

You're Agile or You're Dead

*How to make 20th-century control systems work
for a 21st-century manufacturing enterprise*



DCS Migration White Paper

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Introduction

Pundits have been predicting the death of manufacturing in North America and western Europe (what we used to call the First World) for decades. It hasn't happened yet, and it probably won't happen at all. The markets and the manufacturing capacity are so large it seems certain that manufacturing in North America and western Europe will continue.

When you add in the rising cost of transportation, and the rising cost of manufacturing in the formerly "low cost of manufacturing" countries, it also seems certain that some products now manufactured outside the First World will be brought home.

The Future Belongs to the Agile

Taking manufacturing to the next level.

While it may be true that manufacturing in the First World is becoming more competitive, this isn't a passive phenomenon. Companies that offer innovative product development, manufacturing operations and business practices are more able to respond to changes in business conditions on a global basis than companies that believe they are world-class and thus don't have to change. World-class is a process, not a title, and the process must continue every day.

In 1946, the philosopher statesman Bernard Baruch described the challenge of the Atomic Age. "We are here," he said, "to make a choice between the quick and the dead. That is our business." Baruch could have been talking about the state of manufacturing enterprises as we move further into the second decade of the 21st century. Markets are now global. We need to understand exactly what this means.

Until the 1980s, most manufacturing companies made products that were optimized for their home country, or home market. If they had "foreign subsidiaries" that manufactured, it was up to the subsidiary to either customize or even remanufacture the product to fit their market.

Beginning in the 1990s and continuing today, manufacturing companies are searching for ways to produce products that will sell into any market, anywhere. This means engineering, research and development, procurement, marketing and distribution have to be global in nature. This is a huge step change, and involves a great deal of reengineering of processes and factory assets.

Because markets are global, most manufacturing companies are no longer protected or buffered from changing product requirements by regulations or tariffs. It is necessary to respond today to trends that are discovered today. In other words, our manufacturing enterprises need tremendous agility.

Companies that really embrace global manufacturing and distribution — and are agile enough to cope with nearly constant change — are clearly becoming much more successful than companies that don't. Production costs go down, procurement costs go down, management costs go down, engineering and development costs go down, and profits go up.

In the future, companies that do not make agility a core value will fail. They won't just do poorly. Like Amalgamated Buggy Whip, they will fail. You need to create a "strategic agility plan."

“In the future, companies that do not make agility a core value will fail.”

To stay competitive in the global market, all your systems must be integrated to produce the least possible friction as materials become products and move to distribution. Friction occurs when systems don't talk to one another easily or simply don't interface well at all — and it costs money.

It's time to take a fresh look at your manufacturing operations, from supply chain to distribution channels, and make sure they are all integrated, both horizontally with each other as well as vertically to the business systems of the enterprise. And during that fresh look, you need to look at your existing manufacturing assets.

In the First World, it is simply not possible to knock down existing plants and build new ones from a green field. When you develop your strategic agility plan, a big part of it is going to be making all your existing assets work together in an integrated fashion.

Are you going to be “quick” or “dead”?

Continuous improvement isn't a buzzword.

Real agility means your business systems improve on a continuous basis. If it takes 10 days for a manufacturing change to come down to the shop floor, the plant has been making the wrong thing for 10 days. Systems are now capable of propagating enterprise-wide changes to bills of materials (BOMs) or production recipes or quantities of products to be produced in hours and minutes rather than days. Real-time or near real-time control of the production process is the path to real agility.

At the plant level, both management and supervisory personnel and the operators and technicians who run the processes must clearly understand the business drivers that affect the plant. In the past, plants have been optimized to produce the most of whatever their product is, without regard for the needs of the rest of the enterprise. This leads to stockpiling of products, or shortages of products down the enterprise chain. These all produce friction in the process, and cost money. In fact, some manufacturing theorists believe that operators in plants will be controlling their processes to business units, rather than engineering units in the future. People are already experimenting with real-time scoreboards in the plant and in the control system that make the operators continually aware of the effect of their actions on plant profitability and enterprise profitability.

Continuous improvement can't be a “motherhood” statement, either. Companies whose management, from the C-suite down to the supervisor on the plant floor, emphasize and reward employees for keeping to the blocking and tackling—the fundamentals of process improvement—will certainly be among the “quick.” And companies that pay lip service to continuous improvement will be counted among the “dead.”

One of the key goals in any reimagining of an enterprise's processes is to do all of this while keeping current operations going, continuing current rates of production and current levels of profitability. While concentrating on the processes and procedures of yesteryear is a recipe for disaster, completely throwing out what mostly works is a good way to fail disastrously.

“Sustainability, properly done, is creating manufacturing processes that produce the highest profitability over the longest period of time, taking into account social and political costs as well as cost of materials, labor and energy.”

Real sustainability.

Today, sustainability is a highly charged buzzword. Companies are all jumping on the bandwagon of sustainability, and “greener than thou” advertising is common. Sustainability, however, is more than reducing a plant’s carbon footprint. Properly done, it’s about creating manufacturing processes that produce the highest profitability over the longest period of time, taking into account social and political costs as well as cost of materials, labor and energy.

Energy management is one part of sustainability, and many companies have found rather large savings in changing light bulbs, going to demand pricing for electricity, gas and water, interfacing their HVAC systems to their plant distributed control system (DCS) and working on their manufacturing processes to reduce scrap and waste.

But energy management is only the low-hanging fruit.

Companies, especially process companies, have enormous investments in controls, instrumentation and control systems that are the tools operators use to produce profitable products. Some of these are seriously antiquated.

Real sustainability must take into account the performance of plant systems and controls as well as reducing energy costs. In order to accomplish both agility and sustainability, all control systems in the plant need to be audited for their ability to be used in the world of global manufacturing. One of the first things such an audit will indicate is that the asset management practices of most companies are awful.

Many asset management systems concentrate on either the control systems or the instrumentation and valves, and don’t integrate the other assets in the plant: rotating machinery, pumps, tankage and the like.

If you consider an agile plant an organism that can grow and develop, the control system is exactly analogous to the nervous system in the organism. The sensors that interface with the control system are the organism’s senses, and the operators form the higher consciousness of the organism, directing the input of the nervous system and the necessary actions.

What this requires is a completely different way of looking at control systems — a paradigm shift — that means the control system is far more important to the agile operation of a plant than the low proportion of its cost to the cost of the entire facility.

Do We Know What We Have Here?

The newest refinery in the United States is the ExxonMobil facility in Joliet, Illinois. In 2012, it will be 40 years old. It is an example of the aging manufacturing infrastructure in North America. Western Europe is somewhat better, since the majority of its industrial infrastructure was destroyed in World War II, and had to be rebuilt in the late 1940s and early 1950s.

The control system drawings and the piping and instrumentation diagrams (P&IDs) were made for the Exxon Joliet plant starting in the 1960s and 1970s. This is not unusual in First World plants.

As-builts? Not exactly.

The major cause of headaches for both operations and maintenance personnel in operating plants is the fact that “as-built” documents are often not updated. Many companies dedicated to the kind of agility we are talking about are doing a better job of updating those documents than other companies. Nobody is working from online, instantaneously updated as-built documents. This is like a neurosurgeon trying to figure out what’s wrong with a patient by working from X-rays taken 20 or 30 years ago. This is no longer just the “Holy Grail” of plant operations and maintenance; it is critical to producing and sustaining an agile plant structure. Companies that recognize this are going to succeed, while companies that continue to operate with faulty documentation are doomed. You cannot optimize a control system if you don’t know what you have to work with.

Documentation is sometimes three to four generations out of date, and many companies are lagging in digitizing and databasing the plant documentation. This means that when there’s a problem, somebody has to wade through dozens of drawings and specification sheets just to see where it might be. This takes time and costs money, and in our current economic environment, negative drivers argue that the updating of documentation is a non-essential function. They could not be more wrong.

In the aftermath of Hurricane Katrina, which demolished refineries and chemical plants throughout the Gulf Coast in 2005, the lack of and the destruction of much of the documentation at those plants required that people actually walk around the plant with clipboards, trying to figure out what each instrument, motor and control valve actually did, and where they actually were. Lack of documentation, including software and hardware, caused millions of dollars more, even after the cost of the destruction itself. This was especially difficult because many of the people who built and documented the plants were no longer available.

Who knows why we do that? Because that’s the way we do it.

Since the 1980s, reductions in force, retirements and even promotions have made keeping up the chain of knowledge about plant processes difficult and problematic. When asked a few years ago why he continued to put a process in manual and run it from the control panel, instead of using the advanced control algorithms developed for that process, an operator said he had been taught to do that by his predecessor, who learned to do it when the plant first went online. Why did he do it? Because it was what they’d always done.

The pool of people who know the reasons for the control schemas of the plant is shrinking. Development engineers from 40 years ago have retired and operators have been laid off. This leads to the kind of “magical thinking” that caused our operator to put the process in manual. Throttling down a valve, changing a flow rate — all because that was the way it was done when the operator was trained.

There is a notorious case of a major refinery that wanted to do turnaround on a unit that hadn’t shut down for a decade. They found that no one currently employed had ever done a shut down or a startup on that unit, and the current staff could not figure out from the available documentation how to do it safely. The refinery had to find operators and maintenance technicians who had once worked in that unit, and hire them as consultants for the length of the turnaround.

Training up new operations personnel.

All of this makes the training of new operations and maintenance people problematic. Younger workers do not have the science, mathematics and mechanical skills, on average, that the workers they are replacing had when they started. They don't really understand how the plant works. This is a problem for strategic managers as well as operations managers, because it may be that the management personnel don't really understand how the plant works either. Do you?

Teaching new operators and maintenance technicians how the plant works requires months. According to a refinery training manager at a major refinery, it takes eight to nine months before new hires are competent with the process systems, and it may take up to 10 years before a new hire achieves the same level of situational awareness that the average experienced operator or maintenance technician has. Without that situational awareness, operators make simple mistakes that can kill them, and stop production for months or years. The classic example of this is the incident at BP Texas City in 2005. The operators had had faulty situational awareness, and the incident killed 16 workers. If the operators had the appropriate understanding of the process, and the situational awareness to understand that something was wrong, they might have been able to stop the incident before lives were lost.

Because of the time required to train new personnel to have the same level of competence as the ones that are retiring every day, control system strategies have had to change. To compensate for lack of experience and understanding, control system experts (like ISA's ISA106 standards committee) have been advocating the increased use of procedure-controlled automation, even in continuous process industries.

If an abnormal situation occurs, in a state- or procedure-based system, the system itself knows how to control and recover from that abnormal situation. There's a defined state the system moves to during the abnormality, and there is a clear procedure to return the system to full operating state. The problem in getting to this kind of system is that many legacy control systems are simply not designed to do this.

The overarching issue with training and safety is that the cost of upgrading or replacing a control system is miniscule when compared to the cost of lost production and lost profit when an accident occurs. In 2012, the BP Texas City refinery has still not returned to full production, seven years after the event. If you do the math, the answer becomes self-evident.

Documentation — or lack of it — and reduction in agility.

If you don't know what you have in the plant, you can't reconfigure or redesign it. Yet many plants do not have adequate system and equipment documentation, and even more plants do not have adequate documentation of procedures and strategies that operators use every day. This intellectual property is not often storable in the control system, and is in danger of loss every time an operator quits, retires, is laid off or dies.

When asked how many pressure gauges there were in his refinery, the chief instrumentation and controls engineer of a major Texas refinery said he had no way of knowing — but he thought there were probably “a couple thousand.” Their staffing level had made adequate gauge rounds impossible to achieve years before, and he quite simply didn't know.

In order to achieve the agility needed to compete on a global scale in the 21st century, the prerequisite is detailed documentation and history, both of plant assets and intellectual property, and a means to save and add to it.

Connecting to the Enterprise

In the 20th century, most plants were islands. They produced what they were designed to do, without all that much regard for what the rest of the company was doing.

Ensuring agility.

One of the drivers demanding increased agility is the need to be able to reconfigure a plant in a very short time. Plants need to be able to make one product today, and another product tomorrow, and a third the next day. Otherwise, they may be producing product that must be inventoried, not sold. They might have shortages in their feedstock, too. How does a plant manager determine what the plant should be producing?

Agility demands instant connection to the rest of the enterprise. Every part of the enterprise, from the supply chain to the distribution channels, needs to be connected and data must move freely between operations. If there is a problem with a feedstock the plant requires, and the supplier can't deliver, the plant can switch to producing a product for which feedstock is available. But the plant needs to know that on a real-time basis. Production planning, accounting and analysis functions work much better if the data they're using is fresh and current. The only way to get that is to connect each plant to the enterprise and to each other.

Moving manufacturing data to the enterprise and business data to the plant.

In the past, such connections have been via specialized systems called manufacturing execution systems (MES) or manufacturing operations management (MOM). Data from the plant floor can be moved up to the enterprise layer fairly easily. It is more difficult to translate that data (which is real-time) into information the ERP and accounting systems (which are transactional) can use.

And the fact that the transactional data usually comes from month-end rollups means that instructions sent down to the plant have extraordinarily long lag times. Control system engineers understand that long lag times result in poor control. Most legacy control systems aren't capable of such real-time data exchange with the enterprise. Slapping a data historian on top of the control system and trying to keep the historical data as close to real-time as possible has not worked well. If the operator is going to run the refinery on business information to maximize the dollars per barrel of product, instead of the barrels per hour of product, business information must flow down to the plant while production data must flow up to the business level.

Real-time data must flow bidirectionally up and down the enterprise. An excellent example of how this must work is the spot energy market. Many plants are tied into the energy marketplace and purchase power and natural gas on a minute-by-minute basis. To aid sustainability, the plant often regulates its energy use if it can, to minimize high-cost times and maximize low-cost energy use.

First Make a Plan

If we accept that the control system is the nervous system of the continuously evolving organism that is the plant, we need to make changes and add new features or functionalities to the system at a strategic level, and then move on to the tactical level.

First do no harm — keep the plant running.

The first goal of any change must be to keep the plant producing while the changes are designed and constructed. Many refineries and chemical plants operate at more than 100% of design capacity, and on a 24/7 schedule. It isn't possible to stop all production to change or replace your control system.

This has resulted, however, in efforts to patch and band-aid control systems, to make immediate and tactical improvements, rather than analyzing what the real strategic requirements of long-term sustainable operation are, and implementing them.

What does your plant want to be?

Your plant needs to change to meet the continuously evolving demands of the global marketplace. Some things will give you bigger bang for your expenditure, and you should consider implementing this low-hanging fruit first. But you need to have a strategic plan that tells you what you will need to do after you've picked all the low-hanging fruit, and what to do next, on a continuing basis. You may not be able to upgrade your legacy control system enough to make your plant competitive. Rip-and-replace upgrades are frowned upon, but it could be that over the long term, they are the most cost-effective way to get a control system that can grow and change as the plant grows and changes.

What Goes Up Front

Planning a control system upgrade or migration requires input from a number of stakeholders, some at the plant level and some at other points in the enterprise. Procurement, supply chain management, distribution channel management, IT, health, and safety and security all have stakes in the design of the new system.

Planning should be strategic first, then tactical.

The initial urge is to do the project as fast as you can, with as little disruption as possible, and with as few changes to the control system as you can get away with. While this is seductive, it is usually the wrong course. Planning the project must first align with the strategic goals of the enterprise. Novelist Dorothy Dunnett once wrote, "Strategy is like geography; tactics are like chess. The first tells you where to go, the other what to do when you get there."

Assess your current control strategies.

Strategic planning of a control system upgrade or migration requires work on the front end before

the specifications are written. Do you know what your current control strategies are? Do you know why they were established in the first place? Do you know what goals they were established to achieve, and how those goals have changed since the plant was built and the control system installed? Do your current control strategies contribute to operational excellence and agility? If you wanted to change your control strategies, how would you change them, and to what?

Benchmark how well your control system handles those strategies.

How well are your advanced process control functions working? How many control loops are always in manual? Get operators and maintenance technicians to tell you how well the control system handles upsets, and how hard it is to reconfigure it for new products, feedstocks and higher quality. How well does your system provide you with forensic data? Can you tell how well the system is working by looking at the system itself? Can you determine what went wrong after an accident or incident?

Do a gap analysis.

What do you want and need that your control system isn't doing and can't provide? How well does the system integrate with the production control system, with the asset management system, with the supply and distribution chains? What do your operators want that the system can't provide?

“Nobody does a control system upgrade just because the system is old, or because there are flashy new features in current generation systems anymore. There has to be a realistic business case developed around the upgrade or migration of the system, or it will not be approved.”

Don't Base Decisions on Existing System Design

You need to start your strategic plan by ignoring the existing system architecture. This way, the decisions you make will not be forced by the design of the existing system, or by the limitations of a particular vendor's newest and greatest offering. In order to plan for a sustainable and agile control system, you need to keep your options open.

Plan the system functions and capabilities based on needs, not the hardware or software you have. Satisfy the needs of the plant and the enterprise, and the control system will specify and design itself, and maximize the return on investment at the same time.

Maximizing the Business Case

Nobody does a control system upgrade just because the system is old, or because there are flashy new features in current generation systems anymore. There has to be a realistic business case developed around the upgrade or migration of the system, or it will not be approved.

Some companies want to treat their controls and instrumentation like the piping and valves and tankage in the plant. They feel that the plant has a limited useful life and they just want the equipment and controls to last as long as the plant does. These are the companies that will not survive in the 21st century.

“Companies that just try to take the cheap way into upgrading to a sustainable plant control system will be out of business in as short as five years. The companies who take their control systems to the next level will crush them.”

At the same time, from a strategic perspective, you have to plan for the best overall bang for the buck. But don't plan for the cheapest solution, necessarily. Companies that just try to take the cheap way into upgrading to a sustainable plant control system will be out of business in as short as five years. The companies who take their control systems to the next level will crush them.

Plan for the future, not just to replace the systems you have. Making a plant sustainable requires considerable strategic planning as well as tactical execution and operational excellence. Just replacing the systems you have can well turn out to be false economy.

Innovation, Not Replication

One of the most important concepts developed by the Control System Integrators Association (CSIA — www.controlsyst.org) is the ability of the SI to be vendor-neutral, select world-class products and systems and integrate them into an operational whole. If your objective is a world-class sustainable manufacturing enterprise, that ability may be crucial to achieving your objective.

The control system you have in your plant now was designed for the plant you started with. If you simply replicate the system, you aren't taking the opportunity to design a control system for the plant you are today. Better yet, the plant you will evolve into over the next 50 years. Make sure you “future-proof” your control system as an integral part of your upgrade process.

Use this as an opportunity to really look at your plant and establish strategic and tactical goals so you can remain competitive in the 21st-century global marketplace.

Coda

This has been the first in a series of five white papers designed to help you discover the most appropriate way to modernize your control system. The next white paper in the series will take you through the strategic planning process we've outlined, and give you a glimpse of what other manufacturing companies have done, and are doing.

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