COME TOGETHER:
IT-CONTROLS ENGINEERING CONVERGENCE
FURThERS MANUFACTURERS’ SUCCESS

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EXECUTIVE SUMMARY

As manufacturers continue on their quest for optimum performance in the face of a constantly shifting marketplace, there’s no question that informed decision making based on real-time data is required for success. However, many companies do not have an identifiable group that focuses on plant-level information and systems. Information Technology (IT) does what it does, and controls engineering departments do what they do. That has to change. To truly leverage the data needed to improve performance, companies must tear down the long-standing barrier between IT and plant floor controls engineering systems and groups.

Today’s control systems are grounded in the same operating systems and networking technologies common in IT. The common practice of controls departments “hiding” their computers from IT is thus becoming not only more difficult, but also less productive. Conversely, IT needs to gain a better understanding and appreciation for the unique demands of manufacturing-centric information systems. Most production employees have a disaster story relating to IT standards and maintenance practices wreaking havoc in a manufacturing environment.

That said, IT and controls are realizing that they can help each other achieve department and business goals. Convergence – or at the very least collaboration – between controls and IT can be a logical means to succeed with goals such as globalization, product proliferation, outsourcing, and broadening value to customers. Each has important skills and practices that the other team can adopt.

• Controls professionals are realizing that IT has skill sets, bandwidth, and practices that can help them maintain and standardize systems at lower costs.

• IT groups are realizing the need for accurate and timely data from plant floor operations that originates in the control systems. Some IT groups also recognize that controls engineers are remarkably responsive and sensitive to the special needs of production-critical systems in the plant.

The major obstacles lie in mindsets, communication, and education. Both IT and controls engineering consist of highly trained individuals who can justify what they do – however the main objectives and practices in these two organizations look quite different. Many practitioners on each side of the fence have pre-conceived notions about what the other group does and why it may not be as effective as it could be.
This paper provides a current “snapshot” of the IT/controls dynamic based on interviews with more than 20 professionals in IT and manufacturing. Their feedback was the foundation for development of a maturity model that shows the three distinct paths and five stages of maturity for each of the major categories of issues: organizational, business process, technology deployment and results. In total, 15 separate areas in which convergence appears make up this model.

The benefits of convergence can be enormous and exist at enterprise, plant, department, and individual levels. Companies that have moved further along the path toward converging IT and controls engineering report lower costs and higher efficiency of these departments. They enjoy better business continuity, reliability and disaster recovery. Project timelines are shorter and response to issues is better. Some report better plant performance, and many feel there are better career opportunities.

Breaking down the barriers to allow IT and controls to come together requires planning, hard work, and support from senior management. Those who have been at it longer tend to enjoy the benefits and are in a better position to succeed with corporate initiatives. When converged, both IT and controls engineering can be more productive and support the company more effectively. Their plants have new opportunities to increase their performance as a result of the converged data flows and departmental cooperation. These companies have a competitive advantage that will work for them shift-after-shift and year-after-year.
OPPORTUNITY IN IT-CONTROLS CONVERGENCE

From an information management perspective, personal computers (PCs) running common commercial operating systems across Ethernet networks are increasingly the platform of choice for manufacturers – from the top floor to the shop floor. Other software and hardware is designed to inter-operate well if not seamlessly with this core set of platforms. That’s not news to anyone in manufacturing operations or information technology (IT) in a manufacturing company.

However, many companies have not taken full advantage of this fact. The reason is that the organization has not changed to take advantage of this technology opportunity. Most manufacturers have separate organizations and policies in IT and in controls engineering. Often, the groups are not well aligned and may even feel some tension or antagonism toward the other group because of core differences in objectives and mindsets. To compete, companies must change their practices, processes, organizations and culture to converge on the opportunity to create highly integrated information systems.

This convergence in technology, organizations and processes presents an opportunity for lower cost, leaner plant operations and higher effectiveness for both the IT organization and a wide range of software applications they manage. It could help managers throughout a manufacturing company make better decisions. In fact, it may hold promise for helping to align operations activities more closely with business strategies.

Plant-to-Enterprise Integration

Over the past few years, manufacturers have shown an increasing interest in integrating their enterprise information systems with plant systems and information. One respondent explains it this way: “There are huge benefits there, directly in having multiple systems integrated into one. We can avoid the typical issue where one has to decide whether ERP, MES or DCS is the center of the universe and where different teams are in charge of each system, and information flows only with extremely complex interfaces.”

The need for integration goes both ways. Enterprise systems can benefit greatly from having accurate and timely information from the plant, and plant activities can stay better aligned with enterprise needs when enterprise data flows effectively into the plant.
Production data can increase the effectiveness and accuracy of enterprise software. Enterprise systems need to know things like order status or quantities produced, problems encountered, overall yield, and actual times to compare to standards. The more accurate and timely this data, the more confidently those using the systems can make decisions and take action. If used effectively, production data can pinpoint opportunities for improvement and provide the platform to standardize and raise the manufacturing organization's awareness relative to the process, quality and conformance to standards.

However, process control systems generally have extremely granular and real-time data about starts, stops, conditions and details, well beyond the level that most enterprise systems need. The massive volumes and speed of process data from controls would choke most enterprise systems, and automation and controls data formats are also different from what enterprise systems can easily process.

Fortunately, there are many systems in the plant that can help bridge the gap and create useful information streams from plant data. These plant-level information systems are called Level 3 systems in ISA-95 terminology, and may include data historians, manufacturing execution systems (MES), plant dashboards (also called manufacturing intelligence (MI) or manufacturing performance management (MPM) systems) and other plant information systems.

Enterprise data can help plants to keep their activities aligned with business changes as they occur. The most obvious need is to keep up with changes in demand patterns and order streams as they change. Other key enterprise data includes information on new materials coming in from procurement, such as specifications and expected timing and quantity of shipments, product specification (or engineering) changes, and new plans or goals for output. This type of information may again need transformation from a Level 3 software system to convert from the enterprise system's view to useful directions for the controls and automation.

An earlier Rockwell Automation Manufacturing Technology Series paper, Integrated Control and Information Systems, pointed out a number of drivers for this integration. They include

- Capturing and using automation data by putting it into context for decision-making
- Moving beyond custom ERP systems
- Compliance to environmental regulations, quality standards and track and trace for both governmental and customer compliance
- Technology transition to real-time information on-demand
- Using automation to innovate and improve product lifecycle management (PLM)
- Globalization and consolidation leading to decentralized manufacturing
Aligning plant operations with strategies has always been a somewhat elusive goal. One challenge is in creating timely information flow and another issue is that the metrics used in the plant may not always support business goals. A good example is a plant that measures actual equipment throughput vs. theoretical throughput when a company considers expanding its product mix. The changeovers inherent in making multiple products on one line will lower throughput – but may raise overall revenue and market success.

The 2006 MESA Metrics that Matter study found that only 3% of manufacturers have very effective links between the key performance indicators (KPIs) they use in the plant and the financial and business metrics executives rely on to gauge overall company success, as shown in Figure 1. Because of this disconnect, ensuring alignment between company goals, metrics and operational activities at all levels to increase business success is a topic of interest to many manufacturers.

Major potential benefits of a convergence between controls and IT are available not only for those in the plants and for those in IT, but for the overall health of a manufacturing company. Possible benefits lie in several key areas:

- Increasing the efficiency and profitability of production operations and allowing them to run effectively with relatively small staffs
- Lowering overall IT costs and increasing the benefits available from connected enterprise systems
- Minimizing the waste and errors that result from manual data entry into and out of both enterprise and plant systems
- Reducing duplicate effort in buying and maintaining equipment as well as setting standards and passing along best practices
- Increasing the impact that plant-level improvement programs have on the financial results of the company
- Making the entire organization and its supply chain more agile to respond to situations as they arise, from new product introductions to changes in customer orders to bad lots of materials coming in from suppliers.
Areas of impact are shown in Figure 2. Common or compatible technology is what most people think about and most of what we have described so far. Many of the benefits will come in the area of improvement and innovation – attributes that manufacturers must have to compete. The more aligned and integrated controls and IT are, the more effectively the company can evaluate options for gaining an edge. Clearly, business processes not only span plant-to-enterprise, but the integration can feed supply chain, product design, sales and marketing, and even financial planning.

The key to unlocking the benefits of plant-to-enterprise integration goes beyond the technology or manufacturers would have already made great leaps forward. Nor are fully aligned metrics adequate to ensure that information and activities always support improved company results. The key or missing link in most companies is cultural. Mindsets at least need to change, so production, engineering and IT professionals can begin to understand one another more fully. Some of the manufacturers who are enjoying the greatest progress are converging the IT and controls engineering functions not only through project structures, but also by putting new organizational structures in place as well.

Change management is usually the most difficult aspect of an improvement project. Enabling a convergence between IT and controls engineering will not happen overnight. In some companies, it may never take an organizational turn. However, the waste, duplication of effort, potential impact on system security and reliability, and cost inherent in not moving these groups together in at least an informal way are too large to ignore.

As manufacturers face more global competition, they will find coordinated, low-cost, secure and reliable operations critical to survival, not to mention success. Lowering cost and ensuring that operations are lean has been fairly obvious. The rise in strategic importance of information and IT – and particularly performance dashboards, business intelligence and related decision-support software – reflects the role IT can play in business success. Companies are beginning to spread lean thinking across the enterprise, which not only encourages collaboration across functions, but highlights and seeks to eliminate waste and duplication of effort across every aspect of a business process. While change presents risk, the status quo with silo organizations and minimal understanding – if not outright turf wars – between controls engineering and IT presents perhaps a more dramatic business risk.
As Rockwell Automation offerings expand to span from automation into IT, the disconnects between these groups have become apparent. Most of the companies we interviewed are still at early stages of moving down a converging path where IT and controls will work together in harmony for the good of the plant and the enterprise. Seeing this pending need for manufacturers to change, Rockwell Automation undertook this study of industry progress toward convergence in manufacturers.

The objective is to understand how far companies have come down the path to convergence and what best practices they are learning to accelerate progress toward change. Since progress and benefits from this type of change are multi-faceted and not easily quantified, researchers elected to conduct telephone interviews to gather data.

To accomplish this, Rockwell Automation contracted with manufacturing-focused industry analysts and consultants from Industry Directions Inc. and Systems Innovation Management. This team interviewed 22 individuals from 18 companies with a range of job titles in controls and IT functions. Most of the companies involved are large multi-national companies with household names. However, there were smaller companies involved as well.

The interviewees represented a broad range of manufacturing industries, from engineer-to-order discrete to mill products with a range of batch and hybrid processes as well. They represent a wide variety of consumer and industrial manufacturing segments. One respondent is a consultant to manufacturing companies, as shown in Figure 3.

Since the study examines a convergence between IT and controls engineering, the response base also includes a strong balance between those groups, as shown in Figure 4. The convergence trend is obvious in the variety of reporting structures that a few of the respondents represent. The third, fourth and fifth categories (special group in IT/IS, combined IT/controls group and IT/IS liaison in controls) are clear evidence that some manufacturers are moving convergence

Figure 3: Those interviewed for this study represent many different manufacturing industries, both industrial and consumer.
beyond projects and into organizational reporting and responsibility structures which include more matrix-style and cross-functional organizations.

In all subsequent charts and references to study results, the consulting firm has been omitted to ensure each response clearly represents one company. Unless otherwise noted, the charts also show results by company, so responses from multiple individuals at the same company are combined unless their responses conflict with one another.

**PATHS TO CONVERGENCE & MATURITY**

It’s not surprising that the companies involved are taking different paths to convergence and are at different stages. We will introduce a maturity model in this section. It may be the people in the trenches - the mid-level managers in controls and IT - who identify the need. From there we have found that a company’s success in progressing through the model is largely based on executive-level buy-in. Once that buy-in is achieved, involvement at all levels is critical. This is in part because the paths are so different – but even more so a result of the culture and heritage of the company, the IT and engineering organizations involved, and the leadership.

At a very basic level, we asked respondents whether they see evidence of this convergence between IT and controls at their company. As shown in Figure 5, most clearly see IT and controls engineering converging. Less than a quarter of the respondents don’t believe it’s clear, with even fewer who don’t see that convergence is occurring at their company.

While the majority of the respondents in this study do see evidence that IT and controls are merging, they do not necessarily see it occurring in the same ways. There are at least three distinct paths that these companies are traveling as they move toward convergence.

1. **Parallel paths.** Some companies don’t see that controls engineering and IT in their company will ever truly converge, but do see some movement toward doing things more consistently between the groups or at least not pulling in different directions. If the level of common understanding and respect can grow despite the lack of intersection between these groups, they can mature in their approach to IT-Controls convergence.
2. **Complementary paths.** In some of the responding companies, IT and controls are still separate entities with different approaches, mindsets and methodologies, but are moving closer together. One respondent quipped, “We have seen the future and neither of us can exist without the other. Both groups at the same time realized we can’t be fighting about this stuff.” This mainly consists of developing better defined roles and responsibilities for integrated manufacturing systems, improving understanding and trusting each other more, which can make interaction much smoother and more productive. Over time, some of these companies may move onto a more converged path where organizational changes occur.

3. **Converged paths.** As indicated by the roles reported in Figure 4, some of the respondents are involved in a clear multi-functional role. In these instances, the Controls engineering and IT groups actually have some formal reporting structures that ensure at least one individual is focused on facilitating and taking advantage of convergence. One person heading up this type of converged group reports, “In the past, our working relationship was dependent on the personnel rather than procedures or standards, which is what we are trying to fix. All of those groups report dotted line to me now. It’s not total control, but I’m in a position to influence.” In some cases, a group will be dedicated to this liaison role. In yet other cases, IT and controls will share a common reporting point in the organization’s structure. Some companies will create a converged organizational structure where one reports to the other or there will be one technology group that includes both IT and controls engineering.

These paths may result in different approaches to working together and certainly different organizational structures. The parallel paths approach is the one that suggests convergence will likely only go so far in a company. Complementary paths sound somewhat early, and converged paths the farthest along. However companies on all of these paths should examine how effectively they are moving toward successful leverage of the two groups and the technologies they manage. Not all companies will get on the converged path in the near term, or perhaps even in the long term. The key is to create an effective working environment for the two groups to collaborate.

A number of factors indicate how far down the path a company is and how easily or quickly they can move forward from their current stage. These fall into categories such as strategy and drivers, organizational and human resource skills, standardizing and buying systems, and implementing and supporting systems.
We have developed a maturity model to help companies evaluate where they stand in relation to convergence of IT and controls, as shown in Figure 6. A company may fall at various levels of maturity on each of these aspects and the concept is to see where they are relative to other manufacturers and what adjustment they may want to make to their strategies and activities.

<table>
<thead>
<tr>
<th>Converged Path</th>
<th>Complementary Path</th>
<th>Parallel Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Not Started or Very Slow Progress</td>
<td>Haphazard or Slow Progress</td>
<td>Deliberate or Moderate Progress</td>
</tr>
<tr>
<td>Organizational Maturity</td>
<td>B2S Units/Ops operate independently</td>
<td>Corp. &amp; Div. staff lack influence w/plants</td>
</tr>
<tr>
<td>Business Process Maturity</td>
<td>Infrastructure: Vendor but not model role, Software &amp; MES not standardized</td>
<td>Controls begin to standardize across plants</td>
</tr>
<tr>
<td>Technology Maturity</td>
<td>缩小 by an order of magnitude</td>
<td>Increase line of sight &amp; visibility</td>
</tr>
<tr>
<td>Business Results</td>
<td>Limited increased benefit</td>
<td>Improved resiliency &amp; reliability</td>
</tr>
</tbody>
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Figure 6: The IT-Controls Convergence Maturity Model includes four major categories that progress through five stages. Each company is likely to be at different levels in each category and in some cases even on various factors within a single category.

There are 15 areas or attributes included in the model, each of which may contribute to a company’s progress down the path to converging IT and operations – and thus to effectively leveraging all of the information technology in their companies. This model is described in more detail in the Addendum. It is intended for companies to use as a gauge of where their progress is good, and where they may need to make changes or focus more effort to continue the journey toward convergence. Given the benefits available, we see that many companies will find convergence between IT and controls will help them achieve strategic goals and run more efficiently.

Manufacturers should not be intimidated by the amount of work or change this model may appear to present. In the group of companies interviewed for this study, none that are at a true Stage 5. In fact, the largest portion of the companies we interviewed are at Stage 2, as shown in Figure 7. This means they are making only slow progress toward convergence. A few others really have not started down the path. These companies either do not see any evidence of convergence or are still finding the barriers to working together effectively are quite high.
A number of respondents are at Stages 3 or 4 and have made moderate or excellent progress. These companies have set up either organizational or project-level structures that ensure the two groups work together more effectively. Many have created cross-training opportunities and fostered learning and understanding among the groups. We have considered the 15 attributes to place the companies we interviewed into this model, along with the overall tone and achievements revealed in the survey interview.

As you might expect, some of the 15 attributes appear to have more impact on convergence than others, but one key factor appears to be the amount of time the company has spent on this convergence path. We asked how long ago the evidence for this began to appear, and the correlation to where a company falls on the path is relatively strong, as shown in Figure 8.

Some of the other critical factors in making progress appear to be having strong and open-minded leadership with some clear drivers. If management does not understand the benefits available, it is much more challenging to forge ahead down the path. Similarly, if no one perceives a need to change, natural corporate inertia may present obstacles to further convergence. In some companies convergence begins in one location. One IT respondent reports: “Convergence started at one plant and then spread. Once they saw what we could do and the best practices we brought to the engineering group and its business process, each IT group pushed toward the shop floor levels.”

The next sections discuss some of these issues in more depth. Keep in mind that every company is different and that history and experience – both corporate and individual – will impact the speed with which convergence changes will be adopted.
STRATEGY & DRIVERS

Strategy
A manufacturer’s strategy can play a significant role in whether IT and controls engineering converge and if it does, how high a priority that transformation is to the company. While change occurs slowly in most manufacturing environments, increasingly companies are focusing activities and initiatives to ensure they all feed into the corporate strategy.

Some of the major elements of current business strategy that might either encourage or discourage the convergence between IT and controls engineering include:

- **Globalization or Geographic Expansion**: Companies pursuing broader geographic markets may find the need for consistent practices, processes and data flows critical to ensuring consistency. This is particularly true when the company is opening production and distribution facilities in new markets. Enabling central IT and engineering as well as local technical teams to perform consistently can be critical to this strategy’s success.

- **Product/SKU Proliferation**: Many manufacturers have more products and variations of products than ever before to serve more groups of customers. In this scenario, the complexity of production processes often makes it more critical to have sound information flow at low cost between plant and enterprise. Converging on best practices processes can help keep costs and risk down.

- **Outsourcing of Production**: Companies for whom manufacturing is considered a core competence would be more likely to place a priority on converging the IT and controls organizations. All companies, including those who have outsourced production, may require information to flow from their partners’ plants back to their own enterprise to lower risk, but may not have the capability to converge beyond that point to dictate processes and practices.

- **Outsourcing of IT**: Those for whom IT is not a core competence may similarly find that convergence can only go so far. Since the IT employees actually work for a different company, it may be challenging to blur any organizational lines. Asking them to take on different roles may also cost the company more. The opposite of this is the set of manufacturers who are keeping IT internal and finding that it can help set strategy. These organizations are more likely to set strategy and these are the organizations that are more likely to see convergence as a way to further accelerate the gains they seek from information systems.

- **Total Solutions**: As manufacturers seek to deliver more complete solutions to their customers, part of the offering either delivers or requires information. For example, many manufacturers now ship an entire product genealogy to customers so they can meet regulatory requirements or better use and maintain the product. If the company itself is providing consulting or other pre- or post-sales professional services to clients, having complete information about the products and their production history may also lower costs and increase efficiency in the field.
Many companies also will employ other strategies that might encourage conversion because they rely on lower operating costs, more detailed and timely information about products and their production history, more consistency in operations, or lower risk. Each manufacturer should evaluate their strategy without the boundaries of history or current organizational structures or project practices. As they do that, we believe many will find it makes sense to move toward convergence between IT, controls engineering and production.

**Drivers**

Regardless of the strategy, most manufacturers will also require some specific pressures to drive significant changes. Over the years, many manufacturers have made changes due to problems or crises. There are many more compelling drivers for this convergence.

We asked the respondents what was driving convergence for them. Keep in mind that not all of the respondents are seeing convergence. However, among those who are, the top driver is that management requested it, as shown in Figure 9. One respondent says, “Unless we solve this issue and really lay down an integration manufacturing and IT structure, I don’t think we’ll ever get to the end state where leadership says they want to go.”

Increasingly those who run manufacturing companies – CEOs, CFOs, CIO, COOs and their teams – want instant access to information. Having IT and controls engineering work together more closely enables greater transparency and consistency in how plants report their data. Visibility to operational data may be used to pressure those in the plants (as some fear). However, it also clearly fosters sound decision making and greater predictability of financial results. For example, one company reports that cycle time and gross profit improvements resulted from an MES effort that brought together IT and controls data. Some managers are also realizing the potential for reducing waste and making better use of both human and technology resources.

A significant group of respondents also found that the convergence of technology on operating systems and Ethernet platforms between IT and controls engineering made the move to collaborate between the groups obvious. The similarity in expertise needed to select, implement and support the systems lends itself to best practices sharing and some degree of standardization. Standard IT support for all equipment that passes data can increase reliability if done appropriately, and can also allow controls engineers and production to focus on the production tasks at hand.
When a business changes, often through expansion or acquisition, the pressure on staff to gain efficiencies grows. The increase in complexity can no longer be managed with manual means, and disconnects between IT and controls can become increasingly evident and costly. In some instances, the great challenge is to create a coherent or consistent view of data across multiple environments – the convergence of IT and controls can foster consistency and feed data warehouses and reporting more effectively.

Companies who see manufacturing as a core competence and a source of their strategic advantage are more likely to invest in convergence. One respondent says, “We see manufacturing as a source of revenue enhancement, not a necessary evil. We’re trying to run like a world-class business.”

Most manufacturers have increased efficiency to the point where operations and controls teams are very small. This may occur as part of a lean initiative to eliminate waste. These lean teams often recognize that they need to leverage all resources available – such as the staff to support their PCs, workstations, servers and networks. This can even extend to leveraging best practices for technology implementation projects.

Other drivers may include:

- **Security concerns.** As IT has honed its security capabilities in the office, companies realize manufacturing data security is at least as critical to success. Convergence can lead to a consistent approach to data security to help protect the plant data. A consistent architecture can further boost security.

- **New enterprise systems.** While many manufacturers’ ERP has run for years with only slow updates from the plant, the desire to have greater accuracy and timeliness at the enterprise level is driving integration of appropriate plant data.

- **Operational metrics.** Companies are increasingly pushing to manage by fact and use sophisticated performance metrics. One respondent reports, “We have brought in manufacturing executives from outside of the company who are pushing overall equipment effectiveness (OEE) as a measurement tool. OEE is better than what we have had in the past, and it requires lots of data to be effective.”

- **Regulations and reporting requirements.** Nearly every manufacturing industry is now required to track and trace materials through their entire lifecycle, from incoming raw materials through to finished products and often out in use with customers. Without integrated plant data, these regulations are very cumbersome to comply with and reporting takes considerable effort.

- **Reduce total cost of ownership.** As manufacturing equipment converts from primarily mechanical devices to networked mechatronic devices, increasing levels of skill and support are required to maintain a healthy, reliable manufacturing environment. Some companies are now just beginning to understand the real total cost of ownership from sensor to MES / ERP system. If not managed properly, one can run the risk of reducing equipment reliability or increasing cost.
Obstacles

With so many strategic reasons and drivers, why do companies have so much difficulty effectively bringing controls engineering and IT together? And why are some companies simply not on this path to convergence? There are at least as many hurdles to convergence as there are drivers.

Perhaps the most obvious one is that no one has responsibility for making convergence happen in most companies. Managers usually focus on line-of-sight issues that have a direct near-term impact on key performance indicators (KPIs), such as quality or throughput of product or data.

Challenging organizational boundaries and structures is generally not comfortable and may be politically risky. In fact, whether IT, Controls or Production makes a move toward convergence, it can be perceived as a power grab or stepping on another manager’s turf. However, for those who have made progress, it was advantageous to the individual’s career. “People are embracing this convergence, as they see personal opportunities – career-wise or technically-wise,” reports one respondent.

Each group has a strong focus on what they know and what they are accountable for in the company. They may not even perceive the major benefits of creating convergence between IT and controls in terms of long-term costs, information flows and visibility, efficiency, leverage and lowering risk due to their natural focus.

- VPs of manufacturing are generally focused on keeping costs down and the process running efficiently with high quality output. Many of these managers have a limited understanding of automation and even less knowledge of IT. Many of them don’t have to know – they just want it all to work.
- The VPs of engineering are typically concerned with delivering new projects on schedule and in budget. The focus is more on mechanical equipment and project management than on keeping systems running after the project is complete. Automation and controls are still often second to production equipment.
- CIOs understand technology, but are usually so far removed from both the production operation and the realm of real-time information that they may not fully grasp the differences between controls applications and transaction-oriented enterprise applications. CIOs and their departments also have little appreciation for the fact that a seemingly simple patch or update can have a significant ripple effect on the factory floor.

In fact, most managers focus their efforts on issues that are clearly visible and painful in how they are evaluated or measured. Staff level employees in these groups are usually more risk-averse. They are concerned about keeping systems and processes running and meeting their own job objectives.
There are exceptions: people who have some knowledge across production, engineering, and information systems who see the opportunity to act as a bridge between groups. They may still fight obstacles in the organizational structure and in the understanding of their superiors.

Metrics rarely drive convergence between controls and IT. Usually, these groups have separate gauges for their success. These are often in projects for engineering and in ongoing support costs and downtime for IT. Production metrics are usually focused on issues that may impact automation but are generally not seen as dependent on data flow beyond the immediate line or plant area.

In IT systems, health and true life cycle costs are major areas of focus. They’re common measurement methods for overall department performance. That’s not the case in controls. While there is a lot of talk, there aren’t a lot of metrics or measurements in place - at least not yet.

Conflicting interests and drivers can also create challenges for convergence. One company mentioned, “There are conflicts between logistics and controls. If our biggest customer needs specific information with our products, we will probably focus on a project to achieve that rather than a controls project that might increase yield a half-percent.”

Finally, there are not publicized leaders to emulate. We do not see stories about companies who have achieved convergence between controls and IT and the progress they have made. The results are more likely to be incremental and scattered throughout many aspects of the business rather than a big, impressive focused outcome. So while the manufacturing industries are moving in this direction, the successes may not lend themselves to heroic tales of saving companies and profits.

**ORGANIZATIONAL AND HR SKILLS ISSUES**

Clearly, bringing together groups of employees with different backgrounds and credentials requires some skill. This is true whether the company is creating a new organizational structure or simply fostering cross-functional projects and teams. Creating an environment where IT and Controls engineering employees work together more effectively can be a challenge. But it’s achievable.

The three main paths to convergence illustrate some of the organizational possibilities.

- Those on parallel paths must focus on cross-functional understanding. Even though the departments are not likely to ever converge, the key is to get them moving on parallel paths rather than pulling in different directions.
Companies on complementary paths must do all of that and also create cross-functional teams for projects. These teams can actually accelerate understanding and improved communication.

The converged paths are those where a single organization begins to take on multi-functional responsibility. In this response base, we have examples of IT within controls engineering, controls engineering or manufacturing within IT, and a combined IT and controls engineering group. In most cases, this will start as a single person with deep understanding and credibility in both IT and controls worlds. Sometimes the company creates a new organization with multi-function accountability – it might reside in IT, controls, or production but has explicit goals to bridge the gaps. Here, enormous understanding and changes may be required.

Creating respect, trust and understanding between IT and engineering isn’t easy. Each side tends to have some set notions about the other group and their shortcomings.

**Views of IT from Engineering.** Many controls engineers view IT as an organization that is so tied up in documentation and standards that they cannot take effective action. For project-oriented engineers who also often come in to fight fires when a problem is hurting production, the IT approach seems impossibly plodding and overly complex. What they may not recognize is that IT projects are often rolled out or standardized globally, so the impact of issues ripples. One respondent says, “IT is not clear on how to spec out data from a real-time system. … Getting the spec is double to 10X the time of getting the data they want.”

**Views of Engineering from IT.** Conversely, many IT employees view controls as somewhat undisciplined cowboys who go out and fix problems or conduct projects without regard for future consequences. IT shudders at the high ongoing maintenance costs as well as the risk of not replacing obsolete equipment because it’s running a production process. One IT manager says, “Engineering drives out a problem, then moves to the next one. They do not necessarily have a vision of what they need and how to attain it over time. They are very reaction oriented.” What IT may not realize is how essential control is to keeping the plant running and how expensive even short periods of downtime can be for the company in profits and customer good will.

![Pie chart showing education levels needed for controls and IT to work together effectively.](image)
To bridge this cultural gap and help each side understand each other, the leaders on the maturity curve appear to be focused on education and some degree of cross-training. As shown in Figure 10, the majority believes education is required for IT and controls engineering to work together effectively. In companies on parallel paths, trust and respect may be the major components required, since each side will continue to have distinct responsibilities.

For those looking to actually merge groups, some cross-training often is required. More respondents report that it’s easier to train a controls engineer to understand IT than it is to have IT personnel learn about automation and controls. One major issue is simply a lack of engineering background, but others include the complexity of the production process that the automation is designed to control. Many controls engineers also see significant job opportunity and career advancement in learning more about IT as well. One respondent says, “I think here we are creating new possibilities for automation engineers that were invisible before.”

However, those who indicated it was easier to train IT saw that engineers are trained to look at minute detail, not overall business processes, information flows and impacts of application functionality on the business. One respondent who has set up these cross-functional organizations at several past employers reports that it is equally challenging — that IT and controls both have mindsets and backgrounds that allow them to learn the other discipline if they have the right attitude.

Those who are putting forth a real effort to cross-train employees have used many methods. These include formal classroom or on-line training, attending vendors’ educational events, and simply doing each others’ jobs. Exposure to life on the other side of the IT-Controls divide can build not only skills and knowledge, but trust and respect. One respondent said, “You don’t get as much from an individual in a training seminar as you do by teaming in a lab or on a project or on an assignment. That’s how we cross those functional boundaries better.”

Key to the success of all of this is the leadership and communications skills of those managing the teams. Open-minded managers who believe in the value of IT and controls working together appear to have made the most progress. Communicating in terms that match the particular listener’s background and training is invaluable. An ability to listen as well as guide is critical. Leaders must also have the flexibility to understand multiple viewpoints and attitudes, and the motivational skills to help people take on new roles.
STANDARDIZING & BUYING SYSTEMS

Even when the strategy leadership is in place and the controls engineering and IT groups begin to communicate effectively, there are major differences in how they have operated and what they prioritize. In many companies, budgeting, planning and strategy for lifecycle costs are somewhat different in controls and IT. However, the buying cycles have been completely separated and many do not know how different the practices are.

As these differences become apparent, the issues can cause continued discomfort and misunderstanding. However, much of this discomfort is unfounded. Among the group of companies interviewed for this study, most found that the differences did not create major problems, and some in fact found no issues, as shown in Figure 11. The one company that reports having major conflicts still is also relatively mature. So these differences appear not to stymie progress, only to make the change cycle longer.

It helps that in a majority of the companies we interviewed, there is no competition for budget between IT and controls. There are companies where the groups compete for the same financial resources, but only one reported that the competition is increasing and that was primarily because the budget itself was shrinking.

The IT budget in the plant itself is often split, with IT owning certain aspects and applications and controls others. The split ranges from IT owning only strategic aspects to IT owning MES or the data historian and above in the architecture to IT owning SCADA and all applications not sitting on a PLC. Some have a centralized IT budget or a central capital budget for all new projects in the plant.

More often than not, plant accountants or other finance staff helps the buying team develop their return on investment (ROI) models or they participate in the capital review process. In one case, the finance team developed a spreadsheet that everyone can use in developing project ROI or payback calculations.
It is also interesting to note that the vast majority of the manufacturers in this study do at least some technology development and standardization in advance of, and independent of, an individual project. As Figure 12 shows, half really are creating a blueprint to standardize on systems technology that projects then follow. Many will vary by division or scope of project as well. This illustrates that the IT thinking about lowering overall costs is permeating many companies’ buying habits.

Many of these companies also have long-range systems plans and formalized systems management lifecycle processes. While not universal, these practices are taking hold, and allowing appropriate migration and upgrade plans to protect investments and increase reliability.

IMPLEMENTING & SUPPORTING SYSTEMS

Implementation

In many companies, IT has expanded its role to manage or help manage ISA 95 Level 3 systems such as MES, scheduling, data historians, quality systems, etc. Many of these rely on pulling data from controls, so even in companies with minimal organizational convergence, some projects will require both controls engineering and IT staff on the team. As cross-functional teams take on implementation projects, they will experience benefits.

Among the most significant are:
- Increased clarity on roles and accountability throughout the project
- Greater flexibility now that each group understands the other
- A shift in responsibilities for some of the players to take on more of an analytical rather than administrative role for IT members of the team
- A broader understanding of the objectives, given that both controls and IT views have been fully voiced and integrated into the project design
- Greater efficiency as there is less likelihood of duplicated effort or working at cross-purposes.

Most companies find that each team member should retain specific roles so that everyone knows who to call for various issues. However, they should be cross-trained for flexibility and so that any team member can take on any issue that arises.

Figure 12: Half of interviewees said that technology development is part of a long-term plan, and many more deploy new technology based on a plan in advance of a project at least some of the time.
Some of the keys to success for implementation projects by cross-functional teams are common to nearly any project and team. These include good specifications and clear project plans, sound project management, leveraging best practices, and management buy-in on the value proposition and total cost of ownership.

What may be different is the need for powerful leadership with both organizational skill and personal characteristics such as communicating and listening well. Trust among team members is likely to be more challenging to achieve – but it is critical to ensuring that the team fully leverages the deep expertise available in various team members.

Even something as basic as following best practices may be somewhat more complex when there are two or more sets of best practices that will not all be familiar to any individual team member. Many in this group of companies have a formal process for incorporating lessons learned and changes requested back into the standards or blueprint, as shown in Figure 13. This appears to be somewhat independent of the maturity of convergence for companies in the study.

Support

One area where IT and controls engineering are famous for conflict is in how they support systems. Controls and production people nearly all have a horror story to tell about IT’s maintenance practices. While transaction systems are often taken down for patches or periodic maintenance in the middle of the night or on weekends, plants that run 7 x 24 can easily experience major issues with unavailable systems. If IT manages some of the hardware or applications that help run production, it can even cause disruptions to production.

As controls and IT learn from one another, many companies are finding this is a diminishing problem. Companies that are at lower levels of the maturity model are far more likely to have ongoing problems of this nature.

Those further down the path tend to have one of four situations:
- The IT group has learned strict rules about patches, upgrades and maintenance or has special rules for plant systems.
- Control systems are isolated effectively – in some cases at both hardware and software levels - from corporate or enterprise systems and networks. In some cases, all plant systems enjoy this level of isolation.
- IT requires redundant systems and only upgrades one at a time to ensure
operations and data flows can continue through maintenance events.

- A single individual, such as a plant manager, decides or coordinates when information systems maintenance can be performed to minimize disruption to the operation.

**BENEFITS**

Those at higher stages of maturity have seen ongoing benefits from the convergence of controls engineering and IT. The benefits accrue to every aspect of the environment – information flow and technology, organizational understanding, business efficiency and capability, and security and business continuity.

In particular, more mature companies have seen greater efficiency and lower costs as the team learns to leverage each other, as shown in Figure 14. One respondent explains it this way: "We recently began to rely more on outside firms to do our project development. On any given project, they could use any manufacturer’s technology or a variety of generations of PLCs or HMIs. That combined with the many mergers resulted in a significant amount of diversity across the company. That raises your total cost of ownership of process control, and you must maintain that expertise or pay for it externally. Recognizing that, it became clear that a common strategic direction was needed.” In other instances, both engineering and IT were working to present the same information. By converging, they can reduce duplication and confusion about where to find what.

**Figure 14: The most common benefit of convergence between controls engineering and IT is the performance of the team itself.**

ERP tends to have more accurate data when the data flows as a result of both controls engineering and IT involvement. One respondent says, “when you take the human factor out and it’s digital reporting door-to-door, and you can be assured that the systems are correct, you should be +/- 1% for things like inventory count vs. +/-15% using manual means and paper.”

Many have also enjoyed greater reliability and disaster recovery – or business
continuity – as a result of cross-functional teams. On the one hand, IT disciplines for continuity and disaster recovery are creating broader plans that encompass the plant and controls systems. On the other hand, creating isolated networks keeps mission-critical controls and plant systems operating even through IT network upgrades and ERP system downtime.

Engineers and plant staff historically “implemented the best way they could with the operating system, but they never really were expert in how to tune the system. Since learning to leverage IT, we have much more reliability.” Further, IT lifecycle management practices entering into the engineering realm help prevent use of obsolete equipment and software that vendors no longer support.

One respondent says, “The habits we got into as engineers meant troubleshooting at 2 am. We always just expected that. When people outside the real time process control function were exposed, they encouraged us to develop self-help troubleshooting tools.”

As managers of these converged teams would hope, it can also result in better service and shorter project timelines. Greater understanding at the outset, less contention and duplication of effort, and better communication are clear enablers of project success. Standardization and agreement among groups also encourages successful re-use and central support of systems.

Some have also seen benefits of having a central organization and documentation practices, so that information and the role of various systems is not hidden or unknown to others. One respondent reports, “opportunities to template and standardize more have resulted in better information sharing.”

In a previous job, one respondent said, “We dropped Ethernet ports behind the line to wherever a maintenance person might go – so the maintenance guy could walk up with a screen that allowed them to see all I/O. This alone reduced unscheduled downtime by 75%, since troubleshooting became almost instantaneous.”

Another respondent reported the nirvana that many hope for: improved plant performance, in this case in the form of higher throughput based on process speed and reliability as well as fewer non-conformances. Another sees “a daily punch list for how to improve” coming from their MES implementation, where controls and enterprise information systems meet.
BEST PRACTICES

While every company will discover what works to foster convergence and better working relationships in the specific environment, the interviews did uncover some best practices. We have picked out some that we believe many manufacturers can deploy or will need to build in order to succeed in bringing together controls and IT groups. Here, we group them into organization, technology and projects. The final chart in the addendum also calls out some best practices in each area.

**Organization**

**Ensure top executive support:** Senior Managers such as Engineering VPs, Operations VPs, and CIOs must endorse convergence in support of business goals and create a clear vision of the expected results.

**Create merged reporting:** Forming manufacturing-focused IT groups that report to both operations and/or plant as well as IT and controls engineering with common accountability or at least dotted line responsibility to same executive(s).

**Aligned incentives:** The most mature companies ensure all employees are working to core corporate objectives, and all individual objectives are aligned. One company reports, “The engineering team does not succeed if they don't get the software, and software does not get investment money if the plant does not meet the yield targets.”

**Hire for mindset:** Individuals’ way of thinking, attitude, communication skills, and interest in learning new domains are often more critical than current skills.

**Encourage functional rotation:** Companies that encourage cross-functional moves and even set targets similar to how companies manage diversity programs have been successful. Making someone accountable for an area outside their traditional expertise can really “get their feet wet” and drive further understanding.

**Leverage skills anywhere:** Once the systems are integrated, people from any facility can be called on to assist with situations in any other location. Leveraging human resources more completely can lead to shorter downtimes and optimum skills deployment.

**Allow ownership:** Everyone wants to contribute to value and not just cost, so standards can take hold more effectively if all stakeholders are part of the process and are allowed to take ownership.

**Manage change:** The common theory is that people don’t like change, but they can if it's managed appropriately. One respondent says, “People don’t fear change. They fear the process of change. Upper level management rarely manages change properly.”
Separate development from execution: Project teams should not set technology standards, but instead should leverage the work of a cross-functional virtual center of excellence (VCE) that sets the standards and core architectures. VCEs are ideally across corporate, division and plant to increase buy-in and reduce costs.

Technology

Develop guiding principles of design: Establish guiding principles that ground standards and technology blueprints or roadmaps. For example, in manufacturing good design must allow for maintenance without shutting down the system.

Standardize architectures: Cross-functional VCE teams can create corporate blueprints or roadmaps for architectures, so people in each plant have a framework within which to act quickly when they need to address an issue. Review these blueprints annually. Conduct peer reviews of designs.

Isolate networks: To allow appropriate management of each type of system and ensure production systems are reliable, controls should reside on a separate network or have software and possibly also hardware isolation. New standards for Ethernet on the factory floor do not mean that everything should run on one single network. One respondent says, “We protect the process control or manufacturing layer from 95% of the potential risks by restricting access.” A customer advisory council created by Rockwell Automation and Cisco advocated for converged network standards, but not a single network for controls and IT.

Heed systems lifecycle: While controls systems will have a longer lifecycle than typical IT, the discipline to upgrade or switch out systems before the vendor ends support is critical to reliability. Several more mature respondents have technical architecture maps with a cross-functional team that scores the health of each application every 6-12 months.

Manage contractor IT security: Contractor IT equipment should either be banned from networks or put through a thorough security and health check before each connection to the network.

Control IT change: To prevent the horror stories of IT patches shutting down production, companies are adopting strict rules about what can be changed and when, or giving engineering or plant management final say over timing. At the same time, support and change on controls as well as IT needs to be well documented with formal processes.

Formalize control system change processes: Formalize change management and change control process for all plant floor modifications (including change description, authorization, testing, back-out plan etc.).
Projects

**Demand sponsor participation:** Project teams that will deal with both IT and controls systems or data need to demand adequate involvement from the end user; ideally they drive the project. Teams with good initial and ongoing access to the person who needs the information show faster and better results. Usually these business process owners do not reside in either engineering or IT.

**Form cross-functional teams:** Creating core teams or other cross-functional teams ensures a full understanding of all goals and issues that go into the project design and implementation.

**Simulate outcomes:** Allow for opportunities to test ideas and assumptions. One respondent is using emulation software to show how a proposed project or change to a system will actually work in production.

**Avoid underinvestment:** Many companies that run each plant as a profit center face extreme pressure on spending. IT and controls must both fight to ensure the long-term viability of their systems and currency of their staff skill sets.

**Budget fairly:** As projects cross the line between IT and controls, it’s important that each group bear an equitable portion of the budget burden – and that no piece of equipment or software shows up on both budgets.

**Best practice feedback:** Conduct a postmortem at the end of each project to see if standards, policies or procedures need to be revised.

**Audit results:** Beyond initial justification, have project teams check in at major milestones to show an investment review board or accounting team what they have done and ensure projects deliver the value they promise.

**CONVERGE FOR COMPETITIVENESS**

The dynamic nature of today’s manufacturing organizations is resulting in more complexity in information and controls, while at the same time requiring extremely low-cost yet reliable operations. To survive, manufacturers must be efficient, effective, and enjoy seamless information flow. That can’t be done without more collaboration between IT and controls.
Many executives are pushing the vision of a real-time enterprise. A real-time enterprise enjoys instantly available information from IT that includes controls data. Fostering a real-time enterprise that can operate lean and still be agile is no small feat. While this vision can drive change, it’s generally not sufficient. Companies must take the next steps to enable controls-IT convergence to support that vision over the long haul. These entail making organizational, business process and incentive changes plus an investment in ongoing skills development and cross-training.

Once the IT and controls mindsets and metrics change, information can begin to flow that has not been available before. Projects to make that happen are less time-consuming and technology change is smoother over the long haul. One respondent points out, “You need the groups to have shared objectives – or it won’t happen.”

The manufacturers that are more mature in convergence are finding that benefits accrue at many levels.

- Enterprise benefits range from total costs of operations to improved decision-making to better business continuity. These benefits can also improve coordination with supply chain trading partners and customers.
- Plants can actually gain higher reliability and better performance with integrated systems and greater cooperation between groups.
- IT finds benefits in having secure access and appropriate management of plant-floor data as well as the opportunity for deeper understanding of the revenue-generation operations.
- Controls engineering groups see less disruption from IT practices and significant benefits from leveraging IT’s bandwidth, expertise, and best practices to lower their systems cost of ownership and risk.
- At a project level, efficiency in the team from more effective use of skills and knowledge can create shorter timelines and better service to the rest of the enterprise.
- Managers in IT, controls and production may become more influential as they gain dotted line reports in other groups or see employees with experience in their area move into other departments to provide liaison and understanding.
- Individuals in both IT and controls may find new career opportunities.

In addition, better information flows help align activities at every level. One respondent reports that “once people started trusting plant floor data, the quality department would come down and start working with an associate in the plant – so those plant people got feedback that their data was being used. At that point, things started to get fixed. Once they knew management cared, plant associates started going to the quality group when a problem arose, even before anyone in quality had time to run the reports. It has spawned a whole change of behavior.”
Many executives are striving for exactly that type of behavior change. What may be less apparent are all of the behavior changes required of the IT and controls engineering groups to actually achieve that larger result. Communication and understanding between the IT and controls engineering groups can take a long time to develop. Changes lie in vision, objectives, management, business processes, and every aspect of how the company manages both IT and controls technology.

With fierce global competition and ever-changing technology opportunities, manufacturers and their facilities may literally face extinction if they do not improve the agility, reliability and profitability of their plant operations. Good decisions and communications at every level of the company can help ensure competitiveness. Companies whose IT and controls groups have come together will be able to move faster, at lower risk to overcome threats and seize opportunities.
ADDENDUM: CONVERGENCE MATURITY MODEL

To describe the various areas where convergence is best seen or requires change, independent consultancy Systems Innovation Management, with some assistance from Industry Directions, developed a set of factors and grouped them into four major headings for the maturity model, as shown in Figure 15. Through the interview process, we learned what companies are doing in each of these critical areas and how strategies impacted the ability for IT and controls to operate and collaborate in an optimum fashion.

These 15 attributes or factors were the foundation of survey questions. In the course of the interviews, some common themes became evident. The highlights of these common approaches appear in the IT-Controls Convergence Maturity Model. Figure 16 (which is the same as Figure 6 in the main body of this paper) shows a summarized version of this model. The following pages provide further detail in each of the 15 factors.

Figure 15: The 15 factors in Controls-IT Convergence Maturity Model shown in their four major categories.

Figure 16: The IT-Controls Convergence Maturity Model includes four major categories that progress through five stages. Each company is likely to be at different levels in each category and in some cases even on various factors within a single category.
## Organizational Mutuality

<table>
<thead>
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<tbody>
<tr>
<td>Multiple BUs, units or organization operating independently</td>
<td>There is no single ideal model. Plants run as profit centers tend to have little centralized Corp. IT/Eng. staff. Tech guidance is by small dist. staff or plant mgt. Convergence &amp; tech decisions is led by plant mgt.</td>
<td>New tech flow &amp; project execution done by same team on next new project. Do IBS systems control approach to “tell me how to put the data” Limited collaboration between IT &amp; controls.</td>
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<tr>
<td>Duplication of staff across BUs and IT groups</td>
<td>Plants run as profit centers tend to have more Corp or division leadership and staff resources to set common direction and drive change management across the organization. Want a Corp. IT organization but often times disconnected from plant floor systems. Focus is on business systems &amp; computing infrastructure (planners, data center networks).</td>
<td>New tech flow &amp; project execution done by same team on next new project. Reasonable collaboration between IT &amp; controls.</td>
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<td>High need for very active business owner (i.e. superuser)</td>
<td>IF manufacturing systems not highlighted as a clear discipline or plant mill body, progress is slow, value tpp weak</td>
<td>New tech flow &amp; project execution done by same team on next new project. Reasonable collaboration between IT &amp; controls.</td>
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<tr>
<td>Incentives not an issue</td>
<td>New tech flow &amp; project execution done by same team on next new project. Reasonable collaboration between IT &amp; controls.</td>
<td>Same plus</td>
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<tr>
<td>Incentives not an issue</td>
<td>Reduced if tasks are to be done in parallel (reduce costs)</td>
<td>Kick-off meetings, integrated project plans, &amp; training on IT skills for controls may (know when to ask for help)</td>
</tr>
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</table>

## Converged Path

- Complete
- Strategic Plan or Excellent Progress
- Deliberate or Moderate Progress
- HighLevel or Slow Progress
- Not Started or Very Slow Progress

## Parallel Path

- Corp. IT group formed dotted line with plant staff
- Internal organization change between IT & controls
- Bridge or liaison persons appointed between two organizations to drive standards & cooperation
- New corp. or division mgt. IT formed
- Formalized IT mgt. w/ matrix reporting to both Corp & Div Eng. Mgmt.
- Development organization separate from project execution
- Clear vision and mission to change
- New org. driven reductions in Headcount and TCO, target 20% reduction
## BUSINESS PROCESS

### Business Process Maturity

<table>
<thead>
<tr>
<th>Component</th>
<th>Parallel Path</th>
<th>Complementary Path</th>
<th>Converged Path</th>
<th>Complete</th>
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</thead>
<tbody>
<tr>
<td>1. Not Started or Very Slow Progress</td>
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<tr>
<td>2. Haphazard or Slow Progress</td>
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<tr>
<td>3. Deliberate or Moderate Progress</td>
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<tr>
<td>4. Strategic Plan or Excellent Progress</td>
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<td>5. Complete</td>
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</table>

### 5. Budgets
- Separated at plant level by controls and IT
- Capital plan set at the regional or Div level
- IT is controlled split inside each capital project
- Some
- Core IT projects prioritized on enterprise project then cross-functional project
- Total is capped
- Manufacturing IT leader has a voice in all related systems budgets
  - Capital
  - Expense Mgr.
  - IT Corp.
  - IT Plan

### 6. Standardization
- Infrastructure vendor standard for proc. leverage
- GEACIT inventory bar tool model standard
- Software not standardized for mgmt
- Different tools and applications across DNT for MSS
- Controls written in a single plant may vary by plant project approach or whatever GIS delivers
- Lack of good controls inventory
- Infrastructure vendor standard for proc. leverage
- Social IT inventory begins to standardize on models
- Software begins to standardize, central ARIS services plant custom development
- Controls written in a single plant improve
- Larger diversity across plant
- GIS standards continue to be an issue
- Lack of good controls inventory
- Committees to set standards for IT hardware, software and controls
  - Standards available to all projects but lack systematic way of sharing or enforcing
- Controls standard across plants improve
- GIS standards become a negotiated topic in price and schedule
- Committees mature into VOs and broader buy into standards across DNT
  - Systems map to share and enforce standards
  - Controls high degree of standard across plants
  - Tech migration plans drive conversion of old tech
  - Work with DEVs on standards and automation suppliers on conversion getting plans

### 7. Time in change process
- Overall 3-4 yrs.
- Length of time to achieve a given level of maturity, considered highly to:
  - Degree of senior level management support & alignment
  - The extent of a clear manufacturing systems strategy or vision
  - The presence of a clear leader to drive the required process and cultural change
- Average 3.5 yrs.
- Average 4.75 yrs.
- Average 5 yrs.
## Technology Deployment Maturity

### 8. Tech Development

<table>
<thead>
<tr>
<th>Risk Started or Very Slow Progress</th>
<th>Raphazard or Slow Progress</th>
<th>Deliberate or Moderate Progress</th>
<th>Strategic Path or Excellent Progress</th>
<th>Complete</th>
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<tr>
<td><strong>Generally development done by</strong></td>
<td><strong>Some distinction between</strong></td>
<td><strong>Increasing use of Dev to</strong></td>
<td><strong>New org for development of</strong></td>
<td><strong>New org for development of</strong></td>
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<td><strong>some project teams for both</strong></td>
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<td><strong>face the Dev to</strong></td>
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<td><strong>face the Dev to</strong></td>
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<td><strong>excellence for</strong></td>
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<td><strong>by plant or corp. staff</strong></td>
<td><strong>NEIS projects</strong> into corp.</td>
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<td><strong>Controls dev. mostly done on new</strong></td>
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<td><strong>difficulty getting end user participation on both controls and IT projects.</strong></td>
<td><strong>difficulty getting end user participation on both controls and IT projects.</strong></td>
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<td><strong>between design staff, execution staff</strong></td>
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<td><strong>and plant resources.</strong></td>
<td><strong>face the Dev to</strong></td>
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<td><strong>Improved end user participation in dev. for both controls and IT projects.</strong></td>
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### 9. Tech Implementation

<table>
<thead>
<tr>
<th>Segregated execution between controls &amp; IT collaboration only as required.</th>
<th>Segregated execution between controls &amp; IT but collaboration improves.</th>
<th>Some dedicated support or project teams, joint project management.</th>
<th>Some integrated support or project teams, joint project management.</th>
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</tr>
</thead>
<tbody>
<tr>
<td>NEIS projects implemented entirely by IT or by end users at local plants</td>
<td>NEIS projects implemented by controls, IT and division staff with local plant involvement</td>
<td>NEIS projects implemented by division staff with some local plant involvement</td>
<td>NEIS apps. implemented by division staff with some local plant involvement</td>
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<tr>
<td>Difficulty getting end user participation on both controls and IT projects.</td>
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<td>- Skills shortage in the modern technologies, networks, servers, high level program languages, etc.</td>
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<td>- All struggling with software patch distribution and revision management processes</td>
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<td>- Standardization of CI/CD preferred hardware &amp; software that is compatible with the existing installed base as a growing problem</td>
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<td>- Many are deploying CI/CD on plant floor to reduce the burden of Dev support.</td>
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</table>

### 10. Tech Support

<table>
<thead>
<tr>
<th>Getting in…</th>
<th>General progress in collaborative support between controls &amp; IT, learning both sides, gaining respect.</th>
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<tr>
<td>Second line of escalation to local SS or OEM</td>
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### 11. Tech Migration

<table>
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<tr>
<th>Controls can recommend to Dev to update to newer tech, but Dev usually choses and must justify</th>
<th>Controls are limited to source planning, but NEIS applications primarily, combined with local capital plans</th>
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<td>Control flow in NEIS (PCs) may be replaced on corp desk top cycle, all after is still until no open parts are available</td>
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<td>NEIS software are generally system owners per customer requests. No master tech. migration plan.</td>
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### New Org for Development of Dev to:

- NEIS applications, done in part of systems team, plans, both treated as products in custom dev.
- Controls and Dev. dev. but by Dev. Org. includes teams members from Dev. corp. design, implementation, plant staff, and support organization.
- Business owners embedded in the Dev. staff.
- Business owners sign off on scope & tech.

### NEIS apps.
- NEIS apps. integrated with controls and IT.
- Controls and Dev. treat as products in custom dev.
- Controls and Dev. dev. but by Dev. Org. includes teams members from Dev. corp. design, implementation, plant staff, and support organization.
- Business owners embedded in the Dev. staff.
- Business owners sign off on scope & tech.
## RESULTS

**Business Results**

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<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Use of common off-the-shelf technology</td>
<td>Not enabling</td>
<td>Limited increased benefit</td>
<td></td>
</tr>
<tr>
<td>If plant floor &amp; project are, the controls programs, the</td>
<td>Evolution occurring on its own</td>
<td>Increased integration of plant floor data</td>
<td></td>
</tr>
<tr>
<td>controls programs</td>
<td>Progress driven from bottom up</td>
<td>- Real-time monitoring</td>
<td></td>
</tr>
<tr>
<td>If plant floor &amp; open architecture ownership up for gains</td>
<td></td>
<td>- Quality data</td>
<td></td>
</tr>
<tr>
<td>Ownership generally defined by levels in ISA model</td>
<td></td>
<td>- Inventory</td>
<td></td>
</tr>
<tr>
<td>- Layer 1 (controls hardware)</td>
<td></td>
<td>- Both mean involved in problem solving</td>
<td></td>
</tr>
<tr>
<td>- Layer 2 (HMIs)</td>
<td></td>
<td>Reduced number of plant developed systems</td>
<td></td>
</tr>
<tr>
<td>- Layer 3 (devices, MES applications)</td>
<td></td>
<td>Channels I &amp; O:</td>
<td></td>
</tr>
<tr>
<td>- Layer 4 (business systems)</td>
<td></td>
<td>Improved reuse of systems design</td>
<td></td>
</tr>
<tr>
<td>- IT users</td>
<td></td>
<td>Improved support with fewer on-offs</td>
<td></td>
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</table>

**Complementary Path**

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<thead>
<tr>
<th>Net Started or Very Slow Progress</th>
<th>Haphazard or Slow Progress</th>
<th>Deliberate or Moderate Progress</th>
<th>Strategic Plan or Excellent Progress</th>
<th>Complete</th>
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<td>Poor execution or results on past projects</td>
<td>SAP fails to implement MES systems</td>
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<td>Need for rapid plant expansion</td>
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**Converged Path**

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<th>Deliberate or Moderate Progress</th>
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### Additional Notes

- **Cost Issues**:
  - Costs segregated by IT & controls
  - Generally, IT not shared

- **Business Issues**:
  - Need to connect business systems to plant floor data
  - Staff understanding and outsourcers generally only partially known in IT areas
  - Increasing focus on process efficiency, OEE, yield

- **Solution**:
  - Reduced understanding and drive to reduce costs
  - Drive both operational & supply chain improvements systems technology

- **Evidence**:
  - Reduced integration in plant floor data
  - Real-time monitoring
  - Quality data
  - Inventory
  - Both mean involved in problem solving
  - Reduced number of plant developed systems
  - Channels I & O: Improved reuse of systems design
  - Improved support with fewer on-offs

- **Turning Points**:
  - IT must align with business, as their customer or peer. Their costs are accounting, IT management, purchasing, marketing.
  - Lack of people who know the business.
  - Need to change policies.

- **Benefits**:
  - Reduced overall cycle cost of ownership
  - Reduced plant downtime & increases throughput
  - Reduce non-conformance
  - Reduced system complexity due to fewer interlocks to support
  - Eases issues around resource shortages
  - Enhances ability to drive increased value from manufacturing process

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## BEST PRACTICES

<table>
<thead>
<tr>
<th>Organization Maturity</th>
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</table>
| **1. Structure and Leadership** | Organizational change to improve collaboration  
Plant-level reporting shifts to:  
- IT & Controls report to same person  
- Centralized MIS group formed in plant IT  
Corporate-level reporting shifts to:  
- Corporate or division manufacturing IT group with matrix reporting (CIO, VP Engineering, VP Manufacturing)  
- Bridge or liaison person or team appointed between IT and controls to drive cooperation  
Development organization separate from project execution teams  
New organizations should drive lower costs; possibly headcount reductions  
Clear vision and mission to change |   |
| **2. Business Model** | Highlight manufacturing IT as a clear discipline at every level; plant, division and corporate  
Plants run as profit centers have strong plant manager (CFO) for convergence  
Plants run as cost centers leverage corporate or division leadership to drive change and standardization |   |
| **3. Teams** | Active business owner defines requirements, assumed priorities, assure strong local project management  
Well-defined roles and responsibilities for all team members  
Kick-off meetings and integrated project plans  
Controls engineers increase IT skills yet know when to ask for help  
Technology and application development separate from project execution but collaborate on first few pilots  
Extensive use of Virtual Centers of Excellence (VCE) to develop standards  
Improved contractor management  
Everyone follows standards, procedures and best practices |   |
| **4. Employee Incentives & Training** | Consistent compensation  
Consistent overtime pay  
Consistent job descriptions  
Budget for ongoing skills development |   |
| **Business Process Maturity** |   |   |
| **5. Budgets** | Manufacturing IT leader has a voice in all related systems budgets:  
- Capital  
- Manufacturing expense  
- Corporate IT  
- Plant IT |   |
| **6. Standardization** | Committees or Virtual Centers of Excellence (VCE) to set standards for IT hardware, software and controls  
Standards available to all projects  
Systematic way of sharing and encouraging or enforcing standards |   |
| **7. Time in Change Process** | Gain and exhibit senior level management support  
Develop clear manufacturing systems strategy and vision  
Appoint a clear leader to drive required process and cultural changes  
Increase alignment over time but maintain flexibility for special conditions |   |
<table>
<thead>
<tr>
<th>Technology Maturity</th>
<th>Business Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Technology Development</td>
<td>Development teams, committee or VCE develops standards and best practices to lower total cost of ownership. Team includes IT, control engineering, implementation team, plant staff, support organization. Total systems architecture plan includes controls and MES applications developed collaboratively and managed as products (not custom developments). Design is collaborative between design staff, execution staff and plant resource. Business owners sign off on scope and technology in development and standards-setting phases.</td>
</tr>
<tr>
<td>9. Technology Implementation</td>
<td>Joint project management (Customer &amp; Mfg. IT). Dedicated IT support on project teams. MES implemented as product release with trigger code in data historian not PLC. Large controls projects implemented by division staff with good local plant involvement. Incorporate development group into execution teams for knowledge transfer and standards compliance. Joint participation and collaboration on both controls and IT projects. Integrated execution of controls between plant and corporate or division staff based on skills availability.</td>
</tr>
<tr>
<td>10. Technology Support</td>
<td>Integrated support organization at plant and corporate or division level with resources for controls, MES, historians, SCADA, etc. Integrated manufacturing architecture support team. IT providing more access to controls staff for hardware and software installations. Well-defined support and troubleshooting standards applied at plant and corporate level. Robust processes in software/patch/revision management. Standardize OEM provided hardware and software per improve integration into installed base.</td>
</tr>
<tr>
<td>11. Technology Migration</td>
<td>Comprehensive plan for manufacturing architecture including IT, controls and all applications. Plans integrated with capital and expense budgets. Longer-term view of optimizing value across varying product lifecycles. Plants execute smaller replacements; larger programs may call for corporate or division to execute. Formalize or adopt comprehensive systems lifecycle management approach.</td>
</tr>
<tr>
<td>12. Business Drivers</td>
<td>Ownership for lower 1, 2 and 3 shared between IT and controls. Collaborative effort on MES/production management. Total cost of ownership well understood, with drive to reduce costs. Drive operational and supply chain improvements with systems.</td>
</tr>
<tr>
<td>15. Benefits</td>
<td>Increased integration of plant floor data. Real-time metrics. Quality data. Inventory status. Technicians more involved in problem solving. Reduced number of plant-developed systems. Improved reuse of systems design. Improved support with fewer one-offs. Simpler system integration – fewer interfaces and platforms to support. Lower lifecycle or total cost of ownership. Reduced plant downtime. Increased plant throughput. Reduced non-conformance. Better use of skills. Improved ability to drive increased value from production process.</td>
</tr>
</tbody>
</table>
ABOUT THE RESEARCH TEAM

The principal researchers for this study were:

- Julie Fraser, principal and industry analyst, Industry Directions Inc. has been consulting, advising and researching manufacturing processes and systems for more than 20 years, most recently at Industry Directions Inc., a market research and industry analyst firm.
  www.industrydirections.com

- Ray Zimmermann, principal and founder of Systems Innovation Management, guided convergence processes at the largest US domestic brewing company until he recently “retired” and formed Systems Innovation Management.