

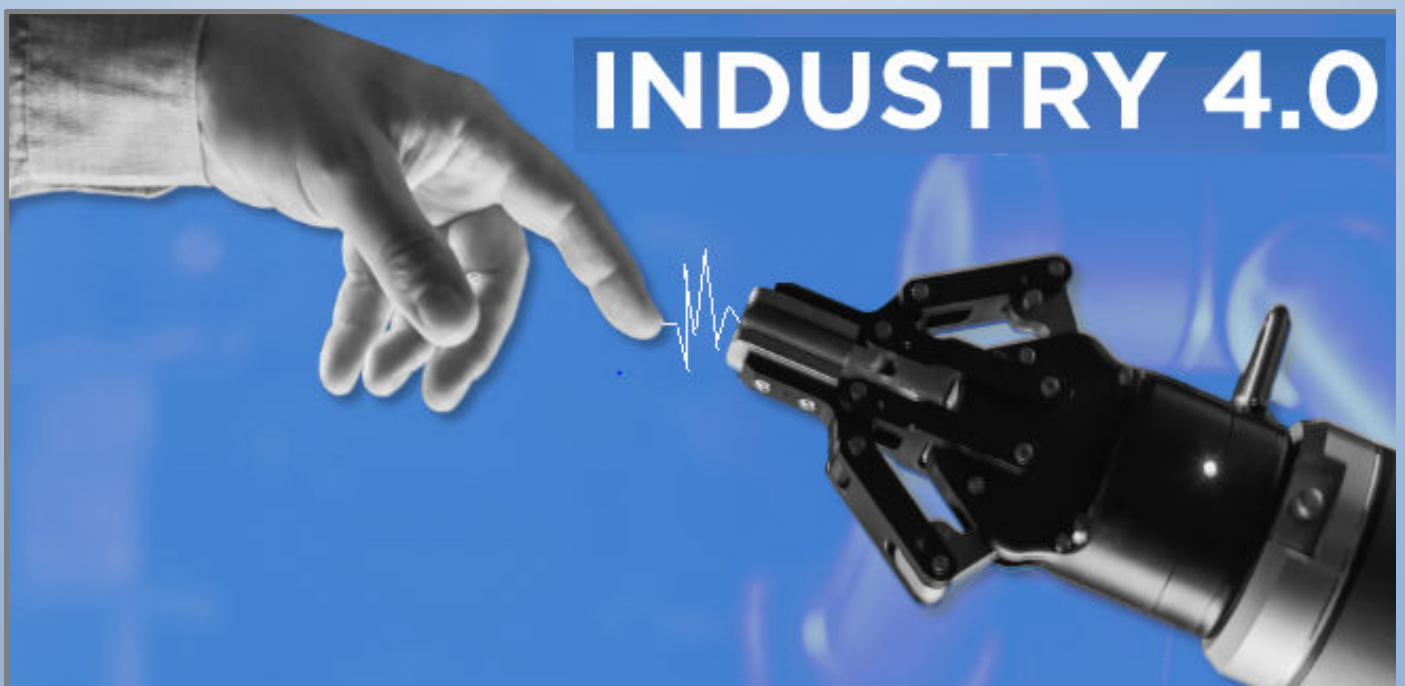
**ACPA7004 Introduction to
Industry 4.0**

**Assignment 2 - Introduction to
Industry 4.0 Essay**

**The challenges in
Implementing
Industry 4.0 within
SMEs in smaller
countries**

The obstacles faced by SMEs in smaller countries
when modernising their processes to suit 21st
Century business and smart manufacturing

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1:1 Introduction –

In most countries, the Small and Medium Enterprises (SMEs) form the very backbone of the economy, feeding into many other SMEs and OEMs alike. In the UK accounting for circa 50% of all exports.

Through the implementation of Innovations and Industry 4.0, companies can achieve improvement on many levels.

Innovation and Industry 4.0 strategies are quite similar in concept.

It can take the innovation lead or inspiration from one person or a group of persons to initiate the adoption of practices that come together as Smart Connected Manufacturing and logistics - Industry 4.0.

'Innovation doesn't just happen. It is driven by entrepreneurship.

This powerful mixture of energy, vision, passion, commitment, judgement and risk-taking provides the power behind the innovation process.' (Tidd & Beasant)

The innovation funnel can be applied to implementation of Industry 4.0.



SMEs and OEMs must recognise the advantages gained through Industry 4.0, its implementation and the ethos of smart connected manufacturing and logistics.

The SMEs have to realise that they may:

- Have out-dated slow and inefficient processes,
- Have hidden factory costs which means paying more than they would expect for an internal service,
- Be lacking in innovation with out-dated technologies and practices at its heart.
- Need to embrace a new 21st Century platform, that would benefit from a platform carrying 'big data' on the cloud for ease of access, rather than using existing practices on the cloud.

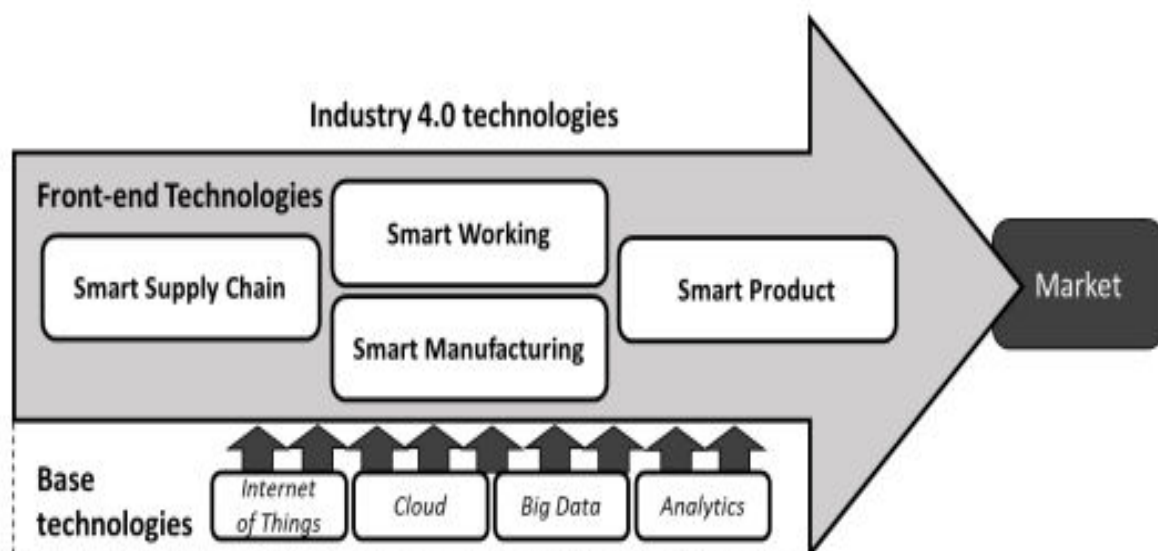
Satell can be utilised to map the definition and implementation of Industry 4.0 around:

1. Whether or not a problem is clearly defined (Having outdated, slow and inefficient processes, with customers paying more than you would expect, a lack of innovation with out-dated technologies and practices)
2. The market in which the issues exist (Suppliers and up-stream processes in the manufacturing sector)
3. The strategy and where to solve these problems (the right investment, the right people, the right skill sets).
4. Maintaining the innovation through investment & incremental change they should keep the technology up to date, further tech acquisitions will help maintain operational excellence and customer care.

It would come as no surprise that some OEMs are now stipulating a connective supply and logistics capability to add visibility from their direct suppliers to protect their own manufacturing processes from disruption and to avoid any costly delays or the upset and cost of arranging the provision of extra transport.

As technology becomes more readily accessible, this will become much more commonplace. The connectivity between linked Information Technology and manufacturing processes will ensure that information is shared as up-to-date data with monitoring and more importantly, corrective actions, should the need arise.

Front End and Base technologies both integrate into Industry 4.0.



Factors that must be considered and go into the provision for Industry 4.0 include:

- Early visibility to foresee planning on demand

Interaction with a manufacturing chain ensures full visibility across the entire supply stream.

- Capacity monitoring affecting availability
- Component logistics (on time and on budget)
- Smart planning to effectively employ sustainability
- Component delivery timing and complexity

Engineer to order (ETO)

Just in time (JIT)

- Planning to avoid bottlenecks and capacity issues.

Bulk buying of components and raw materials to avoid supply issues and price fluctuations.

- Visibility on how change could affect multiple projects
- Efficiency in manufacture

Batching, sequencing, integrated scheduling, maintenance, managing resources etc.

- Dynamic planning

Expecting the unexpected.

These aspects mentioned could come with opposing business and operational goals.

Tough decisions would have to be made by senior management and directors.

Those implementing Industry 4.0 must often overcome convention and social issues in the embracing of the message that there could be a 'better way to do what they do', through a new modern business model.

They must challenge convention and invest in both the digital and physical resources required to assist in turning their ideas into potentially game changing business practices.

Much of the technology required may be already possessed, but what might still be needed by the SME has to be considered and actioned in a planned manner to progress towards the end goal.

Smart Manufacturing technologies can be placed into 6 categories.

The technology required to facilitate Smart Manufacturing being stated under each category.

Vertical integration

- Sensors, actuators and Programmable Logic Controllers (PLC) - Jeschke et al. (2017); Lee et al. (2015)
- Supervisory Control and Data Acquisition (SCADA) - Jeschke et al. (2017)
- Manufacturing Execution System (MES) - Telukdarie et al. (2018); Jeschke et al. (2017)
- Enterprise Resource Planning (ERP) - Jeschke et al. (2017)
- Machine-to-machine communication (M2M) - Gilchrist (2016)

Virtualisation

- Virtual commissioning - Mortensen and Madsen (2018); Tao et al. (2018c)
- Simulation of processes (e.g. digital manufacturing) - Jeschke et al. (2017)
- Artificial Intelligence for predictive maintenance - Tao et al. (2018)
- Artificial Intelligence for planning of production - Gilchrist (2016)

Automation

- Machine-to-machine communication (M2M) - Gilchrist (2016)
- Robots (Industrial Robots, Autonomous Guided Vehicles, or similar) - Gilchrist (2016)
- Automatic nonconformity identification in production - Gilchrist (2016); Jeschke et al. (2017)

Traceability

- Identification and traceability of raw materials - Angeles (2009)
- Identification and traceability of final products

Flexibility

- Additive manufacturing - Weller et al. (2015); D'Aveni (2015)
- Flexible and autonomous lines - Balogun and Popplewell (1999); Wang et al. (2016a)

Energy management

- Energy efficiency monitoring system - Gilchrist (2016); Kagermann et al. (2013)
- Energy efficiency improving system - Jeschke et al. (2017); Kagermann et al. (2013)

The ways the technology driver and connectivity would change processes:

- A move away from the antiquated systems which often frustrated suppliers and customers and limited the products on offer.
- To free up more time for employees to bring customer satisfaction to the fore.
- To vary the products available - Markets are not made up of customers wanting the same thing -there is an underlying challenge to meet their demands for variety and increasing customisation.
- A potentially global platform to make manufacturing easier, faster & cheaper.

1:2 **Barriers**

An unwillingness to buy in to the required investment in both time and resource – The lack of standards or a methodical approach to the implementation of Industry 4.0 would garner the 'by failing to prepare you prepare to fail' ideology.

Some of the obstacles that could stifle the project gestation, as shown below, would have to be addressed early in the project by the management / project team.

1. A lack of shared vision, purpose or strategy
2. Short term thinking
3. A lack of time, both resources and staff
4. A lack of 'spec time' to develop new ideas and opportunities
5. Innovation of Industry 4.0 is not articulated as a company-wide commitment
6. A lack of ownership by senior leaders
7. The company leadership expects a pay-off sooner than is realistic.

The vision would have to be shared throughout the business and embraced by all the team. Time should be put aside for research/analyse data gathered/to keep abreast of the latest technologies and if resources/staff were needed, they should be acquired.

The perceived barriers need to be broken down.

An individual or group would propose any company wide transformation of organisational practices to encourage or facilitate Industry 4.0.

However, the company Directors have the ultimate decision on whether to approve and release funds and approving resource availability or not; the message of 'not everything has to be done at once' should be shared, this would allow for other provision to be catered for in the meantime until a time when finances would allow. A long-term strategy should be applied.

The Management have the job of promoting the ethos and passing this on to the workforce who, in turn, need to embrace it and show their commitment.

The SME management must possess: (Quote from Deschamps, 2003)

- the urge to do new things;
- the obsession to redefine customer value;
- the courage to take risks;
- an ability to manage risk;
- speed in spotting opportunities and project execution;
- a shift in focus and mindset from business optimisation to business creation.

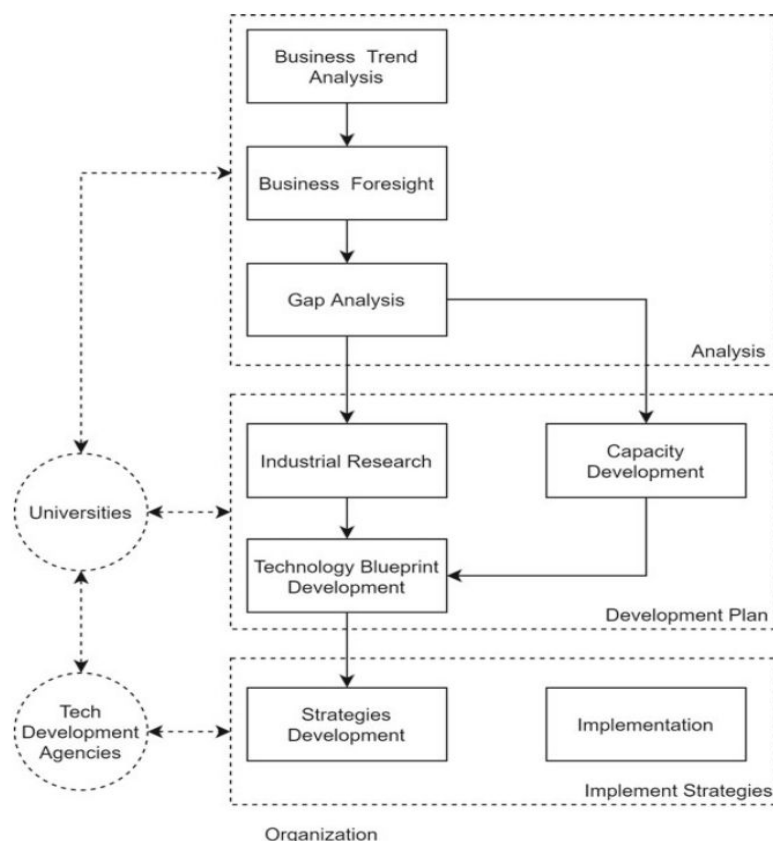
The multi layered implementation leadership team should have the knowledge to gather the far-reaching data required, perform any background checks and studies, formulate the plan for the introducing, implementing and the maintaining of the process overall.

A timing plan with allocated responsibilities to implement the process would be required.

Research into and analysis of the current capabilities of the company would be undertaken.

From the results of the research, a gap analysis would highlight the areas that require the improvement.

Finally, a process flow mapping out the process and the development plan to introduce the changes necessary would be devised and a robust implementation schedule shared. e.g.



The sheer costs of dismantling outdated previous physical infrastructure, could be an initial problem, coupled with the acquisition of new digital hardware (Robots, Cobots, AMRs), software applications, cybersecurity, new system integration and debugging, system maintenance, licensing, external experts and consultation along with the training of employees amongst many other expenses would result in budgetary constraints that would limit most SMEs digital transformation journey.

Additionally, any SMEs do not have the resources to enable the bulk buying of components and raw materials with which to ensure supplies through buffer stocks and avoid, as we see in the current climate, a radical fluctuation in prices in the international markets due to several global factors affecting service industries on all levels and in many cases are beyond their control.

Resource – Sufficient factory space, the acquisition and implementation of new systems and having the right people in place.

- a. Having enough floorspace to accommodate any automation system requirements in partnership with Health and Safety considerations would be key before embarking on any activities pertaining to Industry 4.0.
- b. New systems such as Enterprise resource planning (ERP) - Kanban supply and delivery boards could error proof what is required to be transported to a given manufacturing location or be removed to be sent to a next process or to packing / despatch. This should also assist with Lean manufacturing and the control / monitoring of stock levels.
- c. Computerised Maintenance Management Systems (CMMS) could be used as a means to regulate the maintenance systems, planning maintenance periods and avoiding breakdowns. Manufacturing plants, power grids, communication towers, various machinery, equipment, and even service vehicles are critical infrastructures which could be monitored to improve availability and efficiency.
- d. The right people who must be flexible in committing to the new practices, learn new skills and understand the benefits without doubting and dismissing them.
Empowering all staff to use computers and personal smart devices to report attendance, production stats, quality stats, breakdowns, repairs, maintenance information, and participate in the real-time SPC programme.
- e. Manufacturing digitisation may have deep social implications given that it would, in all probability, be associated with unemployment among a low-skilled workforce, a disparity of power in business relationships, cybersecurity concerns and intellectual property issues. Manufacturing firms that aim for digitisation should be prepared to take responsibility for their digitalisation process and steer it in a direction that would simultaneously safeguard economic, social and environmental sustainability.

The development of a data-based and digital performance culture and the corresponding skills set is key to the successful implementation of Industry 4.0.

The SME should become a “*Technology-led company*” (Roper, 2016)

But technology would not be enough to bring about change – the technology would improve the whole process, empowering staff to improve, greater customer satisfaction and a reduction in costs.

There would be an understandable resistance to change in some departments citing job losses in lower skilled positions – for example, the application of a camera machine vision system, would likely result in job losses in the area of manual inspections and

measurements. These could well be offset by those willing to re-train, but those who do not embrace the belief may unfortunately have to be set aside for the greater good of the project.

Location – This could greatly influence the Introduction of Industry 4.0 to a sector and locality.

Culture, language, Poverty levels, lifestyle, life expectancy, general education and literacy levels would influence the capabilities and skill set of the local community.

If such manufacturing activities are in their infancy or being introduced following the collapse of a large employer in the area such as mining, fishing or steel production as seen within Wales and the UK in general, any of the above be applied. Add in the relatively recent influx of migrant workers, many from a less advanced or emerging economy, could hinder advancement.

The local infrastructure may be lacking in access to the road and rail network.

The link to advanced 21st Century communication systems, phone lines, mobile coverage or high-speed cable connections may mean the requirement for upgrades.

The relevant service companies and local / national government would have to be sympathetic to achieve such outcomes, however.

The distance from suppliers or customers could influence delivery times and should be borne in mind and have sufficiently contingencies planned for.

Instances of power outages from environmental and logistical issues (however unlikely) should be considered and back up facilities investigated and implemented if at all possible.

However unlikely the occurrence, security should be considered as local and international protests or terrorism can strike at any time. Where some governments have monitoring and plans in place to prevent or deal with such events, others may not have the resource or funding to be so prepared, so disruption of any sort should have a contingency plan if perceived to be a potential issue.

Skills – The perceived lack of skills or talent within the current workforce could and should be assessed and addressed in several ways:

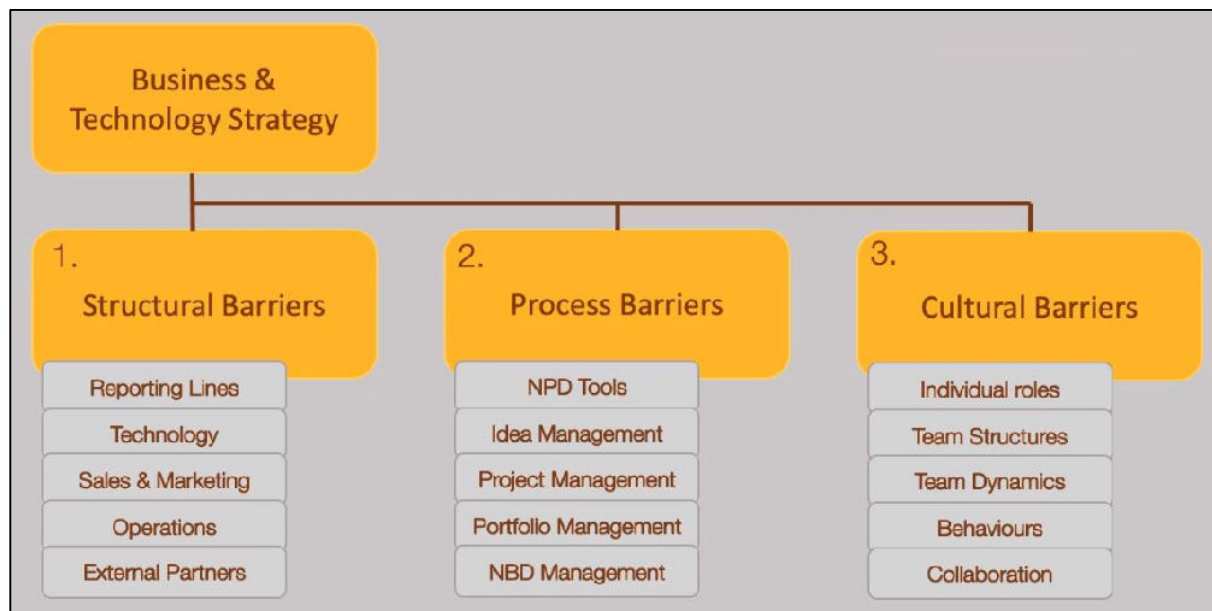
- a. If suitable candidates are identified within the company and share the commitment to progress, they can be trained in the skills necessary.
- b. If funds are lacking in the company structure to make this difficult or prevent this, local or European government funding for training may be available that could provide upskilling more easily, but there has to be the luxury of time in which to facilitate the training. In some circumstances a partnership with a University, Tech. company or an OEM may be available.

- c. If a curtailed timeline was an issue to the implementing of Industry 4.0 and the systems required then this could be offset through external recruitment. This too could have an affect if the company wage structure or relocation issues could discourage interest.

Knowledge and expertise are key to success. The implementation process would become more open as more knowledge and guidance was acquired to grow the business.

'The more we know about something, the more we can take calculated decisions about whether or not to proceed. And in a competitive environment this places a premium on getting hold of knowledge as early as possible.' (Tidd & Beasant)

The management, Information technology and manufacturing structure would be enhanced through the recruitment of several key individuals who would possess experience in the areas where the necessary skills are lacking.



IT – A lack of sufficient reliable digital infrastructure and internal connectivity – the availability of up to date or fit for purpose onsite computing facilities coupled with the provision for large data storage, APIs, application software, virtual technology, Artificial Intelligence (AI), Cyber Physical Systems (CPIs), Internet of things (IoT), secure servers (and back-up servers), enabled machinery, cabling or Bluetooth technology would be required to allow the many facets of the Industry 4.0 process to converse.

The use of sensors to monitor each stage of the process from planning through to delivery and in between, should be implemented at every opportunity.

From the scheduling of production and the procuring raw materials to monitoring machine downtime / efficiency and electricity use, all information criteria pertinent to the process should be gathered from trustworthy sources.

A differentiation between 'passive' Smart tech which only monitors and controls the process, and those that optimise and provide autonomy to machines and processes should be made. With the 'passive' option being the most likely to be implemented as this is the cheapest option but still being reliant on non-automated interactions and corrective actions.

The Real-time machine efficiency and product quality data would be gathered and utilised with SPC tools to enable actions to be taken if KPIs targets are not being met.

On top of the above, the data could be not good, not available or of poor quality. This is often due to the systems that make up the IT infrastructure not being set up properly. Data not being entered or being entered incorrectly; this should be offset by adequate training of the company labour, In order to ensure that data logging facilities to register log data are set up correctly, or the data being manually entered is not of poor quality and matches that expected within the monitoring systems. Data will be generated at a rate like never before and this must have the provision to be stored and protected. Protection of IP should be identified and well catered for from conventional office-based machines and those on the factory floor alike.

Connectivity (External) – A reliable High-speed internet connection (and a backup connection strategy) would be a major pre-requisite to maintain the interaction with external resources for communication.

Supplier Integration Software / Hardware and or purchase of OEM-led control and monitoring software such as SAP could be a stumbling block because of restrictive purchase / set up costs or subscriptions for their use. As stated previously, the external links to communication systems, phone lines, mobile coverage or high-speed cable connections may prompt the necessity for upgrades.

Cloud storage could also be utilised if available.

Cyber Security – All data and connected machines should be protected by firewalls, VPNs (which generally come at a yearly or monthly cost) and passwords (wherever possible) to prevent malpractices from both internal and external sources. Computers and enabled devices should not have programs left open for extended periods, such as overnight or over weekends, and ideally those devices should be switched off when not in use.

The use of blockchains may be applied if a consensus among all stakeholders can be achieved. Without the need for third party certifying agents and in turn fostering trust between customers and stakeholders, data will become a significant asset in the modern

industrial process management. There are mechanisms available to ensure, also to establish coordination processes between various factories. With an increasing number of businesses, blockchain is used in various markets and industry sectors. Blockchain technology improves accountability and efficiency across the supply chain. Companies can use many applications to map and trace content from the source, show origin and authenticity, advance recalls, and generally speeding up the movement of goods in almost every industry. The data is encoded in the blockchain and modified (usually encryption) as it passes through the supply chain with the new modification meaning it cannot be tampered with. The lack of a blockchain could potentially leave the company open to many external corruptive behaviours such as theft, fraud, bribery or coercion within the local and international community.

Other priorities for Capital Expenditure – There will always be something else that may require capital expenditure before something else, the Directors must embrace the commitment to deliver the future, evaluating what would reap the larger dividends and rewards and future proofing the company.

KPI targets, together with the data from the monitoring of the process and sub-processes would provide the required evidential proof that the implementation of Industry 4.0 was required in the first instance and in time successful in order to justify the initial and further investment through the gains achieved.

A measure of the company's success, as defined by Goffin & Mitchell, could be measured not only in the growth in sales, but also the number of innovations that the company grows through its culture.

1:3 **Best Practices**

‘When a vision is clear, consistently articulated and widely shared, decisions throughout the organisation can be made in a more consistent and directed way’ (Dr. Edmond Harty from and interview conducted with Dr. Claire McBride 2016)

Everyone at a SME should know and share the vision and ethos.

The SME should encourage and nurture the culture which encourages employees to embrace and train for the capabilities and goals of Industry 4.0 to be realised.

The addition of a Project Innovation Manager (or similar driving force) would help to break down the barriers and could further enhance the encouragement and channelling of ideas to go hand-in-hand with the introduction, implementation and sustainability of Industry 4.0.

Ideas for improvements should be encouraged from all departments and from all levels of the workforce.

This would promote ownership and kudos for the recognition of making the effort to improve practices. Often the best ideas for manufacturing improvements come from those using the systems and machinery every day first-hand.

The portfolio of ideas and initiatives should be managed by being both prioritised and acted upon accordingly within the framework of Industry 4.0 if an incremental improvement can be attained.



Example:

Guilherme Castro - Project Innovation Manager (Octopus Energy)- comes from a background of business and Government in his Brazilian-homeland where he advised on decentralised energy policy, which led to his move to the UK energy industry initially as a manager of community owned wind farms.

1:4 **Conclusions**

Industry 4.0 using a definition from Trott –

- rewriting the rules in offering something which represents a new process and business model,
- reconfiguring how the manufacturing process is done through effective networks and co-ordination,
- being able to be transferred across differing platforms of supply, manufacturing, delivery and offering flexibility and customer service.

Brexit, COVID 19 and now the cost of living crisis on the back of the issues pertaining to the Russian invasion of Ukraine, have radically affected many industries and manufacturing in particular tightening budgets that would otherwise be available for improvements.

Planning and contingencies have come to the fore. Whether it be keeping abreast of exchange rates for international trade, fuel and raw material prices spiralling or more red tape applied in the movement of resources across borders resources have been stretched, in many cases like never before.

The UK government published a report describing its vision for the revolution of the manufacturing sector by the year 2050 so they are somewhat sympathetic to the issues that are stifling growth through modernisation.

The reasons why Industry 4.0 implementations get bogged down are no different than with other company wide transformations which have the aim to create the sustainable, well-performing organisation. It comes as no surprise that the chance of failure to fully implement is quite high.

The focus should not be too much on just the technical side of the digital transformation, especially in the early stage. Instead, the culture change and the skills change management should be prioritised.

The technology led content side of the transformation is not the main driver, the development of a data based, and digital performance culture along with the corresponding skills set within the organisation is.

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(Online reading resources were accessed through the University Library service or other outlets using student sign in wherever possible.)