RIT | Golisano Institute for Sustainability

INDUSTRY 4.0 PLAYBOOK

© 2023 Rochester Institute of Technology

If you're reading this playbook, you're probably wondering if Industry 4.0 technologies are worth investing in. And, if you're like most other small or medium-sized manufacturers (SMMs), your customers want lower prices while your supply-chain costs continue to rise. All this comes as you struggle to attract skilled workers. SMMs already have a lot on their plates—hopefully this playbook convinces you that it's worth getting started with Industry 4.0.

This playbook does not drill down into the intricate details of Industry 4.0 technologies—there are other resources for that. Instead, it illustrates the where, what, why, and how of implementing Industry 4.0 technologies as an SMM. Using examples of real companies like yours putting Industry 4.0 to work, the playbook is designed to give you a sense of the value digitalization can deliver, and to show practical ways for getting started.

The eight case studies in this playbook were part of a research program conducted by the **Center of Excellence in Advanced and Sustainable Manufacturing (COE-ASM) at Rochester Institute of Technology**. It was made possible by the U.S. Economic Development Administration (EDA) and Empire State Development's Division of Science, Technology, and Innovation (NYSTAR). While the program focused on companies from two regions of upstate New York, the findings should be applicable to your business, wherever you are located.

Here's why you should keep reading:

- The playbook is designed for SMMs like you who rarely have the time, budget, or staff resources to dedicate to research and development that larger shops have.
- This resource is built around eight case studies. Each features a real-world example of an SMM either taking a first step towards digitalization—another word for Industry 4.0—or building on an existing digital foundation.
- Each case study breaks a unique Industry 4.0 technology into practical steps that are most likely to result in quick returns on investment. Our goal is to show how off-the-shelf products can be paired with strategies we have field-tested with real businesses like yours.
- The playbook is a starting point you can use to begin charting your own business's Industry 4.0 journey. Plus, it's a great tool for getting buy-in from decision-makers who may still be on the fence about the benefits of Industry 4.0.

© 2023 Rochester Institute of Technology

What is Industry 4.0?

Plug "Industry 4.0" into your browser and you'll find an endless list of definitions. In simple terms, Industry 4.0 stands for the Fourth Industrial Revolution. It was coined to describe how the advent of advanced digital technologies—computing, communications, and sensors—are transforming manufacturing at all levels, from the shop floor to the executive suite. A number of technologies make up Industry 4.0 that you may be familiar with or even already have in place in your factory. These include but are not limited to data analytics, cloud computing, the Industrial Internet of Things (IIoT), artificial intelligence (AI) and machine learning, robotics, augmented reality (AR), additive manufacturing, and more.

Automation and robotics are common across manufacturing today. Industry 4.0 aims to build on these capabilities by integrating recent—and quick-emerging—advances in communications, networking, and computing densities, as well as the ready availability of cloud-based resources. In a digital factory, a company's existing assets are merged with software-based, "intelligent" systems that can extract actionable information from large and complex data sets. Data flows are created and managed to automate manufacturing processes and propel better decision-making in real-time.

Harnessing Industry 4.0 as an SMM requires an understanding of the tools and technologies that make it work. Taking advantage of it to drive your business forward calls for a long-term commitment to develop the internal know-how and technology and integration roadmaps that a successful implementation demands. But the payoff is worth it: Improved operational efficiencies and product quality, reduced lead times, and other tangible benefits can help your business thrive and grow in a global manufacturing sector where digitalization is increasingly the norm.

© 2023 Rochester Institute of Technology

Why implement Industry 4.0?

If you're considering Industry 4.0 for the first time, there are two ways to think about it:

1. It can help you improve the performance of your business.
2. Your competitors may already be using it to improve their performance.

Most SMMs operate on a much slimmer overhead than larger companies, but that doesn't mean they can't take advantage of the benefits of Industry 4.0. A **report by the World Economic Forum** found that manufacturers that adopt digital technologies can expect to see the following improvements:

- **+ 30% in labor productivity using flexible, automated assembly lines**
- **- 60% in consumer complaints through quality management enhanced with AI**
- **+ 25% in labor efficiency using collaborative robots ("cobots")**
- **- 60% in cycle time through additive manufacturing**
- **- 80% in deviations using advanced analytics**[1]

If successfully implemented widely, the deployment of digital technologies could generate $3.7 trillion worldwide by 2025.[2] But to get there, a sizeable adoption gap will need to be crossed, especially in the United States.

Today, most Industry 4.0 technology deployment is by larger companies.[3] Honeywell, for example, used its extensive information technology (IT) infrastructure to run a plastics factory in Texas remotely when workers had to stay home during the Covid-19 pandemic.[4] Few, if any, SMMs in the U.S. were able to be as resilient during the economic shutdown.

Other large U.S. manufacturers have also experienced concrete success utilizing Industry 4.0. Colgate-Palmolive and Frito-Lay saved 2.8 million toothpaste tubes and 1 million pounds of product, respectively, using AI-driven software.[5] Fast Radius, a software-development firm, introduced a machine-learning system to support root-cause analysis, which can lower inventory by 36 percent and time-to-market by 90 percent for its global manufacturing customers.[6] Nu-Wool Co. Inc., the oldest cellulose manufacturer in the United States, turned to Industry 4.0 when fuel prices and raw material availability threatened overall return. The company recouped the project costs after only two years, allowing it to ramp up production by 25 percent during high-demand periods.[7]

You may feel like investing in Industry 4.0 is luxury that you can't afford, but, in the long term, it will become imperative to remaining competitive. The international SMM sector is rapidly digitalizing alongside larger firms. As this shift has gained momentum, the risk of falling behind your competitors in the global market has overcome the challenges of investing in digitalization.

[1] World Economic Forum and McKinsey & Company. (2018). *Accelerating the Impact of Industrial IoT in Small and Medium-Sized Enterprises: A Protocol for Action.* McKinsey & Company.

[2] National Science and Technology Council. (2022). *National Strategy for Advanced Manufacturing.*

[3] McKinsey Global Institute. (2015). *The Internet of Things: Mapping the Value Beyond the Hype.* McKinsey & Company.

[4] Masood, T., & Sonntag, P. (2020). Industry 4.0: Adoption challenges and benefits for SME. *Computers in Industry, 121.*

[5] *Smart operators: How leading companies use machine intelligence.* McKinsey & Company.

[6] Betti, F., de Boer, E., & Giraud, Y. (2020). *Industry's fast-mover advantage: Enterprise value from digital factories.* McKinsey & Company.

[7] Michigan Economic Development Corporation. Nu-Wool.

© 2023 Rochester Institute of Technology

What other manufacturers are doing

Ninety-eight percent of all manufacturing in the United States is done by SMMs like you, accounting for 43 percent of manufacturing jobs. However, their market share is declining. The contribution to U.S. gross domestic product by SMMs dropped from 48 percent to 43.5 percent between 1990 and 2014, according to the U.S. Small Business Administration.[8,9] The Covid-19 pandemic only worsened this reality; 70–80 percent of SMMs across 32 countries saw a revenue loss ranging from 30 to 50 percent.[10]

Global and U.S. outlooks

Countries seeking to bolster their manufacturing sectors are working to advance SMM access to Industry 4.0 technologies and related workforce training. China and South Korea, both with growing manufacturing sectors, have already embraced a future where Industry 4.0 is well established among SMMs and larger firms alike. Germany and Japan have put in place similar strategies along with over 40 other countries.

Michigan's **Industry 4.0 Accelerator** is the first program of its kind in the United States. An investment fund worth $2.5 million, it aims to help early-stage companies and established ones alike to innovate, commercialize new products and processes, and grow using Industry 4.0.[11]

Another Michigan initiative, **Automation Alley**, is an advanced manufacturing hub (AMHUB) launched in conjunction with the World Economic Fund. This multi-stakeholder organization connects Michigan's manufacturers with Industry 4.0 expertise and developments across the globe. These efforts on the part of Michigan's government look to accelerate Industry 4.0 transition in the state.

Outside of Michigan, Industry 4.0 adoption is a major of focus of Manufacturing USA, a collection of 17 federally funded institutes designed to advance public-private collaboration to improve U.S. competitiveness at the global scale. Each institute is strategically focused on unique innovation areas, funding cross-sector projects that bring together companies and academic researchers to develop solutions that will benefit U.S. manufacturing. Many of the institutes work in and around Industry 4.0 and digitalization. **The Advanced Robotics for Manufacturing (ARM) Institute** in Pittsburgh funds research to spur innovation in robotics and AI. **The Clean Energy Smart Manufacturing Innovation Institute (CESMII)** in Los Angeles was created to advance technologies for smarter processes and controls. And **MxD (Manufacturing x Digital)**, based in Chicago, targets digital technologies at the nexus of product design and manufacturing.

[8] World Economic Forum and McKinsey & Company. (2018).

[9] Small Business Administration. (2019). *Release No. 19-1 ADV: Small Businesses Generate 44 Percent of U.S. Economic Activity.*

[10] Lin, D., Rayavarapu, S., Tadjeddine, K., & Yeoh, R. (2022). *Beyond financials: Helping small and medium-size enterprises thrive.* McKinsey & Company.

[11] Automation Alley, Lean Rocket Lab and Lawrence Technological University's Centrepolis Accelerator launch nation's first Industry 4.0 Accelerator. (2020, May). *Association for Advancing Automation News.*

© 2023 Rochester Institute of Technology

The National Institute for Standards and Technology (NIST) has also developed a number of resources, like **this useful guide**, to support SMMs in understanding and adopting Industry 4.0. NIST operates the Manufacturing Extension Partnership (MEP) National Network, which includes 51 centers across the United States. These were established to help SMMs generate business results through technological innovation and access resources to support Industry 4.0 implementation.

Survey of New York State SMMs

As part of the research program supported by the EDA and NYSTAR an online survey was conducted to help understand current Industry 4.0 practices among New York State SMMs. Sixty-two companies across a wide variety of manufacturing sectors participated in the survey. Seventy-five percent of the respondents companies had less than 100 employees, with 40 percent employing fewer than 20 people. Most of the companies that responded had annual sales of less than $50 million, with the majority bringing in less than $10 million each year. The company sample is likely skewed towards companies with active Industry 4.0 interest, based on their decision to participate, and may be more familiar with digitalization than the average SMM.

The following are observations were derived from the survey responses:

- Fifty percent of the companies have or are developing Industry 4.0 strategies, but 80 percent don’t intend to add new resources to support implementation in the near future.
- Respondents prioritized the following critical key performance indicators (KPIs) as most important to business competitiveness and growth: workforce efficiency, manufacturing cost, manufacturing lead time, and on-time delivery.
- Enterprise resource planning (ERP) systems and quality management systems are widely used digital tools, but companies are interested in enhancing the capabilities of these systems.
- Process automation, machine and process monitoring, robotics, and IIoT were identified as technologies that provide the greatest potential for improving competitiveness.
- Electronic work instructions (EWI), collaborative robots, AI and machine learning, and vision-based quality inspection were most frequently mentioned as technologies that are currently under consideration for implementation.
- Access to skilled labor was identified by nearly every company as a major barrier to acting on new opportunities. Automation of shop-floor processes via Industry 4.0 technologies is one way to address labor availability.

Overall, the most common challenges to Industry 4.0 adoption are limited human resources and know-how, the complexity of system integration, budget gaps, and a lack of clear understanding of return on investment.

© 2023 Rochester Institute of Technology

Making the right start

More broadly, SMMs in the U.S. report a number of challenges and barriers that need to be overcome. These challenges include lack of technical skills and leadership, cost of new technology, questionable return on investment, data security and privacy, and resistance to change.[12,13,14] The only way to understand and overcome these challenges is to get started; below are two complementary strategies to help you begin your Industry 4.0 journey.

1. **Set your baseline and build a plan:** Consider broadly the current state of the business, including opportunities and challenges, and develop a holistic strategy to incrementally develop organizational capability and to evaluate Industry 4.0 technologies broadly against the business needs.

2. **Start by tackling a real problem:** Identify a specific major business challenge or opportunity, and develop a very focused project to evaluate and possibly implement an Industry 4.0 solution. An example of this is to evaluate robots or cobots to perform undesirable tasks to help address a labor shortage.

A strategic approach to digitalization often begins with defining an internal champion to lead the process. Depending on organizational capabilities and knowledge as well as resource availability, the champion may engage a consultant to aid in developing an Industry 4.0 strategy. **The Smart Industry Readiness Index (SIRI)** provides a holistic framework for assessing the current state and Industry 4.0 readiness of your organization as well as providing a mechanism for prioritizing improvement areas. Consultants can aid you in this assessment, and RIT's COE-ASM has experience leading companies through this process, as well. There are two practical pre-requisites to this process: 1) You should have well-documented shop-floor and business processes, and 2) you should have an effective ERP implementation to serve as a foundation for building new digital processes and competencies. If you don't meet these pre-requisites, identifying internal or external resources to help you close these gaps is where you should start.

Starting with a high-value project can help you grow organizational competency and confidence in deploying new digital technologies. As noted above, if you are not already using an ERP system, that is a good place to start. Other technologies to consider that generally have a short payback time include additive manufacturing, computer vision for quality-assurance purposes, digital shop-floor work instructions, or robotics for dirty, dangerous, or dull manual tasks.[15] The project-based approach should focus on challenges or opportunities with a significant business benefit (reduced cost, quality improvement, reduced lead-time, etc.), and ideally those that don't have high technology, financial, or integration risks. Starting with small successes can help in developing competency, confidence, and buy-in at all levels of the organization. Consultants and technology providers can provide expertise and additional resources to support risk-benefit assessment, proof-of-concept, or implementation.

[12] MEP National Network. (2022). *Manufacturers' Guide to Industry 4.0 Technologies.*

[13] D Hockenbrocht et al. (2021, October 26). Wondering how to start your Industry 4.0 transformation? [Web log post].

[14] Madh, A. (2022, November 1). Three ways manufacturers can win in the Industry 4.0 revolution. *Forbes.*

[15] Marr, B. (2017, October 16). The 4 Ds of robotization: Dull, dirty, dangerous and dear. *Forbes.*

© 2023 Rochester Institute of Technology

This playbook contains case studies based on the EDA- and NYSTAR-funded research led by the COE-ASM at RIT. The case studies represent a range of industry sectors and offer an in-depth look at implementation of different Industry 4.0 technologies. They also offer views of SMMs at different stages of their journey to become more efficient and, ultimately, more competitive. You can find many more Industry 4.0 resources designed for SMMs on the **COE-ASM website**.

Use the summaries below to get an overview of all the case studies and find those that are most relevant to your sector, goals, and budget.

Digital-readiness assessment | Faradyne Motors Page 10

Goal: Understand how Industry 4.0 can best benefit the overall business.

Sector: submersible pump-motor manufacturing
Project prerequisites: management support
Resources needed: manufacturing, operations, and IT (information technology) leadership and key staff
Cost/benefit: An assessment is low-cost and identifies the highest impact areas for new technology implementation.
Technical difficulty/risk: low

Electronic work instructions (EWI) | INFICON Inc. Page 13

Goal: Enable faster on-boarding of new employees and more consistent process execution.

Sector: sensors and process-control software for semiconductor industry
Project prerequisites: shop-floor network, good process documentation
Resources needed: process experts, content developer, IT support
Cost/benefit: Software costs are moderate, though content development effort can be significant. Benefits include improved quality and labor efficiency.
Technical difficulty/risk: low

Process monitoring with machine learning | Linton Crystal Technologies Page 17

Goal: Detect operating conditions that can lead to defects to enable proactive process control.

Sector: ingot-production machines for the semiconductor industry
Project prerequisites: relatively large process dataset that includes quality data
Resources needed: process expert, machine-learning expert
Cost/benefit: Software tools are inexpensive, however data collection (if data set doesn't exist) can be expensive and time-consuming. Benefits include less defects and the extra labor and material costs they create.
Technical difficulty/risk: moderately high, but can be reduced based on the level of machine-learning experience and know-how

Remote monitoring of high-value equipment | G.A. Braun Page 21

Goal: Provide better visibility into the status and productivity of production assets.

Sector: industrial laundry machinery
Project prerequisites: understanding of key equipment parameters
Resources needed: project owner to drive requirements, software developers, controls engineers to support machine-interfacing
Cost/benefit: Cost is low if machines already have sensors and accessible controller, otherwise incremental cost can range from hundreds to thousands of dollars per machine. Primary benefits include reduction in unscheduled downtime and improved equipment utilization.
Technical difficulty/risk: low difficulty and low risk (if operational networks are secure)

© 2023 Rochester Institute of Technology

Machine monitoring with the Industrial Internet of Things (IIoT) | Brunner Page 24

Goal: Enable predictive maintenance (PM) to reduce unscheduled downtime and improve quality.

Sector: heavy-duty, commercial vehicle brake components

Project prerequisites: understanding of critical equipment failure modes, shop-floor network

Resources needed: engineer with PM experience, controls engineer, software developer, IT support

Cost/benefit: Monitoring-equipment cost ranges from hundreds to thousands of dollars per machine. Commercial monitoring software typically costs thousands of dollars per machine. Benefit depends on the costs of downtime and lost production, as well as secondary damage when failures occur.

Technical difficulty/risk: moderate difficulty to achieve predictive capability, low risk

Process-temperature monitoring with IIoT | Craft Cannery Page 29

Goal: Reduce manual recordkeeping and risk of product loss due to out-of-range temperatures.

Sector: food manufacturing

Project prerequisites: shop-floor network

Resources needed: controls engineer, IT support

Cost/benefit: Hardware and software are low cost. Benefits include less manual recording and a lower risk of product and ingredient losses.

Technical difficulty/risk: low difficulty, low risk

Enterprise resource planning (ERP) | V Technical Textiles, Inc. Page 33

Goal: Improve the consistency and timing of manufacturing processes to meet increasing customer demands.

Sector: conductive-textile products

Project prerequisites: well-documented business processes

Resources needed: internal project lead, internal process experts, ERP-configuration resources (often contracted), IT support

Cost/benefit: Software is low-to-moderate cost, though implementation costs are moderately high. The key benefit is improved operational effectiveness in many areas of business.

Technical difficulty/risk: Technical difficulty is low, but there are risks associated with properly defining ERP processes and transitioning operations.

ERP | Rochester Colonial Page 37

Goal: Improve digital processes and information flow across business units.

Sector: window and door manufacturing, sales, distribution, and installation

Project prerequisites: well-documented business processes, vision for improving ERP capabilities

Resources needed: internal project lead and process experts, ERP-configuration resources (often contracted), IT support

Cost/benefit: Software is low-to-moderate cost. Implementation costs are moderately high. Benefits include incremental improvement in operational effectiveness.

Technical difficulty/risk: Technical difficulty is low, but there are operational risks associated with the transition, especially if changing to a new ERP software.

© 2023 Rochester Institute of Technology

CASE STUDY

RIT | Golisano Institute for Sustainability

Faradyne Motors LLC targets data connectivity as first step towards digitalization

Company	Sector	Size	Location
Faradyne Motors LLC	Submersible pump motors for water and fuel	25 employees	Palmyra, New York

At a glance

- Faradyne Motors LLC (Faradyne) is a medium-sized manufacturer that believes data-driven digital technologies can improve its overall operating efficiency. While the company has automated many of its processes, automation is only one piece of the much larger puzzle that makes up Industry 4.0.
- Faradyne partnered with RIT to learn how the company could expand beyond automation to enable Industry 4.0. A site assessment by engineers from Rochester Institute of Technology's (RIT) Industry 4.0 Transition Assistance Program was followed by a full-day workshop, which resulted in a digital-readiness assessment. The review focused on specific dimensions of digitalization: 3 process-related, 12 technological, and 4 organizational. Next, the RIT team worked with key company decision makers to create a long-term Industry 4.0 plan: a digital-readiness roadmap and a set of strategic milestones for the next 3 years.
- One of the most important and near-term tasks pinpointed in the plan was to integrate Faradyne's operational and technical data into a global, unified information system. This would serve as a critical step in realizing data connectivity between the shop floor and enterprise, a pillar of Industry 4.0.
- In support of this, RIT and Faradyne worked together to identify areas where data-harvesting technologies, like sensors and edge devices, could be installed across Faradyne's manufacturing processes. This analysis considered different types of process data and the associated opportunities for improving quality or operational efficiency.

Company

Faradyne Motors LLC manufactures submersible motors. Faradyne's motors are sold throughout the United States and Canada, and can serve both low- and high-power applications.

Business challenge

Faradyne has automation technologies in place across its production and assembly lines to improve its overall efficiency. It is more advanced than many similarly sized manufacturers in this regard. While automation is without doubt an important lever of Industry 4.0, it is only one piece of a much larger puzzle; the successful digital factory demands a clear strategy for harnessing and utilizing operations data.

"Industry 4.0 is about advancing data-driven processes to improve business results more than it is about using any specific technology," says Gerry Hurley, technical program manager for manufacturing at RIT. "In that regard, improving the timeliness and quality of decision making, at all levels of the organization, is a key outcome."

In 2022, Dante Volpe, Faradyne's president, began exploring what the company's first steps towards digitalization would look like. He knew that he wanted to build on the firm's existing automation capabilities using Industry 4.0 solutions, but he wasn't sure where to begin. With this in mind, he reached out to RIT's Industry 4.0 Transition Assistance Program.

The Industry 4.0 solution: Digital-readiness roadmapping

"Deploying Industry 4.0 appeared daunting; we were thrilled when we found that RIT was able to help guide us through this process."

Dante Volpe, President of Faradyne Motors LLC

For many SMMs, the biggest barrier to Industry 4.0 is knowing where to begin. RIT's Industry 4.0 program was launched to help companies develop custom digital strategies and to offer guidance on taking first steps towards implementation. RIT's unique Industry 4.0 assessment is based on the Singapore Economic Development Board's Smart Industry Readiness Index (SIRI), a globally recognized standard for measuring and enabling digitalization within manufacturing.

Faradyne's digital-readiness assessment was completed and the results were used to define an Industry 4.0 roadmap that the firm could follow to move forward on digitalization. The roadmap laid out a set of technology implementation milestones covering the next 3 years. This approach has given Volpe and his team the perspective and information they need to align Industry 4.0 with the firm's wider business development goals.

As Faradyne progresses through the roadmap, its technology, processes, and logistics will gradually transform. Some of the key milestones set out in the plan include the following:

- improved shop-floor data collection and consolidation, as well as analysis of data to drive more informed decision-making
- a production-reporting system to better capture labor allocation
- barcode-scanning to improve work orders and material use
- supplier and customer portals to automate routine communications and improve relationships up and down the supply chain
- the introduction of robotics and "cobots" (collaborative robots) onto the shop floor to do repetitive tasks
- a warehouse management system to digitize transactional data currently captured using pen and paper

These incremental and strategic steps —along with others—will help to shape Faradyne's journey towards digitalization.

© 2023 Rochester Institute of Technology

Why create a digital-readiness roadmap?

- **A customized approach:** Every company works differently, leveraging unique strengths to face equally unique challenges. This means a "one size fits all" approach to Industry 4.0 doesn't work. A customized digital-readiness plan helps a firm to better utilize core competencies while filling in important gaps using Industry 4.0 technologies.
- **The right starting point:** A thorough assessment of a company's operations shows where the best opportunities for beginning digitalization lie.
- **Industry 4.0—step by step:** A digital-readiness roadmap shows how a firm can achieve Industry 4.0 over time, step by step. Incremental goals and milestones can be selected to reduce implementation risk and set manageable steps with good return on investment.

Approach

The RIT team's first step was to assess Faradyne operations at the day-to-day level. This hands-on walk-through looked at the company's manufacturing processes, material and information flows, and its use of digital tools. The onsite assessment was followed by a full-day workshop in which RIT's team worked with Faradyne stakeholders to determine the firm's digital maturity. The question-and-answer evaluation (based on the SIRI digital readiness assessment) resulted in scores across 16 different digital-readiness dimensions. These categories included "vertical and horizontal integration," "product life cycle management", and "automation, connectivity, and intelligence for the shop floor, enterprise, and facility."

The readiness scores, along with Faradyne specific key performance indicator (KPI) importance and financial characteristics, were used to prioritize opportunities that were most likely to deliver business benefits. With the results of this analysis, RIT led a workshop with the company to define an Industry 4.0 roadmap, which included resource and budget planning.

Results and next steps

The first milestone on Faradyne's Industry 4.0 roadmap is to establish data connectivity across its shop floor. To achieve this, the company will work to identify areas on its production and assembly lines where data-harvesting technologies, like sensors and edge devices, could be installed. These would capture data and feed it into a global, unified information system. The ultimate goal of this effort is to feed the data into analytics and visualization tools to improve the speed and quality of decisions and drive improvements in product quality and operational efficiency.

© 2023 Rochester Institute of Technology

RIT | Golisano Institute for Sustainability

INFICON Inc. starts transition to electronic work instructions

Company	Sector	Size	Location
INFICON Inc.	Sensor technology and process control software for semiconductor industry	300 employees	U.S. headquarters based in East Syracuse, New York

At a glance

- Strong market demand for INFICON's products led the company to consider how Industry 4.0 could improve its operational efficiency. An initial digital-readiness assessment performed by engineers from Rochester Institute of Technology's (RIT) Industry 4.0 Transition Assistance Program identified a list of best opportunities for leveraging digital technologies to move forward.
- Significant growth in INFICON's production workforce highlighted limitations in the company's paper-based work instruction system. As such, **electronic work instructions (EWI)** became a number-one priority in the company's digital transformation plan.
- Many software products provide EWI capability. Beyond business software like Microsoft Word or Adobe Acrobat, EWI software packages are designed specifically for authoring and deploying manufacturing process work instructions.
- A basic EWI platform can be used to present step-by-step instructions that can feature text, photos, and videos. They can also capture in-process data and track productivity.
- More advanced EWI products can facilitate connectivity to other software, such as an enterprise resource planning (ERP) platform to process status updates, monitor shop-floor material supplies, or submit process measurements or conformance issues directly into a quality-assurance package.
- RIT worked with INFICON to evaluate and select an EWI application that was best-suited to its unique manufacturing environment and business goals.

© 2023 Rochester Institute of Technology

Company

INFICON Inc. is a publicly traded company that supplies a range of sectors—including the refrigeration equipment, automotive, optics, and semiconductor industries—with instrumentation, sensor technologies, and advanced process-control software.

Business challenge

An explosive surge in market demand for INFICON's hi-tech products that support semiconductor-chip manufacturing led to a ramp-up in new hires. The complex production procedures required for product assembly presented the company with a significant challenge: New personnel had to be trained quickly, all while quality and productivity could be continuously monitored.

The company's portfolio includes many variants of highly complex technological products and components. As such, assembly workers relied on a range of largely paper-based instructions that were often in different formats; workers referred to Microsoft Word documents on a personal computer or printouts of design files annotated with handwritten notes and adjustments.

The Industry 4.0 solution: Electronic work instructions

Industry 4.0 offers manufacturers new pathways for streamlining the flow of information across their operations. For INFICON, this came down to improving how production-line workers access and utilize work instructions for a range of products and components that are very complex to assemble. A more uniform, easier-to-update system with better usability would help speed the time new employees need to learn as well as ensure higher quality, more consistent results.

"By shifting to digital instructions we plan to improve our overall productivity and effectiveness."

Scott Walker, Vice President of U.S. operations, INFICON Inc.

Through RIT's consultation, INFICON's leadership saw an opportunity to digitize the company's work instructions process. The transition would fall into wider efforts to better leverage operational data to build greater shop-floor intelligence. RIT's Industry 4.0 experts helped INFICON set out a plan for updating its existing work instructions to an **electronic work instruction (EWI)** system.

Why electronic work instructions?

- A more dynamic and interactive experience than paper-based work instructions: EWIs offer a range of formats—from simple text and annotated graphics to video and even augmented reality (AR)—that can serve many different learning styles and training contexts.
- Easy to update, disseminate, and organize: EWIs are ideal for manufacturers with a wide variety of products—they can be efficiently sequenced alongside many variants to ease access and usability. They can also help to manage the challenges associated with design and process changes, ensuring that all work instructions on the shop floor are up to date.
- Faster, more flexible training: EWIs can dramatically change how new hires and technicians alike learn new jobs, work processes, or tasks. Digital instructions can be optimized for different work settings, and can be delivered to personal computers (PCs), laptops, tablets, smartphones, and AR-enabled headsets.
- The power of data unlocked: Many EWI software products can be used to collect operational data, such as operator process time. Some software products offer an EWI capability as part of a manufacturing execution system (MES), allowing for the capture of product-quality, equipment-state, and other data sources to troubleshoot problems and drive continuous improvement.

© 2023 Rochester Institute of Technology

Approach

After assessing INFICON's location in East Syracuse, New York, engineers from RIT studied INFICON's existing work instructions in light of assembly, quality control, and product testing demands. They then looked to better understand how INFICON's work instructions were created and edited, starting with engineering and following the work flow through to floor release. Next, they documented all available data sources before sketching out ideas for an improved future process.

The information and insights that the RIT team gathered was used to assist INFICON with evaluating available EWI software products following a two-step process. First, a broad search based on INFICON's high-level requirements was done to arrive at a short list of potential EWI packages. Second, the short list was further refined through a more detailed analysis of features and performance based on product trials.

Solution

The software that is right for one company may not be right for another, even if the two seem similar in terms of size or sector. The data collected from across the organization provided an understanding of the most important features and capabilities a suitable EWI system should have. This discovery process allowed the RIT engineers to learn more about INFICON's overall manufacturing and product-development processes. It also helped them to evaluate the scope of the facility's information technology (IT) infrastructure as well as the role of employee preferences in terms of user experience. They also investigated the workflow driving the creation of work instructions, documenting how content is sourced, reviewed, and approved.

The results of RIT's research were translated into a list of essential features that were used to screen the short list of potential EWI packages. A final list of options with strong potential as best fits was developed. The RIT team then worked closely with INFICON's end users and production leadership to refine the list again to find the best possible options, subsequently arranging demonstrations and performing final assessments of features and capabilities.

INFICON Inc. starts transition to electronic work instructions

Results and next steps

RIT's initial search included 38 different packages. Then, using the essential features identified alongside INFICON, they reduced this list to eight options. After these were presented to INFICON's leadership and further discovery of the features that would best serve INFICON's needs, the list was next down-selected to three EWI software packages: FactoryLogix (Aegis Software), Tulip, and VKS (Visual Knowledge Share). RIT then requested demonstrations of each of these from the relevant vendor.

INFICON chose to pursue FactoryLogix with a target of implementing in 2024.

Why FactoryLogix?

There are many different kinds of EWI packages on the market, each with a unique set of configuration and feature options alongside different pricing structures. While these differences make a simple apples-to-apples comparison between popular products difficult, starting with a company's unique needs and goals can help prioritize what matters most in a given instance.

In the end, INFICON chose the FactoryLogix because it

- offered a full MES platform with EWI natively integrated—pursuing an MES was on INFICON's original digitalization roadmap.
- would allow staff to trace part serial numbers and lots as a future capability.
- can be integrated into an ERP and quality-assurance system.
- relies on a local server to keep proprietary data within a secure, onsite firewall.

In addition to assisting INFICON to select a software package, RIT guided INFICON in considering other technology, infrastructure, and resource investments that a successful EWI program demands. These include the following:

- digital devices for workstations and mobile work
- Wi-Fi signal improvements
- internet bandwidth increases (if using a cloud-based package)
- staff time for generating EWI content

© 2023 Rochester Institute of Technology

CASE STUDY

RIT | Golisano Institute for Sustainability

Linton Crystal Technologies looks to improve process quality and yield through machine learning

Company	Sector	Size	Location
Linton Crystal Technologies	Monocrystalline-ingot production for the semiconductor, machined part, and solar industries	25 employees	Rochester, New York

At a glance

- Linton Crystal Technologies (Linton) is an equipment manufacturer that specializes in designing and manufacturing furnaces for growing crystals—cylindrical silicon ingots—based on a method known as the Czochralski process. The crystal ingots are critical components in semiconductors used in electronic devices.
- Significant time and energy is required to produce an ingot using the Czochralski method: Growing a single crystal calls for adjusting more than 400 parameters for a process that lasts over 60 hours and demands a temperature reaching 1,425 degrees Fahrenheit.
- The failure to grow just one crystal ingot represents a major loss of time, energy, and labor for silicon-ingot manufacturers. And the risk will only increase as market demand for digital devices continues to flourish.
- After conducting an Industry 4.0 assessment, engineers from Rochester Institute of Technology's (RIT) Industry 4.0 Transition Assistance Program identified **machine learning** as a potential solution for improving the yield and quality of the ingot growth process. This offers significant potential to increase the value of the Linton product with their customers.
- The RIT team analyzed a dataset of successful and failed production runs to develop two types of data-driven models to predict errors during crystal formation before they happen: an LSTM (long short-term memory) model of process time-series data, and an image-based model.
- The LSTM model showed some promise, but not over long periods of time. The team lacked the volume of production data they needed to fully train the model and validate its accuracy over the length of an entire run.
- Results from the image-based model proved more promising; it used images captured by a vision system already onboard Linton's equipment. A neural network was trained to detect unique features of the ingot's curved surface that are considered indicators of good runs.

© 2023 Rochester Institute of Technology

Company

Linton Crystal Technologies designs, develops, and manufactures furnaces for producing monocrystalline ingots for the semiconductor, machined-part, and solar industries based on the Czochralski process. The company specializes in silicon and also produces equipment for materials such as germanium, gallium arsenide, and indium antimonide (InSb).

Business challenge

Linton's furnaces are used to grow crystals in order to obtain single cylindrical silicon ingots by employing a method known as the Czochralski process. The ingots are used in the electronics industry to make semiconductor devices like integrated circuits. For a crystal growth to be successful, the Czochralski process means maintaining a very high temperature for more than 60 hours and appropriately setting over 400 process parameters.

When a company uses one of Linton's furnaces, a team of experts continually monitors and controls each crystal growth at regular intervals. However, despite their careful observation, flaws in a crystal's structure may still go unnoticed until many hours into the process. Even small quality defects can mean abandoning a run, which, in the end, represents significant losses in terms of time, energy use, and labor.

The Industry 4.0 solution: Machine learning

Machine learning combines several technologies, which, when applied to manufacturing, allow software and machines to sense, understand, act, and learn on their own or augment human activities. Industry 4.0-enabled manufacturers generate a vast amount of data using an array of sensors across their production systems. They increasingly rely on machine learning to quickly analyze and interpret that data to produce valuable insights.

Linton partnered with RIT to learn how—if at all—process data generated by its silicon-growing equipment could be leveraged to improve overall efficiency and operational costs for its customers. Machine learning presented the best strategy for achieving this goal; the RIT team explored the potential for developing a predictive model based on data provided by Linton. Such models rely on algorithms that are trained with large amounts of data, a process called "deep learning." At the core of a model is the neural network, which is made up of node layers that are designed to behave like biological neurons in the human brain.

Why machine learning?

- **Synchronized, intelligent automation:** Machine learning can leverage existing digitalization technologies—such as data-collection hardware, industrial networks, and enterprise software systems—to generate new insights, maximizing the return on Industry 4.0 investments.
- **Optimal efficiency:** Putting machine learning to work in the factory can open entirely new business opportunities for realizing new levels of efficiency and productivity throughout an enterprise.
- **Less surprises, less downtime, less waste:** Machine learning can power predictive maintenance to monitor equipment performance in real time and catch unexpected events coming down the road that might otherwise set businesses back in terms of costs and resources.
- **Continual quality control:** Product and process quality can become nearly constant using machine learning to significantly increase the consistency of overall output.
- **Safer work environment:** Machine learning and related artificial intelligence (AI) technologies—coupled with automation and robotics—can reduce the need for humans to be directly engaged in dangerous and dirty manufacturing tasks.

© 2023 Rochester Institute of Technology

Approach

Engineers from RIT's Center of Excellence in Advanced and Sustainable Manufacturing (COE-ASM) set out to learn if a relationship could be identified between Linton's controllable process parameters and the resulting quality of a crystal ingot. If so, they would then demonstrate a real-time prediction system to anticipate failures before they happen and, subsequently, minimize wasted resources and energy. By doing so, the RIT team aimed to not only improve Linton's operating efficiency, but also the material impact of both the semiconductor industry and other industries where the Czochralski process is used to "crystalize" metals like silver, palladium, and platinum.

Solution

After considering Linton's goals, the RIT team created two types of models over the course of the project. These were based on a general dataset that consisted of a historical log of process data based on more than 400 parameters and a store of in-process images captured by a camera within Linton's furnace. The dataset captured a number of successful and failed production runs.

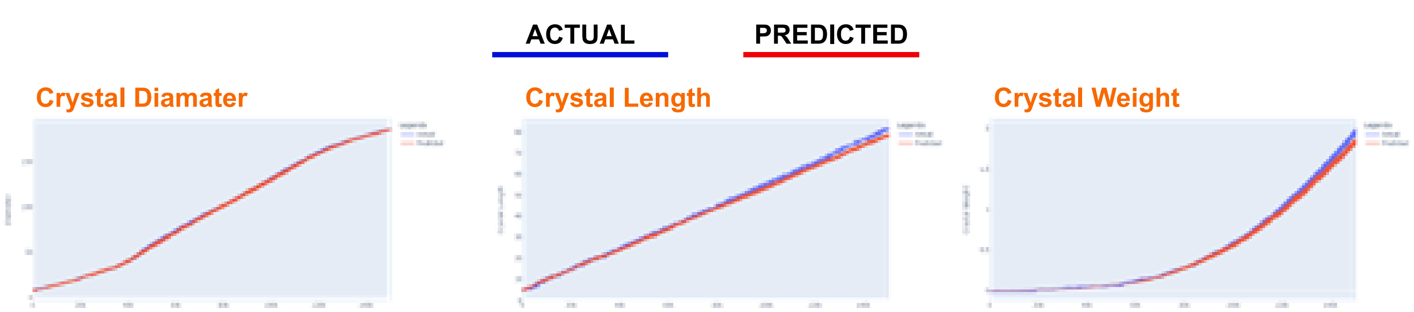
Two parallel approaches were taken for modeling the dataset:

1. The first was a long short-term memory (LSTM) time series model designed to predict future growth trends based on past parameter data. To create this, the RIT team analyzed over 400 parameters tracked in the historical log data. Their goal was to identify those that would deliver essential and unique data points in a model, removing any that were redundant or irrelevant. The parameters included initial process settings and crystal-quality metrics like length and weight. In the end, they selected less than 30 parameters on which to train the real-time prediction system. The time-series parameter signals were converted from a measure of time to band frequencies in order to extract further underlying patterns correlating to either successful or failed runs.
2. The second model used image data captured by Linton's machinery to train a neural network. This model focused on the visual detection of unique geometrical characteristics of growing crystals which are early signals of a good production run.

Results and next steps

The solution RIT developed for Linton is an example of how machine learning can enhance the value of Industry 4.0. Namely, the project explored a way in which a data-driven model can be used to provide manufacturers with advanced perception and decision-making capabilities.

The time-series-data model revealed that it is possible to roughly predict how a crystal will grow within Linton's furnace within a short future time frame. However, RIT's engineers found that the prediction deviated considerably from the results of an actual process as the model's time horizon is increased. The model's discrepancy, they found, was caused by insufficient training and testing data. Given enough samples of data representing good and bad runs, this forecasting method could still be used to detect impending failures; however, that data was not readily available at the time of the project.



Comparison of predicted crystal development to actual for critical characteristics

© 2023 Rochester Institute of Technology

The image-based model showed very promising results. Using laboratory data, the engineers concluded that it is feasible to detect geometric features that are consistent with a good quality end-product very early on in the crystal-growing process. The machine-learning models were deployed on production equipment in the Linton Crystal laboratory and demonstrated that the technology can successfully detect the quality precursors in real-time operation.

Examples of image-based facet identification

To achieve full benefit of the system, the model has to be trained with more data that encompasses a greater range of quality variation within the production environment and process parameters of Linton's equipment. Additionally, it needs a usability interface that would allow Linton's customers to adjust the model, such as stop and restart it or tweak parameters. An operator should also be able to override the model's decisions in order to train it for new circumstances that may not have been encountered during training.

© 2023 Rochester Institute of Technology

CASE STUDY

G.A. Braun Inc. meets consumer demand for remote monitoring using data connectivity

Company	Sector	Size	Location
GA Braun Inc.	Industrial laundry machinery	230 employees	Syracuse, New York

At a glance

- G.A. Braun Inc. (Braun) manufactures industrial laundry machinery in Syracuse, New York. Known for its high-quality products, Braun's systems lacked the remote-monitoring capabilities that its competitors offered—and customers noticed.
- The 77-year-old manufacturer decided that improving data connectivity was an important customer satisfaction driver and wanted to develop the capability for their customers to monitor equipment using a web-based application from any location.
- Braun took advantage of expertise from Rochester Institute of Technology's (RIT) Industry 4.0 Transition Assistance Program to develop a custom remote monitoring solution that takes advantage of data already available within the existing machine controllers.
- The RIT team evaluated Braun's exiting products and software and designed a solution for capturing data generated by the equipment and delivering it to a cloud environment where it could be easily accessed using a web browser.
- Once the application is developed, RIT plans to deploy it at Braun's facility for testing and then, if successful, to conduct a pilot installation at the site of one of Braun's customers. Once validated, this tool will be a significant improvement to Braun's product line.
- While Industry 4.0 often focuses on improving manufacturing processes, it can also be about digitalizing products. Braun's equipment provides a key process technology for its customers, high-volume commercial laundry operations.
- Remote-monitoring will help Braun's customers benefit from digitalization. They will be able to achieve near real-time access to utilization tracking for their equipment as well as fault-code monitoring. The data they gather can be used to improve operational efficiency and reduce equipment downtime.

© 2023 Rochester Institute of Technology

Company

G.A. Braun Inc. manufactures large industrial laundry machines that include washers, dryers, feeders, folders, and material-handling systems. Since 1946, Braun has specialized in products designed to make laundry and textile facilities more productive and profitable. The company's equipment is used worldwide in hospitals, hotels, cruise ships, commercial and industrial laundries, and in government and correctional facilities.

Business challenge

Braun's existing Washnet software is designed to configure and control a group of laundry equipment within a customer's facility. This program runs on a dedicated computer on the shop floor, collects and stores data in a local database, and is used to troubleshoot problems when they arise. However, operators can only access and view this data on this computer – there is no remote viewing capability.

After listening to customers and evaluating what competitors offered in similar products, Braun began considering strategies for upgrading its Washnet software to include a remote monitoring capability. A new cloud-based service suggested by RIT would allow users to access essential performance data—machine status, alarms, and key statistics (e.g., loading time, total loads, and weight)—using a web browser on common digital devices like smartphones and desktop computers.

The Industry 4.0 solution: Data connectivity

While data is a foundation of Industry 4.0, what really makes the factory of the future work is the opening paths for data to move between points across a company's footprint. That might be a real-time look at how a busy production line is performing, or it could be a warning about a potential supply disruption alerting decision makers so they can prepare. In other words, the technologies behind Industry 4.0 come down to connecting the people who make a business work to the information and assets that they rely on for success.

Data connectivity, a key component of the Industrial Internet of Things (IIoT), includes measurement or collection of relevant data, transport of that data through networks, and then analysis and visualization of that data for information consumers. Braun saw an opportunity to leverage data connectivity as a way to improve the value proposition of their products. By connecting customers to essential performance data captured by Braun's equipment, the company is better able to meet the growing market demands for easy, immediate access to information at the click of a button or the tap of a screen.

Why data connectivity?

- **A smart start for Industry 4.0:** Data connectivity is a good place for small and medium-sized manufacturers to begin phasing in digital technologies. Typically, the initial investment is small while the immediate return is large.
- **The power of data unlocked:** Many tools and technologies can be used to collect and interpret data from live operations, product performance, or enterprise-level business activities. Equipment downtime has direct and hidden costs, and data connectivity offers a path to improving both operational and maintenance procedures to reduce downtime.

Approach

Engineers from RIT Industry 4.0 program worked with Braun's engineering staff to discover what they hoped to achieve through a remote monitoring application. They investigated Braun's current products and software to determine its capabilities. They found that Braun's existing Washnet software runs on an industrial computer at each customer site. This computer is dedicated to a group of Braun's laundry machines, and typically collects production data for a number of machines. After their review, the RIT engineers recommended a three-tiered, cloud-based solution that utilizes Amazon Web Services (AWS) as a best-fit for developing a custom software solution that can bridge the collected machine and production data to a web-based application.

© 2023 Rochester Institute of Technology

Solution

The RIT team developed software that can run on the computers already installed at Braun's customer facilities—there was no need for new hardware. The software periodically reads data from the local database and writes it to the AWS cloud. AWS then saves the transmitted data in a time series database and makes it available to clients through a web interface. AWS services are also used to analyze the raw data to create data summaries.

Once a strategy for getting data off Braun's equipment and into the cloud was set, RIT's next goal was to create an interface that customers can use to access and interpret the data. To do this, the engineers developed an application using React, a JavaScript library for building web interfaces. React runs on common web browsers and displays data for individual pieces of equipment, tracking events like current machine state, alarm status, and current jobs underway. Notably, the tool can also aggregate data from multiple machines into a single view—a new capability for Braun's line of products. A customer can view "data roll-ups" which are summaries that use graphs and tables to show production data, allowing operators to determine the key performance indicators of their processes at a glance. These summaries can be viewed by system (a group of machines), site (a group of systems), and company (a group of sites). The solution also makes it easy to generate reports as portable document files (PDFs), which can be printed.

Using the suite of tools available through AWS, the new application allows Braun customers to maintain a list of users and to provide login and authentication so that users can see only the data they have been authorized to view. The web application also provides an administrative interface that allows Braun's customers to create and maintain a list of sites, systems, individual machines and users, and to manage user permissions.

Results and next steps

Braun's leadership believes the web application developed by RIT's team will enhance its product offering by making monitoring of laundry equipment easier for their customers. After undergoing testing at Braun's facility, the web application will be installed at the site of a Braun customer in Binghamton, New York, for trials. Once complete, these will give RIT and Braun insights to fine-tune the tool before eventually releasing it as a standard product.

© 2023 Rochester Institute of Technology

CASE STUDY

RIT | Golisano Institute for Sustainability

Brunner evaluates machine monitoring to improve productivity of stamping process

Company	Sector	Size	Location
Brunner	Heavy-duty, commercial vehicle brake components	325 employees	Medina, New York

At a glance

- Brunner is a mid-sized business that has specialized in the production of heavy-duty commercial vehicle drum brake components for over 40 years.
- With an interest in improving component quality and reducing equipment downtime, Brunner partnered with Rochester Institute of Technology's (RIT) Industry 4.0 Transition Assistance Program to investigate opportunities for process monitoring and predictive analytics to reduce unscheduled downtime in stamping and forging operations.
- RIT's engineers first reviewed material and information flows related to Brunner's business and shop-floor processes, and also reviewed service histories on a 2000-ton stamping press. They evaluated recurring problems on the press, and documented its existing sensors and controls. Then they collected operational data from the machine for analysis.
- Following the initial evaluation, RIT designed a monitoring system that could be used in production, powered by the Industrial Internet of Things (IIoT). A pillar of Industry 4.0, IIoT uses hardware and software to collect manufacturing shop-floor data and store, analyze, and visualize it for decision-makers. The monitoring system was designed to be easily replicated and applied to other stamping and forging equipment onsite.
- The goal of the IIoT-enabled machine-monitoring system was to provide Brunner's operators and engineering team with early indicators of changes in press performance, which may result in non-conforming parts or long downtime due to maintenance. Analysis of data from the existing press identified specific metrics for monitoring different phases of the stamping process. Once implemented, the monitoring system will allow operators to be proactive about reducing defects and unscheduled downtime.

© 2023 Rochester Institute of Technology

Company

Brunner manufactures brake systems for heavy-duty, commercial vehicles in Medina, New York. The company produces brake shoes and drum brake S-cams for commercial vehicle, bus, and trailer markets.

Business challenge

For example, broken counterbalance shafts in the stamping presses can require a day or more to obtain parts, schedule a rigging company, and have the repairs performed. Also, worn stamping dies can result in poor quality parts and an increase in defects. Brunner wanted to utilize machine monitoring as a pathway to reduce both downtime and defects, providing a warning mechanism for process degradation and potential press failures and allowing for proactive repairs.

The Industry 4.0 solution: Machine monitoring through the Industrial Internet of Things (IIoT)

IIoT is a term for a set of technologies that can be used to collect, analyze, and interpret manufacturing data. IIoT's namesake—the Internet of Things (IoT)—was first coined to describe the system of software and hardware for consumer products that facilitates data collection with sensors, public and private networks, and web-based software. Everyday conveniences, like smartphones, smart thermostats, and doorbell cameras, are all consumer-level IoT applications. IIoT offers this same kind of connectivity and automation to manufacturers.

A steady stream of new hardware and software on the market is reshaping how data can be used in the factory environment to monitor equipment performance in real time. On the manufacturing shop floor, access to a network is critical to IIoT; wireless networks are increasingly being used for this purpose. Cloud-computing leaders like Google, Microsoft, and Amazon all have IIoT software platforms that provide architectures for data management and software deployment.

At its heart, IIoT-enabled machine monitoring carries data across a manufacturing plant in three phases, outlined below.

1. **Measure and connect:** First, digital sensors measure a specific parameter that a business defines, such as temperature, pressure, load, etc. These sensors are physically installed on equipment. In addition to sensors and measuring equipment like probes, data connectivity is established at this point, typically over Ethernet or a Wi-Fi gateway.
2. **Connect, collect, and visualize:** A computer—usually an edge device—is installed on relevant equipment. It features software that allows it to "talk" to the sensors and collect data. From there, the data is sent to an information network and displayed on a dashboard on a digital device for staff members to interpret.
3. **Collect, store, and notify:** Once data has been collected and displayed, it needs to be recorded and archived so it can be retrieved for broader analytics activities, such as tracking of historical trends. Data can be stored on a local network or on a cloud-based service, as security and access considerations allow. Alarms can also be set—technically, coded—to signal when specific conditions are met within the data.

IIoT provides a framework for managing acquisition, transport, and analysis of machine-monitoring data. There are many software applications available on the market that are advertised as predictive maintenance tools and can link into an IIoT system and provide advanced data-analytics capabilities, such as machine learning. However, these solutions usually do not provide the know-how on what data to measure or how it should be analyzed to achieve predictive maintenance. This requires an understanding of how to link equipment failure to patterns observable in machine data. For standard industrial equipment, like pumps, motors, or blowers, some predictive-maintenance software tools provide off-the-shelf solutions.

© 2023 Rochester Institute of Technology

Why machine monitoring?

- **Spend less time recording data and addressing issues:** IIoT-enabled machine monitoring provides a direct value-add when it replaces manual condition-monitoring activities. Manually collecting data from machines can require significant labor hours and lead to inconsistent results due to human error and variation between how technicians record those data.
- **Know before it blows:** Leveraging hardware to collect machine data and software to analyze and display it, a machine-monitoring system can warn operators or maintainers when a piece of machinery is running abnormally or nearing failure to prevent costly quality spills or unscheduled downtime.
- **Brings everything under one umbrella:** Machine-monitoring technologies can be applied to a wide range of critical production equipment and infrastructure systems, from CNC (computerized numerical control) machines and injection-molding equipment to air compressors and chillers. An IIoT system allows process data from different machine makes and model years to be brought together, thereby integrating them into a single, unified system.

Approach

To start, the RIT team visited Brunner's facility in Medina to review its production processes and assess what existing data was available to understand the stamping press's operating conditions. In many cases, machine monitoring requires an understanding of what task the machine is performing. It is also important to bring together other data, such as quality or maintenance data, in order to link a machine's operating conditions to other events. RIT performed a material and information flow analysis to understand current data flows related to Brunner's stamping and forging processes (e.g., what parts are running on what machine, what dies are in service, or why did the machine go down).

> *"We were interested in the possibility of monitoring our stamping and forging presses to reduce unscheduled downtime. RIT demonstrated the value of capturing data from our existing tonnage monitor and also provided a scalable concept design for press monitoring. We look forward to the next steps of implementing this solution."*
>
> *Saamir Rahman, Continuous Improvement and Materials Manager, Brunner*

RIT's engineers next focused on evaluating the feasibility of monitoring the condition of Brunner's 2000-ton stamping press. This involved understanding maintenance histories and critical failure modes, and linking these to existing or new sensors that could provide insight into the press's condition. An existing Toledo Integrated Systems (Toledo) tonnage monitor provided dynamic data related to the overall stamping operation's condition. Strain gauges were subsequently added to monitor counterbalance shaft loads. A temporary data-acquisition system was created to collect data from the press over the course of several weeks. The resulting data set allowed the RIT team to build analysis methods and associated metrics for tracking the health of the press process. The information also facilitated the design of a production-grade monitoring system, including both hardware and software components.

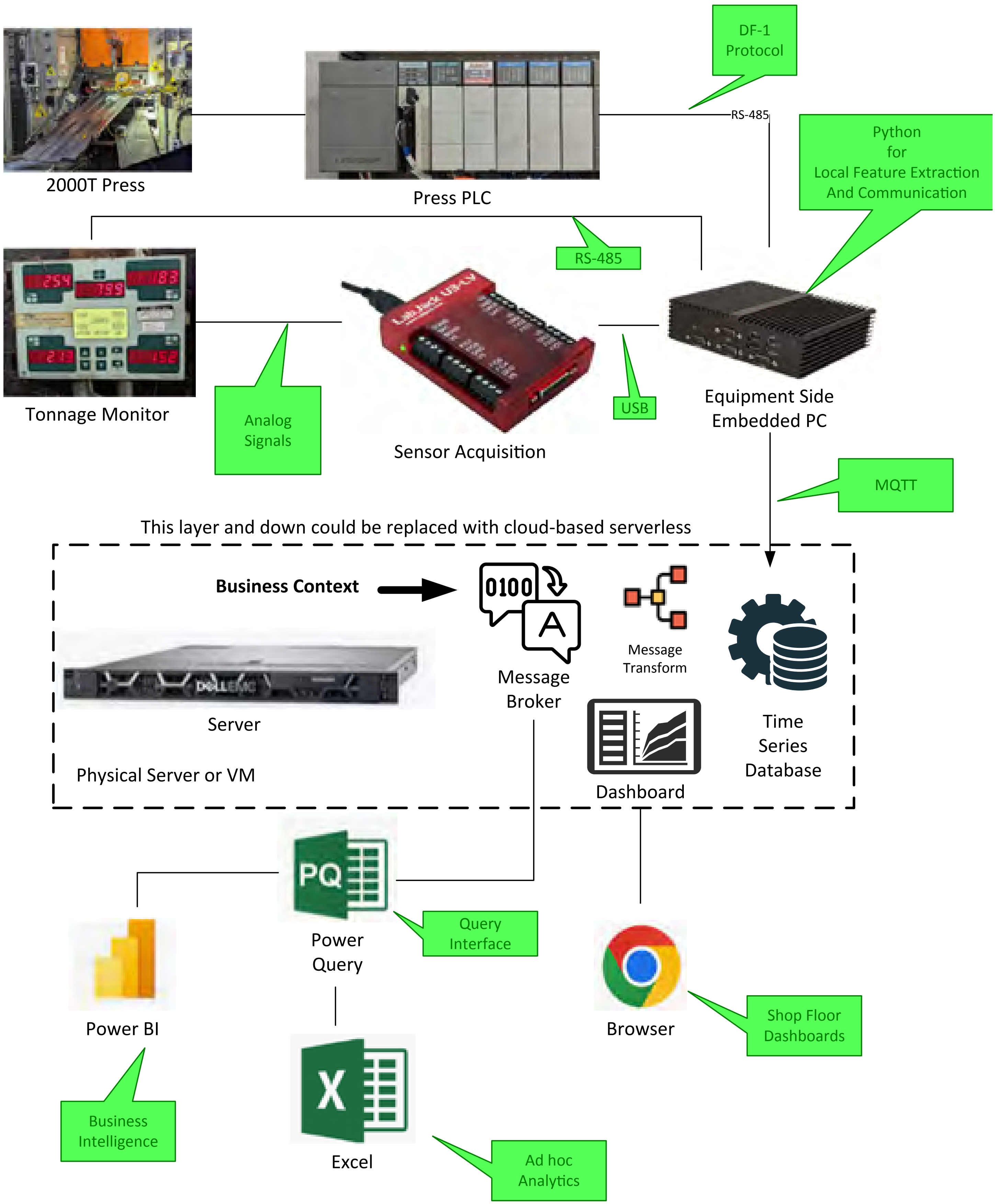
Solution

The 2000-ton press operates with an Allen-Bradley PLC (programmable logic controller) for control and utilizes the Toledo tonnage monitor to measure stamping force. Despite both systems generating valuable data, they exist as "data islands," lacking connectivity and leaving any associated data underutilized.

The RIT project developed a set of metrics from analysis of the Toledo tonnage-monitor data and demonstrated that the metrics were indicative of the condition of the stamping press and stamping die. Further, the project resulted in the design of an IIoT-enabled system to bridge the connectivity gap characterizing Brunner's stamping process. This system will enable the stamping press to transmit real-time status updates, alarms, and other critical measurements directly to the network. The live streaming of data will facilitate real-time analytics as well as analysis of historical trends. To accommodate additional sensors in the future, the design incorporates a USB (universal serial bus) data-acquisition device.

© 2023 Rochester Institute of Technology

Brunner IIoT Stack



© 2023 Rochester Institute of Technology

Node-RED, a low-code development software widely adopted in IIoT, provides seamless machine-to-network integration. This software will run on a cost-effective industrial computer, serving as the interface between the machines and the network. The standardized data format will be transmitted to an IIoT stack that will include Timescale (a time-series database engine), Grafana (an open-source graphing and visualization tool), as well as analysis and reporting tools such as PowerBI Desktop, and Power Query. To optimize data extraction and reduce storage requirements, Python tools will be employed to derive the condition metrics from the high-resolution machine data. This IIoT approach not only ensures efficient data management but also supports scalability for future integration with other machines across the entire factory.

Next steps

RIT delivered the design for the monitoring system concept at the end of the project. Next, RIT and Brunner will pilot an implementation of the proposed solution on the 2000-ton press over a longer period of time. This will serve to verify the value of the system prior to a wider deployment to other stamping and forging presses. RIT will develop any needed software for the production-intent design and support Brunner to install the system.

© 2023 Rochester Institute of Technology

CASE STUDY

RIT | Golisano Institute for Sustainability

Craft Cannery implements IIoT-enabled temperature monitoring to support facility expansion

Company	Sector	Size	Location
Craft Cannery	Food manufacturing and packaging	Less than 100 employees	Bergen, New York

At a glance

- Craft Cannery is a small business specializing in customized food manufacturing and packaging. In the three years since its launch in 2020, the company has quadrupled in size.
- With plans to expand its factory in 2024, Craft Cannery's CEO Paul Guglielmo looked to Industry 4.0 for opportunities to enhance the plant's performance as part of the scaleup. He identified temperature monitoring as a top priority to minimize risks associated with the expansion. Adding this capability would enhance food safety, simplify regulatory reporting requirements, and protect valuable perishable ingredients, delivering a quick return on investment (ROI).
- Craft Cannery partnered with Rochester Institute of Technology's (RIT) Industry 4.0 Transition Assistance Program to develop and outline a digital, connected system to monitor refrigerator, freezer, and cook kettle temperatures across the company's facility. Together, RIT and Craft Cannery laid out plans to implement machine monitoring powered by the Industrial Internet of Things (IIoT). A pillar of Industry 4.0, IIoT uses a mix of hardware and software to collect data from the shop floor and store, analyze, and visualize it for decision-makers.
- The goal of the IIoT-enabled machine-monitoring system was to provide Craft Cannery's factory staff a quick and reliable method for checking refrigerator, freezer, and cook kettle temperatures, alerting them well before any deviations affect food safety. Once implemented, the automated monitoring system will allow them to become aware of potential problems and to react to them immediately, thereby avoiding spoilage and factory downtime.
- RIT's engineers provided Craft Cannery with a detailed concept for a monitoring system, complete with a list of hardware and software that it would require. It offered a phased approach, allowing the company to target high-priority needs sooner for an immediate ROI, as well as to set future milestones to meet as the business grows.
- Based upon RIT's recommendations, Craft Cannery purchased a Wi-Fi-enabled temperature sensor and a communications hub to facilitate a trial of the temperature-monitoring system at RIT. The trial is ongoing, and the results so far indicate that the selected hardware and software will indeed work in the next phase of implementation. A follow-on project has been planned to deploy temperature sensors across the company's refrigerator, freezer, and cook kettles.

Company

Craft Cannery is a food manufacturer located in Bergen, New York. The company manufactures sauces, dressings, oils, marinades, teas, soups, meat sauces, meals in jars, and other related food items. Several of these are sold under its own brand, Guglielmo's. As a contract manufacturer, the company partners with many different brands with a focus on replicating signature recipes and using custom ingredients.

Business challenge

After successfully launching Craft Cannery in 2020, Paul Guglielmo, owner and chief executive officer, saw the company quadruple production over the course of three years. After winning a $500,000 Grow-NY prize in 2022, the manufacturer laid plans to expand the factory in 2024. For Guglielmo, the expansion offered an opportunity to not only increase Craft Cannery's footprint, but also to enhance its technological capabilities. To that end, he and his team considered different Industry 4.0 strategies. Promising a fast return on investment while addressing a major driver of product quality and throughput, they identified temperature monitoring as the best starting point for digitalization.

Temperature control is critical to food manufacturing: It drives taste and quality as much as it does health and safety. Craft Cannery regularly receives inspections from federal and state agencies to ensure that its processes meet existing consumer-health regulations. Guglielmo and his team looked to implement a machine-monitoring system that could automate some of the record-keeping and temperature-monitoring work. They wanted to make it easier for operators to track temperatures across the expanded factory and, when needed, correct problems quickly when they arise. To design this system, they partnered with RIT's Center for Advanced and Sustainable Manufacturing (COE-ASM).

The Industry 4.0 solution: Machine monitoring through the Industrial Internet of Things

The Industrial Internet of Things (IIoT) is a term for a set of technologies that can be used to collect, analyze, and interpret manufacturing data. IIoT's namesake—the Internet of Things (IoT)—was first coined to describe the system of software and hardware for consumer products that facilitates data collection with sensors, public and private networks, and web-based software. Everyday conveniences, like smartphones, smart thermostats, and doorbell cameras, are all consumer-level IoT applications. IIoT offers this same kind of connectivity and automation to manufacturers.

A steady stream of new hardware and software on the market is reshaping how data can be used in the factory environment to monitor equipment performance in real time. On the manufacturing shop floor, access to a network is critical to IIoT; wireless networks are increasingly being used for this purpose. Cloud-computing leaders like Google, Microsoft, and Amazon all have IIoT software platforms that provide architectures for data management and software deployment.

At its heart, IIoT-enabled machine monitoring carries data across a manufacturing plant in three phases, outlined below.

1. **Measure and connect:** First, wireless digital sensors measure a specific parameter that a business defines, such as color, weight, or temperature. These sensors are physically installed on equipment. In addition to sensors and measuring equipment like probes, data connectivity is established at this point, typically using a Wi-Fi or wired gateway device.
2. **Connect, collect, and visualize:** A computer—usually an edge device—is installed on relevant equipment. It features software that allows it to "talk" to the sensors and collect data. From there, the data is sent to an information network, transformed if necessary, and displayed on a dashboard on a digital device for staff members to interpret.
3. **Collect, store, and notify:** Once data has been collected and displayed, it needs to be recorded and archived so it can be retrieved for broader analytics activities, such as tracking of historical trends. Data can be stored on a local network or on a cloud-based service, as security and access considerations allow. Alarms can also be set—technically, coded—to signal when specific conditions (e.g., unusually high numbers of defects) are met within the data.

© 2023 Rochester Institute of Technology

Why machine monitoring?

- **Spend less time recording data and addressing issues:** IIoT-enabled machine monitoring provides a direct value-add when it replaces manual condition-monitoring activities. Manually collecting data from machines can require significant labor hours and lead to inconsistent results due to human error and variation between how technicians record those data.
- **Know before it blows:** Leveraging hardware to collect machine data and software to analyze and display it, a machine-monitoring system can warn operators or maintainers when a piece of machinery is running abnormally or nearing failure—this prevents costly quality spills or unscheduled downtime.
- **Brings everything under one umbrella:** Machine-monitoring technologies can be applied to a wide range of critical production equipment and infrastructure systems, from injection molders and packagers to air compressors and chillers. An IIoT system allows process data from different machine makes and model years to be brought together, integrating them into a single, unified system.

Approach

To start with, the RIT team visited Craft Cannery's facility in Bergen to review its production processes and identify all the specific locations where the temperature-monitoring system would need to be installed. They assessed temperature-controlling assets in the company's existing factory, which featured three cook kettles, a refrigerator, a freezer, and an automatic filler and capper. They also evaluated similar equipment that may be added as part of the 2024 expansion, such as two new cook kettles, with one three-times larger than any it had before, and a new bottle-and-package filler.

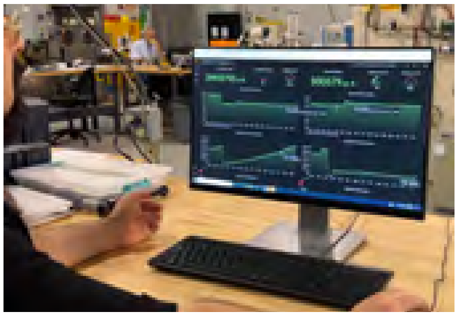
"We partnered with RIT to really look into our critical processes and map out some approaches to add the right type of temperature-monitoring system for us. They helped define a realistic budget we could live with, understand how a temperature monitoring system could work on the shop floor, and select hardware and software that was a good fit."

Paul Guglielmo, Owner and CEO, Craft Cannery

Each asset presented specific temperature-related requirements, either to keep ingredients cool or frozen before processing, or to heat and maintain temperature during production. Although the company followed a stringent process to check and monitor these temperatures, manually recording measurements on paper logs and then typing them into a record-keeping system is a tedious task. Additionally, temperature deviations during processing can ruin a batch if not corrected quickly. Moreover, improper operation of storage systems including during power outages, can lead to spoilage of raw ingredients. Anomaly identification and the ability to rapidly notify key staff were, therefore, both important requirements for Craft Cannery's unique monitoring system. Through the assessment, the RIT engineers were able to systematically define requirements like these to create a design concept.

Solution

Following a careful analysis of both Craft Cannery's existing facility and considering the company's expansion plans, the RIT team put together a concept for a monitoring system using a range of off-the-shelf software and hardware products. The concept system involved robust, industrial-grade components, and was designed to be modular to allow Craft Cannery to grow or adjust it as needed. Taking into account budget considerations, RIT recommended that Craft Cannery pilot the system on a representative cross-section of critical assets, and then build the system up as it is validated and as funding becomes available.

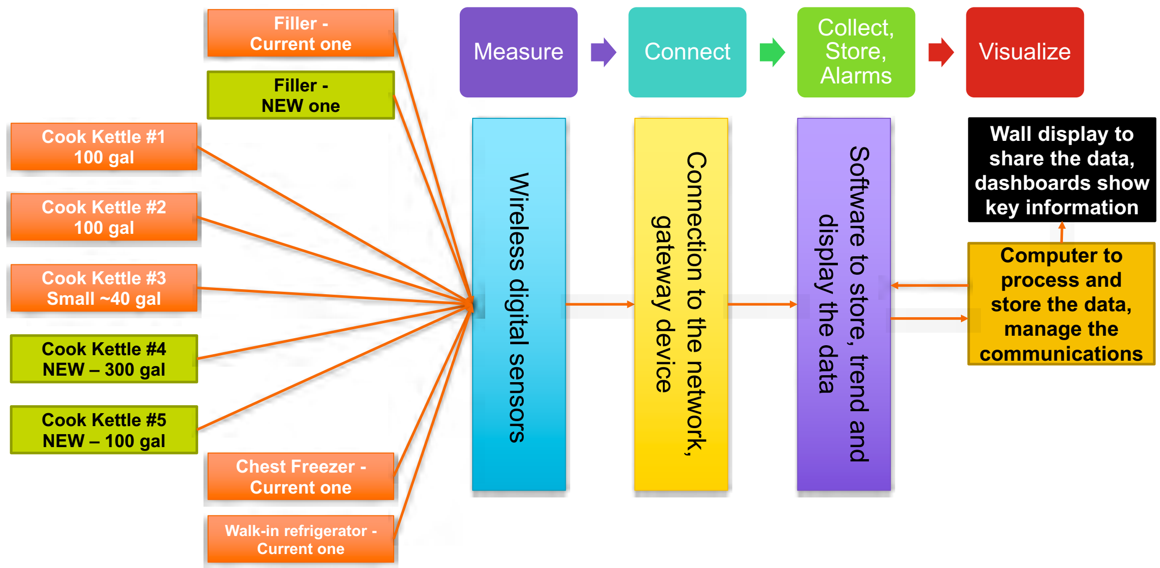


To measure and collect data, RIT recommended a series of industrial-grade, wireless temperature sensors and probes with long battery life that would send data out via a Wi-FI gateway. To connect, collect, and visualize the data—the second phase in the machine-monitoring journey—RIT recommended use of an edge device in the form of an industrial-grade computer connected to both the gateway and the Internet. Installed on the shop

© 2023 Rochester Institute of Technology

floor and connected to the network, this would receive data from installed sensors using NodeRED, an open-source software platform, and push the information to a cloud time-series database, Amazon Timestream. The Grafana cloud service will provide a way to display both live and historical temperatures. Craft Cannery will use this to create a wall display in the kitchen to share this information with workers, as these types of displays have been shown to improve employee engagement and awareness. Grafana will also send out alarm notifications if a refrigerator or freezer departs from its normal range, or if they stop reporting (including due to a building power or communications connection failure). The Grafana "OnCall" notification system also includes alarm de-duplication and automatic escalation. For example, if the primary receiver does not respond within a certain time frame, the system will notify someone else.

Monitoring system concept diagram



Results and next steps

At the end of the project, RIT presented the conceptual design of the temperature-monitoring system to Craft Cannery and provided guidance on what to expect from each of the different segments of the system. The final deliverable included a "shopping list" of the hardware and software products that it required.

Based upon RIT's recommendations, Guglielmo purchased a Wi-Fi-enabled temperature sensor and a communications hub to facilitate a trial of the temperature-monitoring system in a testbed at RIT. The trial is ongoing, and the results indicate that the selected hardware and software will indeed work in the next phase of implementation. Guglielmo and his team look to partner with RIT in a follow-on project to deploy temperature sensors across the company's refrigerator, freezer, and cook kettles.

© 2023 Rochester Institute of Technology

CASE STUDY

RIT | Golisano Institute for Sustainability

V Technical Textiles, Inc. maps out material and data flows to improve operational processes

Company	Sector	Size	Location
V Technical Textiles, Inc.	Conductive textiles for the electronics industry	Less than 100 employees	Newark, New York

At a glance

- Faced with increasing demand, V Technical Textiles, Inc. (VTT) discovered that its existing shop-floor, production, and inventory processes were limiting its ability to grow. To address that barrier, VTT's leadership began exploring strategies to facilitate continued growth, which included Industry 4.0 solutions, and decided to work with Rochester Institute of Technology's (RIT) Industry 4.0 Transition Assistance Program.
- After a preliminary discussion, RIT suggested conducting a material and information flow analysis to characterize the company's current state in order to identify opportunities to better leverage digital technologies.
- Material and information flow analysis uses intuitive diagrams to depict an entire process or workflow, showing the who, what, when, and where across a business's operations. The analysis pinpointed areas within VTT's business and manufacturing processes that affect robustness, throughput, and productivity.
- The flow analysis also proved valuable for defining key performance indicators (KPIs), and allowing VTT's leadership to prioritize those that are most important to meeting the company's business goals.
- The analysis of VTT's operations uncovered the degree to which its business processes were manual and disconnected. This led RIT to recommend implementation of an enterprise resource planning (ERP) system to better synchronize and automate manufacturing-process planning and execution.

Company

V Technical Textiles, Inc. (VTT) manufactures an array of products that require conductive textiles, a class of fabric woven with different materials to support electronic applications. A full-service design, cut, and sew manufacturer, VTT's product range encompasses portable radiofrequency (RF) shielding enclosures, curtains, pouches, bags, and specialized clothing. The company's customers include contractors for the U.S. Department of Defense, such as satellite developers and manufacturers of high-tech communications equipment.

Business challenge

Due to growing demand, VTT had outgrown its existing manufacturing and business processes. The company's leaderships engaged RIT's Industry 4.0 Program to find opportunities for improvement. At that time, the firm's production data were manually entered into paper "job packets" and spreadsheets to record manufacturing status, track inventory use, schedule tasks, and track customer quotes and orders. A separate software system (Intuit QuickBooks) was used for finance and purchasing activities. Most of the shop-floor records were paper-based, which is both time-consuming to manage and prone to errors.

VTT's leadership reached out to RIT because they sought to improve the consistency and timing of manufacturing processes and enhance information flow between the production floor and business processes. They also wanted to identify KPIs to drive overall business improvement and find an effective way to calculate them on a timely basis.

The Industry 4.0 solution: An enterprise resource planning (ERP) system

An ERP system is a sophisticated digital software platform for overseeing day-to-day manufacturing operations. By synchronizing data and processes across an organization, an ERP system can eliminate redundancy, uphold data integrity, and provide a level of automation of administrative processes. ERP systems have evolved into an indispensable operations management tool for the manufacturing enterprise. An ERP system is the centerpiece of digital manufacturing and is a prerequisite for scaling Industry 4.0 solutions across operations.

An ERP can support a variety of activities, including the following:

- customer relationship management
- work-order management and tracking
- accounting
- procurement
- inventory and supply-chain management
- risk mitigation
- compliance

> *"Recognizing the need to modernize our business processes, we faced the challenge of determining how to begin. Thankfully, the RIT engineers provided the clarity and confidence we required to evaluate digital tools to facilitate this transformative journey."*
>
> *Gretchen Reed, Project Manager, V Technical Textiles, Inc.*

Why implement an enterprise resource planning (ERP) system?

- **Integrated information:** An ERP system can gather an organization's information from across all departments and consolidates it into a single source. This makes it easier to share consistent, accurate, and timely data regardless of business size.
- **Increased productivity:** It can automate support and operational work flows to improve accuracy and reduce time. Stakeholders within a company can access key information when they need it to support timely and data-informed decision-making.
- **Automated reporting and planning:** An ERP system can facilitate on-the-spot data analysis and automatically generate more timely and accurate reports—all without the intervention of an information technology expert. This can help analysts identify root causes, develop solutions quickly, and discover emerging opportunities.

© 2023 Rochester Institute of Technology

Approach

In order to find opportunities for improving VTT's shop-floor and business processes, the RIT team conducted a material and information flow analysis. This careful examination of VTT's processes entailed exploratory interviews and more in-depth discussions with process owners to understand the challenges they encountered in order to pinpoint any recurring themes. RIT also closely observed and documented material and information flows in and between VTT's administrative, business support, and shop-floor processes.

The analysis led to a detailed, visual representation of VTT's operations that uncovered barriers and opportunities concerning the flow of material and information across the organization. Diagrams were used to visualize these flows in order to display how critical information was generated, collected, stored, and managed. RIT used the results of the study to build a future-state scenario for VTT, which included a series of recommendations to improve the consistency, visibility, and timeliness of information flows

RIT's next step was to select relevant KPIs that VTT could use to measure progress towards overall operational improvement goals. An important consideration during this process was to link the KPIs to the future-state material and information flow analysis to ensure that they could be accurately calculated on a timely basis.

Project results

The results of RIT's material and information analysis presented VTT with a new, more detailed view of the company's operations. So much so, that VTT's leadership added five new business processes to the seven they had originally identified. The analysis revealed that effectively managing the data flow between these core business processes was quite demanding and that existing procedures were inadequate. In addition to the flow of data between processes, some concern was also expressed over the management of inventory of silver-coated fabric, a critical component of VTT's product.

Often, non-value-added processes are difficult to address because they aren't always apparent. Material and information flow analysis is an effective method for recognizing these operational inefficiencies. Equally important, this analysis sheds light on gaps in process documentation and information capture, whether at the macro-level, like a key operational process, or at the micro-level, like a single task in a workflow. For example, VTT was unable to accurately track actual job hours logged against a job, or how much raw material was been consumed. The information flow analysis uncovers such missing steps in a clear, visual way.

Using the results of the flow analysis, RIT recommended the following steps to improve VTT's overall process efficiency, consistency, and traceability:

- Eliminate generation of low-value data at individual work centers that is not used by subsequent work centers or required by business processes.
- Track important work center performance metrics system using an enterprise resource planning (ERP) system and automate where possible.
- Create an order-variance process to verify the actual shop-floor performance at each work center with the quoted labor and material volumes, by work order. Track job profitability and quote accuracy. Create a new process to improve quote accuracy, if warranted.
- Develop a capacity-utilization and planning process to better balance the workforce with future order volume and to reduce reliance on overtime usage.
- Track lead conversions to improve competitiveness of quotes.
- Set up automated inventory management processes using warehouse management system (WMS) software.

© 2023 Rochester Institute of Technology

RIT's next goal was to define KPIs that aligned with VTT's near-term business-growth objectives while continuing to meet all customer expectations concerning cost, quality, and lead time. There are hundreds of different KPIs that are typically used in manufacturing. It's important to select KPIs that are measurable, directly related to business objectives, and that provide an actionable path to manage or improve them. In line with the targeted improvement areas, the following KPIs were selected by VTT from a list of candidate KPIs selected by RIT:

KPI 1 - Capacity Utilization: To provide feedback on work-order scheduling and resource forecasting effectiveness.

KPI 2 - Order Variance: To improve quote accuracy and profitability by validating labor and materials for completed work orders.

KPI 3 - Lead Conversion Rate: To manage resource effectiveness in converting leads into orders.

The three newly defined KPIs allowed VTT to track valuable process data and improve the management of workflows and shop-floor processes. The company manually calculated these new KPIs over the prior year to better understand their baseline performance and provide context going forward. The findings created confidence in the selected KPIs and proved their value as improvement drivers. RIT recommended that VTT consider implementing an ERP system to facilitate KPI calculation and tracking, and to ultimately realize more efficient processes and documentation.

ERP implementation has the potential to open a new level of visibility, traceability, and planning for VTT's complex production process for conductive textiles; and to drive efficiency while reducing cost and lead time. For example, VTT's process relies on multiple specialized work centers. An ERP system would allow VTT's managers to better balance labor resources across all of them to avoid bottlenecks and improve labor efficiency. An ERP would also allow VTT to automate several manual tasks to free up staff time for more value-added activities. Overall, the system would offer a more real-time, data-driven picture of VTT's operations, from orders and inventory to resource planning and shipping. It would allow the company to shorten fulfilment time for the highly customized orders it delivers to clients like the National Aeronautics and Space Administration (NASA).

Next steps

VTT deemed the selection and implementation of ERP capabilities, such as centralized and automatic data storage and exchange, as essential to streamlining data management and fostering greater overall efficiency. In partnership with the RIT team, a follow-on project was launched to provide the firm with technical assistance to evaluate different ERP-software options to find a best-fit product for VTT. Findings from the initial project will be converted into system requirements and compared against features offered by candidate ERP platforms. This will inform a shortlist of relevant ERP vendors to contact for price quotes and product demonstrations to find the right solution.

© 2023 Rochester Institute of Technology

CASE STUDY

RIT | Golisano Institute for Sustainability

Rochester Colonial advances shop-floor and business processes through ERP upgrade

Company	Sector	Size	Location
Rochester Colonial Manufacturing Corp.	Window and door manufacturing, sales, distribution, and installation	Over 100 employees	Rochester, New York

At a glance

- Ready to jumpstart its digital transformation, Rochester Colonial Manufacturing Corp. (Rochester Colonial) joined Rochester Institute of Technology's (RIT) Industry 4.0 Transition Assistance Program. A team of RIT engineers performed an in-depth assessment of Rochester Colonial's current state of shop-floor, business, and sales processes.
- At the time, Rochester Colonial relied on both paper-based and digital tools to manage its operations—this was only partially supported by enterprise resource planning (ERP) software. Over time, the company's considerable growth as a manufacturer and a distributor and installer of national brands had exposed the limitations of this incomplete ERP setup.
- A team of engineers from RIT collaborated with Rochester Colonial to carefully document the key business processes that support the company's four divisions. Using material and information flow analysis, they created detailed process diagrams that were used to identify opportunities for process improvements that could be implemented in conjunction with an ERP upgrade.
- The project laid the groundwork for a subsequent effort led by RIT to refine Rochester Colonial's key performance indicators (KPIs) and specific requirements for an ERP upgrade. Leveraging new ERP capabilities, this effort will aim to streamline and unify redundant processes across the company's four divisions to drive enterprise-level efficiencies.

© 2023 Rochester Institute of Technology

Company

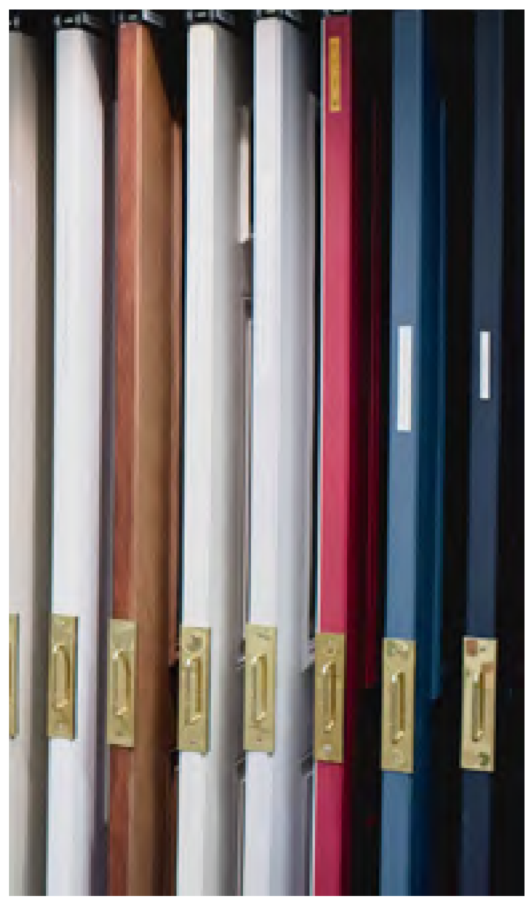
Rochester Colonial Manufacturing Corp. (Rochester Colonial) began in 1947 when it was established as Laquig Colonial, specializing in the production of storm windows. Rebranding as Rochester Colonial in 1960, the company eventually shifted from manufacturing and distributing aluminum windows and doors to vinyl and wood windows. Beyond the manufacture, installation, and service of its own line of products, Rochester Colonial is a prominent distributor of nationally recognized brands.

Business challenge

When Rochester Colonial contacted RIT, the company faced a number of challenges concerning the interoperability of different software systems across its operations. These stemmed from the company's continual expansion. Over time, the functional limitations of its existing ERP software only created more roadblocks. The system's limited capabilities stymied the company's efforts to phase out burdensome manual paper-based systems. In certain cases, paper documents were needed for some business units, while digital systems were used in others—all to accomplish similar tasks. Ultimately, despite having an ERP system in place, ad-hoc workarounds for documenting processes continued to arise across Rochester Colonial's operations. Reaching this impasse with the existing system, the company's leadership selected a replacement ERP product and had entered into an agreement with the vendor. Implementation of this new system had not yet begun when Rochester Colonial engaged RIT.

The company's four business units are supported by a network of over 20 shared and individual business processes. The manufacturer aimed to streamline these processes by both identifying best practices across the four divisions and transitioning processes to a digitally optimized state. Such a transformation would be pivotal to integrating new ERP functionality in order to ensure a seamless flow of data across all divisions and departments. But getting there would mean capturing Rochester Colonial's organizational complexity—the result of over 75 years of business evolution—to map out the best opportunities for improving and expanding its existing ERP capabilities.

The Industry 4.0 solution: Enterprise resource planning (ERP)



An ERP system is a sophisticated digital software platform for overseeing day-to-day manufacturing operations. By synchronizing data and processes across an organization, an ERP system can eliminate redundancy, uphold data integrity, and provide a level of automation of administrative processes. ERP systems have evolved into an indispensable tool for managing manufacturing operations. They are the centerpiece of digital manufacturing and a prerequisite for scaling Industry 4.0 solutions across an enterprise.

An ERP can support a variety of activities, including the following:

- customer relationship management
- work-order management and tracking
- accounting
- procurement
- inventory and supply-chain management
- risk mitigation
- compliance

A comprehensive ERP system creates an integrated data environment that facilitates KPI monitoring. This makes it a powerful tool for continuous improvement and strategic planning.

© 2023 Rochester Institute of Technology

Why replace or update an existing ERP system?

When a company outgrows the capabilities of its current ERP system, it's time to upgrade. There are unavoidable costs that come with making a switch, however these can be offset by realizing the full potential of an ERP system:

- **Truly integrated:** A comprehensive ERP system gathers an organization's information from across all departments and consolidates it into a single, unified source to ensure staff at every level are on the same page. While avoiding the rise of ad-hoc documentation, it also eases data sharing, making it more consistent, accurate, and timely regardless of business size.
- **Less errors, fewer resources:** By automating manual data entry, errors and repeated tasks become less common and employees are freed up to address higher priorities.
- **No more data "black holes":** Key operational data flows are readily available to the right people at the right time, allowing process owners and analysts to quickly see and diagnose problems.
- **Optimized process flows:** Aligning shop-floor and administrative processes to the capabilities of an advanced ERP system can provide operational efficiencies and reduce implementation costs.

Approach

RIT's engineers began by conducting a material and information flow analysis in order to map out the best opportunities for improving and expanding Rochester Colonial's ERP system. This would serve as the basis for upgrading the system. The flow analysis set out to meticulously document how staff at Rochester Colonial use the existing ERP system, other business software, and different paper-based methods to manage information and processes. The analysis informed RIT's recommendations to Rochester Colonial for better integrating and digitizing the company's business and manufacturing processes.

"We partnered with RIT to take a deep dive into our shop-floor and business processes, and to map out all the complexities we live with every day. They really helped us to understand the subtle differences in how the various parts of the business work within each of our four divisions."

Carolyn Weil, ERP Implementation Manager, Rochester Colonial Manufacturing Corp.

The RIT team's first step in the material and information flow analysis was to investigate Rochester Colonial's shop-floor and business-support activities. The engineers interviewed key decision-makers and subject matter experts. Each process was carefully reviewed to assess what is—and is not—functioning well. The results of this onsite exploration laid a solid foundation for creating flow diagrams of all the company's key processes.

The flow-analysis methodology is akin to value-stream mapping in that it aims to create a graphical representation of process details. The flow diagrams not only define the processes but also draw attention to pain points, often manifesting as gaps, parallel processes, bottlenecks, delays, or instances of departmental isolation.

Material and information flow analysis seeks to find every source of information, be it on paper, digital, or in the heads of employees as unwritten know-how. The approach aims to pinpoint who creates, uses, and owns data at various stages in a company's process flows, and can identify important information flows that are not well documented in current processes. The process can also help to identify new KPIs as well as the data sources needed to compute them.

Project findings and results

The material and information flow analysis performed by the RIT team identified pain points and gaps that highlighted areas where current processes were not being consistently applied. It showed where refinements could made, such as digitizing manual processes. It also uncovered opportunities for eliminating non-value-added activities.

© 2023 Rochester Institute of Technology

The RIT team found that Rochester Colonial's original ERP system, as it was configured, was unable to handle the company's intricate manufacturing and business workflows. In addition, procedural documentation was sometimes inaccurate or incomplete, causing employees to rely on other methods to record or share information, whether using paper, other digital tools, or even verbal explanation. In fact, RIT found that in many cases information was passed on verbally by long-standing employees. In short, staff found the existing documentation processes unreliable. These were not always consistent between Rochester Colonial's business units, stressing the importance of synchronizing processes and ensuring that the ERP system meets the needs of each business unit. An improved ERP implementation that accurately follows well-documented business procedures, RIT concluded, would build buy-in among employees and drive broader adoption at Rochester Colonial.

The team highlighted several other focus areas for the implementation and configuration of a new ERP system. For example, over the course of their assessment, the RIT engineers uncovered opportunities for streamlining Rochester Colonial's inventory process. Currently, the locations of products in certain storage areas and warehouses are often known only by individual staff members and, if written down at all, they are kept in isolated paper or spreadsheet logs. Although these logs are typically accurate, maintaining these logs is labor-intensive and presents considerable risk for error in the long term. Adding an appropriately configured warehouse management system (WMS) module to the ERP system could provide an effective digital solution for ensuring a more efficient—and transparent—inventory process. A WMS will be explored in more depth in a follow-on project between RIT and Rochester Colonial.

Next steps

The RIT engineers' thorough analysis culminated in a set of comprehensive current-state flow diagrams for all the company's major processes across its four divisions. RIT and Rochester Colonial will use these as the foundation for a follow-on project to refine business processes, identifying common processes that will work across the four business units, developing specific process flows to optimize the work, and tying these findings into the configuration of a new ERP system.

© 2023 Rochester Institute of Technology

INDUSTRY 4.0

PLAYBOOK

RIT | Golisano Institute for Sustainability

For more information please contact us:

585-475-4210

centerofexcellence@rit.edu

rit.edu/advancedmanufacturing

190 Lomb Memorial Drive
Rochester, NY 14623

© 2023 Rochester Institute of Technology

This material was prepared by Rochester Institute of Technology using federal funds under award No. 01-79-15124 from the Department of Commerce Economic Development Administration and using funds from the NYS Department of Economic Development. The statements, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Department of Commerce, the Economic Development Administration, or the NYS Department of Economic Development. Use of any specific brand or product names within this document is not to be interpreted as any type of specific endorsement of a company's product or service.