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The Unexpected Impact of IIoT-driven Modernization on Plant Operational Profitability

by Tom Clary and Martin Diaz

Executive summary

Today's plants are faced with managing two major challenges: the increasing speed of business and integrating emerging technologies. Both are broad, and each play an important role in determining whether the organization will remain competitive and relevant. This paper reviews best practices for modernizing to an IIoT-enabled control environment and emphasizes methods for rendering assets and operations in a more reliable, efficient and profitable way while still maintaining high safety standards.

Introduction

The nature of plant modernization, including methods for upgrading physical infrastructure and tools that control plant processes, has been turned on its head in recent years. The rapid acceleration in the number of connected devices, a broader acceptance of open communication protocol standards, and a new affordability of digitalized technologies (both in data-gathering hardware and in data-analyzing software) has spawned the arrival of the Industrial Internet of Things (IIoT). This, in turn, has prompted industrial executives to revisit traditional approaches for controlling their operations and business performance.

Leveraging IIoT as a basis for plant modernization could result in big payoffs. The new technologies empower the workforce to move to real-time smart control. By providing operators with useable, easy-to-understand data at the right time and within the right context, they are better positioned to control the real-time risks to the operation. Thus, the more engaged workforce is more capable of enhancing ROI and directly impacting both profits and product time-to-market. This then leads to better real-time operational profitability control at the plant and enterprise level.

Today, industrial companies that are still trying to manage their operational profitability using outmoded monthly reporting cycles are failing. The world is moving too fast, and business management decisions that depend on data that is only generated once every 30 days have become obsolete. It is now possible to use a combination of existing systems and new technologies to safely drive measurable, real-time improvements to the operational profitability of the plant.

The elements of plant modernization in this new era of advanced connectivity consists of several core concepts and what we call “innovation at every level”, an approach that improves operations via connected devices (like drives), edge control (which includes PLCs, DCS, and safety systems) and apps and analytics (such as data management software). The linking of such technologies enables smart control either autonomously at the device level or via the human workforce. Smart control implies more than just smart technologies. The concept of smart control also encompasses the ability to use information to improve control over efficiency, reliability, and safety risk variables, either in an autonomous fashion at the asset level, or through the interaction of the operator.

Figure 1

Modernization using new generation digital tools to enable profitable control is an evolution not a revolution.

Plant modernization has never been easy. Modernizations have historically been characterized as having low ROI. They are also perceived as being disruptive to business processes as employees often have to be retrained. Ripping and replacing legacy equipment simply to improve the manufacturing process is frequently hard to justify in an industry that likes to operate in the "if it ain't broke, don't fix it" mode. But the IIoT revolution is changing all of that. Integrating digitalized solutions is not a start-from-scratch process. It requires an adaptive approach to existing systems, which, in most cases, work reliably and in which capital investment has not been fully depreciated. Plant stakeholders are realizing that much greater ROI and productivity gains can be had by modernizing the existing asset base through use of cloud-based services and enhanced connectivity of devices, and through a redesign of how data is captured, analyzed, and put to good use.

The intelligent use of data and the rapid expansion of connected technologies are redefining plant modernization by placing a new emphasis on profitability. Consider one of the core manufacturing technologies as an example: the programmable logic controller (the PLC). Most of the PLCs in use today are based on concepts that are 40 and 50 years old. But today, innovative new IIoT-enabled controllers like Schneider Electric's Modicon M580 programmable automation controller (PAC), bring a new level of value to a connected factory environment.

The new generation of PLCs ensures that plant floor decisions are made within a timeframe that allows the process to be positively impacted. If the costs of energy, raw materials, and other commodities are changing every 15 minutes, like they do today, so too is the operational profitability of the plant. That means attempting to manage the business only once a month via historical reports coming from an ERP system is no longer effective (or rational). Because today's IIoT-enabled control systems enable process-based decisions within an actionable timeframe i.e., in real or near-real time, controlling operational profitability shifts into the real-time domain as well.

For example, a modern M580 PAC can perform such a control to optimize process assets, while performing both safety and control functions. This case illustrates how IIoT enables control environment modernization. When a connected plant infrastructure provides the workforce with enhanced visibility into asset performance, opera-tors are more likely to exert a positive influence on plant efficiency, reliability, safety, and operational profitability.

IIoT is now bringing us to the point where control technology is no longer con-strained by the design of the system. Therefore, control systems can now be designed and implemented to be more closely aligned to solving a business problem, not a technology problem. That's a big step. Now the question is not so much "what is the technology?" but more "how does this operation work?" This perspective is illustrative of the promise of IIoT-driven plant modernization.

The speed of business dilemma

The speed of industrial business is increasing all the time. This trend is changing the way information needs to flow through the manufacturing enterprise. For example, critical business variables that were once constant over long periods of time, like buying energy at a fixed unit price for 90 days, now change many times a day…and sometimes many times an hour.

Thus, the industry is experiencing a degree of variability in the business that's never been seen before. Traditional ERP systems can't handle it. These systems are designed to resolve pricing on incoming raw materials, like copper and natural gas, once a month, while, over that same period of time, the marketplace is dictating hundreds of changes. Such a scenario means the plant's operational profitability is out of control.

As a result, plant automation must act as a tool that not only controls a process, but that also helps control operational profitability. When control systems and the workforce that operate and use them are able to control risks to the business, specifically safety risks, environmental risks, efficiency risks, reliability risks and, most importantly, risks to the profitability of the operation, manufacturers are properly aligned to the new, accelerated speed of business. Modernizing to an IIoT asset-centric control environment is the answer to achieving real-time business control.

The traditional emphasis on short-term fixes to current problems should not be allowed to supersede the longer-term goals of investing in the digitalization technologies that enable growth and increased market share.

Figure 2

The increased speed of business means real-time data is now mandatory to secure profitable operations.

A potential concern among executives is the amount of money it will cost to up-grade systems in order to modernize. Most industrial sites rely on control system architectures that date back 30 to 40 years. Executives foresee that it will cost them millions of dollars to rip out these productive, yet aging systems. However, this costly and abrupt scenario of “rip and replace” is avoidable. Instead, a gradual modernization approach can begin by adding analytics to existing systems in order to learn more about their performance and to then identify areas that require improvement. Such an approach will generate OPEX related savings, which will, in turn, allow more flexibility for justifying CAPEX to further accelerate the pace of modernization while gradually building ROI.

Success in a highly digitalized plant is not only about keeping things running nor is it about minimizing repairs and downtime but it’s about increasing visibility to data and optimizing the business to meet the current and future needs.

Profitable efficiency

When profit control principles are superimposed onto a process control, a strategy of profitable efficiency emerges. Real-time accounting (RTA), which utilizes a combination of sensor-based data from the process and financial data to calculate the cost and profit points across industrial processes, is the driver for allowing operators to gain access to profitability data. By prioritizing real-time accounting measures as the primary performance indicators of industrial operations, stake-holders can enable continual operational profitability improvements for the life of the plant. Additionally, embedding the RTA models throughout the operation enables the measurement of operational profitability for any initiative that impacts the performance of the operations.

These capabilities generate business value in two ways. First, a performance baseline can be established so that engineers, operators, and executives can begin to measure the value and improvement of automation benefits. Second, once armed with the measurable baseline information, plant stakeholders can begin to behave in a way that drives more operational profitability.

Although the profitable efficiency concept is rather new, early adopters are finding practical applications for tying in modernization efforts to improved profitability. Consider the example of a traditional boiler. A boiler typically has two or three critical process measuring instruments that connect to the DTS system (the system controlling chemicals in the process). In such a scenario, the temperature distribution within the boiler is never 100 percent optimized. Acquiring more data from inside that boiler will result in a more productive process. By placing inexpensive sensors in the boiler, the temperature profile can be sent to the cloud. Data analytics are performed and the data indicates that modifications are needed in the smart process control in order to increase efficiencies. This particular approach is called secondary sensing. This alters the original automation structure without a large capital investment. The efficiency improvements are measured and then translated into dollars and cents.

Service-Oriented Drive Efficiency Example

Pumps and motors connected to drives are primary targets for efficiency improvements. In fact, energy costs represent 40% of the Total Cost of Ownership (TCO) of a typical pump. Technologies such as Variable Speed Drives (VSD) offer significant potential for reducing the energy consumption of pump and motor systems.

The latest VSD iteration, the Services Oriented Drive (SOD), comes with added intelligence, which allows for embedded energy and asset management service capabilities. SODs can measure energy consumption of attached devices (like motors or pumps), can monitor performance of those optimized assets, can improve energy performance through adjustment of operational parameters, and can record the data for analysis.

As SODs are integrated into the network, equipment performance can be measured remotely via a central control panel or even a mobile device. This helps simplify the maintenance process. The SODs perform advanced asset diagnostics which helps to drive optimized predictive maintenance strategies. Optimized asset performance of the drive, motor, and mechanical transmission are all monitored. The possibility of performing true predictive maintenance helps replace what needs replacing without incurring unanticipated downtime, saving hundreds of hours and tens of thousands of dollars per year.

Profitable reliability

For most industrial enterprises, the ultimate objective is for both maintenance and operations to maximize operational profitability. Approaching reliability, efficiency, and profitability from a common strategic plane is essential. This collaborative approach is referred to as "profitable reliability."

Industrial maintenance tools and practices, intended to improve asset reliability, have progressed and evolved over the past two decades. Today, the "science" of predictive and prescriptive maintenance is beginning to take hold. Steps need to be taken before either remote cloud-based Software as a Service (SaaS) or site-based modernized maintenance solutions can be implemented.

First performance data must be gathered from the equipment on the plant floor. Then, through analysis of that data, operators can better assess when/if a piece of equipment will fail and then take preventative measures to either avoid the failure or to adjust the process to ensure production efficiencies. Thus, the assets are optimized.

Advanced analysis is built upon three layers:

- The first layer uses asset-specific algorithms, rules, and thresholds (derived from many data points gathered over time across many sites) to gauge the performance of the assets (e.g., how long that motor will last, or whether warning signs are being detected).
- The second layer consists of a Service Bureau, which is manned by a team to determine if the event the system has detected is a normal condition, or whether it requires additional investigation.
- The third layer, engaging a remote expert, is employed if more investigation is required. The expert analyzes the data, determines the root cause, and develops a detailed event report.

The cloud-based asset management model is scalable. The industrial site can start small and only be billed for the amount of monitoring that is required (four or five pumps for example or, if the electrical system is being monitored, the main breakers). Then, as time goes on, more assets are optimized until site-wide or multiple site optimization is in place.

Predictive and prescriptive (sometimes called proactive) maintenance strategies are usually most improved by IIoT-driven modernization. In both approaches, the processed data is monitored to identify trends and to issue alerts prior to failure. Predictive condition monitoring is most appropriate for simple systems, where single-variable math can be used to predict failure. More complex systems involve prescriptive condition monitoring, where multiple variables are analyzed to predict the failure. This requires a more contextually driven understanding of operating conditions and more accurate diagnosis of the pending issue with fewer false positives.

According to ARC Advisory Group estimates, unscheduled downtime can approach zero when prescriptive strategies are applied.[1] Predictive strategies can deliver twice the cost benefits of preventive strategies, and, in comparison to preventive strategies, reactive maintenance could increase the lifecycle maintenance costs by a factor of 10 when a failure occurs. ARC sees IIoT as offering new opportunities for optimized asset performance improvement by combining the growing wealth of data with advanced analytics.

[1] Rio, Ralph, ARC Advisory Group, "Optimize Asset Performance with Industrial IoT and Analytics," September 2015

In this new world, real-time reliability risk can be measured, and, as a result, real-time reliability control becomes possible. This concept extends itself to traditional maintenance management. For example, if it is likely that a compressor will fail within the next six hours, i.e., the risk is high, the real-time reliability controller, in the form of the process operator, might immediately respond by slowing the compressor rotation, thus extending the reliability time threshold and avoiding a short-term failure. This provides time to optimally and more permanently respond to the condition.

It is important to note that in the IIoT age, smarter, autonomous assets will some-times have the ability to control their own real-time reliability.

The empowered workforce of today maintains constant access to real-time operational profitability data, along with smart process control and real-time reliability risk information. As business-performance managers, operators will be able to adjust the set points and see the impact they and their adjustments are having, not only on the process, but on the profitability and reliability of the optimized assets. They can then apply this feedback to make decisions that maximize profitability without significantly increasing reliability risk.

Empowered Workforce In Action

An empowered workforce is a key element for driving profitability of operations. As industrial machines become more intelligent, with more built-in data points, operators, using mobile devices to perform remote monitoring, can reduce the risk of downtime by identifying and addressing a machine's state change before an uptime-threatening incident occurs.

In addition, using cloud-based tools, workers can access a centralized knowledge base containing updated information regarding the status of plant floor equipment with direct access to subject matter experts if required. All of this allows operators to react more quickly and to make more accurate decisions.

New tools that utilize artificial intelligence and augmented reality technologies will allow workers to further improve plant uptime. The instant and easy access to relevant information helps to reduce operator and/or technician error. When an operator is performing a specific task, a step-by-step set of instructions will appear on their mobile device screen, reducing the time and cost of the maintenance activity. Relevant information is now available outside of the control room and is passed along digitally so more time is spent on generating profitable activities. Ultimately, downtime is reduced as machines are up and running faster.

A service engineer in front of a machine, for example, can pick up an iPad and point the built-in camera at the equipment. A visualization of the equipment inside the cabinet pops up. The engineer taps the piece of equipment on his screen and the relevant data he needs appears. That information could be the history of that particular drive, with information regarding how it's been behaving over the last 14 days. On the screen, he sees a visual model of the equipment and, although he's never seen this machine before, he knows how to repair it.

This scenario presents several key business benefits. The first is the avoidance of unnecessary and costly machine downtime (by being able to open cabinet doors virtually, without disrupting the ongoing process). The second is to locate the information faster with immediate, relevant access to important support materials (like user manuals, instructions, and diagrams).

In addition, access to such technologies can positively impact supply chain management. If a piece of equipment is identified as not functioning, production lines can be shifted to ensure that orders continue to be filled. The incoming supply chain historical data can be analyzed to understand the implications on purchasing of raw materials. In fact, when repairs are completed far sooner than what was possible in a traditional scenario, the entire plant workflows can be reconfigured as a result of higher efficiencies.

Profitable safety

Modernization through IIoT technologies and concepts can transform and enhance the process safety if appropriately applied. IIoT opens the door to forward-looking perspectives on safety that accurately predicts when safety risk factors will exceed the accepted thresholds.

IIoT-driven algorithms and predictive analytics can be configured to identify looming threats to equipment asset safety. The process of deploying predictive analytics includes the gathering of equipment asset historical data, and the building of mathematical models that reflect different operational modes of that equipment. This is then combined with sensors that gather live data to form a profile on a given piece of equipment.

Once the profile or signature of that equipment is established, guidelines for how that particular piece of equipment is supposed to perform can be determined. That information is placed online and a data repository is built-up that compares the actual performance to the expected performance. If there is a larger-than-expected deviation between the expected and the actual performance, then alerts can be sent out to safety and the maintenance teams can then pay attention to the emerging risks.

New tools that adopt a “digital twin” concept, allows testing in a virtual environment before the actual physical implementation of a recommended change to a machine or process. From a safety perspective, this greatly reduces the risk because the impact of the change on all possible variables can be evaluated first before the change is actually implemented in production.

In addition to the benefits in safe process design, digitalization increases the awareness of issues through more efficient alert processing (with the ability to distinguish between “meaningful” and “nuisance” alerts). In this way the information delivered to safety experts has already taken into account the safety risk procedures and process constraints.

While less human involvement will be required for proper decisions to be made, when humans are involved in implementing risk mitigation plans, they will be able to be guided by a richer data set and better technology-enabled information. Machine operators, for example, will be able to adjust the set points and witness the impact their adjustments are having on the process safety, profitability, and reliability of the optimized assets.

Cybersecurity Considerations

Although IIoT and digitization-related modernization initiatives offer many opportunities, connection to the broader internet also introduces the new risk of subjecting safety systems to cyberattacks. Digitization and cybersecurity are 100 percent linked, therefore one should not move forward without the other. Industrial organizations need to understand where and how their operations are vulnerable.

New systems coming into the facility have to be evaluated for secure hardware and firmware and should not be assessed only as standalone pieces. The strategy needs to encompass the site-wide cybersecurity view. Vendors contributing new technologies should also offer IIoT compliant architectures (similar, for example to Schneider Electric's EcoStruxure architecture) that incorporate cybersecurity at the product, edge control, apps, analytics, and services layers. The ongoing cybersecurity strategy should also complement the safety strategy.

An open, but secure architecture

An important key for managing IIoT-driven operational profitability control is to view the cloud, edge, and the on-premise plants as part of a larger whole that is built upon an open, and multi-layered architecture. When piecing together such an architecture, a holistic view should be taken and the development needs to be planned in the aggregate, with the application and the physical environment being the central considerations.

Fortunately, there's no need for control engineers to reinvent the wheel by architecting a digital infrastructure from the ground up. Physical infrastructure companies like Schneider Electric have developed vendor-neutral, validated architectures (which Schneider Electric calls EcoStruxure Plant) that include an open but tailored stack of connected products, like drives, edge control systems, PACs, software, apps, and cloud-based services for supporting data analytics. Such platforms are made accessible to developers and to a wide ecosystem of partners so that systems are more agile, flexible, and secure.

EcoStruxure Plant enables core manufacturing and business risks to be controlled in real time via cloud, edge, and on-premise solutions. Operators are able to view cloud-connected critical data anytime, anywhere from any device. Resiliency and visibility are improved through live sensor data, predictive analytics, and smart alarming. Operators also have access to experts monitoring connected assets 24/7.

Deployable both on-premise and in the cloud with built-in cybersecurity at each architectural level, users are able to perform real-time corrective actions in the short- term and optimize their whole ecosystem in the long-term. This results in better decisions, which directly increase the profitability of the business.

EcoStruxure improves the agility of organizations by enabling key process owners to respond more quickly to market dynamics. By providing a collaborative work-space that connects applications and analytics to the field systems/devices, the architecture allows teams to view combined intelligent dashboards in real-time, enabling faster and more accurate decisions. Such architecture can help drive measurable profitability in the three domains of safety, efficiency, and reliability.

Conclusion

The new options presented in this paper for modernizing industrial processes may appear overwhelming as they raise the question of how traditional manufacturing processes will be altered in the new digital world. Although transformations will have to occur, stakeholders will have many opportunities to drive more value to the core business and supply chain.

For those ready to initiate digitally-driven modernization initiatives, given below are some first steps to consider:

1. **Connect** – Choose a partner with experience in the industry who can connect not only to their own company's products, but also to the products throughout the target industrial site. Make sure the connected products are cybersecure.
2. **Collect –** Choose software platforms capable of interoperability so that more can be done with the data that is gathered via sensors. Look for solutions that connect

to edge controllers that are close in physical proximity to the lo-cal operation. Plan to collect data that has tactical value and that also sup-ports higher level of organization-wide analysis.

3. **Analyze –** Select solutions that involve both automated analysis and human analysis. From time-to-time you will encounter unusual situations that still re-quire intervention from human experts to make sure problems are properly diagnosed and addressed. Select analysis tools that are advanced in terms of asset management, so that predictive and prescriptive maintenance can be performed. This improves ROI and limits unplanned downtime.
4. **Improve Existing Infrastructure –** Real life examples of implementations by early adopters are now opening the door to others seeking operational efficiency improvements and profitability measurement. Start with a prototype and then, if successful, replicate across similar applications in the plants.

Technology trends such as IIoT, enable innovation at every level of factory operations. However, in order to reap the rewards of higher profitability, nothing will eclipse the importance of an empowered workforce of operational experts equipped with the skills (and data) to manage operations in order to enhance ROI and grow corporate revenues.

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