Technology Report:
Follow the Leader—IIoT Use Cases

Follow the leader. It’s a schoolyard game, of course, but also wise advice for those in the early stages of digital transformation, where questions about strategy and concerns about failure can undermine enthusiasm about taking full advantage of the Industrial Internet of Things. In this report you’ll find case studies of digital-manufacturing leaders forging a path toward success. Follow them!
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Connectivity between the plant floor, the corner office and the supply chain is making industrial manufacturing and production near unrecognizable from even a decade ago. If you work in this space, you’re well aware of this.

Digital sensors and instrumentation, coupled with machine learning and big data analytics, is giving manufacturers more insight and more control than ever before into drive quality, efficiency and profitability. The convergence of artificial intelligence, machine learning and big data analytics is making it possible to predict when a part will fail so that none ever do.

Here is a story about the impact that this convergence is already having.

DRIVING FOR 100% UPTIME

A manufacturer of diesel engines for off-highway and various industrial applications runs a plant 24/7/365. Originally designed with an annual production capacity of about 385,000 units, this plant now targets 480,000 engines a year.

How is this possible? That 385,000 assumed that the line would only run about 80% of the time due to repair, maintenance and unforeseen events. Business pressures forced the plant team to push uptime as close as possible to 100%.

The manufacturer has equipped stations on the line with systems for real-time data collection and analysis for each process and test cycle, providing immediate pass/fail determination. It also creates a data repository, indexed by part serial number, that can be revisited at any time to triage a quality issue and trace root cause. This data-driven insight is intended to proactively catch and address issues that lead to downtime.

Over the holidays, the manufacturer ran into a problem with a pressing operation on the plant’s cylinder head machining line. Two days after this new data management and quality-assurance system was commissioned on that line, it started rejecting every single part coming out of the press station.

LOST HOURS COST MILLIONS

The manufacturer halted production and called up the vendor, certain that something had gone horribly wrong with this new quality system. With each engine worth about $6,000, coupled with that target production rate of 480,000 engines a year, even a single eight-hour shift of downtime costs some $2.6 million.

Minutes mattered. But it was the holidays. Few staff were in the office and no one could get to the plant for days.

Since all that process and test data had been collected into a central database, the plant’s quality

When you collect the right data, serialize it, and manage it in a centralized database, it provides the granularity and utility to drive continuous improvement across the entire organization.
engineers could send along the data files from the pressing station to a technical-support person at one of the vendor’s offices. Within 30 minutes, this individual pinpointed the source of the problem—a broken tip on the pressing station’s ram that prevented it from achieving a proper fit. Every part coming out of that station actually was flawed.

It took only an hour to (remotely) trace the root cause of the problem, repair the ram, and resume full production.

INCREMENTAL INVESTMENTS PAY OFF

The data also revealed a broader issue with the plant’s maintenance practices that could be addressed to ensure this kind of disruption didn’t happen again.

Over the previous two years, this manufacturer had, bit by bit, invested some $3 million in this new data management and quality assurance system. Its team has worked with the vendor, one process and test station at a time, to achieve real-time insight and traceability to improve quality and reduce downtime.

Has it been worth it? In this case, that two years of effort and investment is recouped by preventing just 10 or 12 hours of downtime.

WHAT ARE THE TAKEAWAYS?

Industry 4.0 technologies are not merely nice to have. Business pressures are forcing these kinds of investments for many manufacturers. ROI can be rapid when you consider the cumulative cost of downtime, warranty claims, and scrap and rework that can be avoided with the right technology investment.

Industry 4.0 isn’t about machines talking to machines; it’s about data that delivers actionable insight to anyone, anywhere, at any time. When you collect the right data, serialize it, and manage it in a centralized database, it provides the granularity and utility to drive continuous improvement across the entire organization.

Rapid root-cause analysis to address production problems and quality spills isn’t limited to having the quality team physically located in the factory—centralized data-management and cloud-based access enables it be done from anywhere.
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Case Study: Enabling 40% output increase at solar manufacturer

To respond to the challenges brought about by explosive market demand and falling solar-panel prices, California-based SunPower turned to automation and smart manufacturing. The opportunity for change came with the opening of a new factory in Ensanada, Mexico, where the manufacturing system combining smart equipment, improved processes, plant automation and MES software delivered on traceability and compliance requirements as well as efficiencies, resulting in doubled capacity and overall cost/watt reduction of 6%.

THE PROCESS

SunPower had already seen the benefits of using MES software to meet its traceability and compliance requirements. As it was planning for a new assembly plant in Mexico, management decided it was now time to leverage the new opportunities offered by the combination of advanced plant automation and MES software.

SunPower created a cross-functional team and embarked on redesigning its manufacturing system to take full advantage of automation, with a view to deliver ROI within 18 months. MES software would play a central part in making plant operations smarter.

Choosing the processes that would be automated was a crucial step. Prioritized were those involving the highest level of manual labor.

The general objective was for the future factory to produce about 3,000 high-quality modules, i.e. 1 megawatts per day, at full capacity. How would the company ensure it would achieve this however? From the onset, it quantified targets in terms of throughput, capacity per line, reduction in direct labor and cost / watt. The design of the solution would need to deliver on these goals.

Choosing the processes that would be automated was a crucial step. SunPower classified processes based on their cost and quality impact. Prioritized were those involving the highest level of manual labor, or involving decision-making, and thereby risk of error, as well as the processes most prone to defects.

CHOOSING A PARTNER TO DELIVER THE MES SOFTWARE APPLICATION

The MES software application would be the brain of the smart-manufacturing operations, necessary to integrate seamlessly with the PLCs, various devices throughout the lines and Oracle ERP. It would need to offer scalability at minimum investment so that new lines could be added at low cost, and be easy to learn and master.

"The MES system needed to fit into the overall design, be able to support quick fire implementation, be within budget and easy to learn. We chose Shopfloor-Online from Lighthouse Systems, which we already used in other plants, as..."
it met these requirements well," said Nikhil Padhi, manufacturing project manager in charge of key initiatives across the plants.

To achieve the degree of automation desired, the MES had to be embedded deep in process, enabled through a constant dialogue between the MES and the machines via automated scanners and sensors fitted on equipment.

**SOLUTION ARCHITECTURE**

The solution is built on a four-tier architecture: PLC, OPC, MES, ERP. The MES integrates seamlessly with the machines via an OPC server from Kepware and captures the machine transactions automatically with as little manual intervention as possible. The Oracle ERP consolidates all the manufacturing data for costing, reporting etc. Padhi worked closely with Lighthouse Systems to design this architecture.

**THE GOAL: SEAMLESS DATA MANAGEMENT**

Master data like SKUs & Bills of Materials (BOM) are maintained in the PLM tool. The ERP holds the work orders (WOs) and inventory data. For completion of orders, the master data is downloaded to Shopfloor-Online: SKUs, BOM, inventory and work orders (WOs). Separate WOs are released for finished goods (modules) and works in process (string and laminates) to have better control over material consumption and traceability.

Shopfloor-Online generates serial numbers for each panel. As the module progresses through the assembly line, the MES identifies it automatically via its serial number and records transactions for each process step completed at the station. All incoming inventory (cells, solder paste, etc.) that is bought and consumed is labelled and traced in the MES to ensure full traceability.

Once the module reaches the end of the line, it is palletized and the pallets are sent to the truck. As the pallets are completed, information is sent back to Oracle for inventory reconciliation, cost/watt calculation and generation of financial statements. Pallets are shipped out of the Oracle warehouse-management system using handheld devices.

To achieve the degree of automation desired, the MES had to be embedded deep in process, enabled through a constant dialogue between the MES and the machines via automated scanners and sensors fitted on equipment.
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SUPPORTING THE MANUFACTURING SYSTEM
The factory runs 24/7, 365 days a year and with such a high level of integration between the different layers of the system, the MES software is a critical application. Lighthouse Systems is therefore providing 24/7 support to the Sun-Power team.

Some steps still require human operators, of course. Loading raw materials onto machines. Visual inspections at the last stage. Responding to critical faults and rework. But some transactions, especially tests, are fully automated.

With smart manufacturing, improved processes and smart equipment, SunPower can reduce direct labor by 40% from the manual operations. It can reduce throughput time by 40%.

“Automation is often associated with job losses. But at Ensanada, thanks to a robust training program, there was practically no job loss as workers were re-deployed to new lines,” said Nihkil.

REDUCED RISKS OF WARRANTY CLAIMS
The mandatory pass/fail test, as well as the classification test to measure actual power, no longer require human intervention. As a module is tested for power classification, in what is called a flash test, the MES knows which power output should be measured based on the solar cells used in its assembly. If the test returns a different power output, the MES automatically reclassifies the module based on its actual power and usage (commercial or residential). Possible human errors have been removed from this critical stage.

All the performance data for each panel is stored in the MES. That data is sent to Oracle for publication to the SunPower portal, where it is available to distributors and installers. The system gives full traceability of modules and raw material based on the module serial number. In case of a defect in a module, SunPower can track the fault through its production process and all the way back to suppliers.

This degree of traceability offered by the MES gives SunPower Ensanada confidence that it is compliant with U.S. import duty rules at all times.

INCREASED AGILITY FOR NEW PRODUCTION INTRODUCTION
With Shopfloor-Online MES seamlessly integrating with the PLM tool and Oracle E-business suite, SunPower has become more agile in launching new products. The MES manages to the smallest details of how products are made. It downloads BOMs from Oracle and as each panel is assembled, ensuring that every component is qualified, including the solder paste and screws. Shopfloor-Online makes it easy to configure a new product for production, and changeovers are quicker.

The future is bright. ☑
Case Study: Providing real-time production data

By Graham Immerman, director of marketing with MachineMetrics

THE CASE STUDY

MachineMetrics is an IIoT-analytics platform that monitors production in real-time, providing visualizations of real-time production data, instant notifications and predictive capabilities that help identify production bottlenecks, measure process improvements and drive manufacturing efficiency.

Fastenal Manufacturing has eight facilities across multiple continents and is growing in their machining capabilities, transitioning from a simple job-shop environment with low production quantities to a large-scale global operation with thousands of jobs. Fastenal recognized the need to embrace data-driven strategy and digital technology to enhance their understanding of machine utilization, primary downtime reasons and quality issues to optimize manufacturing efficiency and implement process improvements. Fastenal needed real-time visibility into jobs’ progress to ensure efficiency, quality and on-time delivery. Managers wanted the ability to collect and understand downtime/setup procedures (as previous manual tracking efforts were time-consuming and prone to errors), and make proactive vs. reactive improvements. The full team hoped to aggregate, structure and analyze data from numerous machine types, shop-floor systems and manufacturing locations that had been siloed, in order to provide true production transparency and create actionable insights.

THE SOLUTION

Fastenal installed the MachineMetrics platform to collect production data from machine controls and machine operators for the entire production floor and used this data to monitor machine conditions and track the progress of jobs via OEE production efficiency. Real-time dashboards mounted on the production floor provided an at-a-glance indication if jobs were performing at or below expectations, enabling enhanced job-scheduling. Operator touchscreens were mounted at each machine, empowering operators to meet production goals and track machine setup/downtime. Analytics reporting enabled managers to not only track efficiency and quickly identify production bottlenecks related to specific machining operations, but also helped measure the effect of process improvements. MachineMetrics’ open APIs enabled data-aggregation across shop-wide systems, along with the ability to build custom applications, dashboards and analytics.

Analytics reporting enabled managers to not only track efficiency and quickly identify production bottlenecks related to specific machining operations, but also helped measure the effect of process improvements.
“Closed-loop manufacturing” is a term those in the manufacturing industry hear frequently, but many are unaware of exactly how it can be used to add value to their processes. The “loop” in closed-loop manufacturing refers to feedback, which in these processes cycles both upstream and downstream to inform the various stages of production. All manufacturing relies on data and measurements to drive productivity and ensure quality, but closed-loop manufacturing processes apply specific tools and concepts to improve production processes.

WHAT IS CLOSED-LOOP MANUFACTURING?
Collecting measurement data and utilizing it to continually identify issues to improve design quality are the key activities in closed-loop manufacturing. This data can be gathered during manufacturing and fed upstream to enhance future iterations of the process. When implemented effectively, closed-loop processes reduce tooling costs, improve accuracy and produce higher-quality parts on future designs.

To create a data-driven manufacturing process, the manufacturer needs to utilize simulation to validate their Geometric Dimensioning and Tolerancing (GD&T) and assembly processes to meet pre-defined, critical-to-quality characteristics. While workflows vary among manufacturers, simulation and feedback cycles are essential elements in any closed-loop manufacturing process.

First, engineers seek to predict nonconformance through simulation and reduce these issues through iterative design. Then they use the quality characteristics identified during simulation and tolerance analysis to create plans to measure key data points. Those data points are coordinated with corresponding points from computer-aided design (CAD) models. Ongoing inspection and measurement enables manufacturers to identify quality issues so that they can be addressed quickly. When an issue is observed, a Statistical Process Control (SPC) system identifies it and provides tools for root-cause analysis, and both the design and process are updated to resolve the issue and continually streamline the manufacturing process.

KEY COMPONENTS
Every closed-loop manufacturing process begins with a plan, of course. To create an inspection plan, also known as a measurement plan, a manufacturer must first define the design requirements for the specific product. The digital thread, a communications framework that enables data flow among previously disconnected elements in a manufacturing process, begins with considering the CAD models. Some manufacturers mistakenly...
assume that general requirements represented in a non-validated virtual model are accurate enough, but any misrepresentations of the dimensional specifications (GD&T) can complicate the plan execution. Before measurement instructions are created, the dimensional specifications and tolerances (optimally GD&T callouts) should be verified and validated by a dimensional-simulation tool.

Conducting a dimensional analysis to verify requirements early in the product lifecycle enables manufacturers to focus on the quality areas that are most important to their products and process. This “Right Quality” optimizes GD&T on key areas for that particular product, tightening critical tolerances and relaxing requirements for less important details. Before creating an inspection plan, manufacturers should also analyze tolerances to determine allowable variance and identify any build issues. When issues are found in the early design stages, changes can be made more quickly and cost-effectively. It is important to identify critical-to-quality characteristics and tolerances because they will be used to inform the plant-quality team what needs to be measured and monitored.

An accurate, efficient inspection plan identifies the critical data necessary for maintaining high-quality production. The data generated from the inspection plan will serve as the basis for decision-making, so it is important that the appropriate measurements and collection methods are identified during the planning stages. Using fit-for-purpose software enables manufacturers to validate their inspection plans before implementing them.

Modern SPC systems are transforming the way quality managers approach measurement and inspection processes. Once an inspection plan has been validated, it can be implemented to feed data upstream and downstream to improve operational efficiency. A SPC system analyzes this data to determine its significance and make decisions. The business intelligence provided by the software is only as good as its inputs, which is why an efficient inspection plan is so important.

If the process is built upon validated requirements and collects appropriate, accurate data, then analysis and decision-making can be largely automated. Utilizing the findings from the analyzed data to update the design of the process completes the feedback loop.

**USE CASE–JAGUAR LAND ROVER**
The company-wide implementation of global measurement data at Jaguar Land Rover demonstrates how closed-loop manufacturing processes can improve product quality.

Headquartered in the United Kingdom, Jaguar Land Rover is a global automotive manufacturer that produces more than 600,000 vehicles each year and employs some 40,000 people. The brand is utilizing an SPC system to collect, analyze and act upon production data to enhance its dimensional variation analysis (DVA) operations.

**CHALLENGE**
The company’s DVA team sought a solution to improve quality across all of its product families.

To determine the initial design-intent input, the Jaguar Land Rover DVA team uses ISO standards and guidelines to establish variation levels. These variation values and attributes are developed during the design phase to recognize specific requirements and the inherent dimensional capabilities of fabrication processes for each component. Their aim is to enhance design execution by implementing their Statistical Process Control (SPC) system to improve feedback loops. The end goal was to implement a modelling strategy that maintained the principles of design intent while incorporating relevant data from their SPC system to enhance accuracy and, ultimately, improve vehicle quality and line-rate speed and consistency.
To advance their dimensional-variation-analysis capabilities, Jaguar Land Rover partnered with Dimensional Control Systems of Troy, Michigan, USA, to implement a web-based Quality Data Management (QDM) SPC system. Offering various modules for customization, the purpose of this system is to collect, standardize and analyze measurement data to deliver actionable insights that improve production quality. This SPC solution features a centralized database and enables global access for Jaguar Land Rover. With multiple output formats and customizable reports, the QDM SPC system accommodates a wide range of demands from different stakeholders within the organization from shop floor to top management.

The QDM SPC system enhances the DVA team’s ability to optimize design by integrating real-world measurement data. Jaguar Land Rover’s design intents are created in a CAD environment, whereas the QDM system measures data in the manufacturing environment. The design intent determines the process specifications, while the SPC system evaluates the actual process capability.

Detailed data from the end of the manufacturing process can now be evaluated in proper context and utilized to refine the design requirements. Jaguar Land Rover’s process first assesses the CAD analysis results from their CAD simulation tools. Next, the SPC system analyzes the data it has received from actual measurements taken during the assembly process. The results from the CAD simulation and the SPC system are then correlated to determine whether significant variance exists. Jaguar Land Rover has set a tolerance of +/-10 percent to monitor for notable variation. When a significant variation is detected, the SPC data is aligned with the CAD model to identify the source of the discrepancies. These data comparisons are used to derive an optimum body-accuracy model, and the feedback from this process is incorporated to improve the design requirements.

Implementing Dimensional Control Systems’ QDM SPC system is assisting the DVA team with distinguishing significant variations from “noise.” In the manufacturing environment, there are many potential influences that contribute to process variations. The root-cause-analysis capabilities in the SPC system enable Jaguar Land Rover to differentiate between factors that would be beneficial to incorporate into their design models and those that should be excluded.

End users report increased data accessibility since implementing the SPC system. Data from across Jaguar Land Rover’s facilities and suppliers is now available within a single web platform. Engineers are using the customizable reports to track metrics on
specific components and analyze performance over time.

Like most manufacturers, Jaguar Land Rover has dimensional requirements. Their closed-loop manufacturing process provides far greater insight into their production capabilities, which help to drive future standards and goals.

By continuously collecting, analyzing, contextualizing and acting upon production data, Jaguar Land Rover is improving their design models. Producing more robust designs enables the manufacturer to draft better specifications and account for the real conditions in their assembly process. Ultimately, this leads to more efficient processes that produce higher-quality vehicles that are easier to manufacture.

**SUMMARY**

Implementing a closed-loop manufacturing process requires carefully considering design requirements, establishing a detailed measurement plan and deploying the new process with support from appropriate software tools. With the right measurements, processes and tools, a manufacturer’s systems can continuously gather and analyze production data on key variables.

Fit-for-purpose software tools facilitate building real-time feedback loops. Choosing a customizable system designed for manufacturing enables companies to collect, analyze and utilize data more efficiently, while improving comprehension and communication across the organization.

While software is important, outputs are only as reliable as the inputs that they are derived from, so implementing a well-designed measurement plan is essential. Both the processes and measurement plans should continue to evolve as new data provides insights into actual performance.

An efficient closed-loop manufacturing process enables quick decision-making and rapid response to virtually any quality issue. Embracing a digital thread allows manufacturers to run more adaptable and flexible workflows that prioritize quality control. Investing in intelligence-backed processes generates continuous improvements that increase productivity and, ultimately, create better products.

The end goal was to implement a modelling strategy that maintained the principles of design intent while incorporating relevant data from their SPC system to enhance accuracy.
Can IIoT implementation challenges be overcome?

By Jack Simmer, writer for DO Supply

☑ You’re familiar with the challenges of IIoT implementations—security, educating the workforce, connectivity issues, legacy equipment, etc. IIoT technology is developing faster than solutions that will help enterprises actually use it. And fixing that problem falls onto the shoulders of the industrial business owner.

It comes as no surprise to me that, despite the acknowledged benefits of IIoT, widespread digital transformation has been slow. The first step to remedying that is recognizing the hurdles.

TOP IIOT IMPLEMENTATION CHALLENGES

Security

Security challenges for IIoT technologies are the biggest concern because breaches can lead to physical damage and human deaths. Smart organizations using a variety of IIoT solutions recognize their hack vulnerability and prioritize risks associated with IT/OT convergence, lack of visibility and insider threats. No comprehensive cybersecurity solutions currently exist—hackers are always one step ahead—and this is particularly true for environments that partner digital and physical components.

Education

There is a lack of understanding of IIoT solutions, a result of a handful of complications. First is a lack of educational systems for training manufacturing workers. This is complicated by the fact that many enterprises use a mismatched set of solutions that have to be adapted to develop a cohesive system. Therefore, the employer has to spend additional time and funds to train workers on these complicated setups. Likewise, as the setups get updated, the training has to be revamped.

Connectivity & visibility

In some way, all critical IIoT-implementation challenges are rooted in the lack of connectivity. With systems comprised of components from various developers, there is often trouble in synchronizing. Likewise, visibility is a resulting problem, as internet outages, power blackouts, human/software errors can remove some elements of systems from the network, which affects the entire production process and can cost millions in damages. The problem grows exponentially when the business owner is expanding and developing a global network of businesses connected through IIoT solutions.

IT/OT integration

The lack of connectivity between IT and OT infrastructures is one of the trickiest challenges of IIoT implementation because it makes adopting this technology financially impossible and logistically impractical for many businesses. IIoT devices are commonly developed as independent solutions; in best-case scenarios they can be injected into the manufacturing process to become a part of the system. However, more often they won’t allow for effective connectivity and synchronization. Therefore, the business owner has to either replace the entirety of their equipment or rely on faulty connectivity. A fix is considering IT/OT integration during development of the IIoT system.

Is it possible to overcome these IIoT implementation challenges? Of course. But resolutions require monetary investment and a commitment to develop industry infrastructure and services aimed at comprehensive implementation. In order to speed up the IIoT revolution, supporting infrastructure components mentioned above must develop alongside the actual technology.

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