deloitte/Manufacturing Institute, 2018

3 HOWEVER, THE MISSING TALENT MAY LIE IN BUSINESSES' CURRENT HUMAN CAPITAL, WITH THE MAJORITY OF MANUFACTURING EMPLOYEES WILLING TO ENHANCE THEIR SKILLSETS

Employees ready to learn new skills or completely retrain to remain employable



PwC, 2018



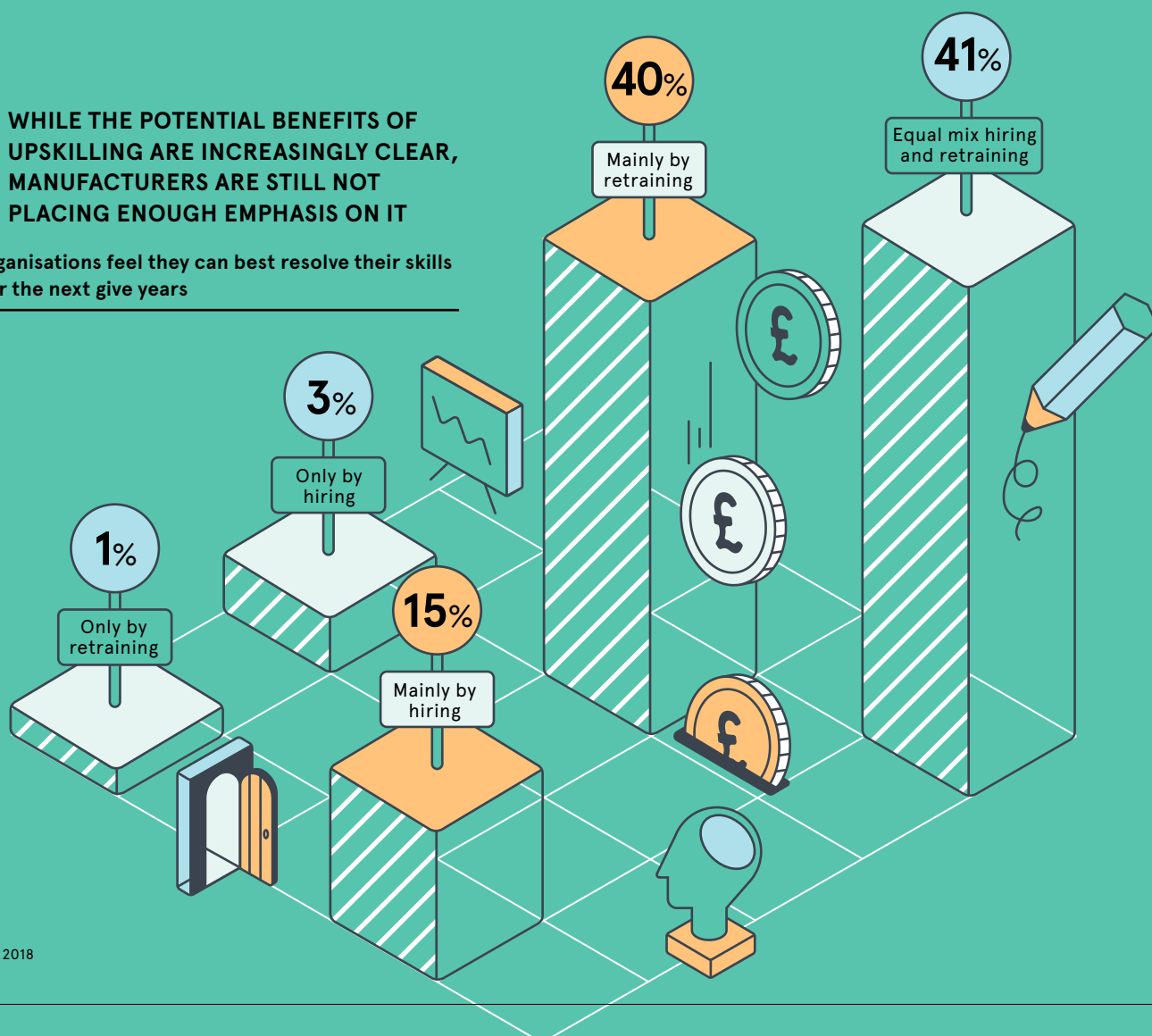
83%

of hiring costs can be saved by reskilling internal hires

Deloitte, 2018

4 WHILE THE POTENTIAL BENEFITS OF UPSKILLING ARE INCREASINGLY CLEAR, MANUFACTURERS ARE STILL NOT PLACING ENOUGH EMPHASIS ON IT

How organisations feel they can best resolve their skills gap over the next five years



McKinsey, 2018

TALENT

Automating to upskill your workforce

Armies of robots are taking over factories and manufacturing plants around the world, and workers are being displaced as a result, or so headlines and statistics would have us believe

Rich McEachran

Consultancy firm PwC estimates the UK's manufacturing sector could lose a quarter of its current jobs by 2035. Meanwhile, an often-cited study from Oxford University predicts 47 per cent of jobs in the United States could be lost within the next 20 to 25 years.

However, it's not all doom and gloom. As a 2017 white paper by global consultancy Cognizant highlighted, there may be some job losses, but the traditional ones that will remain will be enhanced by automation. There will be new roles created too.

According to Prasad Satyavolu, chief digital officer for manufacturing, logistics,

energy and utilities at Cognizant, automation presents endless opportunities. At the same time, its complexity will require manufacturers to equip their workforce with the skills needed to integrate automation into their manufacturing operations seamlessly.

Mr Satyavolu gives the example of intelligent systems and a web of connected sensors that work in tandem with robotic programmes. To make sense of the various technologies and the data being generated, manufacturers will need access to a diverse pool of expertise and, as such, new roles are likely to include digital architects, systems integrators and strategic advisers.



Moving upstairs

While some of these roles will be designated for new hires with specific backgrounds, existing employees, who currently spend most of their time on the factory or manufacturing plant in a hands-on role, may find themselves moving upstairs. Rather than focusing their efforts on manual quality control and fixing faults, for example, automation will mean faults can be identified and prevented through advanced maintenance, leaving employees to focus more on data quality management and long-term strategic planning to achieve competitive differentiation.

“It will be crucial that manufacturers encourage continuous learning so workers know how to interact and work alongside intelligent machines, rather than fearing them,” says Mr Satyavolu.

Andrew Edman, industry manager for product design, engineering and manufacturing at Formlabs, adds that upskilling employees will be imperative if manufacturers are to take advantage of automation. It will also help them to become agile.

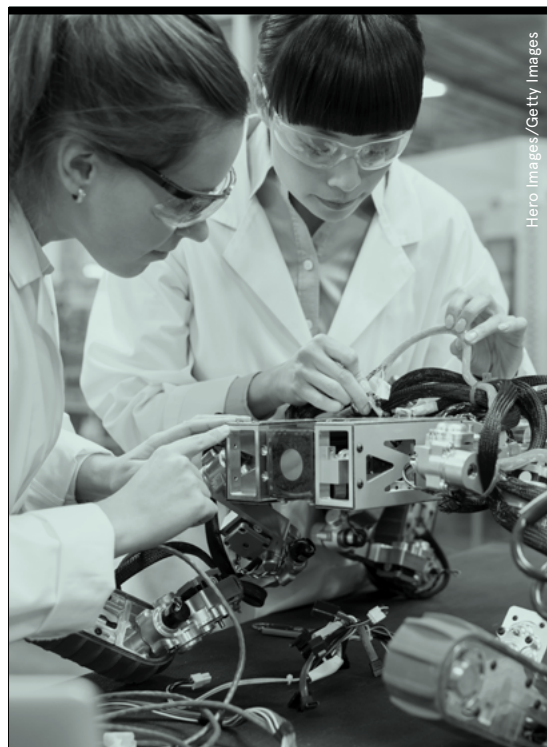
“When teams can access technology such as 3D printers, for instance, they can quickly iterate, test and gather feedback; it provides rapid product development cycles,” says Mr Edman. “What’s more, this feedback creates a repeatable framework that allows manufacturing teams to consistently build products that meet user needs.” ●



46%

of manufacturers are increasing training budgets to address the skills gap

Education Endowment Foundation, 2019



Hero Images/Getty Images

MxD

Complexity of automation will mean that a single manufacturer will no longer be able to meet the demands of an increasingly connected sector on its own. It will have to look beyond the traditional ways of doing things and pool cross-sector expertise, including from academic research.

MxD, previously known as the Digital Manufacturing and Design Innovation Institute, has put together a blueprint, *The Digital Manufacturing and Design Jobs Taxonomy and Success Profiles*, to help manufacturers in their hiring choices. Ultimately, by defining the roles they should be creating, MxD hopes it can help the sector fill any skills gap and be automaton ready.

Research conducted by MxD identifies a broad set of 165 potential roles that will help bridge the current workforce and the type of employees manufacturers will need in the future to thrive. Among these roles, 20 were picked out as success profiles, the main roles that manufacturers should be training and upskilling their staff for.

These profiles include digital-twin architect, machine-learning specialist, predictive-maintenance system specialist and manufacturing cybersecurity strategist.

“

Rather than focusing their efforts on manual quality control and fixing faults, automation will mean faults can be identified and prevented through advanced maintenance, leaving employees to focus more on data quality management and long-term strategic planning

COMPETITIVE ADVANTAGE

Servitisation gives manufacturers breathing space to grow

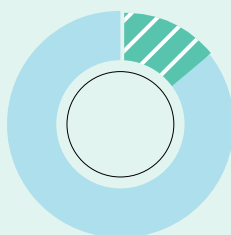
With margins being squeezed in a challenging business environment, servitisation is providing much-needed relief to manufacturers as a model that enables them to design efficiencies into their supply chain and drive growth with new revenue streams

Ben Rossi

Offering value-added services alongside traditional products, known as servitisation, has helped manufacturers produce new revenue streams, slash costs, boost customer relationships and move ahead of competitors. It now makes up 14 per cent of Apple's revenue and more than half at Rolls-Royce. Boeing is looking to grow its services revenue from \$8 billion to \$50 billion in the next decade and in some cases servitisation programmes have evolved into entirely new companies, such as General Electric's launch of GE Digital.

The concept of value-added services is hardly new, but technology advances have multiplied the servitisation opportunity. In the aerospace sector, manufacturers are using the internet of things to add predictive maintenance capabilities. Chemicals companies are deploying consumption-driven replenishment and supply planning, and energy firms are developing managed asset maintenance programmes based on huge volumes of data.

It's not just technology that is driving this trend. Customers are hungry for service-oriented solutions, and servitisation provides a way for manufacturers to deliver differentiation from competitors with new services that address their specific pain points, while also reducing costs, lowering lead times and enabling better flexibility and responsiveness.



14%

of Apple's revenue
is made up by
servitisation

Apple, 2018

Relational mindset

"Manufacturers need to move from a transactional focus to a more relational mindset," says Rafi Billurcu, who leads Infosys Consulting's manufacturing practice in Europe. "This will require continuous nurturing of customer relationships, which itself may entail a shift in culture and organisation. For example, manufacturers need to ensure they have call centres and other customer touchpoints in place, make the necessary adjustments to information systems, accounting practices, and risk and compliance requirements."

Design and manufacturing processes are increasingly converging as manufacturers seek new efficiencies in their supply chain that help enable the best servitisation experience and allow them to build a longer-term relationship with their customers. End-users are more likely to develop a higher degree of trust with manufacturers that consistently provide a great quality of service, which discourages them from looking to the competition.

Servitisation is a gradual and incremental process. Many start with an aftermarket spares-and-repairs parts service before adding break-fix repair services, where they reactively deliver services. Eventually, they add annual maintenance contracts, which increases the amount of revenue flowing from each initial sale. To sell a profitable maintenance contract, the manufacturer has to know what the cost of maintaining the product or



asset will be, so it is only a minor step to then selling the entire life cycle as a service.

Higher margins

This has made manufacturing a higher-margin business and enabled manufacturers to focus more on the outcome they are working towards with their customers, rather than simply exchanging money for a product. The design of a product can also influence what it will cost to service it over its life cycle, which means industries with aftermarket service revenue streams are putting more thought into serviceability and reliability in product design.

“Servitisation will make it easier for customers to purchase products and assets in both consumer and industrial settings,” says Antony Bourne, global industry director for industrial manufacturing at IFS.

“It will also help manufacturers differentiate themselves on the ability to help their customers reach their goals and intended outcomes. If one manufacturer sells only the product and another sells through servitisation, the servitised manufacturer will present



Servitisation is the new competitive battleground on which manufacturers win or lose their reputation

a lower risk profile. Manufacturers will be able to sell based on their base of satisfied customers and the real-time performance of established equipment.”

Servitisation is the new competitive battleground on which manufacturers win or lose their reputation. Those that make a success of it will be able to respond much faster to changing customer needs and will develop a greater understanding of how to deliver the value their customers crave. With customer expectations changing rapidly, gaining this kind of knowledge will be the difference between succeeding and failing in the years ahead. ●



RACONTEUR