Manufacturing of the Future: Thoughts, Trends, Visions, and Strategies

Abstract

At ARC, we’ve been hearing and reading a lot more lately about the future of manufacturing. Some of this is best classified as “doom and gloom” speculation. But we’re also getting many positive signals from manufacturers who have a vision of where industry is heading and what they think they can become within this context. The point of this paper is to both discuss positive strategies for developing your own vision and sketch out a possible roadmap to get you there.

My only caution is not to expect the journey to be an easy one. There are some terrific technologies and frameworks available, but don’t expect someone to hand you a complete solution. There will always be “some assembly required.”

[Note: This paper has an accompanying PowerPoint presentation.]

Introduction

As a manufacturing company, you’ve already overcome considerable obstacles. You should take pride in where you are today. But, as you know, we live in an ever-changing world. Market forces have become global. Today, you can never relax knowing you are a leader in your region or your niche. There is always someone on the horizon with a new product, a lower price, or a lower cost of manufacturing.
Maybe your customers have always been demanding, but, today, customers are becoming even more demanding. If that was not enough, government regulations are putting more pressure on you. If you are in the food, beverage, or pharmaceutical industry, you have seen the impact of regulations aimed at making products safer for the public. At the same time, pharmaceutical companies in particular are feeling pressure to make their products available to populations around the world that often can’t afford them. Everyone around the globe is feeling the impact of rising energy costs. At the same time, today’s manufacturers have to reduce their carbon footprints and deal with other sustainable manufacturing issues, including increased costs for even some basic raw materials.

In many cases, the very people you want to turn to for help in these situations are likely part of the “aging workforce.” If there’s any bright side to the current global financial crisis, it’s that many of your older and most experienced workers are now likely to put off their retirements for quite a while.

But despite all these challenges, there are opportunities for agile manufacturers that can look ahead and have a vision of where they want to go.

**Getting Started: Create a Vision**

At this point, I would like to take a few minutes to help those in the audience that have not yet gotten started with their “manufacturing of the future” vision.

First, you need to establish your own unique expression. This is partly to have a “rally call” for your people and partly to tell the industry that you are on a path to do something really terrific. But mainly, it is to get all your own people on the same “page.”

Think of your vision statement as the “elevator pitch” to your executives. Actually, it must reflect what they already expect and wish to accomplish. It usually says something about “achieving superior performance.” Frankly, I have never seen one that says, “be in the 4th quartile.” Your vision statement should have a date or time span in which the people watching you can expect it to happen. The next part is more difficult, since it starts to get into reality.
Getting Started: Create a Vision

- **Objective:** “Manufacturing of the Future”
- **Vision:** “Obtain 1st quartile sustainable performance by 20xx in manufacturing operations by leveraging people, technology and processes…”

Before you can create your strategy, you have to have an understanding of what is possible. Since you’re probably working in an existing manufacturing operation, you need to find out what is the current state of the art. Certainly, you’ll want to your current suppliers their opinions, but you also want to be sure you have the whole picture of what is possible to achieve. For example, when one thinks about technology today, the topic of wireless seems to always come up. Is wireless ready for your operation? Or perhaps it’s better to ask, is your operation ready for wireless? As one data point, find out what are your competitors doing.

You will ultimately ask the question, “Is there a simple approach to achieve what I want to achieve?” But keep in mind the statement attributed to Albert Einstein: “Everything should be as simple as possible, but not simpler.”

**Automation Technology: Then and Now**

For those of you just beginning this journey, it may be useful to review a little history to put the evolution of automation system technology into a kind of “maturity” perspective. Gordon Moore, co-founder of Intel, predicted that the transistor density equivalent in microprocessors will grow exponentially, essentially doubling every two years. This has become known as “Moore’s Law.”
Relating this to automation system technology, one can trace this back to the ‘60s when the first digital technology was applied to manufacturing. The term used in those days was, “computer integrated manufacturing,” or “CIM.” In those days, the computer was the star and the general philosophy was: “let’s put in a computer and see what happens.” At the risk of dating myself, when I got into this business back in the early ‘70s, I became involved with a project we called, “computer control.”

You can see by the curve that the technology has progressed on an exponential path. What I want to point out is that it has evolved along very distinct stages, or “eras”. After the CIM era, came the invention of two very important approaches to control systems: the DCS in the process world, and the PLC in the discrete world. I refer to this here as the “system centric” era. Next came the “network centric,” era, or as some called it “open systems.” During this era, the focus was integration of PLCs, DCSs, and other technologies that were being deployed into manufacturing. The next era is what we refer to as the “application centric” era, whereby the shift was away from the hardware and basic software focus to a more application focus. It also happened to be the era where information technology (IT) standards and technologies began merging with the automation technologies and applications.

Today, we are at what ARC refers to as the “business centric” era. The focus has shifted once again from the technology, whether it is hardware or
software or networks, to the business problems that these systems must solve. Manufacturers are increasingly aware that, to fully achieve this, we need to have industrial standards to support the advancement of these manufacturing systems as we move forward.

The main point here is that unlike in past eras, technology should no longer hold you back! There is plenty of technology available to achieve what you want to achieve. However, you must have a solid business strategy to make the choices of technology effective for you.

**Wireless Technology – Déjà vu**

Now back to the subject of wireless. In my opinion, wireless technology is in an era today that is a lot like the 1980s was for automation systems. In many respects, we are still discovering the potential of this family of technologies. I say “family” because it is not one thing. Also, it means different things to different people. It is an adjective that needs a noun! For example, “wireless protocol,” “wireless telephone,” “wireless PDA,” “wireless sensors,” etc. I think you get my point.

So if you look at the overly simplified history here you can see that the use of wireless technology has been around for a long time. Going back in time, the “real” SCADA applications such as pipeline control would have been far more difficult without licensed spectrum telemetry. In the ’90s, the consumer era began with the introduction of GSM and CDMA to create the cell phone or mobile phone industry that has totally changed how we personally communicate today.
Next came the Wi-Fi era that allowed computers to become un-tethered. It also allows people to move around with their Wi-Fi enabled laptops and work from places such as Starbucks.

Today we are beginning to see the true potential of wireless technologies for business in general and specifically for manufacturing. And like the previous discussion of automation systems, there is a need for consolidation of the variety of competing technologies through standardization.

**The Need for Standards**

ARC views standards in “three flavors. Formal standards, such as IEC or IEE, are true vendor-agnostic standards that promote choices for the end user. De facto standards, such as Microsoft Windows, which may (or may not) be used by multiple vendors, ultimately limit end user choices. The final category is proprietary. This is not really a standard at all, but rather one supplier’s use of technology. The reality is that this is how the maturity model of all technology begins; someone develops something useful with a new proprietary technology. It is not a bad thing. It is just the way it is. You just have to be aware of what you have when you buy a solution. By buying a proprietary technology, you are committing yourself to a single supplier in most cases and this might limit you down the road.
You should also have your own internal standards, which is all part of knowing where you are starting from – creating a “vision of where you are going” – and your road map to get there.

**Collaborative Manufacturing Management**

This brings me back to establishing your own goals and vision. A few years ago, ARC introduced the model we called, “collaborative manufacturing management,” or “CMM.” In my opinion, this is a good place to start our manufacturing of the future discussion.

The focal point of this model is the manufacturing plant. But first, the plant has to be put in context to the chain of operations in your enterprise. Your plant can be thought of as a “node” or “link” in the chain. It is more than a “supply” chain, in that it must consider engineering and other aspects that enable your enterprise to produce the products you deliver to customers.

We created the CMM model to help visualize what we mean by collaboration. The network might be entirely yours, or it might include your trading partners or service providers. For sure, you need to include your suppliers and most importantly, your customers, in this collaborative picture.

Let’s focus in on the manufacturing activity itself, which I characterize here as the “process plant”. If you think of the manufacturing plant or factory or site as a node moving in time, at the focal point of this node is the intersection of three types of activities that require collaboration.

The first is represented as the horizontal axis that we call the “value chain domain.” This is easy to visualize in that it the chain of activities in which your material suppliers provide you with the raw materials needed to make your product is on the left side of the picture, and on the right side, are your customers that receive the product. If there is no communication with the front end or the back end, you know how inefficient things will be. But if you think beyond mere communications and start thinking collaboration, imagine how much you can increase efficiency. The concept of “demand driven” supply chains is an example. Imagine how effective your plant could be if you were able to anticipate all your customers needs in advance.
The axis labeled “lifecycle domain” actually has two dimensions to it. It is about the lifecycle of both the plant equipment and, if appropriate, the product you make. If you make food, beverage, or pharmaceutical products, then you must be concerned with keeping track of where the materials that go into the product came from as well as where the product goes. At the same time, you also have to be designing the next product you’ll be introducing into the market.

The third axis is where most of the discussions that relate to automation systems are concentrated. This is the axis where production collaborates with the business. It is where the orders are placed on production. It is where production systems provide information about what was made.

A collaborative infrastructure is required to make this work smoothly. Unfortunately, today, a lot of enterprises rely too heavily on humans to provide the collaboration. But to automate this is not easy or simple.

**Business to Production: The Enterprise Domain**

This is a more granular block model of what the functional activities are inside the plant. Again, it is simplified, in that you could take any one of these “blocks” and find a great deal of complexity. For example, “quality compliance” is shown as just one block, but it can easily be further broken into many functional pieces. Also, the lines that connect these blocks are only showing the dominant connectors. If all the interactions were shown, you would not be able to see the blocks. My point is every plant has an implicit or explicit structure such as this that shows the functions that make that particular plant it work.

It helps a bit to understand that these activities fall into classifications such as “product innovation”, or “business planning and logistics”. Collectively, these areas are where your next great product will come from, or where all the order entry and accounts receivable reside, respectively. Let’s focus on “operations management,” since it relates so directly to manufacturing and automation.
Manufacturer’s Problem is Greater than a Collection of Applications

As the different colors in the picture suggest, this is the realm of multiple applications and multiple suppliers. Furthermore, it is the interface between the near real-time and transactional functions in the plant and the very real-time automation and control. Nowhere else in the enterprise is there a need for tighter and consistent collaboration than between the functions represented here.

Besides the view that shows the functions that need to be performed, there is an architectural view to show the equipment and network organization. Traditionally, this has been viewed as levels defined by the technology used to run the applications. For example, at the lowest level, are the field devices, actuators, and sensors. Historically, this level has been heavy on hardware functionality and light on software. Today, however these devices come with a lot of software intelligence. The next level is traditionally the control level. Between these two levels is a very old, yet still dominant standard for communication: the 4-20 mA analog signal. Through this standard, virtually any supplier’s field device can transmit a process variable to any other supplier’s control system. As we have progressed along on the technology maturity curve, we can now connect almost any field device to almost any controller using a standard digital fieldbus. I say “almost”, since on the process side, there is not a single standard, but two dominant ones; Profinet and FOUNDATION fieldbus. The good news is that most systems can support either. And many field devices come with a choice of these two fieldbus protocols.
The problem is much worse for wireless communication and connectivity, where there are still a lot of proprietary approaches and a handful of standards activities battling each other for dominance.

The process control and operations management levels of the architecture are another hotly contested area, but for different reasons. Fundamentally, everything at these levels communicates over Ethernet and the hardware is largely standardized on “Win-Tel” (Windows/Intel) platforms. But the actual protocols used by the automation suppliers are still not based on a single international standard; you can’t plug a Honeywell controller into an Emerson control network and expect it to work. However, there are bridges, such as OPC, that allow applications from one supplier to communicate with another. This too is a work in progress, but it has greatly reduced the connectivity dilemma.

Another reason for contention is that automation suppliers have been busy buying software companies to fill out their respective portfolios in the operations/production management (or “MES”) space. Meanwhile, companies such as SAP, ORACLE, and others have been moving into this space by providing applications that address some of the functions required for operations management.
The problem for you, the manufacturer, is that in this operations management area, unless you buy all your applications from a single supplier, you are faced with the problem of integrating proprietary applications.

In time, the evolving ISA95, “production-to-business” standard will provide the answer. This is not a detailed standard such as the 4-20 mA example of old, but instead, is an “80 percent” solution. This means that it will make different suppliers 80 percent compatible, and the remaining 20 percent or so will have to be accomplished with unique work by you or your integration partner.

The last point of contention is an internal one that perhaps you have already solved in your company: who “owns” this area? Is it your IT group? Is it your automation group? Or is it some combination of the two?

**Lifecycle Domain: Asset Information Management**

Every manufacturer has considerable investment in assets. The simple model here shows the lifecycle of the assets in your plant. These start with the “idea,” and end with “decommissioning.” The “operate and maintain” phase is typically the longest phase. And by virtue of what is at stake for you, it is the most important.

The early phases, however, have more than just casual influences on how the operate and maintain phase performs. The plant and the plant assets must be built for the long term view. Most manufacturing plants are ex-
pected to operate for 20, 30, or more years. Properly designing the assets with this in mind is a good start, but there are performance opportunities that will only come to light with time in operation.

One frequently missed opportunity is that of transferring asset information from the design and commissioning phases to the operate and maintain phases. Often the transferred information is static. That is, the information is in the form of books, or the digital equivalent of books, that go on a shelf. Soon the information in these books or static data files becomes obsolete and untrustworthy.

Asset information management should be one of the state-of-the-art concepts built into your manufacturing of the future vision. First, asset information management is a living database of information. It starts with the information that is developed from the moment that the “idea” of the asset is born. This information evolves as it passes through the various steps of design and implementation.

There’s some real value associated with of keeping your asset information up to date.

For example, ARC estimates that a good management of change (MOC) process is worth from 2 percent to 3 percent of the total CAPEX of a project.

NIST estimates that the interoperability savings, that is the savings on your project by having design/build teams that are working on various applications and steps of a capital project, is worth 1.3 percent of the installed cost.

NIST also estimates that 2.8 percent of the asset value is the benefit of having asset information management extend to the operate and maintain phase. In addition, if the information about the asset is maintained, as much as 30 percent improvement in maintenance efficiency can be achieved.

Finally, as the assets age, having information about the equipment -- such as knowing the optimum time to upgrade or replace -- is valued at up to 30 percent of the engineering costs.

If you don’t believe that asset information management can save you money, just ask yourself how much maintenance time alone is wasted every day just looking for the right information?
**What’s Possible for Manufacturing of the Future in My Operations?**

What do you see when you look at your operations? When looking at a typical photo of an open pit mine, for example, do you just see heavy assets such as haul trucks or loaders, or do you see the exciting possibilities for operational improvements that properly applied modern automation technologies (such as wireless communications) and approaches (such as asset information management) can deliver?

From an automation and asset information perspective, there are a lot of possibilities to consider. For example, chances are, there is a three-dimensional map of the mine’s ore deposits. With the assay information, you know where the concentration of ore is for processing. If you know where the machine is digging, then you know the ore quality that is being loaded.

Another possibility is using the intelligence on board these vehicles to not only monitor asset health, but also to diagnose and inform. With the wealth of communication technology available, this information can and should be sent in real time to people and applications that can optimize the use of the information; to a central command center, for example.

Other on-board systems could include anti-collision software. Not only is this important to protect equipment, but also to protect personnel. Using an industrial wireless infrastructure, you could also implement personnel locator applications, so that you could know where people are and who is operating the various pieces of equipment. Meanwhile, back at the command center, you could be receiving an alert that the operator of the truck is in need of a training refresher.

**What is The Value of Realizing Your Vision?**

Once you start the journey toward your future vision, you realize there are many things you can do. It’s important to always keep the business perspective in mind, so that you do the things that have the most value to your company. Many things, such as investing in asset information management, can deliver benefits across multiple areas. For example, if you were the manager of our hypothetical open pit mine, knowing where your equipment and personnel are in real time, coupled with an actively managed on-board collision avoidance system, can deliver savings in avoided unscheduled downtown, but also in productivity, capacity utilization, and
even energy usage. I believe the following estimates are conservative for this industry. Please let me know if you agree or disagree.

<table>
<thead>
<tr>
<th>Benefit Description</th>
<th>Improvement</th>
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<tbody>
<tr>
<td>Increased Capacity</td>
<td>1 percent to 3 percent</td>
</tr>
<tr>
<td>Capacity Utilization</td>
<td>3 percent to 5 percent</td>
</tr>
<tr>
<td>Unscheduled Downtime</td>
<td>40 percent to 50 percent</td>
</tr>
<tr>
<td>Productivity</td>
<td>7 percent to 10 percent</td>
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<tr>
<td>Fixed Cost Reduction</td>
<td>10 percent to 15 percent</td>
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<tr>
<td>Energy Utilization</td>
<td>5 percent to 7 percent</td>
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(In fact, the percentages above came from an actual case in the petrochemical industry that resulted in more than $20 million in annual savings for an Ethylene manufacturer.)

**Conclusion**

Although I used examples from the mining industry, I hope you all can see the importance of developing your own vision for “manufacturing of the future.” Even the best run enterprises need to realize that there are always improvements that can be made. It is not a technology issue. There is plenty of great technology. Technology is an enabler, as are the people and your business processes. As you develop your solution, remember that there will be some assembly required to reach your vision. Keep it simple as possible, but no simpler.