Improving Operational Efficiency with Industrial IoT

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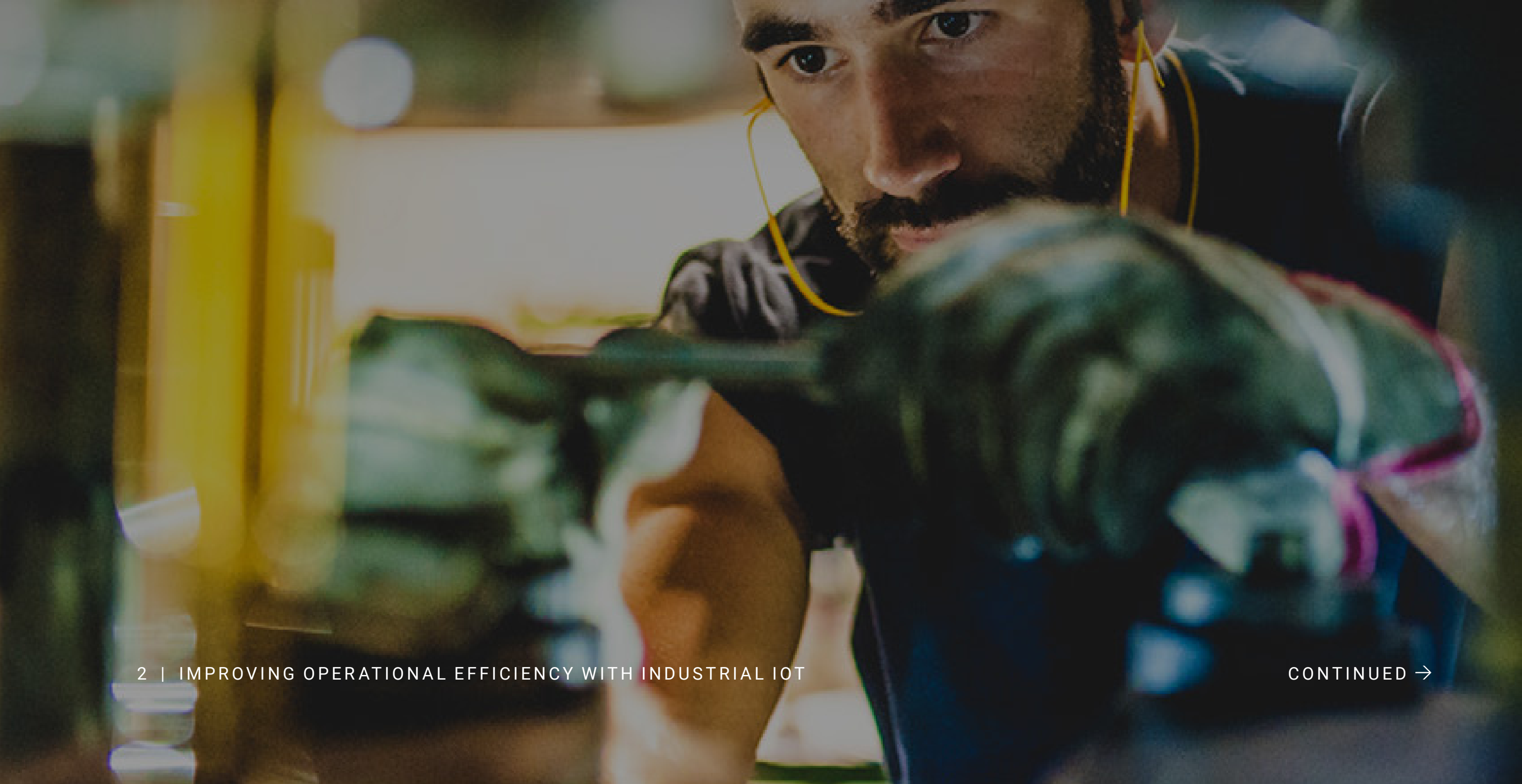
The last two and a half centuries have brought about stunning changes in industrial productivity.

With each passing generation, new and more advanced equipment and methodologies have arrived on scene to push production capabilities to new heights.



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And as each new methodology or technological advancement has matured, the quest for greater operational efficiency has honed and advanced their capabilities, setting the stage for the next leap.

While it would be easy to lump these achievements together over this period, the distinctions that set them apart are important in and of themselves. Because of this distinctiveness, we now identify that there have been four industrial revolutions, each bringing improvements to efficiency to a new level and again setting the stage for the next.

The first of these revolutions began in the 1760s and was marked by the introduction of steam power and mechanization. Moving from hand-produced goods made by skilled artisans to goods produced by unskilled workers in a factory setting disrupted economies and societies and imposed a new reality on each.

At the end of the 19th century, the second industrial revolution saw the advent of the assembly line and the electrification of factories. Equally disruptive, these advancements allowed for continuous operations round the clock and allowed for major improvements in machine design to make better machines that were faster and more controllable through the dependability of electricity.

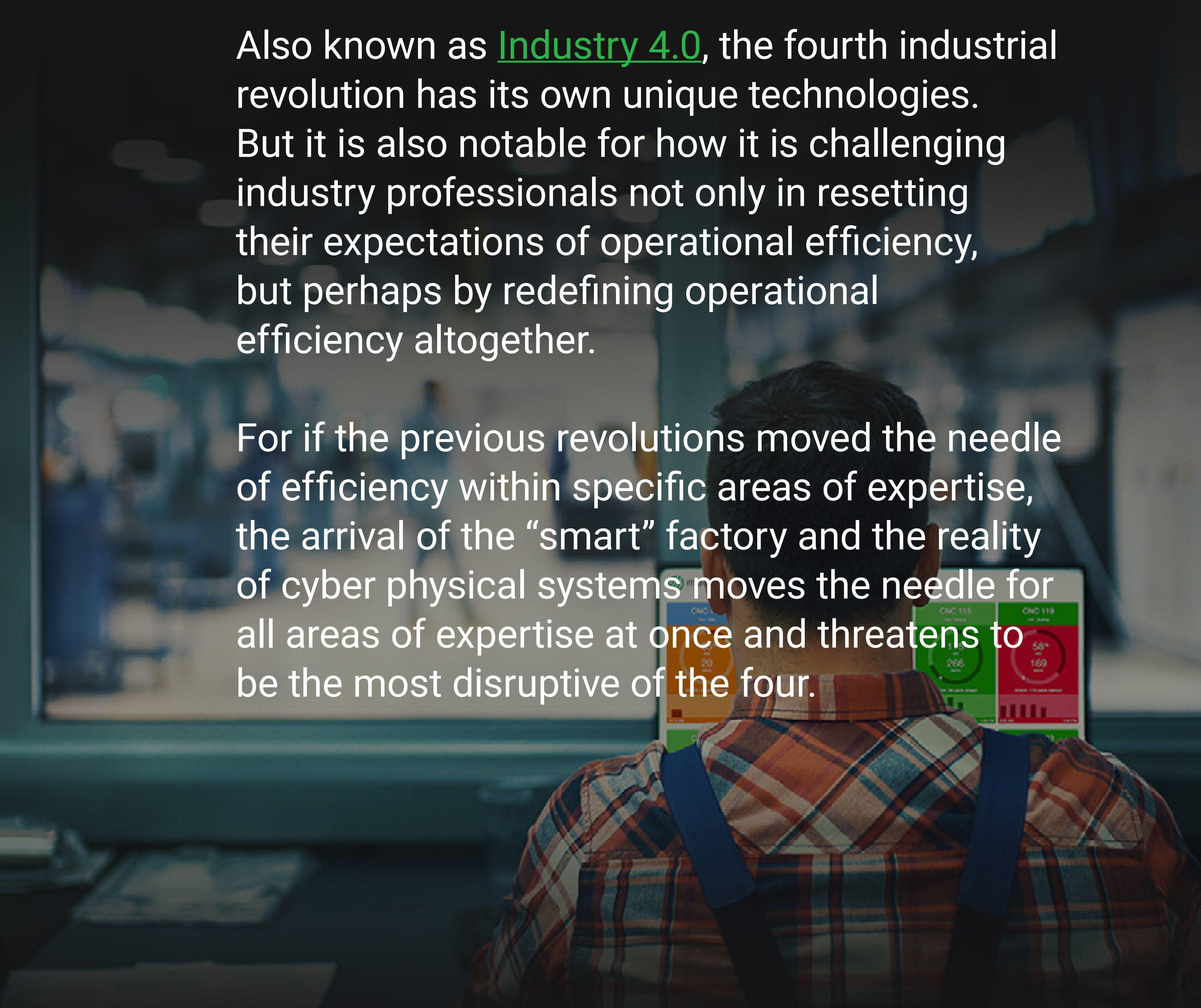
By the 1960s, a new player had emerged to boost productivity and efficiency yet again. With the development and introduction of computers into mainstream manufacturing, industrial equipment could be automated, and data could be leveraged to enhance the equipment's performance as well as to understand and manage broad trends to improve operations across the board.

And as the new century bloomed, yet another host of disruptive technologies appeared on the horizon. The use of software and advanced computer technology has led to the merging of machine and computer. Accompanied by the advent of AI, machine learning and deep analytics, these disruptive technologies have set the stage for explosive growth in efficiency through the creation of the "smart" factory and the Industrial Internet of Things (IoT).

Challenging the Experts

Also known as Industry 4.0, the fourth industrial revolution has its own unique technologies. But it is also notable for how it is challenging industry professionals not only in resetting their expectations of operational efficiency, but perhaps by redefining operational efficiency altogether.

For if the previous revolutions moved the needle of efficiency within specific areas of expertise, the arrival of the "smart" factory and the reality of cyber physical systems moves the needle for all areas of expertise at once and threatens to be the most disruptive of the four.



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In the first industrial revolution, steam and mechanization challenged mechanical engineers. These challenges centered around harnessing steam to create machines that produced goods on scale.

But regardless the miracle of those advancements, the reality was that the machine defined what could be done.

In the second revolution, the arrival of electricity and the 24-hour factory challenged predominantly operational and electrical engineering. For operational leadership, that challenge was the creation of the modern factory culture that operated on shift work and required large organizational changes not previously possible when work was mostly "dawn to dusk". Management systems advanced planning and scheduling, as well as other functions such as industrial engineering, to a science to create metrics that allow management of human assets within a new continuous factory operational setting. And as this culture was developing, electrical engineers developed the capability to bring more and more power into factories safely to take advantage of new equipment capabilities.

With the introduction of computers to assist machine capabilities and deliver more data, the third revolution began to change the direction of the operational efficiency from one where the machine defined what could be done, to one where computer defined what was possible. With less reliance on humans through automation, efficiency gains began to be more data driven. Trends and insights previously not available, coupled with better quality and precision through use automated manufacturing equipment , could be tapped to improve efficiency not just through better machines but through operational awareness across all levels of the factory. Decision making for planning, logistics and software became more sophisticated as new data became available.

With the Industrial Internet of Things in the current revolution, all areas of operations are challenged. By creating a factory of cyber physical systems, mechanical, electrical and operational engineers are forced to break out of linear expectations of improving efficiency only within their sphere. And with the arrival of the connected factory, data has exploded to a level that would have previously been unmanageable. The new reality is that technologies such as AI, deep analytics and machine learning require that operational efficiency be viewed as a single entity affecting the entire operation and where all functional areas contribute to improvements as part of an integrated and connected system that maximizes efficiency.

Operational Efficiency and the Limits of Lean and Six Sigma

The last few decades have also witnessed the rise of process and quality improvement methodologies aimed at increasing operational efficiency. In many ways, these methodologies were an attempt to bring together data and metrics available through the more sophisticated tools the third industrial revolution could deliver.

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Methodologies such as Lean and Six Sigma grew as companies sought ways to improve operational efficiency through process improvement.

Lean grew from the Toyota Management System and was quickly adopted by thousands of companies throughout the world. Using a pull system, optimized layout, machine automation, fast setups and other controllable variables, the lean system was an attempt to take advantage of the fruits of the previous industrial revolutions by using process improvement to improve efficiency.

Six Sigma was originally pioneered by Motorola as a quality management system in the mid-1980s. It focused on the measurement of "defects per million" and developed methodology to achieve lower defect levels that could be used throughout the factory. The philosophy and logic of Six Sigma could also be viewed as a way of doing business by managing to the metrics and processes that resulted in the lowest possible defect rate.

Each of these systems and their methodologies were highly successful and allowed for tremendous gains for companies that adopted them. And their comprehensive organizational structure impacted entire organization. As such, they represent the first attempts to manage production and drive process improvement and efficiency holistically across a factory or an entire company. To be successful, the lean or Six Sigma program had to be adopted across multiple departments and functional areas and create a culture that adopted the methodologies completely.

But while these programs were successful (and will continue to be so within Industry 4.0) there are still limitations to how far they can go as a system. First, despite reliance upon metrics and the use of computers and advanced methods of analysis, they are still human-driven systems. Programs must be led, championed, honed and enforced indefinitely. And barriers such as culture, fatigue, burnout and interdepartmental competition reinforce the reality that there is only so much human intervention can do to influence the system manually.

Secondly, there is the problem of the data itself. Again, while advanced analytical methods are used in both systems, they are often still siloed and the decisions that come from them are still made by humans. There is a limit to human capacity in understanding the metrics and formulating actions based on what they show. As a result, despite a wealth of information, deeper data and trends are often undetected or undetectable. And while there are attempts to coordinate metrics and data between departments and functional areas, there is only so much that can be done before the data sets become too unwieldy to allow them to be used at a deeper, more global level.

These limitations do not suggest that the programs have not been valuable, only that there is a limit to their effectiveness as one can only eliminate so much waste or reduce so many defects before reaching a point of diminishing returns where further improvements would cost more than what is saved.

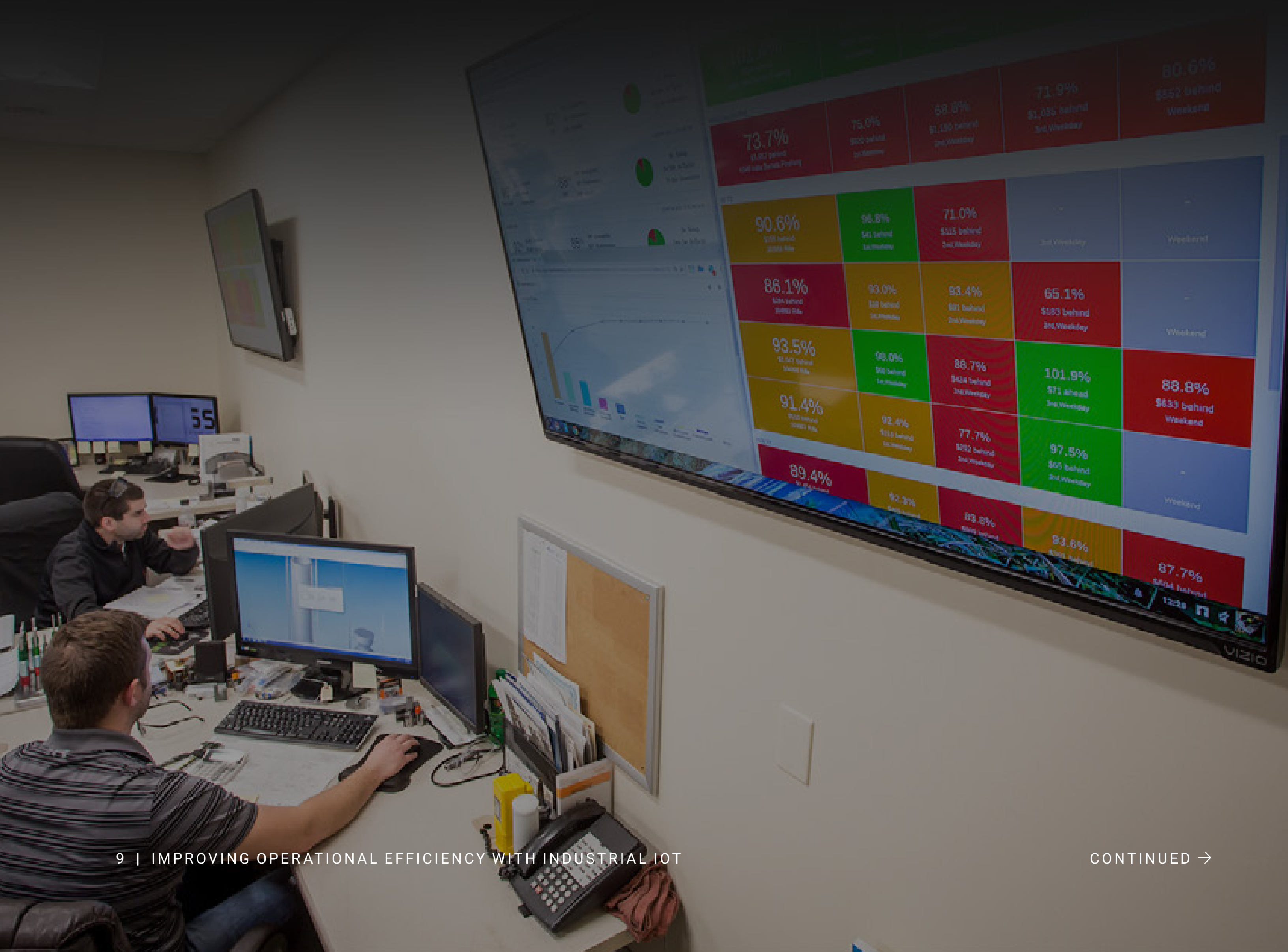
At that point, the system may be able to be maintained, but further gains would be either impossible, impractical or not cost-effective.

Improving operational efficiency further will require the reliance on the Industrial Internet of Things (IIoT) within "smart" connected factories. Here, process improvement is driven not by human initiatives or linear surges within specific fields, but by the complete integration of computer and machine that encompasses the entire operation. This is possible through the introduction of AI, machine learning and deep analytics software that can help realize several benefits:

- These technologies can perform at a micro level that humans cannot.
- They can work faster than humans.
- They can allow for faster, objective and more accurate decision-making.
- Systems can process and analyze data to "see" patterns and trends not readily discernable by humans.
- They can decentralize decision-making by allowing many autonomous or semi-autonomous decisions from with the platforms themselves.

Barriers to Industrial IIoT Adoption

Before manufacturing companies can take full advantage of what Industrial IoT has to offer, there are a few notable barriers that must be overcome.



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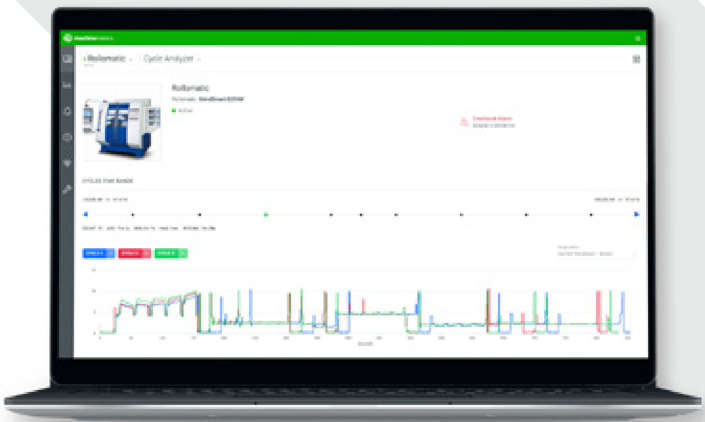

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DATA INTEROPERABILITY

One such barrier is that of data inoperability. In most traditional manufacturing environments data is siloed between departments or functional areas. Production, scheduling, quality, engineering and business monitoring software may not be linked, or, if they are linked, may still not be compatible for analysis.

One study estimates that up to 60% of IIoT potential value is inhibited by data inoperability. But as companies seek to transition to IIoT systems, older systems such as vertical closed applications that focus on single machines will have to be replaced and data will have to be standardized among all functional areas.

2

IT SKILLSETS

Another barrier to leveraging IIoT potential for improved operational efficiency is the lack of skills and access to skills that will be needed for deployment. As a new and evolving technology, many companies have not begun to upgrade these skills and may not fully understand that they need to or what is required to do so. One survey revealed that fully a quarter of respondents cited lack of skilled professionals as a barrier to adoption of IIoT. Just as vertical closed applications inhibit data integration as a relic of the third industrial revolution, skillsets are predominantly geared to maintaining these relics and must be upgraded as well.

3

SECURITY

Perhaps one of the biggest barriers to faster adoption is security. As many devices are powered by open source software (OSS), new connections leave open the possibility for a breach. And in many cases the OSS software is not screened for vulnerabilities. Compounding the problem is the reality that there is no end to end security solution available, leaving manufacturers and service providers at odds over who should provide security and how that should be accomplished. The issue has become critical to the point that governments are now threatening to impose regulation for IIoT unless the industry self regulates to address security concerns.

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The landscape of IIoT adoption, however, is not one of gloom and doom that these barriers may initially indicate.

They must be taken in context as to where Industrial IoT is in terms of history. And as we are at the beginning of a new cycle of industrial revolution, these challenges and disruptions are no different than those faced at the beginning of previous revolutions. In each of those instances, business and technology came together to address initial barriers as the realization that extensive operational efficiency gains were possible if they did.

That is a path that IIoT adoption will follow as well because the potential gains are too great not to. It is estimated that the Industrial IoT market will reach $123.9 Billion by 2021 and that the impact to global GDP will be more than $14 Trillion by 2030. With estimates that high, barriers will fall as the impact on operational efficiency becomes apparent.

Operational Efficiency and a Holistic View of IIoT

To fully understand what IIoT can do for operational efficiency, one must take a holistic view of its benefits.

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As previously discussed, Industrial IoT involves the connectivity of all aspects of a factory's assets. This includes production equipment, inventory, supply chain, maintenance, quality and business operations.

In past revolutions, specific linear progress was made in one or more functional area while progress was made in other areas in subsequent revolutions.

Now, with the arrival of Industrial IoT, all functional areas within a factory are impacted across the board and all assets and subsystems are linked together. This horizontal integration coupled with deep analytics in specialized IoT software allows for the creation of a "smart" factory where all assets are harnessed to improve operational efficiency using AI, machine learning and device connectivity.

The result is a system that can identify trends, take independent and sometimes autonomous action and respond much faster than human intervention to allow efficiency gains previously impossible. It is this distinction that sets Industry 4.0 apart from all past revolutions as it is something that must be utilized by the whole enterprise to understand and implement its benefits. In this system, data is unsiloed from its traditional "island" mentality between departments and one database can be used for the entire operation. The data is available to all so that the entire enterprise operates under a single version of truth. And as the analytics within the software evolve through machine learning algorithms, the system becomes even more efficient over time.

In traditional manufacturing, heavy emphasis was placed on making production equipment more efficient. And beyond the equipment itself, programs such as Lean and Six Sigma evolved to manage and improve on those efficiencies. It was both linear in focus and reliant upon human initiative to succeed. Outside of production, other functional areas were considered ancillary and considered mere "overhead", and to the extent that they were tasked to participate, it was always in support of how to make the production floor, production staff and production efforts more efficient. With Industrial IoT applications, functional areas outside of production such as supply chain, purchasing, scheduling, quality and industrial engineering, move from a strictly support role to one where their use of data and analytics within the system contributes directly to the improvement of overall operational efficiency because they are part of an uninterrupted, integrated system.

Efficiency Benefits by Area

A review of how each critical area is impacted individually can help us understand how overall operational efficiency improves within the system.

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01. Production

The most obvious place to start is in production at the shop floor level. Industrial IoT relies on software and analytics, but it also depends upon devices connected directly to the production equipment.

Here, implanted devices and sensors can monitor such things as production rate, quality specifications such as tolerance or weight variance, ambient conditions, and numerous functions that provide overall health and operational status information such as bearing temperatures, belt tension, and others.

Each of these devices are connected wirelessly to feed data into software for analysis. As a result, operator input, production rates, mechanical and electrical health, upcoming raw materials requirements and other key data can be used to proactively trigger support from other departments, either upstream sub-process production stages or in the form of material from inventory or maintenance needs.

One key benefit of embedded devices is that it can prolong or extend the life of manufacturing equipment as the devices can be retrofitted on older machinery. Much OEM production equipment produced today has IoT connectivity native as part of the machine. But for those manufacturers who maintain older or legacy equipment, retrofitting means that all generations are included in the connectivity umbrella so that all data is captured, making the system more agile and efficient.

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As an example of how these elements work together to improve efficiency, imagine a factory with twenty production machines. Four of the machines are tasked by the scheduling department to each produce a 5,000 lb. lot of finished material and that will take three days to do complete. Once complete, each machine will take four hours to clean and changeover. Assuming the equipment began the production at the same time and ran uninterrupted, the four machines would all stop for changeover at approximately the same time at the end of the lot run.

Traditionally, this scenario would trigger several management concerns. If the staff running the production floor must change over four machines at once, then changeover time for at least three of the machines would take longer than required or the other sixteen machines needing tending would suffer. Likewise, staging and prep for the next lot could create a bottleneck for raw materials entering the production floor for the restart. In traditional environments, all these variables would be managed and coordinated by managers or operators to minimize the drop-in efficiency.

With connected equipment properly programmed and monitoring the entire production floor, mitigation of these issues is removed from human planning and relies upon data from other departments such as scheduling and inventory to trigger a more efficient response. Using the same scenario but with IoT-connected equipment, the system could analyze variables including staff assets and bottlenecks. The system could then autonomously adjust the total requirements for each machine from 5,000 lbs. Each to a staggered production of 2,000, 4,000, 6,000 and 8,000 lbs. respectively so that staff would be available to perform the changeover in the allotted time and raw materials entering the production stream for the next lot would not bottleneck the production floor.

Production operations utilizing IIoT systems have heightened overall visibility of what is happening at the floor level and the system allows for decentralized management as many of the actions can be performed autonomously. IIoT leads to the creation of a dynamic production floor where decisions are made automatically and quickly to the accrual of optimized efficiency.

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02. Predictive Maintenance

Another way overall operational efficiency is improved with Industrial IoT is through use of Conditions Based Maintenance (CBM).

Also known as predictive maintenance, CBM relies on installed or embedded devices to monitor a machine's real-time condition. This monitoring can be analyzed by software against historical performance by lot, by machine condition and by other factors to develop predictive actions to minimize unplanned downtime.

Maintenance strategies can be developed to stage or deploy maintenance resources when sensors show signs of impending failure. Some actions can be automated for minor adjustments during run time until full repair can be made at the next point of scheduled downtime. And decisions and actions, based on real-time data, can proactively schedule maintenance when it is most cost effective.

With IIoT technology, higher overall efficiencies are possible compared to traditional preventive maintenance. Studies have shown that predictive maintenance programs can increase overall productivity by 25%. These programs can also contribute to a reduction in downtime of as much as 75% in many factories. In this way, maintenance programs linked into the system become drivers of efficiency as opposed to simply support or overhead.

Using the same production scenario as above, with predictive maintenance, the system could monitor sensors to identify parts, belts, bearings, individual production zones or spindles that need repair, etc. or recalibration. With the altered production schedule where lot sizes were staggered, the required parts would be identified as needing replacement and maintenance resources notified and deployed for repair during changeover.

Communication would automatically route to parts requirements to inventory where the parts count would be relieved, inventory replenishment for the part initiated and a message sent to the tech identifying not only when the repair would be required during the changeover, but also specifically where the repair would be needed.

Over time, the system would utilize more and more data and run history and apply statistical analysis to ensure that the correct number and type of needed is in stock. This reduces cost and improves cash flow to prevent overstock of parts, but also decreases the chance of stock outs for critical parts to further bolster efficiency through the elimination unplanned downtime.

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03. Quality

Long considered an overhead function and cost, traditional manufacturing quality programs often meant testing, measuring, weighing or some other hands-on method for keeping production runs in specification.

Outside of this active machine level monitoring, some processes required post-production testing where products found out of specification were rejected. This caused schedule adjustments or missed deliveries and increased waste.

As a largely reactive "backward-looking" process, traditional quality monitoring within manufacturing could not always ensure a reduction in waste. It also suffered from the same tendency to produce siloed data as quality data was often removed and analyzed and decisions and actions debated between production and quality managers.

Industrial IoT can assist quality initiatives in producing higher operational efficiencies because it allows the quality monitoring to be automated and proactive. And in many environments, it can even allow for autonomous adjustments for tolerance or out of spec product. Or, if a zone or spindle is faulty, it can stop the zone outright.

In the production scenario previously discussed, with each zone or spindle monitored for product flow to measure production to specification, variations can be detected, and the machine instructed to perform on-the-fly adjustments to the extent that it can do so mechanically. If it cannot, then the zone or spindle can be automatically ordered to stop, triggering an automatic schedule adjustment to have other zones complete the full run and triggering a repair request and part pull to maintenance that can be done during the next downtime cycle for changeover. Overall efficiency is improved because products are produced in spec, faulty production is stopped as it happens and repairs - when needed - are done at an optimal repair time. Quality therefore ceases to be a support function but moves into the organic system as a driver of efficiency as well.

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04. Supply Chain

Depending on the mode of production – MTS, MTO, ATO or ETO – a manufacturing company's supply chain will vary in length and complexity.

But regardless the mode of production, inbound logistics, raw material inventory, scheduling and forecasting, finished goods inventory and outbound logistics can be managed with Industrial IoT to improve efficiency within manufacturing itself.

Industrial IoT devices and software monitoring production may also be tied to any supply chain software or into an ERP system itself. As the system uses the same data across the organization, scheduling and forecasting can rely on real time logistics information for inbound raw material. This can also trigger better JIT planning and performance for additional raw materials and supplies ordered locally or regionally.

By tying inventory and inbound logistics into actual production flow, IoT systems can be programmed to analyze data concerning inventory and usage. These analytics may be able to identify trends that recommend that production lots of certain goods be larger or smaller to take advantage of cost, seasonal issues such as weather and other factors.

Traditionally, these functions operated under data sets produced within individual departments such as scheduling, purchasing, inventory, etc. and then reconciled to produce a plan for manufacturing. Often, a miscalculation in data or an ill-conceived decision due to human error or fatigue could have an "accordion" affect within the supply chain causing unplanned downtime or changeovers within manufacturing. With inbound monitoring, inventory alerts and automated purchase and replenishment coupled with advanced analytics, this accordion affect is eliminated, and the process operates seamlessly using real-time data. Supply chain variations can be automatically included in scheduling analytics and applied directly to manufacturing to reduce unforeseen workflow stoppage.

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05. ERP Systems

On the surface, it would seem intuitive that ERP systems, which integrate all departments and functions into a single system for business needs, would automatically be a natural fit for Industrial IoT software, devices and applications.

However, a recent study finds that only 16% of respondents utilize IoT data within their ERP system. Part of the problem lies within legacy ERP systems that do not integrate with IoT software. But as the advantages of Industrial IoT continue to make themselves apparent, IT and OT partnerships are forming to bridge the gap and ERP service providers are already racing to include deep integration of IoT in future updates.

For those systems that do offer IoT integration, or that can be updated to do so, integration of Industrial IoT and ERP can offer broad advantages for efficiency gains. By linking IoT and transactional data, factories could more quickly take advantage of the data stream to operationalize the IoT data. This move could be considered the "last mile" where the ERP system itself could utilize sales and performance data to adjust work orders or production schedules or take other action based on overall equipment effectiveness calculations.

By linking real time IIoT data to the ERP system, all functional areas can truly operate from the same platform. This includes finance, HR and higher C level functions that may not traditionally be considered as drivers of efficiency but whose reliance upon IIoT and ERP connected systems can impact staffing levels, purchasing arrangements, capital plans and short-term borrowing. Traditionally, these areas, while important, were not necessarily considered as a driver of efficiency. But using real time data, decisions made at those levels impact all the areas below and impact efficiency.

Industrial IoT as an Ecosystem for Operational Efficiency

Industrial IoT and the revolution that it represents is proving disruptive because it is creating an entirely new way of organizing production within manufacturing. It is the creation of an entirely new "ecosystem" within manufacturing where little or no manual intervention is required.

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This shift in paradigm is already producing staggering improvements in operational efficiency for those companies that have deployed.

As one study from the American Association for Quality (ASQ) found, companies shifting to digital processes and Industrial IoT have seen as high as 82% increase efficiency accompanied with 49% less defects.

But just as the data obtained and analyzed through IIoT devices and software can help a single factory improve production efficiency, the analysis of that same data over multiple factories can drive operational efficiency company wide. With a strong analytics program, energy consumption can be monitored globally across all plants within a company to detect trends at the macro level. This data can then be used to develop strategies for production of products with high energy needs to be produced at off-peak hours. So too can companies benchmark their factories to look for macro trends and deploy solutions at the micro level to address operational inefficiencies from factory to factory.

CONCLUSION

Industrial IoT technology and software will continue to revolutionize manufacturing in the coming decades. As AI programming improves and device functionality increases, companies that deploy will find many benefits. The adoption will require a shift in paradigm away from thinking of factories in terms of specific functional areas and toward a complete connection of all functional areas into the creation of one dynamic and organic ecosystem. It is in this ecosystem, aided by advanced analytics software, machine learning and AI where greater operational efficiency will be achieved.

Remember, digital transformation doesn't happen overnight, it's a journey.

Still hesitant? Don't worry. Most companies don't take this journey alone, and will partner with those that have the expertise to help them along the way.

MachineMetrics was designed to help companies overcome the challenges along the digital transformation journey and to advance forward from reactivity, to proactivity, and to predictivity. We've simplified IoT for the shop floor and are empowering manufacturers to develop their roadmap toward manufacturing excellence with the easiest to use and simplest to integrate software on the market.

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