

Quantifying the Value of Digital Transformation in Manufacturing

How to Measure Your Industry 4.0 Investment

At its most basic definition, Industry 4.0 is a real-time approach to decision-making, enabled by integrated and reliable data. Industry 4.0 is built on the industrial Internet of Things (IIoT), which enables manufacturers to collect, analyze, and present real-time data and analytics in easy-to-understand and highly customizable formats.

Augmented reality (AR) is also an important part of Industry 4.0, as it brings that IIoT data to life through 3D, immersive experiences. IIoT and AR combine to create flexible, agile workforces that are redefining productivity and improving operational performance across manufacturing.

The Next Evolution of Cost-Saving and Business Optimization

Industry 4.0's inherent future-forward benefits are driving innovation across the industry and disrupting outdated processes across value chains. With every new Industry 4.0 technology that emerges—from IIoT analytics to artificial intelligence and AR—it becomes ever clearer that Industry 4.0 is not just an opportunity, but an imperative.

This innovation enablement makes it even more crucial for manufacturers to pay careful attention to how IIoT and AR technologies can support their business objectives—or they risk being left behind not just by their direct competition, but by an entire industry-shifting movement.



Our next generation of industry—
Industry 4.0—holds the promise of
increased flexibility in manufacturing,
along with mass customization, better
quality, and improved productivity.
It thus enables companies to cope
with the challenges of producing
increasingly individualized products
with a short lead-time to market and
higher quality.”

– [Intelligent Manufacturing in the Context of Industry 4.0: A Review](#), Engineering Journal

The Challenge of Quantifying Industry 4.0 Value

Increased productivity, lower production costs, faster time to market, and the ability to quickly and profitably respond to changing consumer demands are the most-touted benefits of Industry 4.0. And with such significant business outcomes, Industry 4.0 is a compelling venture—but one that still requires a credible cost analysis. Unfortunately, the intricacy of the manufacturing industry, along with the soft ROI of IIoT and AR, makes it difficult to fully quantify the direct value of Industry 4.0. How do you measure the value of “increased market flexibility,” for example? Or predict the future value of innovation enablement?

An Industry 4.0 initiative can't be treated as just yet another IT project or plant-level initiative, such as upgrading a network or implementing a new ERP system. A vital part of Industry 4.0 is continuous, flexible scalability towards new business opportunities that IIoT and AR technologies uncover. Traditional ROI calculation methods don't work well for investments that are as flexible and growth-scalable as Industry 4.0, as they tend to overstate early-stage costs and devalue the long-term strategic investment—presenting a greater uncertainty at the outset and underplaying future value.¹

Value Analysis: Traditional Manufacturing vs. Industry 4.0

The best way to determine the quantitative—and qualitative—value of your specific Industry 4.0 plan is to work with industry experts who can help analyze your business objectives from an Industry 4.0 framework, how they are likely to evolve in the future, and what digital transformation strategies best align.

Industry experts can provide insights into IIoT and AR technologies and how manufacturers with similar challenges to yours are deploying Industry 4.0 to gain business value. Their methodology is specifically designed to help you determine the most strategically valuable Industry 4.0 path for your unique business needs—in both the short- and long-term—as based on industry experience, analyst research, and use cases.

In the value analysis tables that make up the rest of this paper, PTC industry experts have taken the methodology used to define Industry 4.0 value consultations for specific manufacturers and distilled it into broad estimations. These tables provide generalizations about how much value can be achieved through a digital transformation. They are not as customized and in-depth as an industry expert's consultation, but they provide kick-off points for examining both quantifiable and qualitative benefits of AR and IIoT technology investments.



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– [The ROI of IoT: Quantifying the Strategic Value of IoT](#). Barkai, Joe

To create an accessible foundation for your further value analysis, we've broken the tables into the most common areas of manufacturing challenges:

- [Table 1. Assets: Unplanned Downtime and Operational Visibility](#)
- [Table 2. Workforce: Training, Upskilling, and Flexibility](#)
- [Table 3. Processes: Agility, Innovation, and Visibility](#)

1. [The ROI of IoT: Quantifying the Strategic Value of IoT](#). Barkai, Joe. Accessed 11/25/18.

Table 1. Assets:
Unplanned Downtime and Operational Visibility

Traditional Manufacturing Challenges	Industry 4.0 Approach	Real-World Results
<p>Unplanned Asset Downtime</p> <p>Unplanned downtime is one of the costliest drains on manufacturers. No matter the cause of downtime, the snowball effect on production process is immediate. And over the long-term, downtime can impact equipment’s lifespan, reducing overall plant floor return on assets (ROA).</p> <p>Most plant floor maintenance activities consistently take place on a planned schedule, whether they are needed or not. Or worse, maintenance only occurs when a machine breaks.</p> <p>But this approach is hard on machines, wasteful of time and resources, and lowers your plant floor ROA as it regularly requires machines to be taken offline—whether or not maintenance is needed imminently.</p>	<p>Predictive and Prescriptive Maintenance</p> <p>Understanding the different failure modes of machinery is the best way to prevent machine downtime. IIoT systems enable maintenance to be performed only when it is truly needed, preventing downtime and increasing ROA.</p> <p>IIoT solutions can gather information about device and equipment states, temperature, speed, vibration, individual components, and other objective data for an integrated look into a machine’s health and performance in real-time.</p> <p>This data, combined with powerful analytics, can be used to prevent downtime by predicting what maintenance is needed and its potential impact. AR experiences can make it even more useful by incorporating step-by-step instructions—faster than with a printed manual or video—so workers can address the problem quickly and safely.</p>	<p>Predictive, Real-Time IIoT Maintenance Reduces Downtime Losses by More Than 40,000€ Per Minute</p> <p>A large German automotive manufacturer uses IIoT to create role-based production line information. Maintenance teams get real-time information on any low performing or failing component and can immediately pinpoint the exact maintenance need.²</p> <p>91% Accuracy in Predicting Alarm States</p> <p>In a similar use case, a large automotive tier one supplier was able to develop new models that could predict alarm states with approximately 91% accuracy. Technicians are now able to be more proactive with maintenance and prevent downtime, rather than react to it.²</p>

² Results from PTC customer

Table 1: Assets, cont.

Traditional Manufacturing Challenges	Industry 4.0 Approach	Real-World Results
<p>Limited Visibility into Asset Utilization</p> <p>Siloed and inaccessible asset utilization data hinders visibility into operations. This makes scheduling difficult and creates unnecessary downtime.</p>	<p>Real-Time Data for Real-Time Flexibility</p> <p>By providing greater visibility into the myriad of value chain activities, Industry 4.0 solutions coalesce data for easier and faster analysis. Technicians have real-time visibility at all times, which gives them the flexibility to respond immediately and effectively to any transpiring value chain events and increase asset availability.</p>	<p>Sophisticated Data Analysis Eliminates Need for New CNC Machine Investments; Historical Data Drives Improvements</p> <p>HIROTEC collected and analyzed real-time and historical in-depth data to improve inefficiencies. Along with process improvements, HIROTEC fixed other bottlenecks that resulted in removing the need for a new CNC machine investment.³</p>

3. [HIROTEC Launches IoT Initiative](#); PTC case study. Accessed 11/25/2018.

How Much Value Can You Realize?

Based on PTC's experience working with our customers and industry analysts, we believe that the average manufacturer making \$1 billion in annual revenue can expect to save between \$2.6 million and \$5.6 million, depending on a variety of factors.

These savings are achieved by preventing unplanned downtime, increasing asset utilization, and enabling real-time, role-based visibility

Estimated Value:
**\$2.6 million to
\$5.6 million**



Using IIoT and analytics for condition monitoring and predictive maintenance can help ensure high uptime for critical assets – particularly among those 82 percent of assets having a random failure pattern. IIoT provides an opportunity to significantly improve operational performance with higher reliability, business process automation, and even transformative changes.”

– [Improve Asset Uptime with Industrial IoT and Analytics](#), ARC Advisory Group report

Table 2. Workforce:
Training, Upskilling, and Flexibility

Traditional Manufacturing Challenge	Industry 4.0 Approach	Real-World Results
<p>Disparate Systems and Information</p> <p>Manufacturing operations rely on a number of disparate IT and OT systems across the shop floor. But these disconnects reduce plant floor efficiency and product quality.</p> <p>Without real-time views into contextualized data, plant managers and operators have limited visibility, and plant operations can suffer from increased operational costs, missed customer delivery dates, and excess waste.</p>	<p>Unified, Role-Based Dashboards</p> <p>With an integrated, single screen view providing bi-directional access to all data from various systems—such as MES, ERP, PLM, historians—all employees have access to real-time, unified data. This specific, real-time, and integrated information improves production efficiency and product quality. For shop floor workers, this means access to all information needed—including work instructions and inspection requirements—tailored to their unique business unit or geography.</p> <p>For plant managers, this means increased visibility into all levels of the manufacturing process.</p>	<p>Realized Operator Efficiency Gains and Cost Savings Drive an Estimated Annual \$1.7 Million in Savings Per Plant</p> <p>With an IIoT-enabled integrated, single screen view, Woodward, Inc. is able to vastly increase data insights, streamline work orders, and improve employee performance, training, and operations across the enterprise.⁴</p>
<p>Skills Gap and Retiring Workforce</p> <p>Since 2017, the number of open manufacturing positions has been growing at double-digit rates.⁵ Industry average is about 12 months time to proficiency for new hires; this is a very long and costly lead time. Additionally, maintaining a level of expertise to pass down that training is difficult due to tribal knowledge being lost with retiring workforce and overall resource constraints.</p>	<p>Improve Training Pass-Down Efficiency and New Employee Learning Curves</p> <p>With immersive, consistent, and flexible training tools, AR increases training effectiveness and new employee productivity, maximizes production times, and reduces errors. It also enables remote over-the-shoulder expert guidance, which helps address specific problems and reduces the learning curve for acquiring new skills.</p>	<p>30% to 40% More Efficient Training at a Tenth of the Cost through AR Training Guides⁷</p> <p>Using IIoT-enabled AR software, BAE Systems created a guided step-by-step training solution that teaches assembly skills more efficiently and at less cost.⁶</p>

4. [Streamlined Data Systems Accelerate Woodward's Digital Transformation](#); PTC case study. Accessed 11/25/18

5. [Job Openings and Labor Turnover Survey](#). Accessed 11/25/2018

6. [BAE Systems Does More with Less, While Maintaining Quality with PLM](#); PTC case study. Accessed 11/25/2018.

Table 2: Workforce, cont.

Traditional Manufacturing Challenge	Industry 4.0 Approach	Real-World Results
<p>Lack of Workforce Flexibility</p> <p>Once a technician is skilled on one process, transferring them to a new position requires complete re-training. Employees can feel stagnant in their skills, but transfers are costly and slow.</p>	<p>Increased Workforce Agility and Job Satisfaction</p> <p>Technicians can use AR to follow easily consumable and immersive guided work instructions, repair procedures, production line setup, changeovers, and more as part of on-the-job training. Technicians gain a complete understanding of new tasks, without needing new in-person training.</p>	<p>Improved Efficiency through Real-time, Step-by-Step 3D Guided AR Work Instructions.</p> <p>Sysmex replaced paper manuals with immersive, 3D AR work instructions that provide technicians with the right information, right at their fingertips.⁷</p>
<p>Workforce Safety and Efficiency</p> <p>The complexity of manufacturing processes and a lack of skilled labor increases the occurrence of costly human error and create safety risks.</p>	<p>In-Depth, Immersive AR Training Solutions</p> <p>Overlaying step-by-step, 3D, immersive digital information directly onto the physical equipment enhances worker efficiency and increases awareness of in-context safety risks and hazardous alert conditions.</p>	<p>60% Reduced Installation Time and Vastly Improved Safety due to Immersive AR Work Instructions</p> <p>A global leader in the design, manufacture, and distribution of agricultural equipment, AGCO reduced installation time by 60% while improving technician safety and accuracy with AR-based installation and service instructions. Pictures and 2D drawings were inefficient to show sensors and high-tech equipment, creating a safety concern. With AR-enabled safety instructions, AGCO technicians are safer, more efficient, and more accurate in their work.⁸</p>

7. [ThingWorx Delivers Business Transformation to Sysmex](#); PTC case study. Accessed 11/25/2018.

8. PTC customer results, courtesy of AGCO

How Much Value Can You Realize?

Based on PTC's experience working with our customers and industry analysts, we believe that the average manufacturer making \$1 billion in annual revenue can expect to save between \$1.2 million and \$2.3 million, depending on a variety of factors.

These savings are achieved by using IIoT and AR to improve training efficiency and safety, overcome workforce skill gaps, and increase workforce flexibility and agility.

**Estimated Value:
\$1.2 million to
\$2.3 million**



From training new workers in a classroom setting to managing knowledge transfer from seasoned experts to young professionals in on-the-job settings, AR has a clear role to play. The beauty of using AR for training is that it offers trainees an opportunity to move beyond paper manuals and watching videos to interacting with the tools and machines they'll use on the job. The value of placing employees in a work setting where they can learn the nuances of a job versus just understanding the task at hand in broad strokes is hard to overstate."

- [How Augmented Reality Drives Real-World Gains in Services, Training, Sales and Marketing, and Manufacturing](#), IDC 2018 Report

Table 3. Processes:
Agility, Innovation, and Visibility

Traditional Manufacturing Challenge	Industry 4.0 Approach	Real-World Results
<p>Slow to Adapt to Market Needs</p> <p>With increasing product complexity and mass customization of products, the production floor can't easily pivot to meet these new market demands. With inflexible IT and OT systems and processes, manufacturers are unable to continuously improve and keep pace with the competition and customer expectations.</p>	<p>Iterative and Innovative Flexibility</p> <p>With real-time, in-depth industrial ecosystem awareness, businesses can easily adjust production and roll out new products and processes to meet market demand. They can provide up-to-date, agile forecasts on plant output and risk assessments, while driving supply chain and workforce management accordingly.</p>	<p>Manufacturing, Quality, Maintenance, and ERP Systems Integration Enables Rapid Role-Based Decision and Flexible Operational Excellence</p> <p>The ATI Allvac manufacturing and IT teams use an IIoT platform to integrate manufacturing and IT data visibility for real-time operational intelligence across the business.⁹</p>
<p>Yield, Scrap, and Rework</p> <p>Lack of real-time insight into the production process means its harder to identify issues or delays as they are occurring—and impossible to prevent the issues. The result is higher operating costs, more waste, and slower ability to fix product- and quality-impacting conditions on the production floor.</p>	<p>Process, Production, and Correction Awareness</p> <p>With real-time alerts and insights into the production process, technicians can proactively identify quality inefficiencies and correct them, saving scrap, stopping waste, and freeing up time for more valuable tasks.</p>	<p>100% Reduction in Time to Manually Inspect Production Systems, Enabling Technicians to Re-Invest that Time in More Value-Driving Tasks</p> <p>HIROTEC's IIoT solution provides real-time visibility into its business operations, which in turn enables real-time solutions for inefficiency, waste, and throughput issues.¹⁰</p>

9. PTC customer results

10. [HIROTEC Launches IIoT Initiative](#); PTC case study. Accessed 11/25/2018.

Table 3: Processes, cont.

Traditional Manufacturing Challenge	Industry 4.0 Approach	Real-World Results
<p>Ineffective and Inconsistent Benchmarking</p> <p>Similar to the inefficiencies caused by lack of unified visibility across the production process, production data silos can negatively impact plant operations and OEE measurement.</p> <p>Without integrated, standardized production data, there’s no way to consistently track and measure all operations. This leads to an increase in operational costs, interrupted customer delivery dates, and excess waste.</p>	<p>Standardized OEE and Operations Reporting</p> <p>Real-time, integrated reporting across the enterprise provides effective plant benchmarking, along with reliable OEE and KPI measurement.</p> <p>Plant managers can combine, analyze, and deliver data-based insights from disparate and diverse silos of assets, lines, operators, and enterprise systems, for unified real-time visibility of KPIs across the entire factory.</p>	<p>5% to 8% Productivity Improvements, Due to Real-Time Operational Intelligence</p> <p>A global food and beverage company uses IIoT to gain role-based access to standardized metrics and information. Despite numerous diverse systems, this single-source system enables the company to consistently calculate OEE and performance.¹¹</p>

11. PTC customer results

How Much Value Can You Realize?

Based on PTC's experience working with our customers and industry analysts, we believe that the average manufacturer with \$1 billion in annual revenue can expect to save between \$4 million and \$12.2 million, depending on a variety of factors.

These savings are achieved by using IIoT and AR to deliver unified IT and OT data to operations, reduce scrap and rework, improve OEE and KPI reporting, and increase market agility.

**Estimated Value:
\$4 million to
\$12.2 million**



The effective usage of data not only involves improving manufacturing efficiency, but also drives greater agility and deeper integration with other parties, such as logistics and supply-chain management entities. "

- [Intelligent Manufacturing in the Context of Industry 4.0: A Review](#), Engineering Journal

Beginning Your Industry 4.0 Journey

Industry 4.0 is disrupting manufacturing enterprises around the world.

A focused and accurate value assessment is the best way to ensure that you get the most value out of these revolutionary tools—both in the immediate results and long-term scalability.

These value analyses are only starting points. With a focus on your specific business objectives, an industry expert can help you balance the immediate value and long-term benefits of Industry 4.0 initiatives.

Learn More

To explore how digital transformation with IIoT and AR is redefining industrial manufacturers' productivity and improving operational performance, read this [*Industrie 4.0 Maturity Index: Managing the Digital Transformation of Companies*](#) study from Acatech research. For more on how AR technology is supporting Industry 4.0, read the [*Augmented Reality for Manufacturing: Bringing Digital Transformation to Skilled Workers*](#) report from ARC Advisory Group.