Industry 4.0

AMERICAN CHAMBER of COMMERCE IRELAND

60TH ANNIVERSARY

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About the American Chamber

The American Chamber of Commerce Ireland (henceforth 'the American Chamber') is the leadership voice of US business in Ireland. Our mission is to strengthen the US-Ireland-EU business community through advocacy and networking with purpose.

American Chamber membership includes US companies operating from Ireland, Irish companies expanding in the US and organisations with strong bilateral links between Ireland and the US.

This year the American Chamber of Commerce Ireland celebrates sixty years since its foundation on January 9th, 1961. The American Chamber was established to encourage business linkages between the US and Ireland. Today the American Chamber is the leading international business organisations in Ireland and abroad, representing our member's views in Ireland, Brussels and Washington DC.

Throughout 2021 AmCham will be running a year-long programme to celebrate the global impact our members have had over the past six decades.

Executive Summary

The American Chamber warmly welcomed the publication by the Government of a National Strategy on Industry 4.0[1] in December 2019, and the Government recognition of the importance of advanced manufacturing for the future of the Irish economy and jobs. In response to the publication of the Strategy, the American Chamber developed an expert led taskforce with our members from across the manufacturing sector to analyse and understand how the strategy can ensure

> *'that by 2025 Ireland will be a competitive, innovation-driven manufacturing hub at the frontier of the fourth industrial revolution and at the forefront of Industry 4.0 development and adoption'*

The recommendations, as set out below, represent the views of the American Chamber on how Ireland can ensure that the advanced manufacturing sector continues to thrive in the years ahead. In particular, the American Chamber has made recommendations, with more detail set out in the paper, under the following four key themes:

1 – Ireland as a Global Leader

2 – Talent

3 – Governance & Coordination

4 – Funding

1 'Ireland's Industry 4.0 Strategy 2020-2025', Department of Enterprise, Trade & Employment (formely DBEI), found at https://enterprise.gov.ie/en/Publications/Publication-files/Irelands-Industry-4-Strategy-2020-2025.pdf

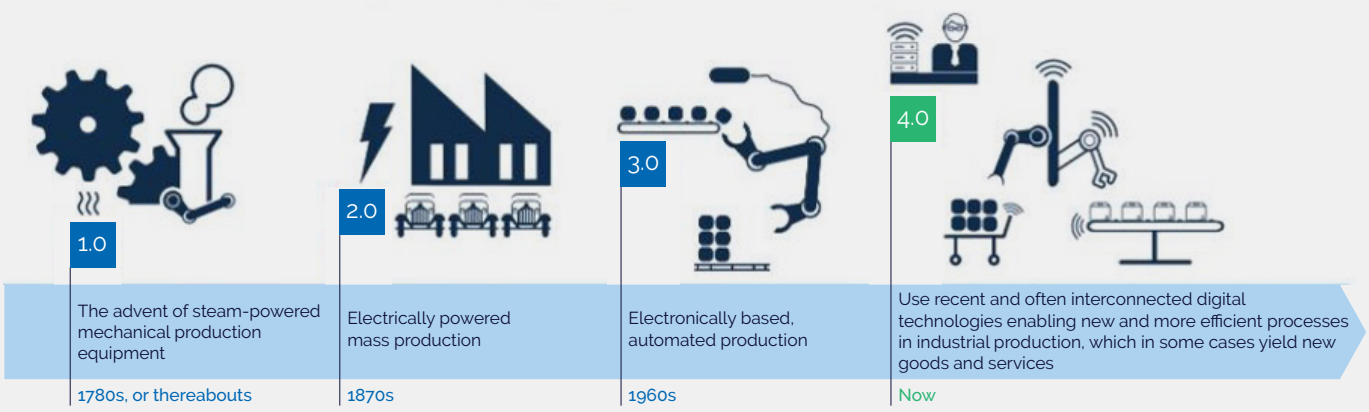
Industry 4.0 explainer

The manufacturing ecosystem is witnessing significant shifts in technology, customer needs and the competitive landscape. This shift is characterised and led by maturing and emerging digital technologies such as big data, artificial intelligence and autonomous robots or cobots, which has been coined the 'fourth industrial revolution' or 'Industry 4.0'. The fourth industrial revolution is the next set of significant steps in innovation for the manufacturing sector. Leveraging technologies such as Industrial Internet of Things (IIOT), Big Data Analytics, Artificial Intelligence, Simulation, Autonomous Robotics/Cobotics, Augmented/ Virtual Reality, 3D Printing and Cloud Computing. Like the three industrial revolutions that have come before it, this wave of industrialisation has dramatically changed the manufacturing process and the changes in each industrial revolution are demonstrated in the below diagram.

With cyber-physical systems[2] at its core, Industry 4.0 promises to have a disruptive impact on every business domain of future manufacturing organizations delivering breakthrough capabilities and efficiencies.

Figure 1.1 denotes the different stages of industrial revolutions[3]

INDUSTRIAL REVOLUTIONS & INDUSTRY 4.0



2 The integration of physical machines and IT

3 Sourced from OECD publication, 'The Next Production Revolution, Implications for Governments and Business', found at https://www.oecd.org/governance/the-next-production-revolution-9789264271036-en.htm

Context

The manufacturing sector is at the heart of the Irish economy, and it has proved its resilience both in the aftermath of the Global Financial Crisis, as well as more recently during the onset of the global covid-19 pandemic in 2020. In the face of a global health crisis, our manufacturing members kept essential supply chains going and in some instances those operating in the medical devices and pharma sector actually increased production.

The adoption of industry 4.0 technologies is gathering pace. The World Economic Forum (WEF) completed a study of 'Lighthouse' adopters of Industry 4.0[4] that scanned and assessed more than 1000 factories world-wide and concluded that the sixteen below represent leading lights in terms of aspects Industry 4.0 adoption.

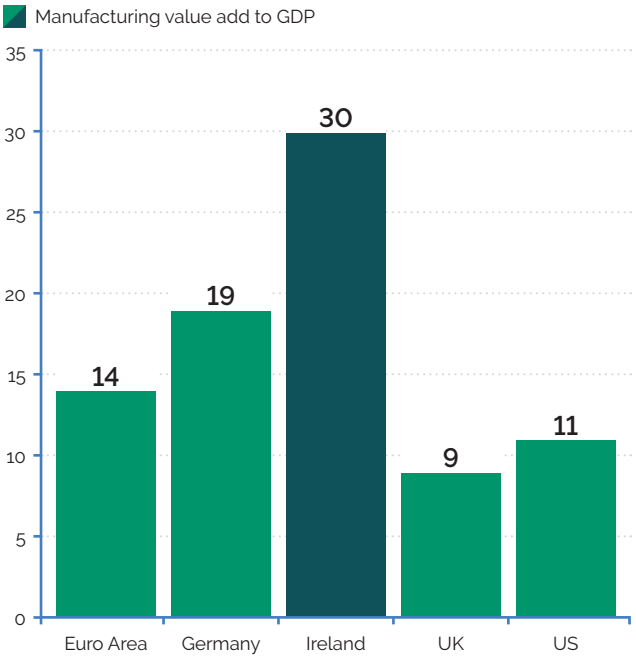
Figure 1.2: Leading lights 'Lighthouses' in Industry 4.0 adoption

4 'Fourth Industrial Revolution Beacons of Technology and Innovation in Manufacturing' World Economic Forum Report, January 2019, p9, found at http://www3.weforum.org/docs/WEF_4IR_Beacons_of_Technology_and_Innovation_in_Manufacturing_report_2019.pdf

The World Bank estimates that just over 30% of the GDP of Ireland is created by the manufacturing sector in Ireland. As a comparison, manufacturing within the German economy accounts for 19% of GDP, the UK 9%, the US 11% and the Euro area at 14%[5]. There is evidence of a reversal of outsourcing for manufacturing and supply chains towards a greater desire for insourcing, where goods are manufactured in the country or region that it serves. Industry 4.0 provides both threats and opportunities to all incumbent manufacturers.

American Chamber manufacturing members represent the broad sectoral and regional spread of manufacturing across Ireland. There is a substantial contribution to the manufacturing sector, both in terms of employment and investment in technologies, by the multinational manufacturing firms operating in Ireland. The manufacturing sector in Ireland employs 227,000 people with FDI companies creating 112,240 of these roles[6]. The IDA estimates that 67% of FDI investments in Ireland stem from North America[7].

Figure 1.3: World Bank Data



It is clear that Ireland punches above its weight for manufacturing, an Irish Government commissioned study[8] recognised this and our hosting of 'a disproportionate share of top global firms in a few manufacturing sectors (both process industries and product manufacturing), many of which have established globally strategic sites in Ireland'. The Government has advocated that Ireland 'must exploit and enhance cutting edge technological areas such as Artificial Intelligence, Augmented and Virtual Reality, Data Analytics, and the 'Internet of Things'[9]. Likewise the Government's Innovation 2020 strategy recognised priority themes and areas for 2018 to 2023 for innovation to be 'advanced and smart manufacturing'. [10] The American Chamber strongly agrees with these Government positions, and has assessed from an industry perspective how Ireland can bring all of this ambition together under one umbrella comprising industry, government and academia to achieve these targets.

Smart manufacturing or Industry 4.0 has the potential to transform the manufacturing sector globally and Irish operations have adapted through their talented innovative driven workforce ensuring that Ireland remains a global location of choice for advanced manufacturing operations. It is no accident that Ireland is in this position, instead it is the cumulative result of decades of work by both the government, industry and academia working together to mould Ireland into one of the most attractive global locations for FDI, however complacency at this critical junction will not ensure future success.

Manufacturing firms across Ireland are experiencing challenges, regardless of the stage of their Industry 4.0 journey, on developing and implementing new technologies. To ensure Ireland remains competitive, the American Chamber recommends that Ireland focus on the four key areas we have detailed in this paper: Ireland as a Global Leader, Talent, Funding and Governance & Coordination.

5 Figures obtained from World Bank data, 'Manufacturing, value added (% of GDP)', found at https://data.worldbank.org/indicator/NV.IND.MANF.ZS

6 16,700 firms are operating in the manufacturing sector in Ireland with 97% of these Irish owned, however the 3% of FDI firms operating represent half of the total employment figure of 227,000 jobs, outlined by 'Ireland's Industry 4.0 Strategy 2020-2025', p13, found at https://enterprise.gov.ie/en/Publications/Publication-files/Irelands-Industry-4-Strategy-2020-2025.pdf

7 IDA results for 2020, found at https://www.idaireland.com/newsroom/regional-investment-grew-as-foreign-direct-investm

8 'Study on digitalisation of the manufacturing sector and the policy implications for Ireland', Jan 2018, found at https://enterprise.gov.ie/en/Publications/Publication-files/Study-on-digitalisation-of-manufacturing-sector-and-policy-implications-Ireland.pdf

9 'Future Jobs Ireland 2019', Department of Enterprise, Trade & Employment (formerly DBEI) p1, found at https://enterprise.gov.ie/en/Publications/Publication-files/Future-Jobs-Ireland-2019.pdf

10 'Innovation 2020', Department of Enterprise, Trade & Employment (formerly DBEI), found at https://enterprise.gov.ie/en/Publications/Publication-files/Innovation-2020.pdf

Ireland as a Global Leader

The Government's National Strategy sets out the vision that by 2025:

> *'Ireland will be a competitive, innovation-driven manufacturing hub at the frontier of the fourth industrial revolution and at the forefront of Industry 4.0 development and adoption.'*[11]

The American Chamber wholly supports this statement, noting the positive news that this is not a vision but a reality already for many of our members and other firms in Ireland. Industry 4.0 is a journey with many firms operating at this level already while others are only beginning their transformation. As part of the collaboration process, the American Chamber outlines in Section 3, Governance & Coordination, how those firms that are ahead can share their experiences with others ensuring a system of best practices.

Many of our manufacturing members are already at the 'frontier' of Industry 4.0 and pivoted their business strategy and operations towards it, and as a result they are leaders in their respective areas. This leadership should be harnessed and in particular to help meet the goals[12] outlined by the strategy to stimulate firms to adopt and build capability in Industry 4,0, harness the opportunity it brings and to position Ireland to achieve its own target of being a global leader in R&D.

The Government sets out under Theme 5 of the National Strategy the 'Framework Conditions for Industry 4.0' and the American Chamber is supportive of both the strategic actions[13] outlined under this theme, including the development of standards and improving international connectedness. As part of our broader analysis of all the themes set out in the Strategy, the American Chamber notes that many of the themes are process focused and while this is welcomed, there is another important element to the framework conditions for Industry 4.0. In particular, we strongly encourage a focus on specific technologies that will set Irish based firms and Ireland apart from other competitor countries.

11 'Ireland's Industry 4.0 Strategy 2020-2025', Department of Enterprise, Trade & Employment (formerly DBEI) p5, found at https://enterprise.gov.ie/en/Publications/Publication-files/Irelands-Industry-4-Strategy-2020-2025.pdf

12 1. To stimulate firms to adopt and build capability in Industry 4.0 technologies. 2. To stimulate firms to harness the new opportunities enabled by Industry 4.0 technologies. 3. To become a global leader in RD&I which underpins Industry 4.0

13 'Ireland's Industry 4.0 Strategy 2020-2025', Department of Enterprise, Trade & Employment (formely DBEI) p11, found at https://enterprise.gov.ie/en/Publications/Publication-files/Irelands-Industry-4-Strategy-2020-2025.pdf

> 'As a small country, Ireland cannot be a leader in all areas of enterprise research and innovation. Instead, we need to target our investment in areas of opportunity that are strategically important areas that present particular market opportunities for us and where there is a pre-existing, proven combination of enterprise relevance and research strength in Ireland.'[14] Future Jobs Ireland

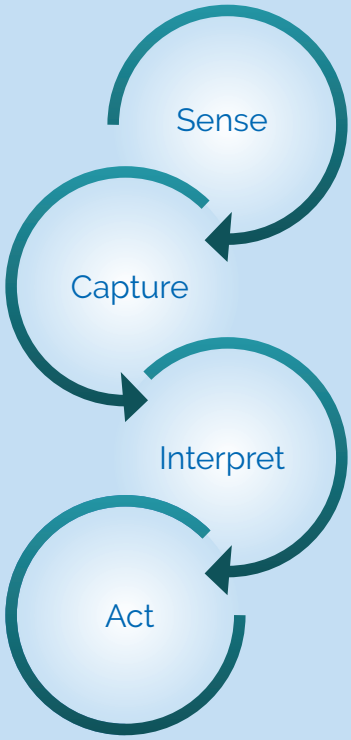
The Government recognises the importance of Ireland focusing on key areas as referenced in the above statement, we must apply this same method to Industry 4.0. Industry 4.0 covers a range of different technologies, an outline of which can be found below.

The American Chamber recommends that Ireland selects a smaller number of key technologies that are critical to the success of Industry 4.0 and which can be focused on by Government, industry and academia.[15] With finite resources, Ireland must maximize its impact to remain competitive on the global stage and ensure that it is a global leader in Industry 4.0. There are a large number of technologies that make up the advanced manufacturing sector, and while Ireland cannot be leaders in all of them, we can make strategic decisions to support the development and adaption of key technologies. The American Chamber has identified four key technologies that have the potential to position Ireland as a global leader, identified by experts from within industry, through the lens of industry impact and ease of cross industry collaboration.

Following four technologies:

1. Industrial Sensor & IIOT
2. System Integration & Big Data
3. Artificial Intelligence
4. Autonomous Robotics & Cobotics

... are interconnected through:



Industrial sensors and IIOT enable machines to **sense** its environment, System Integration and Big Data **capture** that data. Artificial Intelligence is used to **interpret** the data and make decisions. Autonomous robotics and cobotics execute and **act** on those decisions.

14 'Future Jobs Ireland 2019', Department of Enterprise, Trade & Employment (formerly DBEI) p23, found at https://enterprise.gov.ie/en/Publications/Publication-files/Future-Jobs-Ireland-2019.pdf

Industrial Sensor & IIOT

Explainer

Connected sensors are the foundation for advanced manufacturing processes. They are widely used across manufacturing, including in process industries, pharmaceutical and discrete manufacturing. Practically, sensors are used on the manufacturing floor to measure a raft of critical parameters such as pressure, temperature, current, vibration, etc. Industrial sensors or 'sense' is the first step in creating valuable insights for firms as it enables critical data to be sensed and then collected.

As shown in the below use case, adopting sense is the first step for advanced manufacturers, and it is a prerequisite for firms who are seeking to become leaders in Artificial Intelligence, Big Data or Robots/Cobots. Without these sensors in place, firms cannot generate the relevant data that are needed for AI or Robotics. These sensors aid the manufacturing process as they can act as a quality control or monitor equipment, and if this data can be made usable it can ultimately provides insights to firms on how to improve efficiency within the manufacturing process.

However, it is not just about the sensors, firms also need to develop a network of data, and this is where Industrial internet of things (IIOT) comes into play. IIOT is the use of the Internet of Things in an industrial setting, allowing the different sensors on a manufacturing floor to be connected and secured. It is only when this takes places that firms can then have system integrations in place and begin to garner insights from the sensors.

USE CASE

Johnson & Johnson, Analog Devices, Dell Technologies and Confirm SFI centre

Utilizing the mid-west ecosystem in Ireland with Johnson & Johnson's (J&J) Advanced Technology Center (ATC) and Analog Devices (ADI) Catalyst collaboration center we are building testbeds and prototypes to design new automation and industrial asset health systems that introduce more flexibility, quality control, and safety to manufacturing.

Analog Devices 3D Time of Flight Sensor

One technology being utilized with J&J in the Catalyst Center is Analog Devices (ADI) 3D Time of Flight (3D ToF). This breakthrough technology is a type of scannerless LIDAR (Light Detection and Ranging) which uses high-power optical pulses in durations of nanoseconds to capture depth information, typically over short distances from a scene of interest. ADI ToF utilizes a high accuracy sensor, which provides 4 times higher resolution than many of the ToF sensors on the market. This enables users to detect smaller and thinner objects that would be invisible to other ToF sensors.

For manufacturers of healthcare products like J&J, what this means in a practical sense is that instead of requiring a human to be able to safely operate at a minimum of 6 feet away from a cobot, they can now operate within 3 feet or less without sacrificing safety measures. Robots can work safely on their own, slow down when a human is near and stop completely when the human is in very close range. With 3D ToF in place, firms can create added trust in the human/robot relationship.

System Integration/Big Data

Explainer

System integration and big data is focused on capturing the information that firms have collected using their sensors. Sensors, as described previously, only become usable when system integration and big data can be utilised, capturing the information from sensors and then integrating it into manufacturing systems.

The term 'Big Data' is used regularly in commentary on the new digitalised world we are in and it is expected to take centre stage in the next decade[16], and already industry and government are preparing. The European Commission released their 'European Data Strategy[17]' in 2020, the aim of which will be to create a single market for data that will ensure Europe's global competitiveness and data sovereignty. The Commission also expects big data to increase the productivity of all sectors of the economy through improved business intelligence. The manufacturing sector is a clear example of one sector that has and will continue to improve innovation and productivity with the avalanche of big data becoming available and more importantly, usable. The World Economic Forum (WEF) has highlighted[18] some of the increased opportunities from data sharing such as increased productivity, enhanced customer experience and a positive impact on society and the environment.

With Ireland host to the most significant cloud computing providers in infrastructure, we must ensure that we can take advantage of it by making it usable for firms. The significant challenge on that front is connecting data from multiple sources and then bringing it together in a manner that allows firms to form insights that can be then used to take actions. The reason being is that current data is collected from multiple legacy systems that have been built and installed at different times, by different integrators, and from different suppliers.

To solve this, allowing the data to connect and become usable, firms require the requisite infrastructure. This infrastructure must enable both current and future equipment to deliver data in a manner that will be usable, in its simplest form we need a system that can bring the old and new world of data together. This is not an impossible feat, however it would be a significant undertaking, even for the most advanced and well-resourced firm, to attempt to build a bespoke system that is one-off and which can be difficult to maintain and expand. The cost alone is prohibitive and reduces the availability of firms in investing in other areas. **The American Chamber recommends that what is required to solve this ubiquitous issue for manufacturing firms is a coordinated effort led by Government across industry and academia to create and develop a use of standard for data sharing.**

The solution we are seeking, allowing for the connection of these data sources, is a perquisite for creating a process whereby data can deliver insights into plant operation not previously available. Without this in place, it is not possible to take advantage of big data and undertake the data analytics, prediction, artificial intelligence and machine learning, that offer the productivity and efficiency improvements required. Any solutions developed in this area would benefit the entire ecosystem, positively impacting both larger firms and smaller firms.

USE CASE

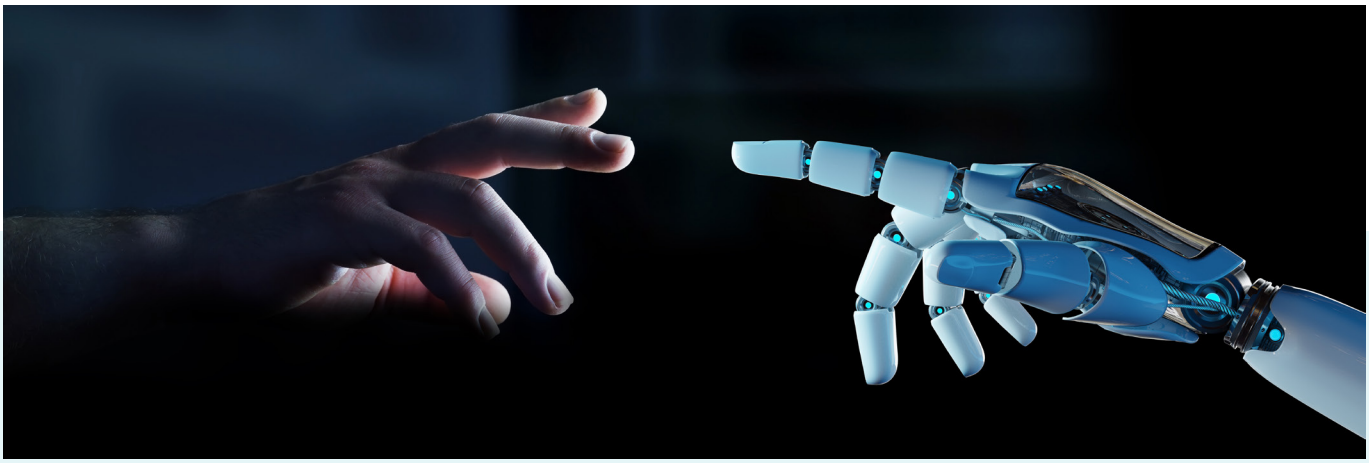
Intel Leixlip

A technician is pictured performing high precision preventative maintenance wearing augmented reality glasses which stream real time location based instructions and data to deliver the highest quality outcomes at a world class pace.

16 The European Commission predicts that by 2025, there will be a 530% increase of global data volume with the value of data economy in the EU 27 Member States estimated to be at €829 billion, found at 'Projected Figures', https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-data-strategy_en#projected-figures-2025

17 European Data Strategy, published by the European Commission, found at https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-data-strategy_en

18 Data Excellence: Transforming manufacturing and supply systems', WEF, found at http://www3.weforum.org/docs/WEF_Data_Excellence_Transforming_manufacturing_2021.pdf



Artificial Intelligence

Explainer

Sensors and big data are the precursor to intelligent decision making or artificial intelligence (AI).

> *'Artificial Intelligence, in its simplest definition, is the ability of a computer program or a machine to think and learn.*[19]'

The World Economic Forum has described how AI promises to be one on the most transformative and disruptive technologies of our times. More specifically, with meaningful data, AI enables better and more precise predictions.

> "The current wave of advances in artificial intelligence doesn't actually bring us intelligence but instead a critical component of intelligence: prediction[20]."

Prediction is a central input into decision making and in turn each is central to every step of a smart or cognitive manufacturing process and supply chain. AI or algorithms are better, faster and cheaper predictions for the millions of decisions that are made on a daily basis, answering questions such as: When should we take a tool for maintenance?, When will a part fail?, What is the fastest path for a product? What is the optimal operation point for a process?

Machine Learning and Deep learning are a critical subset of AI, and the use cases for Machine Learning in manufacturing are numerous particularly in the areas of process control, excursion prevention, inventory management among others, or indeed anywhere an empirical model can be created. Deep learning delivers near human level categorization on images and patterns for example. The key is that this can be repeatable and achieved at scale for applications such as defect classifications and pattern recognitions.

When AI predictions are integrated into a Manufacturing Execution System (MES), they can deliver transformative improvements in Key Performance Indicators (KPI) or even enable disruptive business strategies i.e. onshoring of manufacturing or mass individualization. While AI will radically reduce variation and lead to breakthroughs in manufacturing process control, these technologies also enable and elevate human capital to set new standards, innovate and deliver disruptive business models.

The government has committed to developing a National AI Strategy, and has also outlined that Ireland encourages the development of a Public-Private Partnership in AI, data and robotics that will harness the efforts of the private sector through R&I and co-investment.[21] The American Chamber looks forward to the launch of the paper which is an important step towards bringing a strategic focus on AI nationally.

19 'The 2020 World Manufacturing Report, Manufacturing in the age of artificial intelligence 2020', p11, found at https://worldmanufacturing.org/wp-content/uploads/WorldManufacturingForum2020_Report.pdf

20 'Prediction Machines: The Simple Economics of Artificial Intelligence', Agrawal, Gans, Goldfarb, HBR Press, 2018

21 'Ireland's National Submission to the Public Consultation on the EU White Paper on Artificial Intelligence', found at https://enterprise.gov.ie/en/Publications/Publication-files/National-Submission-EU-White-Paper-on-AI.pdf

Robots/Cobots/Autonomous Vehicles – the New Automation Horizon

Explainer

High levels of manufacturing automation and robotics have been costly, and as a result have remained a preserve of high volume and expensive manufacturing processes with robots encased in cages. With cost falling dramatically, technological advances and a new breed of robots termed 'Cobots' that are conscious of their surroundings in a manner that allows seamless collaboration with other robots and in particular with humans, there is the opportunity for all manufacturers to embrace the advantages of automation.

For advanced manufacturing, the ability of manufacturers to be as flexible and agile is crucial. The outdated example of a factory with equipment or machines that are designed to only produce the same product day after day with no room for adaption or customization is not the reality for manufacturers today. Instead, they need equipment and machines that are capable of adapting at speed to new product developments with automation as the drivers of this flexibility and repeatability. The development of Big Data and AI, as discussed above, has also laid the foundations for the decisions that are actioned by robots/cobots in a flexible and highly repeatable, precision environment. In other words, with the three previous technologies in place, firms can then automate and take action based on the insights derived from AI, big data and sensors.

Global pressures on competitiveness are ever increasing and this, combined with trends displaying aging demographics and skills shortage is a threat to manufacturing. The increased adoption by the leading economies in basic robotics is maintaining their ability to run factories and remain competitive. However, we need to prioritise automation to ensure that Ireland can remain a leader in this space. Manufacturers need to have access to leading edge automation that can be reconfigured quickly to produce multiple different products and free up labour for more value added activities.

USE CASE

Boston Scientific (Galway)

The Pack & Seal machine developed by Boston Scientific is an automated packaging machine for medical device products whose key features include automated handling, label inspection and seal inspection. The machine uses robotics and vision throughout to move a finished catheter into its pre-sterilisation packaging that has a fully inspected label applied. System database and Internet integrated for secure remote access and management. The module is integrated into the MES database for production control and enabling secure remote access and management.

Talent

The pace of technology is changing at a faster rate than ever before and as a result there is a demand for third level institutions and other training providers to be as flexible and versatile as possible to adapt to these changes. Third level institutions need to have the ability to change course material to meet industry needs and, in particular, there is an urgent need for 'Life Long Learning' and Continuing Professional Development education within the workforce to keep up with the rapidly changing environment. The American Chamber recognises the renewed focus on third level institutions, SFI and research centres and we look forward to sustained investment in these areas to ensure that we have readily available talent.

Upskilling of current workforce

In the coming years, the majority of today's employees will need to develop new skills through either upskilling or reskilling. Preparing for the future of work is one of the defining business challenges of our time. Continuous education through micro courses specifically designed to meet these needs will advance the opportunities for industry in Ireland. A broad approach at all levels of education from innovative and new apprenticeships in areas such as robotic technicians to PhDs on data analytics will be required.[22]

Understanding the combination of skills required for future roles, prioritising the most widely applicable skills and developing and deploying the infrastructure needed to reskill at scale will be crucial in sustaining Industry 4.0 into the future. Shifts in pathways towards economic growth are commonly reflected in changing demand for distinctive skill sets and professions. A combined Government and Industry approach to preparing for the workforce of the future will be a strategic advantage for Ireland as we embrace the opportunities that emerging professions will bring.

Increasing the attractiveness of apprenticeships

This paper has set out a number of recommendations that can set Ireland apart and make it a global leader in advanced manufacturing. However, firms in Ireland need to attract top class talent to ensure this happen. Ireland needs to focus on how it can attract the best talent for advanced manufacturing, in particular showcasing the significant opportunities in terms of skills that will be needed in AI and data analytics for example. These roles span from apprenticeship to PhD level with specific gaps identified at level 5 and 6 in the field of robotics, automation and equipment maintenance. These are roles set in a manufacturing environment with an IT component, and

22 A recent publication by MIDAS highlights some of the skills requirements that firms will need in the coming years including for AI, data analytics and machine learning. Electronics Sector Resources & Skills Needs, MIDAS Ireland, p26

firms in Ireland note that we do not have a national pipeline of talent in these areas, this contrasts with other mature manufacturing economies.

The American chamber recognises that apprenticeships have undergone significant change in recent years, as 'traditional' apprenticeships have also made way for apprenticeship is other sectors such as IT and financial services. The American Chamber recommends that there is a special focus put on advanced manufacturing within apprenticeship courses to help fill the skills gaps that will be there. Our members are already working with government agencies on this, but would welcome a national collaborative effort, such as a national communication strategy, which they would support with their expertise.

Flexibility on apprenticeship courses

The American Chamber recommends that the Government encourages and enables apprenticeship providers to be more versatile and ready to change course material to meet industries need for 'Lifelong Learning' and continuous CPD (Continuing Professional Development) within the workplace. In particular, the American Chamber supports the Government enabling agencies such as Solas to pivot and adapt apprenticeship courses in this area, nothing that some of our members are already working individually with Solas to tailor these courses. Pooling resources, and supporting Solas, to continue to upscale this work and role out adaptable apprenticeship courses nationally would be greatly beneficial. The American Chamber notes that Solas' new strategy outlines working on upskilling and reskilling on a sectoral basis and this would work for apprenticeships in manufacturing. As a final point, some apprenticeships courses in the financial sector are evolving on an annual basis, the American Chamber would support this method for apprenticeships in the manufacturing sector as well, recognising the rapid technology advancements the sector has to deal with.

Industry/academia partnerships

The SFI (Science Foundation of Ireland) Industry fellowship program is an excellent template for engagement between academia/research institutes and firms in Ireland. The 100% SFI funding of collaborative industry-academia research projects allows for placement of post-doc Fellowships in Industry with a duration of between 1 and 12 months if full-time, and between 2 and 24 months if part-time. The program stimulates excellence through knowledge exchange and training of engineers and scientists.

As an example, companies like Analog Devices (ADI) have used the program to engage experts in Chemistry, Piezo electrics, Polymers, Pharmaceutical, Industry 4.0, Electron Microscopy, Advanced Materials, Metallurgy and has led to two way benefits for industry and academia, with an increase in knowledge base for ADI, improved links to the research institutes/universities that have supplied the Fellows and also acts as a talent pool to hire new engineers. **The American Chamber recommends that this type of partnership is enabled across other research agencies to increase collaboration and aid the development of expertise for Industry 4.0.**

Governance & Coordination

Future Manufacturing Ireland (FMI)

The American Chamber welcomes the strategic action[23] outlined under Theme 1 of the National Strategy to establish a new coordination mechanism 'Future Manufacturing Ireland' (FMI) to ensure there is alignment across research centres in Ireland. **We recommend that this forum is established as quickly as possible to achieve this objective. Outlined below are recommendations on areas of coordination and alignment that FMI could cover.**

The American Chamber recognises the broad swath of expertise that colleagues in the research centres such as IMR, CONFIRM and I-Form have developed in their respective areas, and we welcome the development of the Advanced Manufacturing Centre (AMC) by the IDA. From an industry perspective, the research activities within these centres are of a high standard, the topics are relevant and most importantly, they are focused on practical application within industry.

Most notably, it is a key strength for Ireland that there is a strong overlap between industry and academia, many of the research personnel have years of relevant experience in industry, and bring a practical focus and established network to their roles. To utilise this expertise to the best of our ability we need to deepen the coordination and communication between our research centres.

Higher tier research

Within the research centres, **the American Chamber supports an increased focus on higher tier Research TRLs (technology readiness levels) closer to firms competitive needs,** which would aid companies in moving from Proof Of Concepts to process and systems for implementation. While industry recognises the value of primary research, there is also value in research that is short term and which industry can utilise and see the impact of immediately. Given research personnel are a strength with the research centres, the American Chamber also notes there may be an opportunity to broaden their remit. The current focus of staff is often on implementing Proof of Concept type work with individual partners, however there may be significant value add if these academic staff could potentially also act in a consulting role, helping companies collaborate in a pre-competitive fashion, or just understanding, and disseminating best practices. As collaboration, both public/private and within industry itself is critical to the success of Industry 4.0, assisting and directing companies on how to collaborate with each other in the eco system would be

23 Establish a new coordination mechanism - 'Future Manufacturing Ireland'

greatly beneficial. Given the breath of practical experience many of the academics possess, resolving "impediments to adoption" of more mature Industry 4.0 technologies could also be beneficial for firms. For example, better cross fertilization between the researchers developing Industry 4.0 approaches, and the Regulatory bodies (e.g. HPRA) that will approve their adoption would accelerate the "time to value" and provide a unique strategic advantage for Ireland.

Industry 4.0 accelerators

The American Chamber notes that there are some success stories in the area of accelerators, however these facilities can be costly to build and staff. One of the clear competitive advantages of Ireland in the area of Industry 4.0 is that with our higher than average levels of FDI, Ireland is home to a number of modern production facilities at various scales, across the country. **The American Chamber recommends that research centres focus more on partnering with Industry to demonstrate the practical application of Industry 4.0 in action on a real shopfloor rather than in bespoke research facilities.**

MNC/SME collaboration

MNC's can play a significant role in supporting SMEs in the development of their advanced manufacturing capabilities through various events such as Lighthouse tours, benchmarking, and providing access to internal resources for consultation and information purposes. The American Chamber fully supports initiatives in this area.

Funding

It is clear that funding processes have been designed to ensure meaningful industry participation and that the governance approaches have encouraged Irish research organisations to fully integrate into a wider ecosystem of research consortia across the EU. These are critical to the continued success of Industry 4.0 initiatives in Ireland.

The Industry 4.0 transformation we are witnessing now is a long term process and our funding calls and targeting of funding need to adapt to this. The rapid changes in market dynamics will drive technology change requirements at a quick pace, and support funding will be needed to match these quick developments in order to ensure companies can keep pace and continue to invest in this transformation. As such, **the American Chamber recommends that the Government to publish a roadmap of the long-term funding strategy for Industry 4.0.**

There is also room for optimisation in this space, specifically to ensure that the processes to establish funding can be simplified with a quicker turnaround time for firms. Time is of the essence for many of these firms who often need to move rapidly during the startup of a new facility or product. When processes are too complex for firms to navigate in a short space of time, they may pursue their project without academic involvement or funding, creating a lose lose situation for industry and the research centres who would otherwise be involved.

Increased coordination and communication between research centres in the area of funding should be a top priority, particularly on the various EU funding that is available and ensuring that Irish based firms can effectively tap into and draw down this funding. This is an activity that the Future Manufacturing Ireland (FMI) could coordinate and take responsibility for, ensuring that research centres do not compete against each other on funding calls but instead collaborate and broaden the amount of funding that is secured. This would ensure that there is one National Call Out to companies rather than research centres approaching firms independently.

The significant amount of funding available, particularly at an EU level, requires a holistic and coordinated approach nationally. Both Irish and European research funding opportunities come from multiple different organisations, this can be difficult for industry to navigate, in particular to understand:

- what funding is available to them and when,
- the differing application requirements,
- how to negotiate the terms and requirements behind these funding opportunities.

Information on Funding

The American Chamber highlights that many funding opportunities are usually initiated by universities and research funded centers approaching industry to seek their interest in funding calls. The American Chamber proposes that FMI develops a centralized platform for funding calls for sharing of information on the resources and calls that are available, with the overall to increase the uptake in funding for Industry 4.0. This would empower academia, SFI funded organizations, industry including multinationals and local SMEs, and other interested parties to identify opportunities and potential partners to build proposals that will benefit the entire ecosystem of Industry 4.0 research.

A key output for FMI should be to publish a funding bulletin identifying all available opportunities and requirements for industry and academia. The American Chamber cites the example of Enterprise Ireland in the area of cyber security, as part of the Irish Security Research Network (serenity) program. This communication discusses industry trends and research, and also identifies upcoming calls for potential collaboration between research and the private sector. Other areas of interest should be made readily available to industry and academia such as the number of projects accessing funded, progress being made using KPI's, success stories to promote advanced manufacturing capabilities, as well as feedback from key stakeholders

The overall coordination mechanism within FMI should also act as a support tool for Irish based firms on how to access domestic and EU funding, in tandem with developing a network of relationships between universities and technical colleges across the EU.

MNC collaboration on funding

The future of FDI in Ireland is centred on the development of industry specific clusters and eco-systems, within this, MNCs in Ireland are 'critical to Ireland's innovation performance' and 'embedded in the national innovation ecosystem'. To achieve these ecosystems, it is a prerequisite that Ireland must have in place funding mechanisms that allow MNCs to collaborate together. Under current funding structures this is not feasible for the majority of MNCs, despite the fact that they want to collaborate and innovate together. **The American Chamber recommends that funding mechanisms are established that allow MNCs the opportunity to collaborate together.**

Future Manufacturing Ireland

- FMI to coordinate funding calls between research centres to allow them to collaborate rather than compete
- FMI should develop a centralized platform for funding calls for sharing of information on the resources and calls that are available, with the overall to increase the uptake in funding for Industry 4.0.
- FMI should publish a funding bulletin for industry and academia
- FMI should also act a support tool for Irish based firms on how to access to domestic and EU funding

Summary of Recommendations

Ireland as a Global Leader

- The Government to select four key technologies, when viewed through the lens of impact and ease of cross industry collaboration, to be prioritised by Ireland:
    1. Industrial sensors & IIOT
    2. System Integration & Big Data
    3. Artificial Intelligence
    4. Robotics/Cobotics
- A coordinated effort led by Government across industry and academia to create and develop a use of standard for data sharing.

Talent

- Encourage education institutes to be more versatile and ready to change course material to meet industries need for 'Lifelong Learning' and continuous CPD (Continuing Professional Development) within the workplace.
- Develop and deliver Industry 4.0 apprentice certification in the domains of Robotics, IIIOT, Advanced Equipment Maintenance etc.
- Manufacturing apprenticeships should evolve on an annual basis to meet the needs of industry, similar to the process employed for apprenticeships in the financial sector
- Develop a communication strategy, alongside industry, to attract the best talent into manufacturing showcasing the innovation and impact it has on the world and Irelands role.
- SFI fellowship program should be replicated across other research agencies to increase collaboration and aid the development of expertise for Industry 4.0.

Governance & Coordination

- The proposed coordination mechanism FMI (Future Manufacturing Ireland) should be activated as quickly as possible.
- The activation of FMI and increased coordination across existing agencies could help to determine the specific areas of expertise of each research centre which would allow for greater collaboration and avoid unnecessary perceived competition between agencies.
- Research centres to focus on higher tier Research for technology readiness levels (TRLs) closer to firms competitive needs.
- Research centres to focus more on partnering with Industry to demonstrate the practical application of Industry 4.0 in action on a real shopfloor rather than in bespoke research facilities.

Funding

- It is important that the government publish the long-term overall funding strategy for the advanced manufacturing sector.
- Increased transparency and information on funding available to industry is required, which should include the creation of a centralized funding publication identifying all available opportunities as well as the development of a centralized platform which lists all available information on funding calls.
- The overall FMI coordination mechanism should act as a support tool for Irish based firms on how to access domestic and EU funding.
- The American Chamber recommends that funding mechanisms are established that allow MNCs the opportunity to collaborate together.

Conclusion

As the manufacturing sector continues to evolve with the advancements stemming from industry 4.0, Ireland needs to position itself as a global leader in research and innovation with the capabilities in technology and talent to continue to attract global investment. Although the manufacturing sector in Ireland is coming from a strong base, with many of the global leading firms establishing locations throughout the country, relentless innovation in Manufacturing is critical to remain competitive.

Ireland is a small country with finite resources, therefore we must select key technologies within industry 4.0 that we can position ourselves as global leaders in. The technologies which will allow the greatest collaboration and enable cross sector impact are Industrial Sensors & IIOT, System Integration and Big Data, Artificial Intelligence and automation via Robotic/Cobotics. In selecting these technologies, Ireland must also increase the level of coordination across our advanced manufacturing research centres and focus on industry specific needs. Likewise, our targets on funding must be ambitious and we must ensure that funding calls are easily accessible by both firms and academia to allow industry 4.0 to continue to flourish and keep Ireland ahead of our competitors. Finally, we need attract and grow a pipeline of talent to leverage Industry 4.0 technologies to ensure that Ireland is a world class manufacturing and technology leader.