Low Carbon Shared Smart Factory

A membership model multi-organisation Smart Manufacturing Facility for Scotland

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Overview

The general requirement

UK manufacturing is suffering a skills shortage and investment in manufacturing in Scotland is shown to be in the fourth quartile for developed nations, climate change and dwindling resources are forcing us to reconsider our economic models and a vast engineering challenge is looming as we make the transition to a zero-waste low carbon economy. It is recognised that with this change comes significant risks and also opportunity for engineering manufacturing as the systems and equipment of the carbon economy become redundant and need to be replaced or repurposed. For Scotland, the challenge is to prevent the loss of her manufacturing base, retaining skills, capability and capacity while ensuring industries successful transition to the low carbon economy.

Confidence in manufacturing is still low from the hit taken by traditional manufacturing industries in the 1980s. The scars of this time are still evident in many large manufacturing facilities. I have visited many machine shops, and worked in some, where investment seems to have stopped at this time and where the organisation is still today relying on machine tools and equipment installed in the 1980s and early 90s despite the technological change since and is still entirely dependent on a workforce essentially made up of the last wave of EITB apprentices. Manufacturing after this time was not seen to be a good career prospect and for some time at least was actively discouraged as a career path for the more academic, draining the industry of talent at a time it should have been undergoing rapid transition into complex, value added and highly automated work to remain competitive globally. UK manufacturing is now at a crossroads. The requirement for investment in skills and capital has been generally recognised by government and industry as being vital for the urgent transformation of the economy toward environmental sustainability with opportunities for a renaissance in manufacturing engineering based on the energy and transportation systems and sustainable products of the future circular economy.

While there are a good number of world class manufacturing facilities in the UK, generally industry is lagging behind with firms still undergoing the transition to CNC from conventional machining technologies a move now known by some as industry 3.0. With many manufacturing businesses in the UK feeling they must “run just to keep still”. Progression toward environmental sustainability and circular economy is not yet on the mind of the average manufacturing company director who is still predominantly focused on survival.

For the progressive firm in this situation there is now an opportunity to move directly to industry 4.0 where safety, environmental sustainability, sales, Product Life Management, Document Management, Engineering Resource Planning, scheduling, maintenance, training, capital resources, human resources and all other aspects of the facility are connected together by intelligent computer systems, laying problems instantly before management and showing real time true cost of production and dynamically

forecasting availability of capacity to give sales accurate lead time and costing information for new projects. With the implementation of I4.0 systems the opportunity to build an organisation tailored to environmental and operational sustainability is apparent. The smart factory will deliver the data required to allow industry to take its first significant steps toward the carbon neutral zero waste manufacturing of the future.

This approach will require a departure from the traditional management structures generally employed in UK manufacturing with the emphasis being placed on productive jobs. Typically, production has been the focus of automation, reducing shop floor head count and direct manufacturing costs while back offices have swollen with non-productive staff to cope with the large amounts of documentation required to compete in the high value-added manufacturing and engineering project sector where the quality documentation and trace-ability can be as important as the product. Ironically it will be the case that computers can far more rapidly and cost effectively automate back office jobs in an industry 4.0 implementation than they could automate manufacturing activities in an industry 3.0 based one.

Stable manufacturing jobs of the future will, I believe be the ones focused on systems integration, connecting every resource to drive the accuracy of data available to management and process owners' alike ultimately delivering automated day to day management leaving people to focus on improving processes, systems and sustainability. We need to make a departure from the firefighting culture, throwing resources at the one shouting loudest, to one based on intelligence and reason with a workforce consisting mainly of productive staff allowing computers to deliver the promised productivity and efficiency savings through efficient internal organisation.

Computers that can calculate the best route to a destination in the form of satellite navigation have been around for a decade. Computers can be programmed to accurately predict delivery outcomes and make informed automatic recommendations about work flow, human and capital resources and investment requirements within a manufacturing organisation. As yet this is not the generally accepted method and firms that employ computers in the automation of management and back office jobs will have a significant competitive advantage and an ability to focus on investment that UK firms currently do not appear to have. The retail and banking sectors are an excellent shop window into the potential commercial gains open to the manufacturing industry through the effective deployment of computer technology.

Accurate data will be crucial in delivering on the urgently required capital investment now required in UK manufacturing. Risk aversion and a requirement for short term gain has been a serious problem when trying to secure investment and automated systems that make the arguments for investment based on operational data will become an important tool, simplifying justification for equipment high in both productivity and energy and resource efficiency.

<u>Integrate staff and capacity to successfully diversify.</u>

Many engineering and manufacturing skills are highly transferable however it has been the case that Manufacturing facilities are not. Large amounts of waste are associated with the commissioning, operation and decommissioning of manufacturing facilities. Factories of the future need to be configured to keep the skills together in a transferable asset that can react rapidly to changing market conditions and even change hands from one industry to another with minimum reconfiguration and therefore minimum waste. I4.0 and the smart factory will be a focus for re-doubling efforts in this area. The integrated factory will enable much higher levels of project complexity to be handled and enable staff to move flexibly from one type of work to another by delivering accurate information to the

workforce and management.

The flexible factory will cater for a larger spectrum and scope of work with many integrated processes controlled centrally. In the UK these facilities should include design and engineering expertise dedicated to bringing the next product or project to manufacture in the most efficient and sustainable way possible. Design For Manufacture has a key role to play reducing manufacturing costs by the reduction of processes and materials consumed. In the UK where practical manufacturing skills traditionally held by designers that had worked up through the shop floor are no longer available to young design teams, made up of graduates. I4.0 systems will be capable of delivering manufacturability and product sustainability and life cycle advice to designers and dynamic estimation of project costs and environmental impact. A factory with an integrated product and tooling development team on hand to assist customers with their own design solutions will be part of the flexible factory. The shared factory would be a valuable resource when made available to startup companies and growing green energy and alternative technology companies not yet manufacturing or manufacturing abroad.

The Solutions

All the technologies needed for what has been dubbed “the next industrial revolution” are all broadly available, so why is it not happening?

From experience, trying to implement this technology over existing systems and technologies that are time proven in a highly risk averse industry like manufacturing is not easy. Over years of implementation experience we have only ever been able to implement aspects of a system that really has to work as a whole to deliver its true potential. Manufacturing investment cycles mean the industry is working with an eclectic mix of technologies and ageing management and workforces lack the enthusiasm to change.

Skills barriers are obvious. The number of computer programmers employed in manufacturing lags far behind those employed in Banking or e-commerce. This is a critical factor when considering the move to industry 4.0. Manufacturing technologies are now so advanced the typical ageing EITB Trained machinist will not be using 20% of the technology built into the equipment they are using. A large manufacturing facility should be looking to have a coding team at their disposal full time. Development and maintenance of the overall business machine they will be building will become a priority and will be a project that lasts the life of the facility. UK manufacturing also needs to be developing the next generation of professional engineers and engineering technicians and the development of these individuals needs to include proper exposure to these new technologies and working methods and an understanding of the requirement to change our behaviors as engineers and designers toward sustainability and efficiency, building products of the future for the circular economy. The education provision by the state will not be able to deliver change for manufacturing on its own and it is the industries responsibility to promote engineering career opportunities and train people to fill positions within our own organisations’. I would suggest any manufacturing business should have training and development of its people as a core business objective. In my own experience, it doesn't take a very long time to develop a good candidate into a fantastic asset and the industry has been plagued by lack of action on training and professional development particularly of engineering technicians.

For the last 15 years we have been developing the required software to achieve this I4.0 implementation and have built a software engineering platform called X6 specifically for Industrial data handling and communication. The system requirements have been determined by our experience as sub-contract machinists and through our experience at PCT Group, a material handling OEM based in Glasgow. We had for several years been developing it primarily as our own internal system but about 8 years ago we realised it had the scope to become an I4.0 solution in its own right. With initial research in to the manufacturing software market we see the approach we have taken and the way we have integrated functionality is unique. We also realized that to succeed it would need to be offered on a different basis to the likes of CAM and ERP systems. To achieve true integration is an expensive and lengthy process requiring significant cultural change and dedication from management and staff. For our product to be taken up on a large scale it likely has to be delivered free of charge into industry as a set of standards and we need to find a method to progress its development not directly attributed to the products distribution.

Our business model is one based on implementation in an environment that can in itself generate the revenue. In short, we need to keep the software project running inside a manufacturing environment. This was the basis for our decision to sell Bittleston Ltd in to PCT group for consideration in shares. We felt we could learn a considerable amount transitioning our systems into a larger OEM environment. The development of the system has gone hand in hand with an increase in technology take up and capacity at PCT that now has revenues of c. £15 million. This has led to significant improvement in manufacturing output at PCT group where the first wave of development has left us with an operable advanced industry 3.0 system that is now being further developed to fit the I4.0 bill.

We have been grappling with how best to get our technology to market. Simply offering it free of charge is not going to deliver the user volume needed to generate revenue. While we believe the interest would be high the take up would still be poor due to the effort involved in implementation of these systems and the fact that while free access to systems helps it does not address the lack of understanding, skills shortages and resistance to change. Given our experience we do however have

high confidence in our ability to deliver a single fully integrated smart factory facility. This is something we will not be able to achieve without assistance at PCT as it has been made clear to us that there are limits to the influence they will accept our systems having on their business from a risk perspective, they do not want to become a "guinea pig" to a fully integrated solution.

The shared smart factory.

The next step to ensure continued advancement of our project is to create a demonstrator facility that is not bound up by any of the factors contributing to slow take up of technology. Offering membership of this project to SMEs would open access to our manufacturing systems and technology and create a model for continuous investment and for the refinement of engineering and environmental best practice. Our focus would become delivering the manufacturing productivity solutions and integration technologies required to most effectively process members work in a way that would demonstrate the effectiveness of these new technologies with the highest levels of environmental awareness allowing members simplified access to future manufacturing technology and a fuller understanding of the cost and environmental impact of their businesses and products. Critical to the performance of such a facility would be the assistance offered to its members promoting appropriate use of materials and processes key to reducing members costs and securing the projects sustainability and value.

Key advantages.

- Members given system tools that unify their design, documentation and document management for manufactured products acting as a user front end to the facility. These are web based and can be deployed worldwide with only web access as a technology requirement.
- Members are given access to factory scheduling systems and can cost and time trial their manufacturing requirements using the software tools. These tools would be extended using the existing technology platform to give members better understanding of the environmental impact of their designs, products and operations.
- The Smart factory operation is 100% transparent to members, banking, insurance and government partners ensuring and proving strict adherence to best practice and allowing for optimisation and continuous improvement with assistance from all partners.
- Members and other partners have access to live camera feeds and data from the factory production areas and can watch their jobs being manufactured. Special security measures would be deployed in certain circumstances but if possible, members gain advantages by sharing process information as big data.
- All manufacturing difficulties and issues are shared with the member organisations through their system interface they have real time visualisation of progress and can see what is being done to improve performance and throughput of their work.
- Members can suggest improvements and changes to processes or commission other organisations to do this based on the data and watch the improvements being implemented. The relationship between members and the facility is collaborative.
- Design teams will quickly understand the manufacturability of their designs and how they can improve them from the shared data and process footage.

- Membership is based on predefined blocks of shares in the organisation and comes with proportional representation and spending powers, a member with 10% shares can spend 10% of the capital available on their processes and equipment or multiple members can club together to make larger more strategic investments. Certain limitations will apply that would prevent ultimate control by one member etc. Investment decisions are suggested by the smart factory systems and ratified by the board of member representatives.
- Ties with academic & research establishments would be simpler managing one manufacturing entity for several member organisations.
- The model would work well for heavy infrastructure and investments that are difficult for any one member to justify.
- It could be piloted at small scale to prove the model and technology.
- Training and staff benefits are standardised and could likely be higher than average standard due to the likely efficiency of such an operation. This would improve skills utilisation and staff retention along with job security.
- The model would allow for currently unlikely projects to be re-shored and give members access to latest technology.
- The plant could be equipped with remanufactured equipment when this was possible. Member's factories could be re-cycled into the shared smart factory demonstrating circular economy through the upcycling of older heavy equipment. There would be potential for a local machine tool remanufacturing
- Members would be quickly delivered the benefits of a smart factory initiative without carrying all the risk and access to the skills required to deliver would be spread across the membership.
- Broad technology and skills base possible over time along with security of retention, ease of identification for optimum processes and maximum flexibility.
- Member companies benefit from de duplication, reducing the amount of waste and increasing equipment utilisation across the members organisations, reducing transportation between processes and allowing for investment in cost effective alternative power sources for the facility such as wind and solar.
- Fully integrated customer and supply chains allow the role out of new ideas and business models to all smart factory partners and could get a larger number of businesses thinking about the opportunities for the sustainable manufacturing systems of the future.
- Membership as an alternative to manufacturing inhouse would secure jobs in Scotland by offering an alternative to any company looking to divest of manufacturing and source abroad.

Key risks

- Member conflict of interest/member to member confidentiality
- I4.0 is a largely untested model especially at this level in this membership model.
- No or low interest in membership. A feeling potential members are doing fine as they are or that changing the way they work is not a requirement at their organisation. “A good idea, for other people to look at”
- Loss of confidence at the start of the project, the model would take time to mature before efficiency surpassed general manufacturing management practice.
- A failure to create robust company policies on training, health and safety, career path and governance structures or other miss management of the company would affect multiple organisations.
- Stoppages caused by power failure or computer system failures affect multiple organisations and would have potentially serious productivity consequences and knock on affects.
- Loss or unintended distribution of data could result in legal action affecting other members and losses to the affected members.
- Financial losses would prevent the organisation delivering the continuous investment policy it would have. Multiple members being affected by economic pressures simultaneously and their membership agreements could potentially leave the facility without work and unable to swap low productivity members (whose circumstances have perhaps changed) for new ones.
- Naïve legal structures in collaborative working arrangements could leave much to chance, a very tight legal framework would need to be employed tailored to the project scope and member needs.
- Finding suitable staff who understand the model sufficiently to effectively implement processes and systems at the pilot and scalability of human resources could hold back progress. It would need to be understood this was a limitation we needed to overcome with training and that this is not an instant process.

Current readiness levels.

After 15 years of development the core algorithms in BitzList are stable and the platform is now fully scalable the specifications for continuing development is very well defined with a finished product specification that has been settled upon. The programming language X6 is ready for deployment on new integration projects.

The system is running at PCT as the primary production system.

We have been in discussion with AFRC on how we could progress the software project together and our technology has been well received. AFRC are considering ways we could jointly progress the

software project, this would be an interesting development platform for AFRCs services and for the development of their digital manufacturing and other departments.

It would be possible for us to acquire PCT manufacturing as a basis for the pilot facility.

We would be looking to understand the levels of support available to allow us to establish this shared manufacturing facility. We would need resources to draw in members and promote the model before then looking at a follow-on project to build the Smart Factory facility. PCT could become a first member organisation and other initial investment will come from bank loans and government support with a view to selling off the membership slots to recoup this investment.

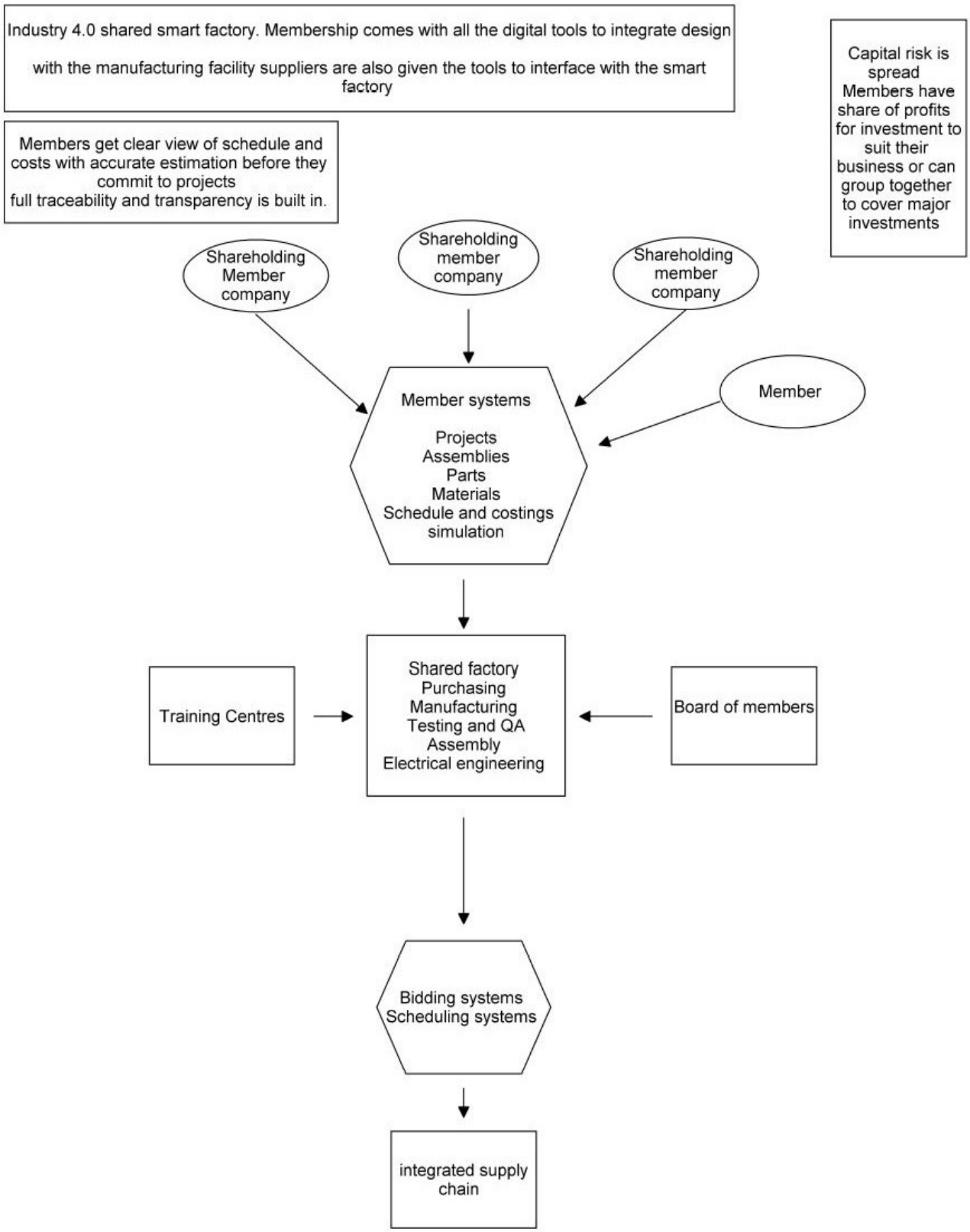
Advice is required on a suitable corporate structure for this membership model that would be universally recognised as suitable for the levels of collaboration and intercompany operation.

We are already adapting the technology we have to fit this model. Suppler and member interfaces will be available for demonstration and our core technology is already demonstrable.

Financial forecasting is dependent on the profile of any interested members and the levels of enthusiasm and support available for the project from potential members and government.

The software project continues and we are a few months away from realising our goal of fully dynamic production scheduling and resource optimisation. There are some significant environmental savings to be made in manufacturing with access to this type of optimisation software and we feel to complement our cost and time forecasting, suggestions for optimisation of production based on energy consumption would be a good example of the kind of tools that can be deployed in the smart factory.

Keeping the shared factory as an ultimate project aim a good first step would be to run a technology pilot to demonstrate how industry 4.0 systems can reduce waste and build up an understanding of how future development could be made to align with zero waste Scotland ambitions and goals.


Industry 4.0 shared smart factory. Membership comes with all the digital tools to integrate design
with the manufacturing facility suppliers are also given the tools to interface with the smart factory
Capital risk is spread
Members have share of profits for investment to suit their business or can group together to cover major investments
Members get clear view of schedule and costs with accurate estimation before they commit to projects
full traceability and transparency is built in.
Shareholding Member company
Shareholding member company
Shareholding member company
Member
Member systems
Projects
Assemblies
Parts
Materials
Schedule and costings simulation
Training Centres
Shared factory
Purchasing
Manufacturing
Testing and QA
Assembly
Electrical engineering
Board of members
Bidding systems
Scheduling systems
integrated supply chain

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Notes