Industry 4.0 & the Industrial Internet of Things

Manufacturing Insight
Executive Summary

Industry 4.0 (or the 4th Industrial Revolution) is a vision that evolved from an initiative to make the German manufacturing industry more competitive. In its broadest sense it is a data driven transformation of industrial processes related to the notion and evolution of the “Smart Factory”.

Unsurprisingly, the above definition does not explain anything. When the UK manufacturing sector was surveyed, only just over 50% (Accenture 2019) said they had heard about industry 4.0 and only 33% understood the benefits! When surveyed further last year only 7% (RS Components) of UK manufacturing said they had a plan to implement industry 4.0 projects.

In an increasingly competitive world it is vital industry plans to move into the digital age. We are already in the age of the 4th Industrial Revolution and most manufacturing companies have not realised this yet. As the famous saying goes;

“In business, the competition will bite you if you keep running, if you stand still, they will swallow you!”

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This white paper will cover the following topics to help us better understand Industry 4.0, and the steps to achieve true efficiency.

• What is Industry 4.0 and IIoT?
• What are the benefits to be gained from adopting Industry 4.0 interconnectivity?
• How Industry 4.0 concepts can be adopted by manufacturers, allowing them to reduce costs, release resource and drive manufacturing efficiency
A Definition of the Various Stages of the Industrial Revolution

To understand what Industry 4.0 is, we will have to understand a little bit about the history of Industry and manufacturing. So let’s start with a brief explanation of the 4 Industrial Revolutions that have taken place or are currently taking place.

Industry 1.0 or the original “Industrial Revolution” was the transition from a rural based economy to a largely urban centralised structure. This was typified by the cotton mills of Lancashire in England, where steam or water was used to drive a mechanised process. This delivered huge efficiencies to the cost of manufacturing and streamlined supply chains.

Industry 2.0 was the invention of true mass production. This was epitomised by the early car assembly lines of Ford and other automotive manufacturing companies. The manufacturing plants were powered by electricity rather than steam; however, most processes were manual involving humans to complete each stage of the manufacturing process.

Industry 3.0 was the automation of industrial processes. This was typified by the use of control systems (DCS, SCADA) and the introduction of PLC’s, sensors and robotics. This led to the reduction of manual processes. Humans are involved in production only where robots and automated processes cannot complete the tasks as efficiently. Despite describing this as a thing of the past, this really describes most organisations are at the present.

Industry 4.0 can be defined as the current trend of automation and data exchange in manufacturing technologies. This includes cyber physical systems (more about these later), Industrial Internet of Things (hereafter referred to as IIoT) and the use of Artificial Intelligence (AI) / Augmented Reality (AR) to create the “Smart Factory”. The ultimate goal will be to create a truly interactive end to end supply chain.
What is IIoT?

The Industrial Internet of Things (IIoT) is defined as industrial networks that take data from sensors and intelligent devices and uses this data to drive Artificial Intelligence (AI) and predictive analytics. A typical application of this would be to deliver predictive maintenance for manufacturing equipment. This would drive minimum downtime for that equipment and increase OEE (Overall Equipment Efficiency). Ultimately reducing manufacturing costs to an optimum level, without compromising quality and safety.

IIoT and Cyber Physical Systems

Most IIoT applications are about automation, optimisation and tactical or strategic goals internal to the company implementing the application. However, the implications of IIoT run far beyond the boundaries of a single company.

A “Cyber Physical System” is one that takes in data and translates it into physical operations without the intervention of human beings. In the case of manufacturing the ultimate manifestation of this will be the “Smart Factory”. The “Smart Factory” will be able to integrate seamlessly with end consumer requirements. Being a truly “pull” based process, Cyber Physical Systems will organise logistics, order inventory and set work orders perfectly tailored to customer requirements.

The “Smart Factory” will also be able to forecast production requirements, raw materials, maintenance requirements, lead times and see future manufacturing requirements based on live data feeding in from the outside world. This will drive not only optimized production costs but allow a level of consumer customization that is not currently available.
Market Challenges

IIoT is widely considered to be one of the primary trends affecting manufacturing businesses today. But Why?

The key reasons are that:

• Manufacturers are being pushed by customers to modernise systems and equipment
• Meet new regulations and legislation.
• Increasing demand for speed
• Volatility in customer requirements.
• Complexity of customer requirements
• Climate change

In order to understand the benefits of Industry 4.0 and IIoT we need to look at a typical information flow and connectivity of a Smart factory.

As illustrated manufacturing processes are directly linked in to a cloud-based platform. This provides:

• greater visibility
• ability to link with other internal and external systems
• Allow real time decisions to be made.

This greater level of information, visibility and speed of reaction leads to many benefits for manufacturing businesses outlined in the next section.
Benefits of Industry 4.0 and IIoT

Operational Maintenance
The use of Intelligent Sensors in manufacturing equipment enables condition-based maintenance alerts. There are many critical machine tools that are designed to function within certain temperature and vibration ranges. Intelligent Sensors can actively monitor machines and send an alert when the equipment deviates from its prescribed parameters. By ensuring the prescribed working environment for machinery, manufacturers can conserve energy, reduce costs, eliminate machine downtime and increase operational efficiency.

Production Flow Monitoring
IIoT in manufacturing can enable the monitoring of production lines starting from the refining process down to the packaging of final products. This complete monitoring of the process in real-time provides scope to recommend adjustments in operations for better management of operational cost. Moreover, the close monitoring highlights lags in production thus eliminating wastes and unnecessary work in progress inventory.

Inventory Optimization
IIoT applications permit the monitoring of events across a supply chain. Using these systems, the inventory is tracked and traced globally on a line-item level and the users are notified of any significant deviations from the plans. This provides cross-channel visibility into inventories and managers are provided with realistic estimates of the available material, work in progress and estimated the arrival time of new materials. Ultimately, this optimizes supply and reduces shared costs in the value chain.

Digital/Connected Factory
IIoT enabled machinery can transmit operational information to partners like original equipment manufacturers and to field engineers. This enable’s operation managers and factory heads to remotely manage the factory units and take advantage of process automation and optimization. Along with this, a digitally connected unit will establish a better line of command and help identify key result areas for managers.
Improved HSE

IIoT combined with Big Data analysis can improve the overall workers’ safety and security in the plant. By monitoring the Key Performance Indicators (KPIs) of health and safety, like the number of injuries and illness rates, near-misses, short- and long-term absences, vehicle incidents and property damage or loss during daily operations. Thus, effective monitoring ensures better safety. Lagging indicators, if any, can be addressed thus ensuring proper health, safety, and environment (HSE) issues.

Quality Control

Intelligent sensors collect aggregate product data and other third-party syndicated data from various stages of a product cycle. This data relates to the composition of raw materials used, temperature and working environment, wastes, the impact of transportation etc. on the final products. Furthermore, if used in the final product, the IoT device can provide data about the customer sentiments on using the product. All of these inputs can later be analysed to identify and correct quality issues.

Packaging Optimization

By using intelligent sensors in products and/or packaging, manufacturers can gain insights into the usage patterns and handling of product from multiple customers. Smart tracking mechanisms can also trace product deterioration during transit and impact of weather, road and other environment variables on the product. This will offer insights that can be used to re-engineer products and packaging for better performance in both customer experience and cost of packaging.

Logistics and Supply Chain Optimization

The IIoT can provide access to real-time supply chain information by tracking materials, equipment, and products as they move through the supply chain. Effective reporting enables manufacturers to collect and feed delivery information into ERP, PLM and other systems. By connecting plants to suppliers, all parties concerned with the supply chain can trace interdependencies, material flow and manufacturing cycle times. This data will help manufacturers predict issues, reduces inventory and potentially reduces capital requirements.

Carbon Footprint and Other Environmental Issues

The interconnectivity IIoT provides a company with and the subsequent optimization of the supply chain and manufacturing will drive the carbon footprint of a manufacturing company to its minimum. In a world of ever-increasing environmental legislation and scrutiny from customers, IIoT can provide evidential data that the organisation is minimising it environmental impact.
Industry 4.0 Projects – How to run and key success criteria

How can you run an Industry 4.0 project? Here we will explain how an Industry 4.0 project can drive improvement in energy cost, resource targeting, engineering inventory, asset life and operational efficiency.

PROJECT MANAGEMENT OF IIOT PROJECTS

Build Partnerships
The key to success is setting up the right multi-functional team. Inclusion of operational teams, IT, finance, decision makers and other organisation wide expertise is critical. This is a change management project not just a technical exercise. So, it is key not to narrow the view of what skills will be involved in making the project a success. Building those internal partnerships to allow the project to flourish.

Clarify Business Outcomes and ROI
Establish goals, set metrics, define your strategy and establish clear business goals. Measure each project’s financial performance so you can see how your investment in plant and people is progressing.

Start Small
There will be many hurdles when starting along the road to deliver IIoT projects. The most common are legacy IT, lack of internal skills and the vision of what you are trying to achieve. Change doesn’t happen easily or quickly. So, start small with clear objectives and deliverables for the projects. As you progress you can widen the scope of the projects. Incremental scaling of each individual project will provide the greatest opportunity for success.

Cyber Security
Perimeter of security in IIoT projects is everywhere. Embed security in the systems as you go along. Ensure this is an ongoing priority as the projects and scale of integration develop.

Define Analytics Architecture
Data integration challenges may exist due to legacy systems etc. However, design the project for outcomes, turning data generated into actionable intelligence. Do not create data silos. Ensure each project builds the understanding of your manufacturing process. Design each project so it can layer into the next project. The aim is to integrate all key systems allowing better business decisions and increased efficiency of operations.

Be Prepared for Bumps in the Road
Change management projects are not just a technical exercise. Business transformation rarely goes smoothly so allow for this. As projects progress you may see them impacting on many different things; such as recruitment, working practices and interaction with the wider supply chain. Try to anticipate problems and build in contingency actions wherever possible.
As described earlier in this article there are key benefits to the implementation of an IIoT strategy. In manufacturing one of the most obvious benefits is to drive up OEE (Overall Equipment Effectiveness). This will deliver reduced production costs as well as deliver other up and downstream process cost / efficiency benefits.

A key IIoT strategy to increase OEE is the use of predictive maintenance. Current best practice for a maintenance strategy is to utilise proactive maintenance practices in a well-maintained CMMS (Computerised Maintenance Management System). This can deliver between 75% and 90% OEE if implemented effectively. However utilising predictive maintenance practices this can drive OEE even further, beyond 90%!
Example of the impact of Predictive Maintenance

An example of predictive maintenance is vibration analysis to predict motor failure. Below, abnormal vibration from the motor starts 165 days before failure.

Differing maintenance strategy will deliver different outcomes:

**REACTIVE** - Motor is replaced on failure. The plant is down until spares are sourced and installed. Let’s hope there is one in the stores!

**PLANNED** - It is obvious performance is dropping and the motor is getting hot. A controlled down time is planned to replace the motor as soon as a suitable replacement is sourced. Proactive – Signs of wear become obvious through oil debris analysis and once again a controlled down time is planned, maybe in conjunction with other planned maintenance to reduce the overall downtime. This allows sourcing of spare and also gives other upstream and downstream operations and processes some notice of shut down.

**PREDICTIVE** – With a smart sensor predicting failure 165 days out and because this smart sensor is talking to other systems in the business, it allows the business to make the lowest cost and minimal operational impact decision.

For instance:

- Run the motor to 1 day before failure only replacing the motor at the optimum point of its life cycle.
- Repair the motor before it is irreparably damaged reducing equipment cost.
- Another alternative could, as failure has been predicted so far out, be to replace the motor during periods of predicted slow running or other production outages so as to have a minimal impact on OEE.

The point is that the business has choices and time to plan the optimum solution.

By following a predictive maintenance strategy, it is forecast to reduce maintenance costs by up to 30% and reduce energy consumption by up to 10% (Accenture 2019). This is achieved through production planning and reduced inventory. After all, why stock a motor if you can predict its failure 4/5 months out?
How to Implement a Predictive Maintenance Strategy

The key to implementing a predictive maintenance system is understanding the integration of new smart sensors into legacy software and capital assets. In most cases industry is not starting from a green field, so retrofit and integration to existing software systems is the only way forward.

**Key steps:**

- Understand failure modes and frequency of failure of key assets.
- Understand the key assets and opportunities to retrofit smart devices.
- Use historical failure data to target key manufacturing assets (harvest the low hanging fruit to give the project momentum).
- Understand how to integrate into legacy CMMS and ERP systems.
- Plan to ensure all new assets have smart sensors included.

**THE PROCESS OF CHOOSING WHICH SMART DEVICE TO FIT**

1. **Understanding Failure Modes**
   - Identify common failure modes and impact on key metrics:
     - Failure modes
     - Frequency of failure
     - Location of failures
     - Key business metrics

2. **Review Existing Models**
   - Evaluate existing predictive maintenance models and applicability to field equipment:
     - Variables
     - Failure modes identified
     - Model performance

3. **Map to Sensors**
   - Identify potential sensor types for identifying pre-failure conditions on target devices (ex. Temperature, vibration, RPM)

4. **Recommendations**
   - Create recommendations for next steps based on discovery period:
     - Data collection
     - Instrumentation approach

Create a replacement plan and review continually. Ensure that the whole business understands the process you are going through and work hard to ensure the benefits not only help with maintenance but flow though the whole fabric of the manufacturing organisation. Do not create silos and think big!
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