

DISSERTATION

Master's in International Innovation Management (MSc)

STRATEGIC ALIGNMENT AND DATA GATHERING, UTILISING CONNECTED TECHNOLOGIES TO IMPROVE EFFICIENCY IN SMALL & MEDIUM-SIZED ENTERPRISES (SMES)

WITH A CASE STUDY ANALYSIS OF A DIGITALISATION IMPLEMENTATION
PROJECT WITHIN A MULTI-NATIONAL MOULDING COMPANY

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An old dog can learn new tricks!

Abstract

Small and Mid-sized Enterprises (SMEs) are under ever-increasing pressure to improve efficiency within their processes to maintain an edge on competitors. Through the implementation of the key building blocks of Industry 4.0 improvements in the way data is captured, manipulated, shared, reported, stored, and understood can be achieved. The data gathered must be of both good quality and accuracy. Many OEMs have a connective supply and logistics capability that enables visibility from their direct suppliers to protect their manufacturing processes from disruption and avoid costly delays. As technology becomes more accessible, this connectivity will likely become more commonplace.

The connection between Information Technology and the manufacturing processes will ensure that information is shared in real time and corrective actions are made. In a business that has production sites in several countries on several continents, this can be utilised to share business-related data and information to support reporting of all required criteria that require feedback. With all SMEs being increasingly squeezed to improve performance and productivity in the face of increased costs across many levels there is a great drive to increase efficiencies including data management. The means by which data captured, manipulated, reported, understood, stored, and shared between different departments or sites would promote the interconnection of information, the strengthening of relationships between departments and sites, the promotion of knowledge transfer, the optimised allocation of resources, and would contribute to the work environment which nurtures innovation. (O'Regan & Ghobadian, 2002)

The business value of alignment is driven in some ways by the systemic approaches made possible by integration across design, engineering, and database capabilities in modern PLM (Product Lifecycle Management) solutions. (Terzi et al., 2010)

With origins in CAD (computer-aided design) and CAM (computer-aided manufacturing), these integrated technologies can also permit the ability to re-utilise parts, manufacturing processes, the sharing, and re-use of the rules, guidelines, and procedures that define engineering knowledge to reduce wastes and improve efficiency.

This would be more easily achieved by implementing an alignment strategy for data gathering, sharing, reporting, and procedures.

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Abbreviation	Definition
AMRC	ADVANCED MANUFACTURING & RESEARCH CENTRE
BDA	BIG DATA ANALYTICS
CAD	COMPUTER-AIDED DESIGN
CAM	COMPUTER-AIDED MANUFACTURING
CAPEX	CAPITAL EXPENSE
CE	CIRCULAR ECONOMY
ERP	ENTERPRISE RESOURCE PLANNING
FMS	FLEXIBLE MANUFACTURING SYSTEM
FS	FIBRAX SANOK
HF	HUMAN FACTORS
I4.0	INDUSTRY 4.0
IOT	INTERNET OF THINGS
IP	INTELLECTUAL PROPERTY
JIT	JUST IN TIME
MADE	MANUFACTURE ADVANCED DESIGN ENGINEERING
MES	MANUFACTURING EXECUTION SYSTEM
MOPs	MARKETING OPPORTUNITIES
MPM	MOROCCO PRECISION MOULDINGS
NPI	NEW PRODUCT INTRODUCTION
OEM	ORIGINAL EQUIPMENT MANUFACTURER
OEE	OVERALL EQUIPMENT EFFECTIVENESS
PLM	PRODUCT LIFECYCLE MANAGEMENT
PPM	PARTS PER MILLION
R&D	RESEARCH & DEVELOPMENT
SFDC	SHOP FLOOR DATA CAPTURE
SIPOC	SUPPLIER INPUT PROCESS OUTPUT CUSTOMER
SMACT	SMART MANUFACTURING & CONNECTED TECHNOLOGIES
SMDH	SMART MANUFACTURING DATA HUB
SME	SMALL & MEDIUM-SIZED ENTERPRISE
TPM	TOTAL PRODUCTIVITY MAINTENANCE
TPS	TOYOTA PRODUCTION SYSTEM
UWTSD	UNIVERSITY OF WALES TRINITY SAINT DAVID

1. Introduction

1:1 Background & Introductory notes

In recent years, where the relative share of manufacturing in the UK economy has declined more rapidly than in other developed economies, with the service sector share growing at a greater rate. This growth of the service sector in the UK is consistent with growth in other developed economies including France and the US. (Foresight, gov.uk, 2013)

Wales, is characterised (Henley., 2005.) as peripheral and economically lagging. A business based in Wales with production sites in several countries on several continents, such as that referenced in the case study within this report, would benefit greatly from being able to share business-related data and information to support reporting of all the pertinent criteria that requires feedback. In the new global economy, Small and Medium sized Enterprises (SMEs) are under constant financial pressure from many varied market forces to improve efficiency and productivity across all functions in the face of increasing costs across many fronts, competition from emerging markets, there is a great drive to increase manufacturing and logistical efficiencies including the introduction of data management strategies and the use of connected technologies (Gligor., 2012). Companies must have the ability to change and adapt if they wish to survive, (Trott. 2016). How data is shared from its source with different departments or sites, could promote the interconnection of information, strengthen relationships among departments and sites, promote knowledge transfer, optimise the allocation of resources, develop lean manufacturing and contribute to the nurturing of innovation (Lam *et al.*, 2021), (Khurana *et al.*, 2013).

There is a growing body of literature that recognises the importance and business value of data science and alignments (Reddy, *et al.*, 2024) and it is driven by the systemic approaches made possible by integration across design, engineering, and data utilisation capabilities in modern Product Lifecycle Management (PLM) solutions. (Ghobakhloo *et al.*, 2020)

Most SMEs have integrated Enterprise Resource Planning (ERP) systems to obtain a competitive advantage (Zhang *et al.*, 2005) paired with a lean production principle (Powell *et al.*, 2013) but the dawn of Computer-aided design (CAD) and Computer-aided manufacturing (CAM), in the later quarter of the twentieth century has led to an increase in more integrated technologies that can also permit the re-utilisation parts, manufacturing processes, share the rules, the guidelines, and the procedures that define engineering

knowledge (Subrahmanian, E. *et al.*, 2006). This dissertation specifically aims to highlight the gains achieved across a number of disciplines by adopting Strategic alignment for data gathering, sharing, reporting, and procedures.

1:2 Aims

‘When a vision is clear, consistently articulated and widely shared, decisions throughout the organisation can be made in a more consistent and directed way’ (Goffin & Mitchell., 2016)

This dissertation aims to provide key considerations and information to reference when implementing their own data alignment and connected technologies. It aims to highlight what SMEs can achieve through adopting strategic alignment, commonality, and improved data practices in conjunction with connected technologies as part of I4.0 and Smart Manufacturing. How the business collectively identifies data, collects the data, stores it, and how it is understood is key to providing a firm basis on which connected technologies can be built by SMEs. My personal experience of poor data handling and collection has prompted this research and report on how it can be improved.

1:3 Objectives

In addition to the good acquisition of data, the quality and consideration for the ease of understanding of the collected data, the training of personnel in related practices, will assist in reporting, analysing and acting upon through many related activities. A clear process method to ensure the clean-up of existing data already stored, and for the correct input of any future data, would be the best practice. (Batini et al., 2009 [#1]) Teams in the parent (and sister sites) need data collected from across the group to facilitate various exercises, from establishing new products and processes, costing analysis, price increase analysis, monthly sales reports, tool condition reports, and numerous other ad hoc exercises. Further investigation into how the data is reported will indicate if data quality issues across systems such as Enterprise Resource Planning (ERP) systems, hampers performance. (Batini et al., 2009 [#2])

Data science and quality is not what you would call a ‘sexy subject’, but it is one which, if found to be lacking in quality would need addressing if a business wants to ensure a more robust, data-driven decision-making process as desired in Industry 4.0 (Tao et al., 2018). The

improvements driven by improved data handling and alignment will create value streams for those closely linked to that data and all stakeholders across the business (Arenas et al., 2019).

1:4 Justification

Manufacturers must always strive to improve their ability to perform tasks on within their means whilst considering profitability, costs, sustainability and the assets they have available. Large manufacturers will undoubtedly have the means to implement turn-key technology and applications that will perform a whole manner of connected tasks, but these systems generally come with a significant price tag, something that SMEs simply could not feasibly consider. This dissertation looks to provide information on how SMEs might use different methods to adapt their working practices to embrace connected technologies and the alignment of data to improve performance and efficiency.

1:5 Methodology

Because this dissertation is not limited to a single question, it represents an integrated assessment covering several factors in a wider-ranging topic. This research is designed to provide insight into the benefits achievable by SMEs looking at strategies to enhance their data handling efficiency in a manufacturing capacity. Both quantitative and Qualitative research will be employed in the study.

1:5:1 Literary Review

A comprehensive review of existing academic research literature will be undertaken. This approach intends to provide a useful source of Secondary Data. The research will be flexible in that it will also provide additional related subject discussion that should be of interest/benefit for inclusion in the report.

1:5:2 Secondary Data Collection and analysis

The literature review employed in this dissertation consisted of a thorough search for published academic books and papers which directly focuses on the subject matter and associated topics. Extensive use of the media types available through online resources, mainly the UWTSD library and connected sources, supplied the initial subject matter.

Primary filtering of the subject matter was by relevance to the research requirements with an evaluation of the reliability of the source and author(s), followed by the publication date to ensure that the most up-to-date research was acquired. The details of these sources were noted, with citations being recorded in the required Harvard format for future reference. These have been arranged in alphabetical order based upon the primary author surname. Wherever possible, the referenced work has been downloaded and placed in the Appendices section for further reading, also arranged in alphabetical order of the primary author surname.

The research in the literary review will provide a framework and basis of the questions that will be posed within the Primary Data collection activities.

1:5:3 Primary Data Collection - Questionnaire

Both quantitative and qualitative evaluations will be utilised in the report. (O'Gorman et al., 2015) The questionnaire was composed and sent to colleagues across the Fibrax Company. This was presented via e-mail in a reader-friendly format requesting answers to a number of questions with multiple choice answer options. The survey questionnaire was split into 3 categories covering 10 questions posed in total. The questions were designed to gauge participant understanding of aspects of data alignment, connected technologies and their place in Smart manufacturing/I4.0. Surveys were presented and recorded on a one to one basis either in person or via teams meeting. The questions were presented in a manner which provided the answers to each question with one of 5 possible responses being picked from a Likert scale as follows: Strongly Agree, Agree, Neutral, Disagree or Strongly Disagree. The feedback from the survey primarily provided qualitative data which was then analysed as laid out in section 1:5:4. This would provide an insight into colleague understanding of both the importance and benefits of data alignment and collection practices. The respondent was presented with the option of anonymity if so desired, to encourage their participation, however they were asked if they could share their position title. Respondents were invited to add further information/opinions in a comments area following the final question. The findings from the study will be shared in section 9 of the report.

1:5:4 Analysis of Primary Data from Questionnaire and Part Number proposals

The Primary Data that is collected from the surveys will be analysed as follows:

- The ratings obtained for each individual question.
- Number of respondents in relation to specific department/function,
- Any patterns in the ratings received in any of the sub-groups,
- Feedback/comments received.

1:5:5 Primary data Collection – interviews and case study

Following the initial questionnaire, a cohort of more closely aligned stakeholders would be interviewed to gain their perspective on what deliverables they wish to obtain from the implementation of data alignment and connected technologies, and how data collection and quality can improve their personal performance, that of their department or section, and that of the business as a whole.

Those selected are:

- Production Manager/Supervisory representative,
- New Product Introduction (NPI) Managers (Sales, Materials, Design and Project Management, Tooling)
- Accounts Manager,
- Compliance Manager,
- Maintenance Manager,
- A company director,
- Company Managing Director.

Each of the above has a key role within the senior management / Departmental Supervisory structure and would be most likely to be overseeing the processes of data gathering, data reporting, data analysis and decision-making.

This assisted in providing further primary data for the case study.

Interviews will be in person wherever possible and via Microsoft Teams as and when required. The interviews were recorded in an effort to reduce the time required, encourage participation and provide a valuable resource for referring back to following the exercise.

These findings will be shared in section 9 of the report.

1:5:6 Part Number Alignment exercise

The need for a common part numbering system is identified as a key requirement within a group. Parts can be placed within “families” dependent on which Industry/Engineering category they are supplied, their designated end use, the base material and whether it is a stand-alone part or a sub-component of an assembly. A similar methodology is referenced by Marr et al., 1996 in their published work in proposing a structure for family grouping of sub-component within Computer-aided part designs.

In the case of Fibrax, each site has set up their own unique part identification numbering system as part of their initial development. Add into the mix the fact that sub-assembly components are generally referred to by their drawing number, the same part might be produced in multiple locations whilst being referenced by a different part number at each site, there is much scope for confusion. Also, several customers can potentially be ordering the same parts, from the same tool but under another customers number rather than a common “Fibrax part number”.

A set of part number structure that would be wholly compatible with all industries, part end uses/types, internal departments, base materials and assemblies were devised by an inter-departmental and inter-site management working group. These proposals were sent to stakeholders to proof out the suitability of the proposals and obtain constructive feedback on which preferred option to take forward as alignment of part number terminology to use for the group and the connected systems within it. These findings will be shared in section 9 of the report.

1:5:7 Research Limitations

Industry 4.0 and Digital Manufacturing can divide opinions depending on the respondent’s hierarchical position within the workforce. Biases in the results could result, and there are several cognitive frames which can go some way to explain some responses.

i.e.:

- Utilitarian – see themselves as an employee only, weighting their personal cost against their personal gain,
- Functional – knowledge of systems, their benefits and their limitations,
- Anthropocentric – a central figure that can be open to influence,
- Traditional – likes the old ways,
- Playful – express their desire to engage with new technologies.

(Schneider et al., 2020)

To minimise any traits stemming from the above, the option of anonymity was offered as it would lessen the biased perceptions in each of the five points of view listed above.

In these cases, the capture of job titles, within a range of respondents, would likely allow for an analysis of the responses to reduce any biased results found in the overall findings and provide feedback as to the communication status, direction and drive to succeed throughout the company.

1:6 Research Guidelines

The previously stated, the practice of recording the details of any referenced subject matters directly or indirectly associated ensures credit is duly paid to all authors and sources to avoid any risk of plagiarism. Furthermore, where possible the source academic work was downloaded for reference and further reading in the Appendix.

2. What is Strategic Alignment and Digitisation?

2:1 Strategic Alignment – What is it important?

Organisational performance, particularly in SMEs, is most likely to be optimised when there is alignment and consensus in the strategies within a business. (Walter et al., 2013) This can be shown in a graphical form, utilising a similar concept to a decision/Knowledge/innovation matrix (Henver et al., 2022)

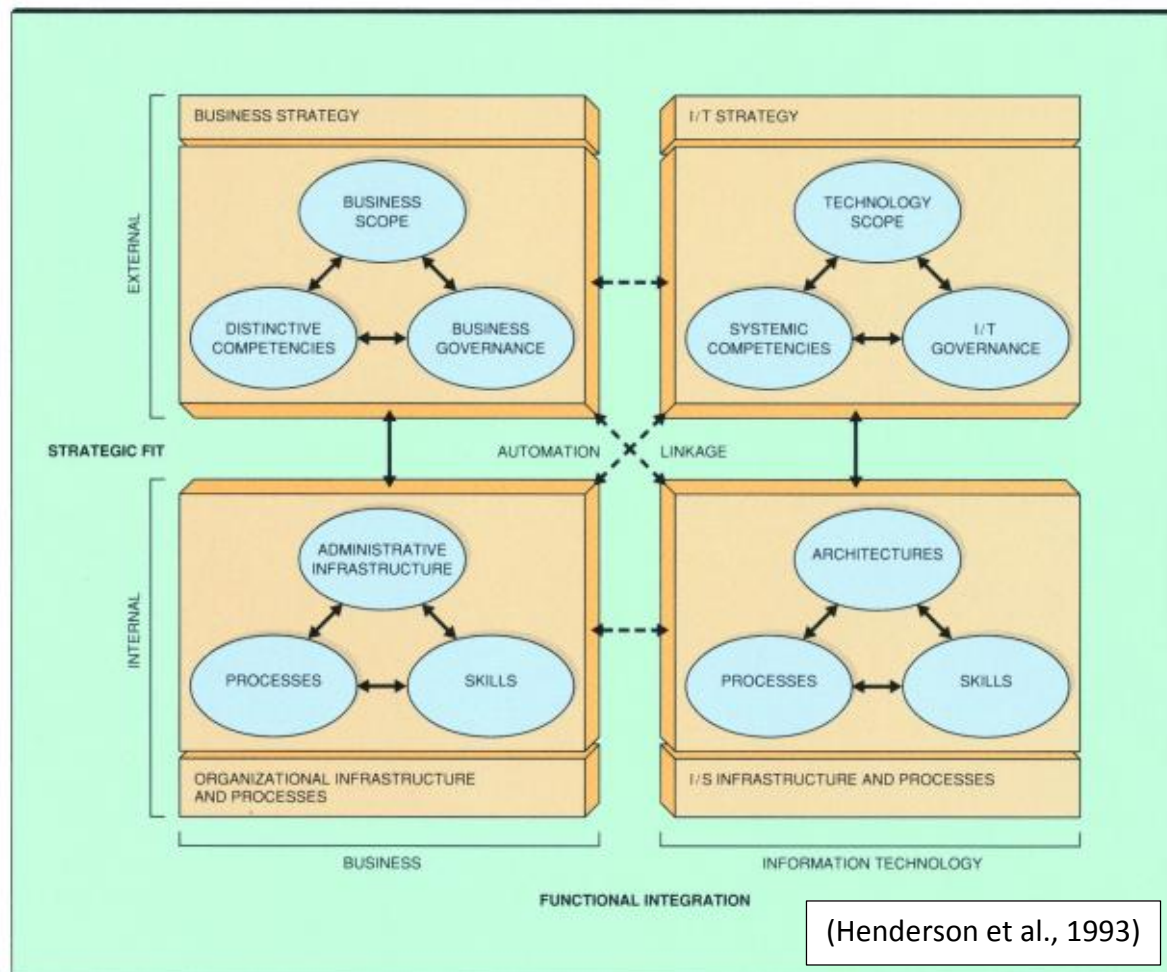
		Strategic alignment	
		Low	High
Strategic consensus	Low	Cell 1: Chaotic Low levels of consensus inhibit efficient strategy implementation, and low levels of strategic alignment direct behavior in maladaptive ways.	Cell 2: Isolated insight On average, strategic priorities fit environmental conditions, but lack of consensus hampers efficient strategy implementation.
	High	Cell 3: Misaligned consensus High levels of consensus enable efficient strategy implementation, but lack of strategic alignment directs behavior in maladaptive ways.	Cell 4: Aligned consensus High levels of consensus enables efficient implementation of desirable strategic priorities.

Put simply, all the business has to work cohesively, pulling in the same direction and strive for a common goal. Functional Integration between the business and IT domains is key. (Henderson et al., 1993)

2:2 Methodology

Cross-functional integration and ease of communication of data is a key building block of both alignment and consensus. The required relationship required between Business Strategy and IT Strategy can be explained in the strategic alignment model (Coleman et al., 2006/ Henderson et al., 1993). This is depicted as a square composed of 4 quadrants, (see below, with Business Strategy and Organisational Infrastructure being shown on the left hand side quadrants with IT Strategy and IT Infrastructure being shown on the right hand quadrants. Each quadrant contains 3 items relating to the quadrant headline. The linkages between each of the 3 items in each quadrant relates how decisions are made in that element. The links between each quadrant show how each quadrant can influence the

decisions being made in the other three quadrants. (Influencing them by enhancing or threatening their ability to perform effectively)



For each unit to be effective, each item within the quadrant has to be sufficiently addressed for the role of that quadrant to be successful and sustained for future performance.

Examples of how each quadrant could have its efficiency impaired.

1. If there are Skills and Processes within the Internal Business quadrant, but a lack of an effective Administrative Structure, this could potentially cause all 3 elements to be threatened. (i.e. The scope of what the business wishes to achieve is but the manner in which that workforce achieves a product or service is not controlled and open to errors as a consequence)
2. If IS infrastructure and processes are excellent, but the personnel lack the skills to use and maintain their performance the system will not be fully utilised and will experience outages. (i.e. A data system that is not error-proofed or has built in

- volition rules might allow incorrect data types to be input, causing errors in the reporting outputs)
3. The Business scope and Distinctive Competences are satisfied but the Business Governance is lacking backbone. (i.e. If the Business Scope is documented, with distinct departmental competences required, but the performance of a single or multiple departments is lacking, making several other departments open to hindrance or errors as a consequence, there has to be a strong Business Governance to bring them into line to achieved prime efficiency and eradicate this from the business)
 4. If there is sufficient Technology supporting the IT Strategy, with Strategic Competences it would lack performance if the IT Governance was lacking (i.e. an ultra fast wifi/server and cabling connections are installed but many of the workforce can access wifi for video streaming or other internet services, thus choking the performance of the automated data gathering/sharing sytems required for the business – solved by renewing passwords for wifi connections and blocking of non-work related internet services by the IT Administrators)

The functional integration between Business strategy and IT strategy is classed as Strategic integration. (Henderson et al., 1993)

2:3 Data Gathering

Connected Technologies permit a move away from the usual manual data gathering and will ensure a removal of most, if not all, human error from reporting loops. i.e. the automatic logging of machine cycles through sensors to enable real-time tool and machine records that flag up preventative maintenance intervals, or the use of system-connected inspection/weigh stations equipped with devices such as tablets and pre-devised tare weights for packing box types and parts through the use of pre-prepared working practices that are uploaded from a server, when required, to control packed part quantities, eradicating human error from reporting and achieving enhanced inspection performance and efficiency.

2:4 Digitalisation

Where OEMs and larger businesses might have the finances available to jump right into a well-known off the shelf system offerings from companies such as SAP, Siemens and Oracle, to name but a few, SMEs have to be much more prudent as they lack the deep pockets and resource of OEMs. In the age of austerity, SMEs might wish to travel along the path of Jugaad, in adopting a more frugal systems and innovation (Radiou., et al, 2012) rather than one of the “Bells and whistles” expensive alternatives

A thorough review of the available plug-and-play digital integration systems on offer will have to be undertaken by any business setting out on the digitisation journey. With due diligence being in-place for costing exercises and assessing performance desired now against what is achievable plus the considerations of future requirements.

A SME might wish to cherry-pick and implement certain desirable elements as a first step of introducing connected system technologies and beginning the journey towards embracing I4.0. Future needs and requirements should be considered to ensure the expanded and further use in more situations.

Existing PLM system data and any subsequently added New Master data must be controlled for quality through both accuracy and completeness with anyone chosen to input that data doing so with consistency, precision, reliability and integrity.

The system chosen whilst likely requiring the purchasing of new IT devices, might necessitate an upgrade of existing computers, peripherals and software widely used throughout the business which will become connected to the new PLM system(s) The cost of this wide-ranging upgrade needs to be added into the overall costs found through the financial study.

2:5 Connected Technologies

As with PLM systems, SMEs often lack the finance required for purchasing state of the art systems, staggering their introduction could still stretch budgets to uncomfortable levels unless the decision of what is immediately required for the benefit of the business versus what might be desirable for the entire workforce is made. The outlay to procure the required hardware should be given due diligence

with all avenues for cost reductions being investigated. Generally low-cost bolt-on peripherals are available and will simplify the traceability of data, stock, materials, machine cycles, temperatures across a variety of ambient locations and machinery, and tool use etc. across the business.

2:6 Considerations

Strategic Alignment can be further carried over with the underpinnings of the core principles of the Circular Economy, through the revision of design principles to target a more niche collection of materials to be used, and re-used throughout more than one site, which could enable the bulk-purchase of cheaper materials, to be used in more productive ways, better part and tooling designs promoting a reduction in the amount of material being used, and the recovering or recyclability across the parts range and the business group. (Yuan et al., 2008)

Alignment can promote other savings such as savings on refining a process to improve productivity through smart manufacturing, improved production times, better plant utilisation, reductions in the associated energy use, a reduction in used storage space through the reduction of many material compounds, scrap movements, related disposal costs, and an overall decrease in material expense. (S. Wang et al., 2016) Procedures, processes and working documents should be transferrable across language and location barriers.

2:7 Implementation

An Implementation team with a range of skills and knowledge should be assembled.

The individuals included should have an excellent knowledge of the IT systems currently utilised by the company and be able to know what would be required for both the initial installation and to sustain the new systems for future growth and upgrades.

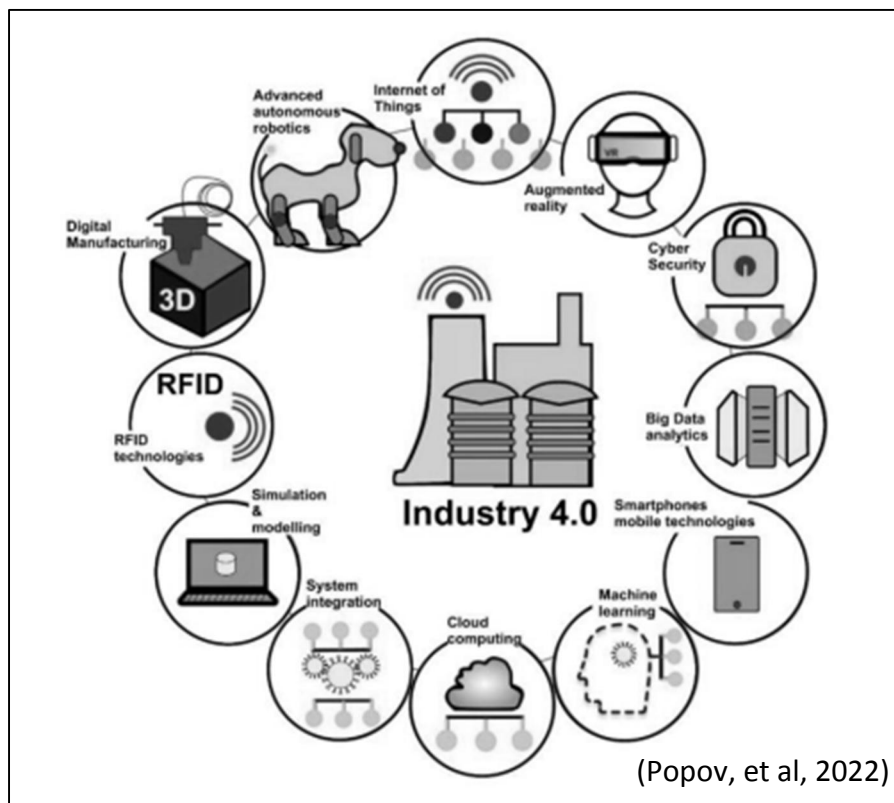
A working knowledge of the systems of each of the departments included and the required inputs and outputs that they would seek. Any doubts of these should be investigated through questioning the required department leaders for clarification.

The Implementation team should have a good understanding of what is currently capable in the world of connected technologies and peripherals to achieve the desired outcome. The implementation team should build a considered and well planned strategy to ensure the initial integration, and the sustaining of the systems introduced (Rauch et al., 2020), which will provide a robust data analysis platform.

3. Industry 4.0 & Continuous Improvement

3:1 What is Industry 4.0 & Smart Manufacturing

The past half century has seen an unprecedented advancement in technology, transforming how we live, work, and interact with the world. From the rise of personal computers, to the advent of the internet, the increase in all manner of mobile devices, and the emergence of artificial intelligence, technology has become an integral part of our daily lives. We have seen increasingly rapid advances in the field of IT, connected technologies and the business methodologies which have emerged as powerful platforms when integrated throughout the workplace. (Porter et al., 2014)



The advent of modern technologies and innovative methodologies has allowed I4.0 to assist manufacturing businesses to achieve better performance and achieve greater visibility/achieve tighter process controls through automated process improvements through a system of data gathering, analysis and processing (Schumacher et al., 2019). The Internet of Things (IOT) is the manifestation of objects communicating with each other and interacting through wireless and wired means. By successfully deploying matured digital technologies, with ICT and real-time analytics, the IOT can offer wide-ranging applications. (Vermesan et al., 2016) The multitude of connected devices and machines provide the

framework to potentially transform the means by which businesses nurture and deliver innovation, create different business strategies, and optimise group operations (Brody & Pureswaran., 2015).

Several key factors will influence the success of any I4.0 implementation. Namely, IT Strategy and Cyber Security, Enablers, Smart Factory, Value proposition and Customer experience. These factors will also measure the success of the exercise(s). (Castelo-Branco et al., 2021)

IT strategy can be described as the ability to establish an IT Function, considering Cyber Security and Risk management. This requires a clear IT strategy, where IT investment and governance are clearly aligned with business needs (Mithas et al., 2016)

Cybersecurity - the reliance on cyberspace for internet-based technologies exposes businesses to heightened vulnerability, putting them at greater risks related to information security and privacy (Mendhurwar et al., 2019). This challenge should be recognised as a very real present-day threat. Cyber risk management and training for colleagues to detect the signs of 'cyber mis-behaviour' should be a high priority, thus creating a cybersecurity aware culture (Toth, 2024). The protection of systems from internal as well as external malpractice should also be evaluated.

Enablers – the informed and capable persons, or the resources that will be required to ensure a successful implementation of Industry 4.0. Funding should also be defined as an enabler. Factors such as the recognition that the training to both use and maintain any new technologies and equipment is required, and these are further investments on top of any management system outlay (Horváth et al., 2019).

The "**smart factory**" - the connective element of Industry 4.0. The integrated production processes and processes that interact with suppliers and customers, having the adaptability to possibly reconfigure a manual process with automated tasks and tools that permit data originated by production processes to be monitored and assessed in real-time allowing proactive decision making. (Gilchrist, 2016)

Value proposition - The value proposition relates the company business model. Any aspect which requires efficiency and profitability of products that would be beneficial in acquiring new business opportunities, or more complete customer solutions. Sometimes known as servitisation (Iriarte, et al. (2023).

Customer experience – The ways in which a business interacts with its internal and external customers. This can influence strategic decisions regarding Industry 4.0 implementation, and its acceptance. By creating a good customer experience a business can achieve customer loyalty and repeat orders, whereas a good internal customer experience translates as a system which makes tasks simpler, is operator friendly, and easy to retrieve information from, interrogate and understand (Mihardjo, et al., 2019).

Along with these foundations the key building blocks of Industry 4.0 (I4.0) can be better achieved by SMEs through the adoption of a Flexible Manufacturing System (FMS). This response will transform established methods of mass production into a mode of flexible production to better meet the needs of the consumer, when integrated with connected systems, which can capture data, and minimise the human interaction/inputs, which could lead to possible inaccuracies (Ding et al., 2011). The original and subsequent set-up data must be of a consistently high standard of accuracy (Balogun et al., 1999). “The vision of Industry 4.0 focuses on promoting the company as part of a dynamic, real-time, optimised, and global cross-company and value-added network” (Schwab., 2016). This implementation will assist in the seamless production and movement of products, as well as the transfer of related data and information (Cohen, Y. et al., 2019).

Many OEMs now insist on a connective supply incorporating push/pull production requirements and logistics capability to achieve visibility from their direct suppliers using pull systems such as SAP, which protects their manufacturing processes from disruption and costly delays, so data must be accurate. As technology becomes more accessible, this connectivity will likely become more commonplace. (Lau., 2004) The connection between Information Technology and the manufacturing processes will ensure that the reported data can be shared throughout the network in real-time with the agility and capability to accommodate the continuous change in customer needs and perform well-placed corrective actions if required. (Coronado *et al.*, 2002)

3:2 What areas need an increase/improvement in data?

Thorough consideration should be applied in the reasoning of what areas need improvement in data capture and reporting. All departments should be consulted and their

perspective of what can be garnered from better data needs to be gathered through both group discussions and individual interviews.

By recording their needs and wants in a data gathering tool such as a SIPOC, these can be analysed through a decision making tool, providing the solution to how all the combined wishes of all can be accommodated.

3:3 Analysis

How can this data improvement exercise be categorised withing the as an innovation? In the case of manufacturing SMEs, it should be regarded as an Open loop Innovation, continually feeding back into procedures, processes, products, design, allocation of resources and asset maintenance on many levels.

3:4 Hardware requirements and connectivity

Ultimately an IT hardware system within the company has to be capable of carrying this system, of holding the increased volume of data, and be able to communicate internally and externally without hindrance. The most up to date wired connections internally and externally along with good broadband connectivity and Wi-Fi ensure communications are maintained across any connected tech that requires. The capabilities of all peripherals needed within the system have to be assessed and upgraded as required to converse with the system.

3:5 Challenges & Downsides

Upgrades come at a cost and SMEs would not necessarily have the immediate access to the funds required to upgrade every computer, tablet and peripherals to the latest specification required to be connected directly to the system, so a series of upgrade events would have to be planned, with those systems and persons at most urgent need of having the capability to integrate fully with the new system being the persons at the head of the queue.

3:6 Desired outcomes

Shared knowledge and experience, lessons learned, Improved processes and procedures, better decision making abilities, less reliance on the experience of one person or a select few for their knowledge or abilities.

3:7 Measuring success

Success will be measured by the willingness to continue implementing further digitisation and smart technologies. The effectiveness of the new systems and processes will provide evidence of a tangible pay-off and benefit to the business. Manual data collection will be superseded by the automatic collection and storage of that data in a way that the reporting and manipulation of the data will be simpler.

4. Business elements which will be enhanced

4:1 Improved Management Processes

Factors that would benefit from this strategic alignment with accurate data gathering and understanding include timesaving across many business elements - through the shared interaction of all sites sharing the same methods for data recording, reporting, and sharing. A reduction in time to market for both 'Made to Print' and 'Design and Development' projects - which leads to quicker approvals and payments. An improved understanding of terminologies - through a recognised structure of product and failure mode recognition strategies. Reduction in data handling - through the utilisation of shared templates and structures for referencing data in the recording and reporting streams through the adoption of digital systems where possible.

The items above would assist with an increased visibility of all data criteria recorded, which can be accessed easily from a central data repository, allowing dynamic analysis of all data with an early visibility to foresee planning on demand through the Interaction with a manufacturing chain to ensure full visibility across the entire manufacturing supply stream. Dynamic planning - Expecting the unexpected. Planning to avoid chokepoints/capacity issues and Foreseeing the Bulk buying of components and raw materials to avoid supply issues and price fluctuations. The logistics planning associated with the materials, ensuring on-time receipt of incoming goods and materials, all within budgeted costs.

Component delivery timing and complexity – enhanced with Engineer to order (ETO) and Just-In-Time (JIT)

Visibility of how a perceived isolated change could affect multiple projects.

Dynamic reporting through a process requiring minimal handling, and manipulation of the data already gathered for ease of interpretation and reporting.

Capacity monitoring affecting the availability of raw materials, manpower, and machines.

Manufacturing Efficiency – analysis on batching, sequencing, integrated scheduling, maintenance, managing resources, etc.

Total Preventative Maintenance (TPM) – proactively maintaining machines and tooling to prevent lost time in manufacturing, and maximising Overall Equipment Efficiency (OEE)

A more in depth consideration of factors mentioned, now in respect to departments within a manufacturing SME.

4:1:1 Production, Maintenance, Logistics & Tooling

- Common Identification and traceability of raw materials across all sites.

Compound Type, Hardness, colour, material/particle content, common incoming product suppliers

- Common Identification and traceability of bought-in and child parts across all sites

Material, Type of part, dimensions, where used, common incoming purchased part suppliers

- Common Identification and traceability of sub-assemblies and final products across all sites.

- More reliable methods for tracking product movements

Product Type, part number, end-use.

- Common Identification and traceability of tooling inventories and ancillaries across all sites

Recognised group tool numbers

- Common Identification and traceability of plant inventories across all sites for machine numbers and ancillary plant references
- Monitoring of tooling use to provide pro-active feedback for customers and stakeholders to ensure peak tooling performance and OEE
- Increased productivity from operators/engineers through timesaving on many levels

Process controls

- linked to warning systems to alert personnel of deviations from defined parameters in fully/semi-automated systems
- More reliable methods for Inspection (either through automated systems, digital reporting or digital inspection instructions)
- less investment is required in production equipment and tooling.
- obtain every possible price advantage on purchased materials and components

Reporting accuracy

- Common templates and methods for the reporting of manufacturing sales information across all sites

- Common templates and methods for the reporting of manufacturing performance information across all sites
- Common templates and methods for the reporting and sharing of process information and settings across all sites
- Occurrences of issues resulting through human error removed/reduced (such as inventory losses, errors in order fulfilment, deliveries, etc.)

4:1:2 New Product Introduction (Sales, D&D, Project Management, Materials, New Tooling)

- Good part data for both the quotation of new work arising and utilising what parts are already produced or procured for re-use.
- Sub-assembly parts being combined with other suitable components to form new assemblies without the requirement to manufacture new bespoke tooling.
- Incorporating Design Briefs with established, well-defined, and robust design rules across product types creating a family of similar designs that would require minimal change to be offered elsewhere.
- Well-defined and robust tool design rules with layouts pre-determined from experience with similar parts and layouts
- Common Process Flow reporting templates across all sites
- Common Failure Mode and Effect Analyses reporting templates across all sites
- Common Control Plan reporting templates across all sites
- Common Capacity reporting templates across all sites
- Common Work Instruction templates across all sites
- Common Capability Study and R&R reporting templates across all sites
- Common Test Report templates across all sites
- Common Part Submission Warrant templates across all sites

4:1:3 Accounts

- Increased efficiency and speed in invoicing, receiving and making payments
- Simpler processes for reporting business performance across departments and sites

4:1:4 Senior Management

- Occurrences of issues resulting through human error removed/reduced
- Linked systems to report worker outputs, performance, hours worked
- Management Administration such as holiday booking can be reduced to a minimum by enabling worker facilitation to raise a request for management to approve in place of management performing the whole request process.

4:2 Downstream Improvements

- less investment is required in production equipment and tooling.
- obtain every possible price advantage on purchased materials and components

5. Implementation

Satell (Satell, G., 2018, 1) suggests that any innovation should be defined within the domain in which it resides.

The needs of the processes requiring enhancement should be evaluated through the use of a data gathering tools and then decisions on the prioritisation of which inputs and outputs are most important should be assessed using a form of decision matrix.

Any implementation should follow a well devised strategy/plan drawing on many various skillsets.

A champion, one with good communication skills across all levels, knowledge, one with personal and team drive, a persuasive personality, awareness of where investment can be achieved, reporting the projected payback scale and timescale, with a logical project management ethos to integrate any innovation into the company business plan will be the one to see the plan through(Satell, G., 2018, 2)(Tidd et al., 2020, 1).

The right culture has to be nurtured to create a greater chance of the new way of working succeeding in its implementation and sustainability goals. (Jaruzelski et al., 2011)

Five factors that a champion should be aware of and track throughout any implementation are suggested by (Brunet-Thornton et al., 2018)and as follows:

- I. The technical feasibility of the solutions and their implementation. The solution might be an improvement for some aspects but does the solution make any aspects overly complex?
- II. The Implementation and development costs –the cost and difficulty of implementation will vary, and funding options should be investigated through all means available. Networking and accrued knowledge of where to apply is key. Does all the implementation have to be introduced at the same time and could a saving be made by introducing some aspects at a later date?
- III. The Dynamics of the labour market and its geographical diversity – when to deploy advanced technologies can depend on criteria in countries with higher wages such as minimum wage increases in National Insurance etc. or conversely some countries may lack the infrastructure and capital to acquire the systems available.

- IV. The Economic benefits – increased labour and maintenance cost savings, increased productivity, improved quality of product and services.
- V. The Social acceptance – there may be a reluctance of some workers stemming from the misconception of their being replaced by a machine, where there may be other benefits unbeknown to them.

5:1 Assessment of which terms and systems require alignment

For any given business these considerations might include:

Part numbers, of individual parts, assemblies and sub-components.

Material types and from suppliers.

Tooling location and condition monitoring.

Machine location and condition monitoring.

5:2 Performance and Controls required

For any given business these considerations might include:

Resource and performance monitoring.

Data collection methods.

Data Storage.

Internal computer systems and connectivity.

External systems and connectivity.

Scales, Sensors and Peripherals.

Health & Safety considerations.

Cyber security.

Offline testing and error proofing of systems before they become live and connected.

5:3 Fit for the Future?

Any system should be given due consideration on whether it is capable to interact with all the current systems within the business. Utilising existing systems will assist with the integration and cost management processes.

How easily a system can be upgraded in the future and how easily additional future partner software and machine upgrades can be integrated.

The capacity to connect to an increased volume of input data from new machines, sensors, hardware and peripherals should be confirmed along with the ability to accommodate machine and peripheral upgrades as and when required.

5:4 Multidisciplinary Focus Teams

The Identification of enablers, IT practitioners, stakeholders, suppliers, internal and external customers should be considered, with their needs and wants to be recorded. How their input and output interactions might influence another stakeholder should also be considered.

5:5 Liaising with colleagues for feedback on proposals

Communication at all levels must be cross-departmental and multi-directional (not purely instructions from above) to ensure that all potential issues are reported, investigated and overcome. The sharing of the information of what might be coming whilst encouraging involvement and buy-in with a positive viewpoint, reduces the “shop floor gossip factor” which would tend to fall on the side of a negative scenario.

5:6 Internal and External Skills Requirement

Any investment in seeking outside assistance should come with a form of intellectual property protection and future service provision to future-proof the system.

The recruiting of new skilled labour or the upskilling of current workforce from within, must consider a strategy of retaining these skills within the business.

5:7 Limitations

The importance of commitment on all levels is indisputable (Longoni et al., 2015).

The reasons behind the unsuccessful applications of lean and ERP in SMEs can be defined to by a few key characteristics shown below (Sun et al. 2005, Achanga et al. 2006):

1. Financial capabilities – SMEs are often deficient in the capacity to successfully free up capital to implement fully integrated connected ERP systems.
2. Skills and expertise – SMEs are usually more inclined to employ workers with lower skill levels than OEMs, and these would tend not foster the ideology of skill

enhancement through available resources and the confidence/competence to develop and improve their production systems.

3. Supervisor & management leadership – Many SMEs are strategically stymied because of the lack of well-planned strategic drives born from good leadership attributes, mainly through top management's continued engagement in improvement projects.
4. Work Culture – SMEs can appear intransigent to embrace change, both in the way that the company works within its culture under the personality of the owner/manager and are thus inhibited in suggesting and undertaking change.

Evidence suggests that many SMEs choose to combine an ERP system of some description, usually as a planning and scheduling tool, with other disparate planning and control systems being used to control the flow of materials and manage the utilisation of resources.(Koh et al., 2006)

6. Funding

Sources of funding come in various forms and the desired route is one that would be taken after consideration of the particular needs of a business. Some that are on offer to businesses in the UK from a simple internet search are as follows:

- **Made Smarter:** Offering grants and support for digital transformation, including up to 50% match funding for equipment and advice. Made Smarter also provides guidance on creating a digital roadmap plan.
- **Smart Manufacturing Data Hub:** Offers grant funding of between £5,000 and £315,000 to help small and medium-sized manufacturers develop data-driven innovations.
- **Business Productivity & Digitisation Grant:** Available through a local authority application.
- **Capital allowances:** Commercial property owners can claim tax breaks on eligible capital investments, including plant and machinery. R&D capital allowances can be claimed for R&D projects.
- **Venture capital:** Investors provide money in exchange for shares in your company.
- **Bank loans:** A common choice for financing large-scale projects but may require significant collateral to be in place.
- **Private equity:** Firms that can offer or provide access to considerable capital

6:1 Costs Involved

A considerable outlay will be required for any system. As an example, a full turn-key application such as SAP, with installation and configuration of the basic SAP Business One option costing in the region of \$100,000, with each required licence costing circa \$3000 per year (Source - Silvertouch UK, 2022). Adding the required totals together, with hardware, this is clearly not an option for most SMEs. The quote that Fibrax received from PlantRun was £113,000 with an extra cost for additions such as licences with their system specifying the use of their own tablets and other peripherals, again at an extra cost. (Source – PlantRun quote)

A more realistic figure would be around half of that amount, with as many savings through the utilisation of existing systems and hardware being sought. A system such as H-SYS comes with the provision of 500 licences built-in and allows for the use of peripherals not supplied by the development company, but still having the flexibility and scalability of the other options.

6:2 Internal sources of funding

The business case would have to be made to the company owners or directors to permit the release of funds to cover the internal investment. The justification for the CAPEX would be based on the pay-off of a targeted investment against the removing of waste from processes and an improvement in efficiency in the scoped areas.

The required provision of hardware such as upgraded computers, tablets, upgrades to internal/external communication means would likely have to be met by the business itself.

6:3 External sources of funding

The SMDH Digital Innovation Fund is one example of external funding available. The Smart Manufacturing Data Hub (SMDH) supports small and medium-sized manufacturers to become more competitive by harnessing the power of data. Digitalisation solutions, mentoring and funding are made available to businesses, allowing them to explore and evaluate their processes, make operational savings, de-risk investments and become more digitally aware. Businesses who partner with the Smart Manufacturing Data Hub, are eligible to apply for up to a ceiling of £50,000 in grants available on a company-match basis, to allow for the further development of digital technologies in their business. (SMDH, 2024)

They work with businesses to develop a digital roadmap leading to long-term success and achieve access to funding in support. Fibrax enablers investigated this avenue through a network of relationships nurtured through involvement and partnerships with UWTSD and AMRC Cymru, Broughton. Once investigated, this was found to have provision for covering much of the practical costs of implementing a digital transformation in a manufacturing SME, covering items such the wages of those involved whilst developing and implementing the system, the testing of the system by the developers and aspects of training related to the system.

7. System Trialling

7:1 Business and Performance Requirements

Any new system has to be able to communicate seamlessly with any chosen part of the existing PLM network, through ease of use for the operator and ease of access and manipulation of data by other users.

7:2 Offline trialling and error-proofing

Off-line simulations and remote testing of either the system in full or the sub-routines is critical to ensure a smooth transition and implementation. A form of digital twin of the system will test the effective integration with existing systems to reduce risk during the implementation and minimise any potential disruption to the business. With the H-SYS system already being used in a manufacturing scenario in MPM, much of the de-bugging of the system will already have been completed, plus any desirable additions could be trialled withing an aspect of that system set-up to confirm a favourable outcome.

7:3 Assessment of which terms and systems can align

All aspects of potential terminology alignment are discussed in section 4.

7:4 Is the current data fit for purpose?

An in depth investigation into the suitability and correctness of the current stock data would have to be devised and performed.

7:5 Integration and Transfer of Information

Three types of integration are often considered in Industry 4.0 and the aspects of its implementation.

1. Horizontal integration goes across the manufacturing network involving the integration of different customers, business partners, and business models.
2. Vertical integration is the networking of manufacturing systems involving intelligent connected production systems thus producing a network within a smart factory.
3. End-to-end engineering spans the entire product life cycle involving manufacturing and other departments through to the customer. (Vaidya et al., 2018)

Digitally integrating a manufacturing process allows for the automation of communication between machines. Horizontal and vertical integration allows an assimilation within a business through connectivity various departments, in addition to companies and customers. This creates a 'data-integration network' for the manufacturing process (Tortorella et al., 2019).

7:6 Data Analytics

Data collected will assist in many areas, but improvements should be seen more rapidly and prominently in the areas of quality assurance, lifecycle-impact assessment, and design improvement (Helu et al., 2015).

7:7 Reporting

Reporting can be through whichever means is desired to be used, tables, graphical form, dashboard etc. locally and remotely. Ease of interpretation and understanding should be paramount.

The alerting of remote personnel to potential and real problems is an option for inclusion, along with specific alerts to one or more of the following, Shift Supervisor, maintenance department, tool room, IT department, planning department, process engineers, and quality departments depending on the nature of the issue transpiring and reported.

When reporting the data, the unit of analysis for comparison will be the business in its current state. Any improvement will then be tracked so there is no slippage from any improvements gained. (Tortorella et al., 2019)

8. Business & Strategy

8:1 Shared Knowledge & Experience (Less reliance on the knowledge of Individuals)

The sharing of knowledge should be managed with a company and should be a collective rather than an individual activity, networking infrastructure supported by IT/Intranet will encourage participation and benefits (Huysman et al., 2004)

Any SME can inadvertently develop a dependency on a group of key individuals whose accumulated knowledge of the company, through reasons such as length of tenure, their exposure to the workings of many different departments, to the many different processes, their retention of part/tooling references etc., might give some colleagues the perception that these individuals can be utilised as a “fountain of knowledge” when some may fail, within the company. While this might be a good job retention asset for those individuals, there would be the disadvantage for others that the knowledge is locked within the individual’s brain and not shared. They could be queried at inopportune times and be unable to reply or the time taken to assist and provide an answer would be to the detriment of their current position and workload. The sharing of this data through such data sharing systems such as a knowledge database, detailing key information such as all possible references for a part, the lessons learned from a particular project etc., would permit the release of this burden from these individuals and place the onus onto colleagues to seek the answers through logically investigating and accessing the knowledge on the database, or through references or links, finding the required answers within another data storage system.

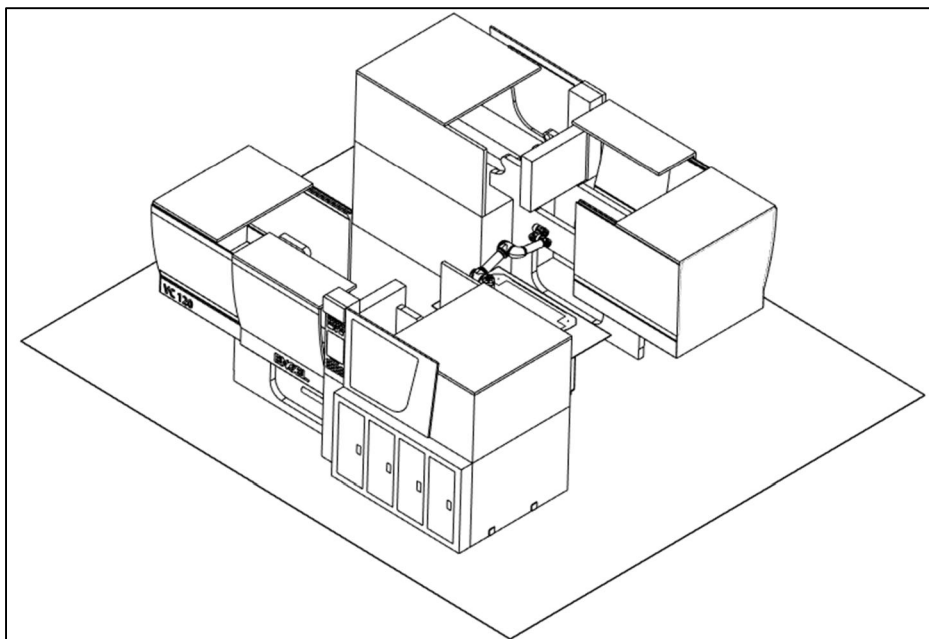
The value of shared data can be categorised into 2 streams.

1. The sharing of data where all stakeholders contribute to the success of the data-sharing activities, generating value from themselves and the network.
2. A range of value propositions for the stakeholders participating in the sharing of data, and activities within the value network, aim to achieve value propositions for all the participants. (Arenas et al., 2019)

8:2 Innovation Expansion

‘The more we know about something, the more we can take calculated decisions about whether to proceed. And in a competitive environment this places a premium on getting hold of knowledge as early as possible.’ (Tidd. et al., 2020, 2).

Through the sharing of knowledge and experience, many more minds can be utilised to analyse data and uncover the solutions for problems encountered. New ways to look at all processes and procedures, from many differing points of view can be tapped to innovate where the previous knowledge holders may have throttled the flow of ideas. Only through the expansion of innovation within Fibrax, has the advancement of the automated production cell been conceived and brought to fruition. From gaining skills and networking connections initiated whilst undertaking the MADE Innovation course with UWTSD, and further nurtured through negotiations **with SMDH** to achieve the ideal means of extra funding, has the project been conceived, planned and achieved.



8:3 Responding to Changes in Markets, Legislation and Standards

Just as SMEs tend to develop a group of individuals within their team to be able to cope with systemic change and leverage new opportunities, with entrepreneurial mindsets, such as the capacity to work in a team, active learning, tolerance to uncertainty, flexibility and accountability (OECD 2018), any system must have the flexibility and capability to encompass any perceived changes that might occur in a work environment. Demonstrating

a reduction in carbon footprint through the monitoring of ambient temperatures, ensuring machines are powered down if not in use, lighting being automated in low-traffic areas etc.

8:4 Introduction to the next chapter, Fibrax Group

In the new global economy, the importance of research into the identified elements required when implementing both Strategic Alignment and Connected Technologies into a manufacturing business, all requiring due consideration, cannot be underestimated. The next section aims to familiarise the reader with the case study business, Fibrax Limited, who are a full-service (Design to manufacture) supplier of rubber and plastic mouldings, primarily for the automotive industry. The company will be referenced within the next chapters and will provide an insight into the processes involved in the sourcing, off-line trialling, on-line testing and full integration of their chosen Strategic Alignment plan and Connected Technologies into their business.

9. Case Study

9:1 An Introduction to the Fibrax Group

The Fibrax Group was formed in 1911 and has been a privately owned business since 1975. They specialise in the full-service design & manufacture of rubber and thermoplastic mouldings, utilising Vulcanised Rubber, Silicone, Thermoplastics and Thermoplastic elastomers, supplied to customers mainly within the automotive, oil and gas, and cycle sectors. Some of the supplied parts are designed to be constructed into more complex assemblies which achieves added value.

The group employs approximately 350 staff across three sites, with manufacturing being based at Wrexham, Sanok, Poland(Fibrax Sanok, FS), and Casablanca, Morocco, (Morocco Precision Mouldings, MPM). Altogether these sites supply parts to UK, Europe and worldwide.

The site in Wrexham also houses the group HQ, New Product Introduction hub, Toolroom (manufacture and maintenance), Group Compliance management, along with the Group Technical department, which is responsible for Design, Project Management & Validation activities.

9:2 Problems Encountered that initiated the Digitisation & Alignment project

Inventory management is key to the implementation of all Lean strategies and any implementation of I4.0(Valamede et al., 2020). Any manually based system for production and tracking stock inherently comes with the risk of human error(Torres et al., 2021). Stock losses through the mis-reporting of inventory through the production lifecycle can be a costly problem to correct. There are many ways to minimise this risk by automating the process of tracking the manufacturing process. The Fibrax Group has recognised the need for an effective Shop Floor Data Capture (SFDC) system to track inventory more effectively and aims to minimise the risk going forward, initially on their Wrexham site and then to be rolled out to the other 2 sites as a fully connected system. The ultimate wish is to facilitate a feedback loop across the entire product lifecycle to improve and sustain existing markets and develop new Marketing Opportunities (MOPs) through the accrued knowledge, but for the initial term of system use the interest will be in a sub-set of the technologies on offer.

9:3 Project Objectives

To achieve a more effective manufacturing process and reporting through the reduction of Human Factors (HF) and a lean process with the removal of costly errors through the lack of accurate and pertinent data for the manufacturing process.

9:4 Project Desired Outcomes

- Remove as many HFs in the reporting of inventory as possible.
- An improvement in record reporting across sites and group-wide.
- Real-time monitoring
- Positively track the quantity and location of inventory in real time.
- Positively track and implement solutions quickly and more effectively.
- Use the data collected to report performance, efficiency and profitability,
- Undertake and report maintenance schedules for tools/equipment more effectively.

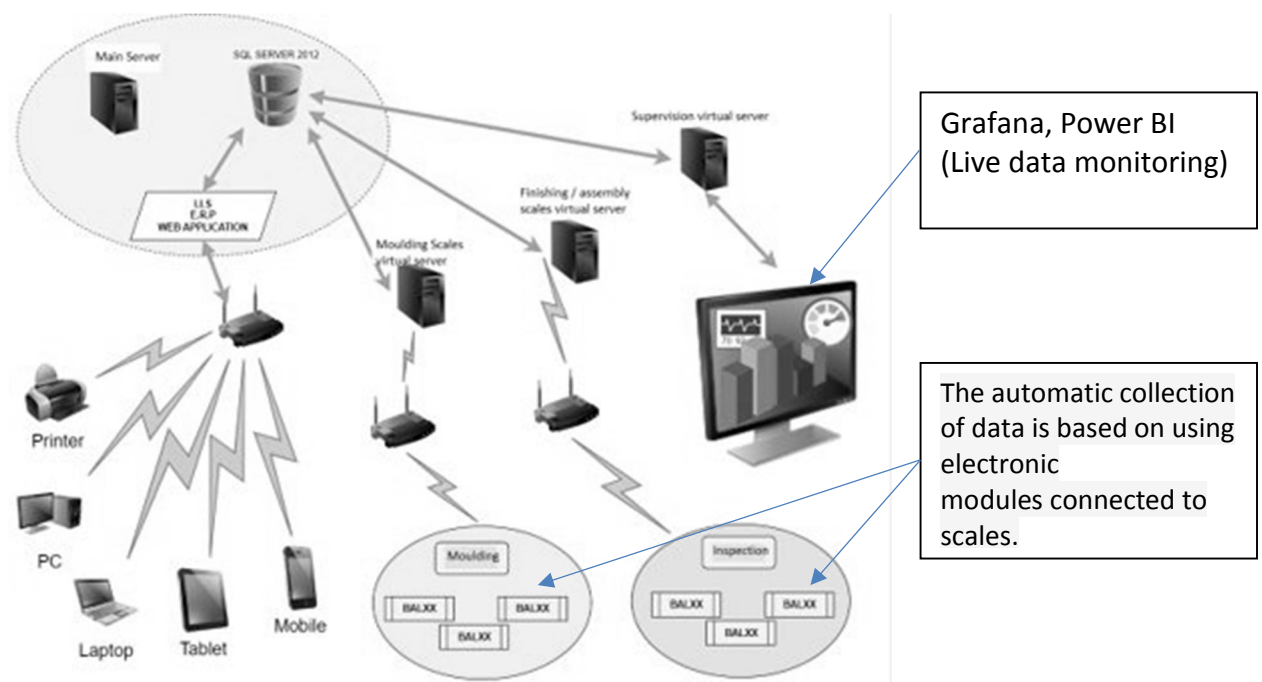
9:5 Measuring Success

Ultimately the success in the case study will be the efficiency of a fully integrated system for controlling all functions within the product lifecycle. If finance was not a limitation then more would undoubtedly have been given greater impetus to be implemented at this stage, however funding, and immediate business needs have directed the implementation team to consider an initial direction which, in choosing the selected system to implement considered 7 different ERP systems initially, H-SYS, EFACs, Codeway, Intouch, Lighthouse, PlantRun and Cyclades. After consideration across the many desired options for adaptability and future upgrades as well ease of integration across the group, this was filtered down to 2 systems, H-SYS and PlantRun. Both were found to be very capable systems, but the deciding factors were cost, and data accuracy (some peripherals required more development on the PlantRun system).

H-SYS, based in Morocco, has provided ERP and SFDC solutions for Morocco Precision Mouldings (MPM) since its inception in 2018. The system is used for end-to-end processes, capturing real-time data, ensuring traceability across the process, including maintenance, and capturing most operational KPI data. So in summary H-SYS offered:

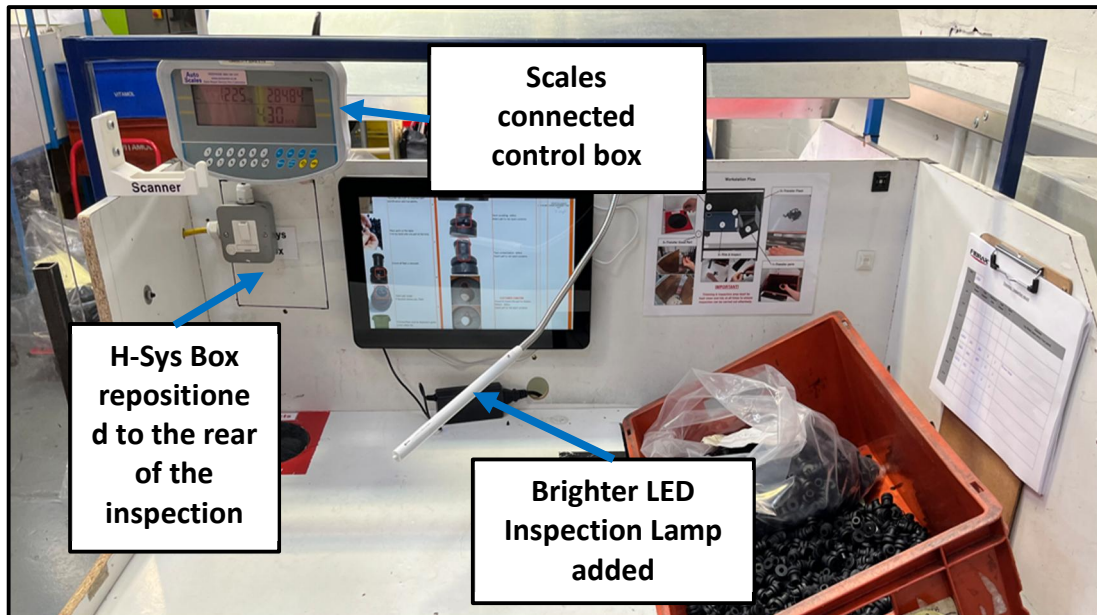
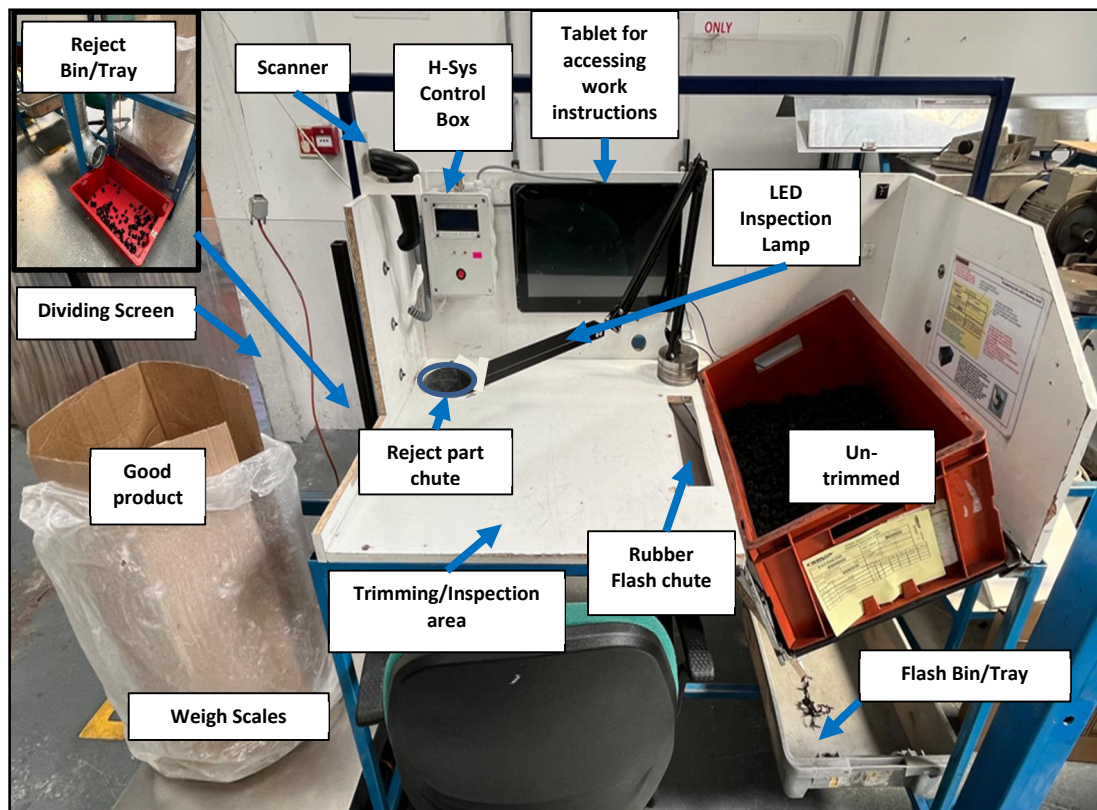
- A known supplier to the Fibrax group,
- A low-cost solution,
- A low-cost hardware,
- A proven system in our Morocco Plant (MPM),
- A proven solution for injection moulding

With H-SYS chosen, the implementation team began several months of liaising with the developer and colleagues to improve the system for the specific needs of the Fibrax group. H-SYS will work in conjunction with 2 of the existing systems used at Fibrax, the EFACs ERP system and Fibrax's own knowledge hub, the Development Database.

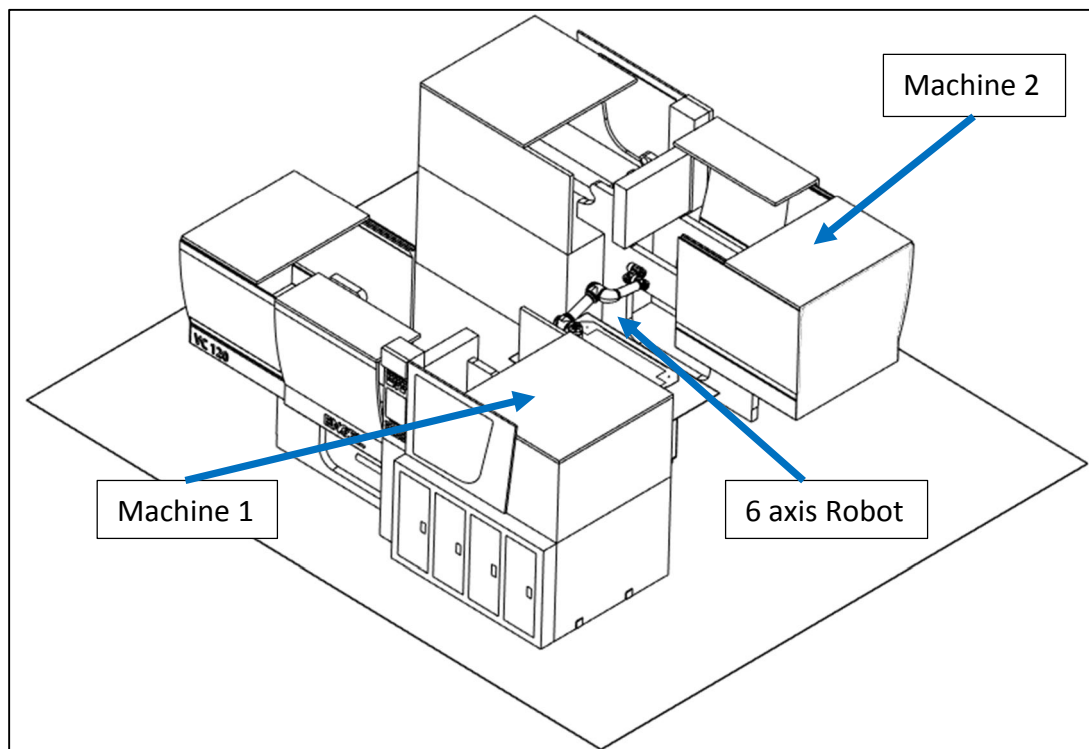


The first major “bolt-on” peripheral that will be implemented to H-SYS is a much-needed standardised “Inspection Cell” (see images on next page), which will make great strides in reducing stock losses through positively tracking the parts that are moulded, through inspection and on to packing in bags/boxes through a real-time weigh station connected via a control box to the H-SYS ERP system. An instruction from the tablet positioned on the table will call for the tare reset; the packing box will be placed on the connected scales to log the required amount of parts. When the required (quantity) weight of parts (downloaded from the recipe in the instruction document) is achieved, the system will instruct the operator to scan the box for transportation to the warehouse. The inspector in the inspection cell will then be instructed to start a new box of product.

Inspection Table with connected devices



Automated Production Cell



As with the inspection table and the weigh count connection, the automated production cell aims to remove the manual tasks from creating a part formed through the over-moulding of a plastic (PP) frame with over-moulded metal inserts with flexible TPE.

The metal inserts will be loaded by the cell robot from a bowl feeder, into the first machine. The PP frame will be moulded over the inserts to produce the sub-assembly.

The PP frame sub-assembly will then be transferred via the same robot to the over-moulding machine where that injection moulding operation will take place. As well as the opening and closing of the mould tools, the movements of the robots and the mould parameters of both tools will be recorded to track production efficiency and predict when machine or mould maintenance is required. Human-robot mutualism will be achieved through extolling the benefits of advanced training in the robot use and maintenance, as well as the reduction in repetitive manual tasks to a state of increased ergonomic and workload efficiency through the collaboration (Soldatos et al., 2019). Once the cell can be seen in operation, the virtues of being a member of the team who attend to the automation cell will be a highly visible incentive for others to advance themselves should they wish.

9:6 Limitations

Input data has to be complete and accurate as a starting point and whomever is responsible for the data inputs required to instruct the ERP must be proven to be diligent to ensure the data inputs are correct and accurate but also knowledgeable and empowered to question the data provided should it not fit the accepted format and content. Part numbers within the Fibrax group have not set format and generally are either the primary customer or take the Fibrax internal drawing number. As you may understand, this can lead to confusion. Considering this, and in an effort to close this loophole at an opportune time, there was a proposal to adopt a “Fibrax Part number” for each component, sub-component and assembly. To make this as democratic and to gauge opinions of a varied group of colleagues, a survey on how part numbers could be rewritten to reflect was devised based upon:

- The sphere of industry to which the part is supplied (denoted by letters or numbers)
- The type of part it is within that given sphere (i.e. a door grommet)
- The material used to make the part (Types of Rubber, silicone, plastic etc.)
- Unique sequential number (1-9999)

The survey set out to find a best-fit across a cohort of senior colleagues and for comments to be accrued and considered when assessing suitability of each option offered.

9:7 Research & Findings

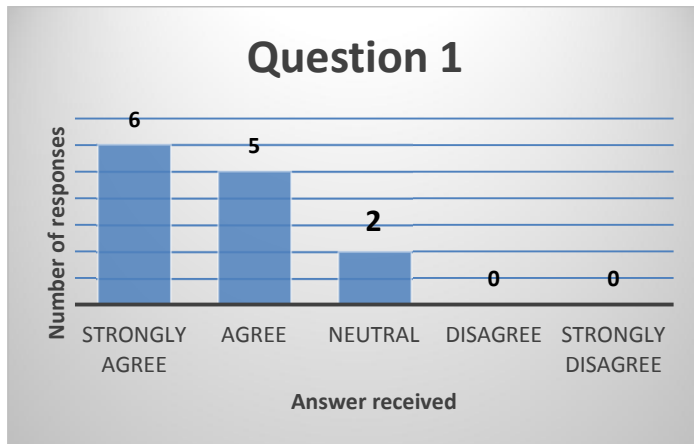
The research is primarily to address and gauge the understanding, communication and planning of the exercises being performed at Fibrax and compare this with the literary research findings, to gauge any gaps or deficiencies in the academic works cited and the exercises system being introduced at Fibrax and to critique both accordingly recommending good practices.

Questionnaires were sent out along with the request to either respond in person, via Microsoft Teams meeting or by submitting their answers in a written reply. These invitations were sent to 16 colleagues within the Fibrax Group to gain their insight. The survey sample is shown in the supplied Annex. The number of respondents that completed the survey was 13, due to a mixture of 3 reasons, annual leave, sickness and work schedule. A balanced mix

of individuals who would use the system for reporting, analysing data, and decision-making was sought and, despite the non-responses, was achieved. The cohort ranged from Shop floor and warehouse supervisors through to Company Directors.

Questionnaire 1

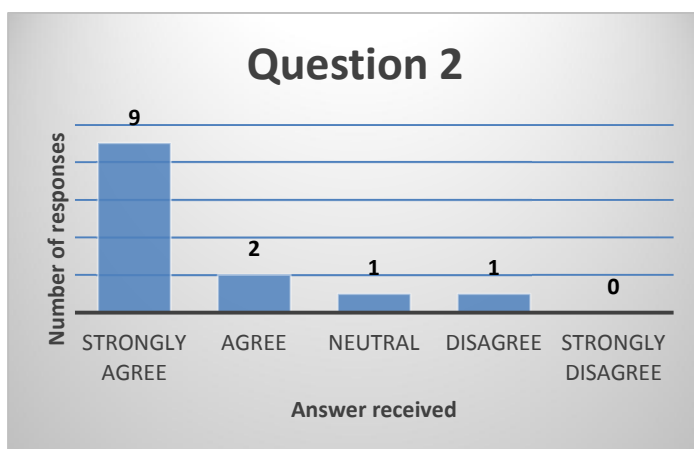
Questions 1 to 4 were devised to provide a survey to quantitatively investigate the knowledge of SMACT across the spectrum of respondents.



Q1 - "I am aware of Smart Manufacturing and connected data collection/management technology"

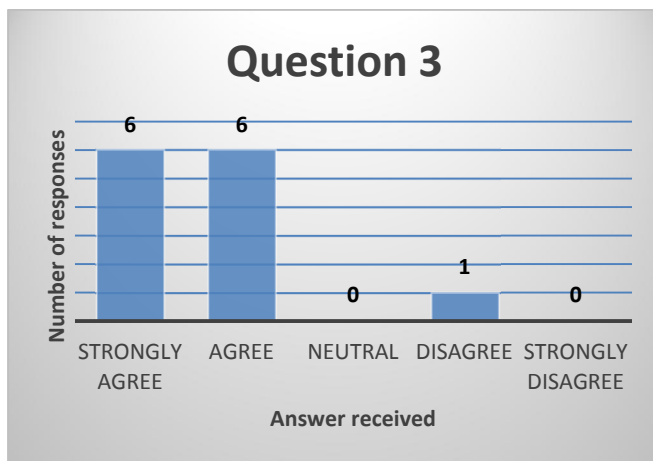
The answers received suggest respondents are aware to some degree of the subject matter.

A 46% response of Strongly Agree and 38% agreeing. The neutral responses (16%) would suggest that some colleagues would benefit from insight into what can be achieved by SMACT.



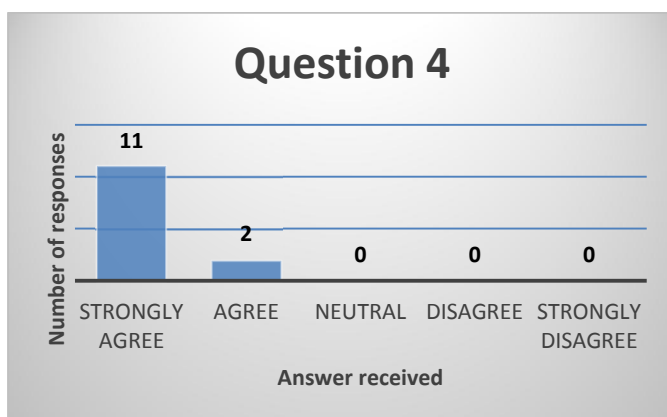
Q2 - “I am aware of the advantages achieved through the strategic alignment of data.(using the same format of part numbers, tool numbers, data reporting and documentation reporting strategies across all departments and all sites)”

As with question 1, the answers received indicate a good appreciation of implementing the criteria mentioned in the question will benefit the company, Strongly Agree(69%) and Agree(15%), but some colleagues would benefit from insight into what can be achieved. Neutral and Disagree (8% each).



Q3 - “I am aware of the aspects of Smart Manufacturing and data management that are being introduced to the workplace as part of future company strategy.”

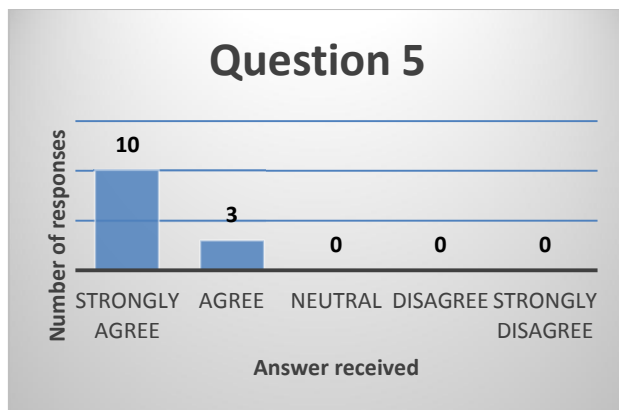
This was specifically aimed at finding out if the respondent knew what was being introduced into their workplace. The answers received indicate the majority have knowledge of what is being implemented (Strongly Agree and Agree both at 46%), but that some colleagues (Disagree at 8%) would benefit from an insight into what is being implemented and what can be achieved.



Q4 - “I am aware of the issues and hidden costs arising from stock losses and logistical errors within the workplace.”

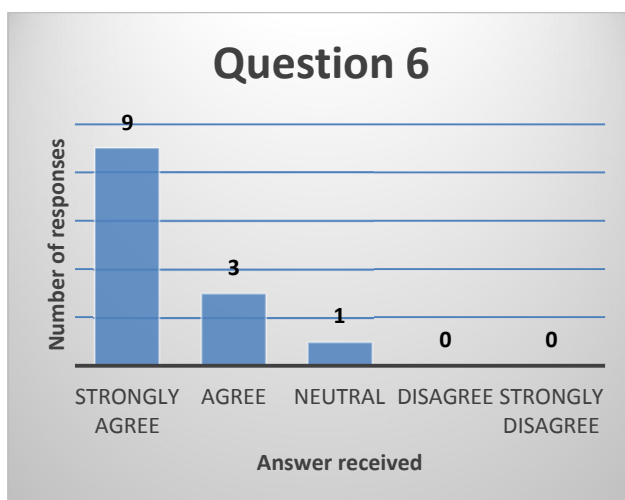
As most of those questioned should have a good appreciation of the issue there was no doubt that the team know of the need to improve. Strongly agree seeing 85% and agree seeing 15%.

Questions 5 to 8 were devised to gauge opinions on the benefits that would come through the integration of SMACT



Q5 - “I agree that Smart Manufacturing and data management would enhance the operational effectiveness of the manufacturing processes. (Traceability of labour, machines, materials, and products wherever possible)”

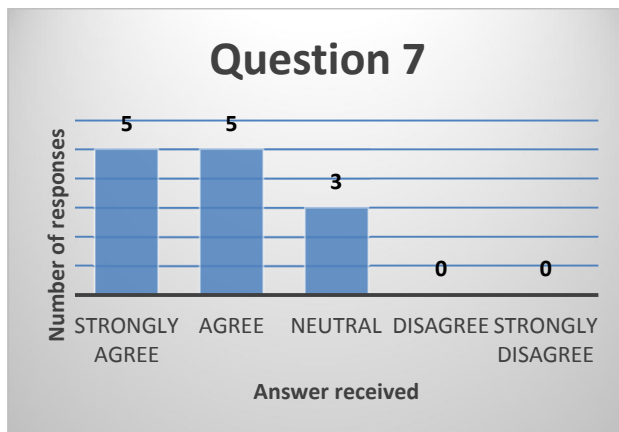
A fairly overwhelming agreement across all those questioned shows a knowledge that benefits will be achieved. Strongly Agree at 77% and Agree being 23%.



Q6 - “I perceive Smart Manufacturing and data management as a major factor to improve efficiency and productivity in the workplace.”

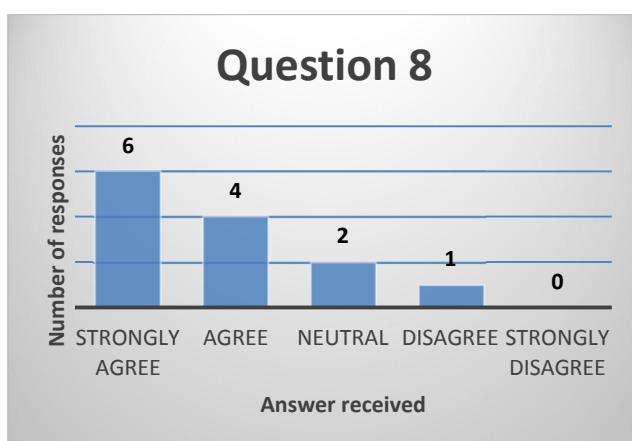
Again, a good agreement across the majority of those questioned shows a knowledge that benefits will be achieved. 69% Strongly agreeing and 23% Agreeing. 8% Neutral.

It is worth noting that the one neutral responder stated that they would like to have more knowledge on the subject for their particular role.



Q7 - “The integration and implementation of Smart Manufacturing and data management will be a significant challenge for the company.”

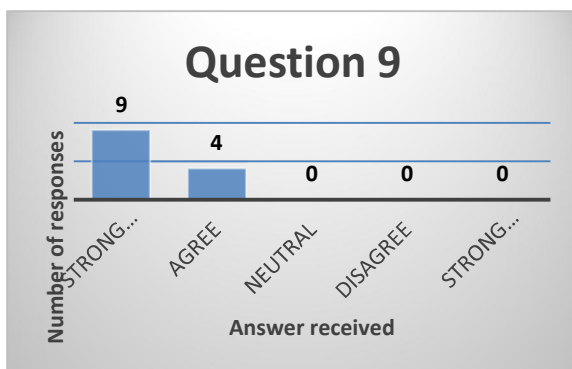
Opinions were split on this question, but almost all fell on the side of there being a challenge to successfully implement the systems. 38.5% for both Strongly Agree and Agree, with 23% staying Neutral.



Q8 - “The cost of introducing Smart Manufacturing and data management would be a significant challenge for the company.”

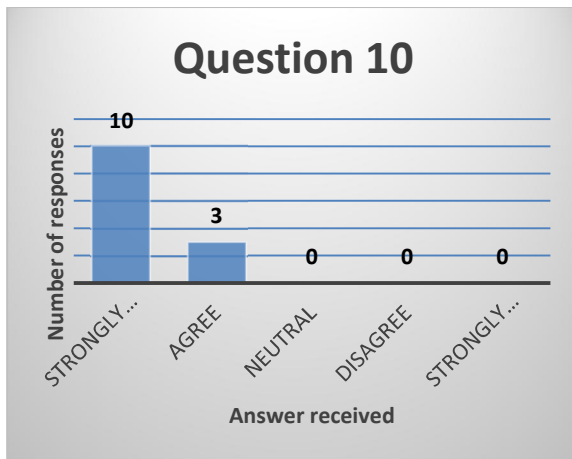
This was a very interesting question. All of the respondents based their answers on their own perception of how funds could be achieved. The majority of respondents based their responses on the current financial climate which are seeing some issues with 46% Strongly Agreeing and 31% Agreeing. A small number of colleagues more closely aligned to how external funding could be achieved, responded with the neutral/disagree responses as they had insight into either what had been achieved recently or what can be achieved with the correct knowledge of what funding is available and how to achieve it. (Neutral 16% and Disagree 8%)

Questions 9 & 10 were devised to gauge the appreciation and willingness to engage with SMACT



Q9 - “I appreciate the need for good collection and management of data throughout the whole product lifecycle. (From Sales Enquiries to Part Design to Product/Tooling Management to Production planning/manufacture to Part delivery and then feeding back into the cycle to drive improvement at every opportunity)”

This set of answers provided a good gauge of colleague commitment. With all agreeing that good product data is key to the improvements that the company wishes to undertake. 69% Strongly Agreeing and 31% Agreeing.



Q10 - "I embrace the changes in work practices needed to integrate Smart Manufacturing and data management and will strive to sustain its use through the entire product lifecycle."

77% Strongly Agreeing and 23% Agreeing should serve as an excellent barometer of colleague commitment to make the changes work. A workforce who want to ensure the required changes work for both their own benefit and that of the company as a whole.

Questionnaire 2

Questionnaire 2 took on the form of a longer format interview session. By employing qualitative modes of enquiry, I attempt to illuminate the knowledge of SMACT and what is being introduced to their place of work and how it might help their role now, and in the future. Eleven colleagues were approached for interviews. These were performed in person in the main and recorded with the transcripts recorded for future reference. This study should highlight any areas of concern that may hinder the implementation and provide methods by which they might be prevented or overcome.

Those selected for interview were:

1. Production Manager/Supervisory representative,
2. NPI Sales manager,
3. NPI – Materials and processing Manager,
4. NPI - Design and Project Manager,
5. NPI - Tooling Manager,
6. Accounts Manager,
7. Compliance Manager,
8. IT Manager,

9. Group Development Manager,
10. Technical Sales Director,
11. Group Managing Director.

(Q1 & Q2 were name and job title respectively)

Q3 - How will Smart Manufacturing and connected data collection/management technology assist your department and your role?

All respondents possessed at the very least a snapshot of how SMOACT could assist their role. Some more acutely connected to the implementation were intimately aware of how the system would transform working across many departments. The key observation going forward must be to widen the knowledge base and this will expand the possibilities of improvements across the whole framework of the business.

Q4 - Do Financial Constraints limit the implementation of Smart Manufacturing and its elements?

Most respondents, working on their limited knowledge of company finances responded as it would be difficult. Those with a more closely linked relationship with current improvements projects were the outliers who knew of other sources of finance that are available and of company investment based upon the payback projections of value being returned.

Q5 - Is there a lack of quality strategic drives drawn from good leadership traits in top management & supervisors, particularly in improvement projects? And commitment to? Where and at what level?

There was a definite agreement that there were drives of this type but historically they tended to fade due to a lack of impetus to see them through. Latest trends are seeing a drive to complete these projects, something that can only be good for the business going forward.

Q6 - What benefits will be achieved by strategically aligning data within your department and your role? (using the same format of part numbers, tool numbers, data reporting, and documentation reporting strategies across all departments and all sites)

The consensus on this was it will make their working lives easier and allow them to focus on other value-added activities and new projects.

Q7 - How can you and the company proactively encourage all colleagues to embrace new data collection practices within your department?

This set of responses demonstrate a strong and consistent association between communication and success. Keeping interested parties informed of the improvements and opportunities whilst extolling the benefits for all is key to that success.

Q8 - How can you and the company ensure the integration, implementation, and governance of new data collection practices within your department?

In short, the respondents stated that the implementation has to be embraced and given the support required to succeed. Educating all in the improvements that will come out of the exercises. Clearly created guidance on why the data is necessary and making department heads accountable for their department performance with regards to data collection, its use and reporting.

Q9 - How can the company sustain the use of data through the entire product lifecycle?

Respondents generally came to the same conclusion that all departments have to make proper and full use of the capabilities of the new system. This will provide the information of what activities create company profit and which create a loss, enabling better allocation of costings and resources.

Q10 - Do you see the Introduction of Smart Manufacturing and good data management as integral for future company efficiency, productivity, and profitability?

A collective Yes. Working smarter was recognised as a key imperative.

Q11 - Is culture and worker morale hampering progress? Where and at what level?

A difference of opinion with the set of responses saw some as being somewhat circumspect and many being on the side of yes it will.

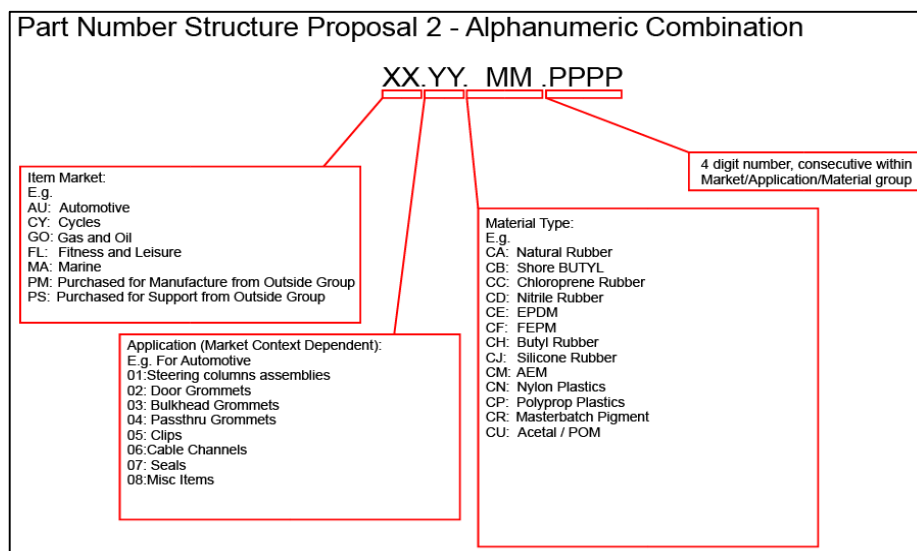
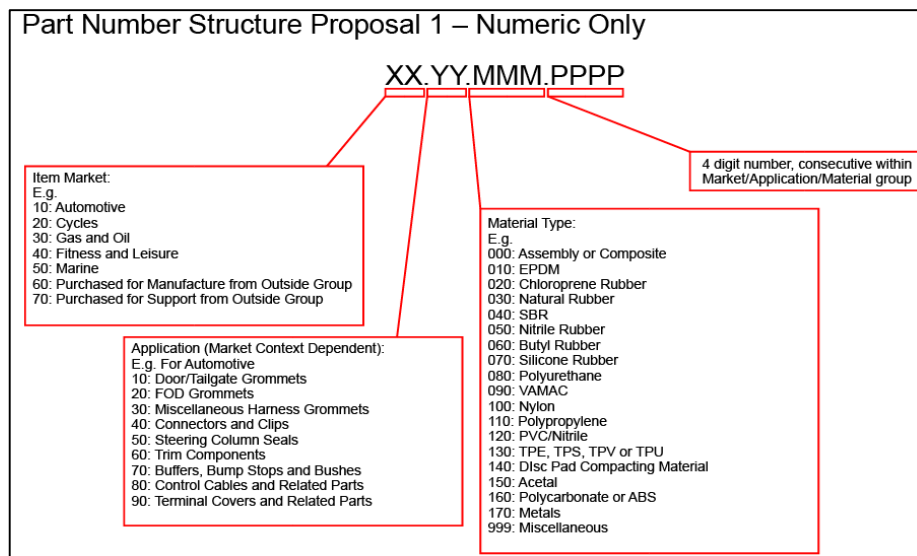
Q12 - Is communication hampering progress? Where and at what level?

Again, a difference of opinion with one set of responses seeing communication from the upper hierarchy being the issue and some seeing the communication in the middle to lower ranks as the issue.

Either way the consensus is that there is room for communication improvement on all levels. Education and briefings on what might be happening would easily improve both the morale and communication situations.

Part Number Format Evaluation

After some pre-deliberation and consultations upon options to be considered, a proposal for either alphanumeric or numeric group part numbers was evaluated. Proposals below.



Part Number Structure Examples

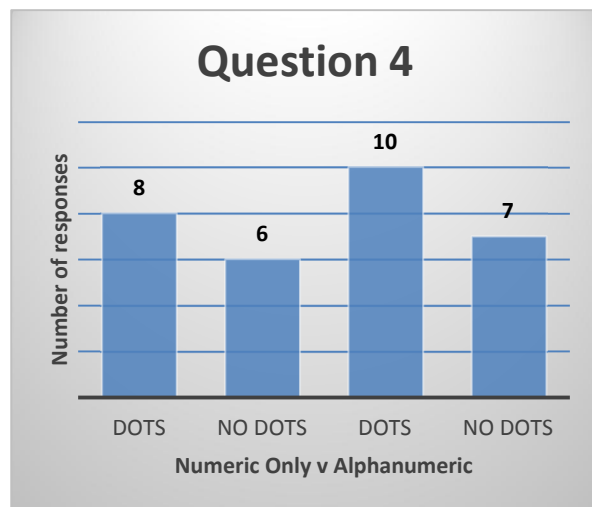
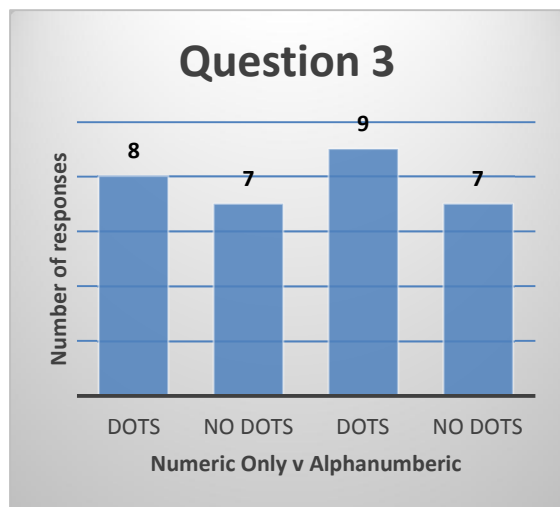
Proposal 1 Example with Dots	10.20.010.0001	Automotive, FOD Grommet, EPDM, Part Number Sequence
Proposal 1 Example without Dots	10200100001	Automotive, FOD Grommet, EPDM, Part Number Sequence
Proposal 2 Example with Dots	AU.03.CE.0001	Automotive, FOD Grommet, EPDM, Part Number Sequence
Proposal 2 Example without Dots	AU03CE0001	Automotive, FOD Grommet, EPDM, Part Number Sequence

Part Number Format Evaluation
Questionnaire

Questions	Response	Comment
How frequently do you interact with parts reference codes?	Hourly/ Daily/Weekly/Monthly/Rarely	
What is your primary use for parts reference numbers?	- Data entry - Inventory tracking - Order processing - Reporting - Other (please specify):	
Which parts reference format do you find most readable?	Refer to example in page 3 of the presentation : 1- Proposal 1 example with dots 2- Proposal 1 example without dots 3- Proposal 2 example with dots 4- Proposal 2 example without dots	
Which format do you think will minimise errors during data entry?	Refer to example in page 3 of the presentation : 1- Proposal 1 example with dots 2- Proposal 1 example without dots 3- Proposal 2 example with dots 4- Proposal 2 example without dots	
Do you have any concerns about using dots (.) in the parts reference codes?		
Do you have any concerns about using the numbers only in the parts reference codes?		
Do you have any concerns about using a mixture of numbers and letters in the parts reference codes?		
Do you have any suggestions to improve the proposed parts reference formats?		
Please provide any additional comments or feedback regarding the parts reference structure.		

Part Number Format Evaluation Questionnaire

33 Colleagues were invited to give their opinions on the 2 part number formats being offered for consideration. 31 responses were received. See graphs below.



There is a very even spread of results for preference, with the Alphanumeric option coming out on top at a combined 53%, the option of having dots was marginally more preferable from the responses received at 56% of the total responses received.

Therefore, from these results, an Alphanumeric part number with dots separating the subsets is the preferred standard. A final decision is yet to be made at Fibrax.

10. Acceptance

10:1 Differences in Working Culture (UK)

Change in any level is generally treated with a degree of trepidation by those having to incorporate the change into their normal working lifestyle. Keeping the change through the integration of new ways of working to a minimum or seamlessly integrating with the existing norms will markedly advance the acceptance of the new norms. The symbiosis between the new technologies and systems and the existing working practices is more readily introduced through the instruction and organisation from top levels being twinned with training and communication with those who will use the technologies and systems. A well-developed value chain will map out the advantages but must be laid out for all to see through good communication and any negatives received should be addressed. (Soldatos et al., 2019)

From the Case Study, it is clear that the respondents are fully aware of the need for change, and are behind the drive to implement it, however more grass-roots conversations on how technologies can benefit the greater team need to be undertaken and the possibilities explored.

A definitive person of reference, such as an Innovation Manager, whilst investigating further means of utilising the system in more workplace scenarios, could be the interface between the push of Implementation instruction from higher levels and the pull for the need of acceptance and training from the lower workforce.

The five factors set out in section 5 which might hamper any implementation should be continually considered by this person of reference and observations made throughout the development and implementation period and this person should be astute to provide an adequate reaction to any developing situation. (Manyika, J., & Chui, M. 2017).

10:2 Differences in Working Culture (expanding use to Multi-national locations)

There is an acknowledgement that the ratio of influence of the five factors set out in section 5 that affect implementation success varies depending on the selected country and the sphere of industry (Manyika, J., & Chui, M. 2017). From personal working experience this has been noted and these differences in working attitudes are observed on an almost daily basis through interactions with colleagues in sister production sites and customers from all over Europe, North Africa, United States and beyond.

10:2 Futureproofing, Feasibility and Profit

Any new system that incurs a capital investment in has an inherent risk involved on how well it can perform the requested tasks be fully integrated. If a system is already a proven commodity, being successfully integrating with many of the tasks it will be required to perform, the risk can be minimised and the reassurance of its future capability, expansion feasibility and experience on how it can assist with future profit attainment can be demonstrated.

10:3 Fibrax Group

The chosen system for Fibrax is already in use performing the required tasks at the sister Morocco site , the development to include more tasks, a strategic alignment of terms etc. plus an expanded vocabulary to include the working languages of the other sites that would be pertinent to both the Wrexham head office and the production site in Poland, so reporting can be connected across the group.

As far as the sister sites are concerned, the Morocco site tends to require an element of extra explanation of items for discussion and this should be accounted for. Colleagues located there tend to possess an attitude of ‘we have what we have, let’s get on and do it’, with the minimum of fuss and disquiet. This can be to the detriment of not achieving an adequate volume of pertinent feedback to make further changes or task sharing easier in the future. As H-SYS is already a working known commodity in use on the Morocco site their liaison with the developer and their working input has been key in developing the system for its wider as a group-wide solution for all the Fibrax sites to be fully integrated and connected with.

The Polish site, where it demands an extra explanation and information up-front, colleagues generally accept any change shared and whilst providing a good level of constructive feedback, this usually comes with a caveat of questioning and critique on how it could be done better.

Either way, both sites present their own unique challenge to implementing a group-wide system, a challenge that the implementation team appear to be prepared for through involving representatives from both sister sites in the development of the H-SYS system chosen to be integrated. The extent of how these differing cultures might affect the implementation is still to be fully understood.

11. Conclusion

11:1 Sustainability & Good Practices

Where the initial conception and development of the H-SYS system was not fully documented, and followed a somewhat ad-hoc development process, it adequately fits the need of the business for which it was envisaged. The current development and the project as a whole are being recorded, scrutinised and is following a strategic plan and roadmap so a successful outcome should be achieved across the group in an expanded, multinational and multicultural landscape.

As stated in Section 2 of this report, “Organisational performance, particularly in SMEs, is most likely to be optimised when there is alignment and consensus in the strategies within a business.” (Walter et al., 2013) There must be a sustained drive both to implement and maintain the digitisation initiatives.

The message coming from senior personnel in the business cited in the case study is we need to communicate better and need to work smarter.

“ As we (Fibrax) develop as an integrated group comprising of 3 sites in different countries the need for digital integration is ever more critical. This is especially true in automotive component manufacturing where the OEMs demand dynamic and responsive suppliers who can adapt to changes at short notice with minimal disruption. Robust and accurate data is the key to strong decision making, if this data is available in real time and in a form that can be interrogated decisions can be made reducing cost and time.” R. Winterbottom, Technical Sales Director, Fibrax Group.

11:2 Implementations within the Fibrax Group

The case study has demonstrated an alignment and cohesive direction from Directors down within the workforce. There is a willingness to achieve the goals set out.

The implementation team for the Digitalisation exercise have rigorously investigated what was required of the system and this was then a basis for investigating the systems that were available and assessed for their pros and cons as set out in section 9. The process is ongoing and only a fraction of what could be achieved has been embarked upon.

The automation cell when matured will pave the way for more projects of a similar type.

11:3 Objectives

The goal with all these initiatives is to gain a competitive advantage and improve performance and efficiencies wherever the opportunity permits across the whole product lifecycle.

As John O'Brien, Managing Director, Fibrax Group, stated in his interview responses, "Fibrax has always targeted investment to remove waste where possible. Our best option is to ensure all areas are measured, targeted, run to process, and where possible are improved. We need to understand accurately where and why we are not manufacturing at optimal levels. Consistency across all sites will be imperative and will enable efficiencies in reporting MOPS/KPI's. The lack of good data has meant that we currently have many jobs which are losing money for the company, which has to stop and be corrected. All sites and departments will have to engage with the system."

Due to timing constraints, this paper cannot provide a comprehensive review of the whole implementation at Fibrax as it is still a work in progress, but progress is on-plan and it will be implemented in Quarter 4 of 2024 on the Wrexham site before expanding to the other sites.

12. Limitations & Further Reading

12:1 Limitations

With the current crop of technological innovations, what can or cannot be performed through the application of connected technologies is generally only limited by finance and one's imagination. The range of sensors and monitoring devices on offer cover almost everything that can be considered. The main consideration would be functional necessity within the processes and their actual pay-back value in providing relevant data.

The addition of Gemba/ Pulse walks around the various reporting stations could bring focus and ownership to a multi-level cross section of the workforce and management, enlightening some to the issues seen in manufacturing and their impact on the business.

12:2 Next steps and further research

A great many works of literature on the theory behind strategic alignment and connected technologies is available to manufacturers wishing to improve their current systems with this report acting merely as a guide to what is possible. The report is designed to act as a guide for manufacturers.

Any SME setting out to improve their data and technological connectivity should evaluate their own needs, in their sphere of industry, then assess their ability to apply their chosen system(s) with the finances and skillsets available to them.

Further investigation into the subject matter would be strongly advised especially where specialised literature on their sphere of industry might be referenced.

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(Online reading resources were accessed through the UWTSD Library Service and other outlets using student sign-in wherever possible.)

Annex - Questions used in Questionnaires and Interviews

Understanding of Smart Manufacturing & the benefits achieved from its implementation

1. Initial set of questions designed to gauge colleague understanding of Smart Manufacturing & Connected Technologies. 'Questions 1'

Question group & reference number		Question
Gauging understanding of Smart manufacturing & connected technologies	1.	I am aware of Smart Manufacturing and connected data collection/management technology
	2.	I am aware of the advantages achieved through the strategic alignment of data.(using the same format of part numbers, tool numbers, data reporting and documentation reporting strategies across all departments and all sites)
	3.	I am aware of the aspects of Smart Manufacturing and data management that are being introduced to the workplace as part of future company strategy.
	4.	I am aware of the issues and hidden costs arising from stock losses and logistical errors within the workplace.
Gauging the benefits of integrating Smart manufacturing & connected technologies	5.	I agree that Smart Manufacturing and data management would enhance the operational effectiveness of the manufacturing processes. (Traceability of labour, machines, materials, and products wherever possible)
	6.	I perceive Smart Manufacturing and data management as a major factor to improve efficiency and productivity in the workplace.
	7.	The <u>integration and implementation</u> of Smart Manufacturing and data management will be a significant challenge for the company.
	8.	The <u>cost</u> of introducing Smart Manufacturing and data management would be a significant challenge for the company.
Gauging appreciation and willingness to accept Smart manufacturing & connected technologies	9.	I appreciate the need for good collection and management of data throughout the whole product lifecycle. (From Sales Enquiries to Part Design to Product/Tooling Management to Production planning/manufacture to Part delivery and then feeding back into the cycle to drive improvement at every opportunity)
	10.	I embrace the changes in work practices needed to integrate Smart Manufacturing and data management and will strive to sustain its use through the entire product lifecycle.

2. Lickert scale used in response to the initial questionnaire, 'Questions 1'.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

3. Persons participating in 'Questions 1' questionnaire. In no particular order.

	Name	Job Title
1.	Mourad Hissou	Group Development Manager
2.	Glenn Griffiths	Technical Manager
3.	Jonathan Coupe	Materials & Processing Manager
4.	Lisa Bainbridge	Accounts Manager
5.	Alyn Williams	IT Manager
6.	Jamie Fleet	Logistics Supervisor
7.	Andrew Groom	Assistant Production Manager
8.	Louisa Jones	Sales Manager
9.	Peter Katihrob	Production Manager
10.	Craig Jones	Tooling and Process Manager
11.	Neil Andrew	Group Compliance Manager
12.	Simon James	Maintenance Manager
13.	John O'Brien	Managing Director

4. Answers received to 'Questions 1'.

Question group and reference number		Respondent and answers received												
		MH	GG	JC	LB	AW	JF	AG	LJ	PK	CJ	NA	SJ	JOB
Gauging understanding of Smart manufacturing & connected technologies	1.	SA	N	A	N	SA	A	SA	SA	SA	A	A	A	SA
	2.	SA	A	SA	D	SA	SA	SA	SA	SA	A	SA	N	SA
	3.	SA	A	A	D	SA	SA	SA	A	SA	A	A	A	SA
	4.	A	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	A	SA
Gauging the benefits of integrating Smart manufacturing & connected technologies	5.	A	SA	SA	A	SA	SA	SA	SA	SA	SA	SA	A	SA
	6.	SA	SA	SA	N	SA	A	SA	SA	SA	N	SA	A	SA
	7.	N	N	A	N	SA	SA	A	SA	A	SA	SA	A	A
	8.	SA	A	SA	SA	A	A	SA	N	SA	D	A	SA	N
Gauging appreciation and willingness to accept Smart manufacturing & connected technologies	9.	A	SA	SA	SA	SA	A	SA	SA	SA	A	SA	A	SA
	10.	SA	SA	SA	A	SA	A	SA	SA	SA	SA	SA	A	SA

5. Second set of questions designed to further investigate perceptions of Smart Manufacturing & Connected Technologies within the workplace, 'Questions 2'.

Gauging understanding of how Smart manufacturing & connected technologies will assist	1.	Name
	2.	Job title
	3.	How will Smart Manufacturing and connected data collection/management technology assist your department and your role?
Gauging current culture and practices and what benefits can be obtained through the successful integration Smart manufacturing & connected technologies	4.	Do Financial Constraints limit the implementation of Smart Manufacturing and its elements?
	5.	Is there a lack of quality strategic drives drawn from good leadership traits in top management & supervisors, particularly in improvement projects? And commitment to? Where and at what level?
	6.	What benefits will be achieved by strategically aligning data within your department and your role? (using the same format of part numbers, tool numbers, data reporting, and documentation reporting strategies across all departments and all sites)
	7.	How can you and the company proactively encourage all colleagues to embrace new data collection practices within your department?
	8.	How can you and the company ensure the integration, implementation, and governance of new data collection practices within your department?
Sustaining Smart manufacturing & connected technologies	9.	How can the company sustain the use of data through the entire product lifecycle?
	10.	Do you see the Introduction of Smart Manufacturing and good data management as integral for future company efficiency, productivity, and profitability?
Limitations to successfully integrating Smart Man. & Connected Tech. into the workplace	11.	Is culture and worker morale hampering progress? Where and at what level?
	12.	Is communication hampering progress? Where and at what level?
	13.	Any further comments?

Interviews were either in person or on Microsoft Teams, and with permission, were recorded for future reference and analysis.

6. Persons participating in 'Questions 2' interviews

	Name	Job Title
1.	Mourad Hissou	Group Development Manager
2.	Glenn Griffiths	Technical Manager
3.	Jonathan Coupe	Materials & Processing Manager
4.	Lisa Bainbridge	Accounts Manager
5.	Alyn Williams	IT Manager
6.	Louisa Jones	Sales Manager
7.	Peter Katihrob	Production Manager
8.	Craig Jones	Tooling and Process Manager
9.	Neil Andrew	Group Compliance Manager
10.	John O'Brien	Managing Director
11.	Robert Winterbottom	Technical Sales Director

7. Part Number format evaluation questionnaire

This study undertook an investigation of views on how an aspect of strategic alignment might be furthered. There is no set Fibrax Part Number format, instead there is a tendency to use the customer's part numbers as references which leads to much confusion. Respondents were asked to reply indicating their exposure to part numbers, and their views on the proposed Fibrax Part Number formats. The results table is shown after the question form.

Part Number format evaluation questionnaire		
Questions	Response	Comment
How frequently do you interact with parts reference codes?	Hourly/ Daily/Weekly/Monthly/Rarely	
What is your primary use for parts reference numbers?	- Data entry - Inventory tracking - Order processing - Reporting - Other (please specify):	
Which parts reference format do you find most readable?	Refer to example in page 3 of the presentation : 1- Proposal 1 example with dots 2- Proposal 1 example without dots 3- Proposal 2 example with dots 4- Proposal 2 example without dots	
Which format do you think will minimise errors during data entry?	Refer to example in page 3 of the presentation : 1- Proposal 1 example with dots 2- Proposal 1 example without dots 3- Proposal 2 example with dots 4- Proposal 2 example without dots	
Do you have any concerns about using dots (.) in the parts reference codes?		
Do you have any concerns about using the numbers only in the parts reference codes?		
Do you have any concerns about using a mixture of numbers and letters in the parts reference codes?		
Do you have any suggestions to improve the proposed parts reference formats?		
Please provide any additional comments or feedback regarding the parts reference structure.		

Part Number evaluation study results

	Numeric		Alphanumeric		Totals	There were 33 invitations There were 31 responses
	Dots	No Dots	Dots	No Dots		
3	8	7	9	7	31	
4	8	6	10	7	31	

Graphical analysis can be found in section 9.