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CMTC's Guide To
Smart Manufacturing

SMART MANUFACTURING
THE NEXT REVOLUTION IN MANUFACTURING

This white paper aims to inform manufacturers of the Smart Manufacturing components, how it affects business productivity, economics and plans, its importance in the value chain, how it changes the workforce and the future of manufacturing overall.

It was a joint project between California Manufacturing Technology Consulting® (CMTC) and the Smart Manufacturing Leadership Coalition (SMLC).

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Chapter 1:
Introduction of Smart Manufacturing

Of course every manufacturer would like to believe what their organization is doing is smart, but this concept of SM isn't exactly about individual intelligence. Rather, it's about the manufacturing industry as a whole and amplifying its productivity, technology and communication along the value chain. In this white paper, you'll learn the importance of Smart Manufacturing, how it can transform one's organization and what to do to prepare your employees for this change.

What exactly is Smart Manufacturing?

Over the past several years, the topic of Smart Manufacturing (SM) has been a conversation among industry experts, strategists and thought leaders. However, despite its media coverage, many on the front lines of manufacturing aren't quite sure what Smart Manufacturing entails or why it's even relevant to their organization.

To state it simply, it is the use of real-time data and technology when, where and in the forms that are needed by people and machines.

But, if you are looking for more comprehensive definitions, there are two from leading organizations. According to the National Institute of Standards and Technology (NIST) SM systems that are *"fully-integrated, collaborative manufacturing systems that respond in real time to meet changing demands and conditions in the factory, in the supply network, and in customer needs."*

The Smart Manufacturing Leadership Coalition (SMLC) defines SM as "the **ability to solve existing and future problems via an open infrastructure that allows solutions to be implemented at the speed of business while creating advantaged value.**"

The concept and successful implementation of SM is being predicted to be the next Industrial Revolution. And with many other advances in recent years, it all has to do with **technology connectivity and the unprecedented access to, and contextualization of, data.**

The Tools that Make SM Work

In the same way there are "microprocessors" that make it possible for smartphones to operate like mini-computers, there's the "cloud" where an almost-unlimited amount of data can be stored and retrieved.

Also, there are "apps" that can be downloaded to help us keep track of what we spend, track the location of people and devices, track how many steps we've walked, etc. SM utilizes all of the same components, addressing the complexities of security, interoperability and intellectual property for manufacturing.

SM will create an **open atmosphere** where fact-based decisions can be made and decision makers will have the trusted data *when* it's needed, *where* it's needed and in the *most useful form needed*. Solving problems will be based on a total picture.

Smart Manufacturing Benefits: What Are They?

This merger of the physical and virtual worlds (cyber physical systems - CPS) opens up new areas of innovation that will optimize the entire manufacturing industry to create **higher quality products, improve productivity, increase energy efficiency, and sustain safer plant floors.**

Furthermore, smarter factories also offer the opportunity to boost employment 2-4 times over the current national manufacturing workforce of 12 million. As SM is adopted, new technology based manufacturing **jobs will become available creating direct manufacturing and non-manufacturing positions.**

Creating smarter factories will allow the U.S. to remain competitive with manufacturing organizations abroad. New, overseas manufacturing facilities are being constructed with Smart Manufacturing technologies built-in. In order for the U.S. to remain competitive, it needs to embrace Smart Manufacturing with people who have the desire to get in on the ground floor. *See more about SM's benefits in Chapter 4.*

What Does SM Mean for the Manufacturer?

If you're a small manufacturing organization, *what are your strategies for improving upon your processes? What do you want to accomplish – increase sales, reduce costs, improve efficiency, or have a more agile supply chain?* It's likely that you've purchased hardware or software along with a license to use the technology to help you accomplish one or more of your goals.

While the intent of these products is beneficial, **"the ability for a small manufacturer to leverage any type of business intelligence from legacy systems has been extraordinarily limited. These systems are generally not interoperable,"** explains Denise Swink.

"The business model by solution providers is generally **non-scalable, non-replicable, complex and highly costly.** It's becoming out of reach for many organizations and especially to small companies. Smart Manufacturing on the other hand brings small and medium manufacturers the ability to **access new and growing forms of business intelligence.**

SM offers tools to analyze data and test simulations that can drastically improve their performance, products and designs." It also offers the ability to collaborate with suppliers, both upstream and downstream, more effectively.

Chapter 2:
The Smart Manufacturing Buzzwords You Should Know

Now, the idea of SM can be overwhelming with new buzzwords to understand and a new way of thinking that needs to be mastered. In this section, we'll break down the essentials to ensure you're aware of every component that makes up this new Industrial Revolution.

For further definitions on all of the Smart Manufacturing terms, refer to our Glossary of Terms at the end of this white paper.

The Smart Manufacturing Platform

The concept of a cloud-based **open access SM platform** allows manufacturers to integrate existing and future plant data, simulations and systems across manufacturing functions. What does this mean?

The cloud is basically a secure network of servers on the internet to store, manage and process systems data and analytics. Why is this important? **This eliminates the need for companies to purchase and maintain a large IT infrastructure** that requires support.

Today, although many manufacturing processes rely on control contributions by computers, the systems and data on these computers exist in silos **with little or no connectivity**. The SM platform will allow processes to be integrated to support informed decision-making. In some cases, the integration of currently siloed processes may bring to light hidden inefficiencies and waste.

Companies of all sizes will be able to gain **easy, affordable access to run simulations and gain analytical data for their particular needs**. Manufacturers will have the newfound ability to **shop for applications through the Marketplace** that cater to their organization's needs using ANY device with internet capability.

The Smart Manufacturing Marketplace?

The SM Platform will be supported by an open Smart Manufacturing **Marketplace** that will offer both **free and pay-as-you-go applications (apps)** to help manufacturers fine tune their business.

With a business model that resembles an App Store that you find today on your smart phone, this cloud-based Marketplace will allow users to affordably "window-shop" for applications while **offering app reviews from fellow manufacturers** and **app testing abilities** upon purchase of a trial version.

However, unlike the apps on your smart phone where you can only use one app at a time, SM allows you to **link multiple apps and create workflows** that use existing processes in your company to solve specific business objectives. There will also be a certification process to ensure the validity and quality of apps in the marketplace.

The Marketplace will reduce the need to invest in long-term hardware solutions. Because you are accessing the Marketplace through the SM platform, the platform will serve as a layer of reasoning and intelligence that extends the capabilities of the physical equipment you already have.

Real-Life Example

Let's say you access the Marketplace and you are searching for apps that are associated with metal fabrication facilities and optimizing processes. Your search would retrieve apps that would offer processes optimization for metal fabrication facilities. Additionally, the Marketplace would include a basic history of the app and other types of businesses that have used it along with their reviews.

Manufacturers will have access to a broader set of talent and innovation. An open architecture will attract entirely new communities of solution providers. These providers will enhance existing solutions and lower the barriers to contributing or commercializing new, innovative software applications used in manufacturing.

While the infrastructure of the SM platform and its accompanying Marketplace has yet to be finalized, it has the potential to flip the current state of manufacturing processes and automation on its head.

How Manufacturers Can Prepare

Without a doubt, the SM journey is already underway in larger manufacturing facilities like those of General Mills. Once the Marketplace is fully functional, progress within your organization will be possible.

There must be a way to extract the quality control data of interest from your business operations and machines. Although the SM platform is still under development, there are things that a manufacturer can do to prepare.

One is to make planned equipment purchases with a view toward SM. There is manufacturing equipment today that offers data gathering and data collection capabilities. Another way to prepare is to confirm capturing of data and its contextualizing information that will be most relevant to answering/addressing your pressing business needs and challenges (use cases).

These approaches, in combination with the SM platform and the Marketplace, promise **to give companies that have adopted SM a competitive advantage by better enabling fact-based decisions to address challenging issues.** In order to be ready for these technological advances, a manufacturer can start taking small steps today to improve their overall production performance by **beginning to invest in "low-cost" smart technology** that they can use in the future.

In the next chapter, we will go into more detail about the infrastructure changes that manufacturers should consider for the future.

Chapter 3:
Infrastructure Changes: The What, Where & Why

A common misconception about Smart Manufacturing (SM) is that it will require organizations to drastically transform their current operations and invest in advanced technology that will be too complex to adjust to. While some change is necessary, of course, SM greatly simplifies this transition **by building to the capabilities that manufacturers have *currently*.**

One of the key concepts of Smart Manufacturing is recognizing the value of data as a key asset to be developed and managed. Put another way, for a system that analyzes data, the key asset is not the analytics system itself but the data itself. It's the data used to build and validate the analysis and the data that are generated. Such an emphasis on data causes us to think differently about where to focus resources.

For any operational objective there needs to be a source of relevant data. The sources of data can be as basic as a fax machine, tablet or smart phone -- or as sophisticated as a wide area sensor network. The point is, data is valuable in the context of the operational objective, not the sophistication of the sensors. There are many highly beneficial applications that can draw upon data.

Put simply, as long as it's possible to get data to the SM network, the factory can begin their SM journey. Infrastructure changes needed to accommodate the applications that use and act on the data **happen within the SM platform** — giving manufacturers the convenience of making less drastic changes within their facilities.

Smart Manufacturing will lead to significant changes in business opportunities and operations over time. Jim Davis, Vice Provost of Information Technology at UCLA stresses the importance of starting small and working Smart Manufacturing as a *progression*.

Data: The Glue between Operations & Results

End-to-end sensor to action software systems that have been cost prohibitive will become more affordable. B2B applications will have a trusted and secure platform that supports IP policies encouraging collaboration with respect to data, models, and analytics, as well as ensuring data owner agreements, policies, regulatory requirements, etc.

In a fully developed smart factory and/or supply chain, employees will be able to access pay-per-use applications from a **SM Platform Marketplace** (see page 7), assemble data management, analytics, models, dashboards and interface applications into a full range of enterprise systems including real-time systems for optimization. Data is drawn from sensors and/or manually input data from operations. Manufacturing workers in the loop are readily accommodated including validation and decision-making. The employee can focus on function and outcome and **not** on infrastructure technology and maintenance.

When there is an ability to begin using data more robustly, manufacturers can begin to see untapped opportunities— and in real time. For example, enterprise analytics across plant floor operations give managers the ability to pinpoint areas of opportunity not readily seen otherwise.

"If you're able to "see" the product while it's in production and "see" the overall production process it opens quite a few doors to be responsive to product and manufacturing demands, as well as more dynamically predict and adjust to improve productivity and the quality of the product," says Davis.

There is quite a bit of untapped opportunity by now considering the enterprise and not just vertically optimized operations. Initial benefits are invariably with performance. This includes: less downtime, fewer defects, unnecessary back-and-forth adjustments, higher productivity with quicker, more effective ways to manage the manufacturing operations and the quality of the product.

Many possibilities that have already been considered cost prohibitive now become doable. Progression enables manufacturers to grow into using **big data** for new operational insights.

Using Sensors and Data Today

In terms of SM, the implementation of sensor and data collection methodologies should always have an objective. "It's far better to start with a fairly simple problem and understand the intended outcome before applying more data and additional sensors to help navigate the solution," explains Davis.

For example, if we refer back to the idea of **progression**, starting with a less ambitious objective often leads to a more contained data and sensor set. This is advised so a facility can master its data capabilities and, most importantly, get to really know the data and learn from it. With this kind of staged approach the manufacturer can determine set objectives, ensure growth, reduce risk and conserve capital. It is all about thinking about how data can move a business and/or operation to achieve efficiencies or increase revenue.

The Cloud, IT & Interoperability

In Smart Manufacturing's IT infrastructure (SM Platform), companies will be able to access applications and resources from the cloud that can be directly used to analyze and manipulate data to the benefit of their manufacturing processes.

The open infrastructure scales to lower cost and interoperate securely with commercial applications and infrastructure providers. Most importantly, the SM Platform makes it possible to substantively reverse the mindset about data, applications and IT infrastructure.

Rather than being restricted to using less-than-ideal software or constricted with moving to new software, SM makes it possible for small, medium and large manufacturers to more easily change. By reducing the emphasis on infrastructure, companies can reach untapped potential with more resources and innovation available at their fingertips through the data.

Piloting new technologies that draw further information from the data with low risk should be easier. Resources include individual software applications, libraries, deployment infrastructure for setting up simple to complex real-time data systems. Also, non-proprietary shared data and information about applications (not operations) and trusted and secure data interoperability. This allows for B2B **collaboration opportunities with other companies.**

"What we're doing with the Platform is providing a set of services in an integrated cloud format that significantly lowers the infrastructure set up and **integration that is as much as 70% of the cost of a one-off system.**"

As mentioned, the SM Platform provides a consistent and scalable infrastructure for progressively extending a system – when one wants to extend with more data and new analytics or when infrastructure technologies grow out of date, etc. there is no longer a need to tear out and build new infrastructure. **Smart Manufacturing offers solutions that can evolve with technology.**

Security & Intellectual Property

Manufacturers are appropriately cautious about the security of valuable data, information and IP, especially when it comes to cloud-based technology. But, a major security advantage of SM infrastructure is that security risks are being addressed at every level and across all interfaces, horizontally and vertically, while the system is being built.

"Security and interoperability are fundamental to the SM Platform foundation. But no system is 100% secure. Security risk detection and mitigation are as important as prevention," states Davis.

"The platform infrastructure actually provides additional security prevention for the manufacturer. It provides ways to detect, compartmentalize and mitigate attacks. When a manufacturer wants to work with multiple vendors or work with protected data sharing, **security requirements are enforced and do not need to be "reinvented"** for every interchange."

Not only does the platform offer the possibility of greater security than many individual plants and with many B2B treatments of security, it also makes it possible for users to access and view data in ways that are not possible in enterprise operations and supply chains today (and which isn't able to be done through individual vendors).

"You can see the data moving end-to-end and if you see a pattern different than expected, you have new security information that you don't have with the way it's being done today."

The focus on data and its management rather than applications makes it possible for intellectual property, regulations and policies to be managed in far better ways that remain owner-controlled.

Chapter 4:
The Benefits of Smart Manufacturing to the Value Chain

Truth be told, the benefits of SM go far beyond the manufacturer, but affect each member of the value chain as well. Each stakeholder has the chance to reap the benefits of a totally integrated work environment that is seamless, affordable and (most importantly) more productive and competitive.

Value Chain v. Supply Chain

The notion of a value chain is one that is often misconstrued and may need clarification. A supply chain in manufacturing refers to the company-to-company chain of suppliers and manufacturers involved in producing the final product. Interchanges tend to be more requirement and transaction-based and can also occur in between operations within an individual company or across multiple companies.

A value chain, on the other hand, refers to **how each manufacturing process step adds value** to the product and impacts the end-to-end manufacturing process, including overall environmental impact energy and materials usage. The intent is to identify the transaction points and focus on optimization across both sides of the value chain **to achieve increased productivity, sustainability, innovation and competitiveness** at the individual and collective stage.

Benefits for the Supplier

A More Informed & Fluid Value Chain Path

In an environment where there's limited communication with customer demand, it's extremely difficult for a manufacturing facility and its suppliers to adjust to the needs of the end-user in real-time. In a value chain, business real-time exchanges and decisions are enabled among and between suppliers and the OEM — collectively addressing manufacturing and process performance impacts throughout the network.

This can all be based on and managed to an integrated, agreed upon, set of key performance indicators. SM brings to the table infrastructure that better enables demand dynamics throughout a value chain as outlined by Jim Davis, the Vice Provost Information Technology at UCLA.

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> *From a supplier's standpoint, it has always made sense to be as precise as possible with the product produced, and the demand for product, including individualized features. SM makes it possible to approach new levels of precision in new ways with data, information, analytics and modeling. [In a perfect world], the demand dynamics and key performance indicators are managed throughout the entire value chain as an integrated asset.*

For a world example, let's take a food-processing manufacturer that depends on an extensive supply chain. From their manufacturing perspective, the idea of having the certificate of analysis as data before the product is shipped, rather than when the product arrives at the factory's loading dock, **is a big help**. The data about the product can be incorporated into the final recipe at the factory so that the factory is configured and ready to go when the product arrives — saving both time and cost.

> *From a supplier's point of view, if they have information on what the manufacturer needs and when, then they can work better with their products. Suppliers usually ship to more than one company, so if they have this information from multiple businesses, they can be more responsive to all of their partners. They both win if they can get the B2B relationship established and the information shared in an appropriate way.*

Benefits for the Manufacturer

For both the supplier and the manufacturer, the benefits result in more efficient and effective communications. The stage is set for greater product transparency and track and traceability. One can now see ways to use models to predict needs and mitigate product variations between the supplier and the manufacturer. A digital certificate of analysis (that both parties can access via the SM platform's cloud technology) is a key step that can lead to an increase in production, quality, visibility and optimization **across the value chain.**

Affordable Access to New Technology & Innovation

A mainstay element of SM is the ability to scale IT infrastructure and software access to drive down costs. It facilitates the extensive implementation and reuse of real-time software systems and metrics, provides trusted value chain data, interoperability and manages security in networked enterprises.

Rather than being restricted to using less-than-ideal software or constricted with moving to new software, SM makes it possible for small and medium manufacturers to change more easily. By reducing the emphasis on infrastructure that companies need to **develop and manage**, companies can access untapped potential with more resources and innovation available at their fingertips. Piloting new technologies with low risk could not be easier.

Pilot New Technologies for Larger Manufacturers

Small manufacturers can play a huge role in developing the evolution of SM due to their size and ability to move more quickly than larger manufacturers.

> *In many situations, small companies have the particular expertise about a specific part, process step or product. This expertise can be used to develop new product opportunities or even software ventures by developing software models that can be used upstream and downstream.*

At the same time that small companies are seeking opportunities for product lines, large companies can more easily work with small companies to pilot new products for which the small company has the expertise. These small companies are often more agile and have better expertise.

Increased Productivity via Sensors

Sensors and real-time data serve as the underlying ingredients that manufactures need for better, more affordable and more productive operations. You can't tap into new opportunities without "seeing" the operation, process or enterprise better and you can't manage metrics that you cannot measure.

Davis states, "What we're also doing with SM infrastructure is making it possible to build sensor-to-action enterprise systems that incorporate the integrated data, analytics and models to inform decisions and to take action in business real-time." The SMLC is focusing on the SM Platform infrastructure, accessible software and deployment capabilities to put real-time integrated data to use that meets all manufacturers alike at their readiness levels.

Benefits for Software Vendors & 3rd-Party Integrators

For the software solution providers, the concept of SM will bring about **change to the software and systems overall business model.** Licensing, purchasing and software support models will make available fee-for-use, value-added support services and product expansion opportunities. The goal is not to simply drive price down, but to increase access to new markets and service potential.

Providers are critically important. The objective is to build the necessary relationships with the providers and demonstrate their business opportunities along with the opportunities for manufacturers, explains Davis. "We're doing everything to be partners. We don't want to build infrastructure that competes."

With an Open Platform, users and providers will benefit from a pay-per-use pricing structure that also opens business opportunities and incentives for all to participate. New business models open the floodgates to more customers and opportunities for product and service ideas.

Better User App Development & Feedback

Having a wider consumer base means having greater ability to experiment with new applications (apps) to create systems. Rather than investing completely in one company, the Platform opens the opportunity to test software among several companies and industries, at the same time seamlessly transitioning from development to deployment and optimization phases and beyond.

The managed data and communication structure of the SM Platform also means vendors will be able to get feedback more quickly and from a variety of industry perspectives and users.

Less Nitty-Gritty Integration

> *For the software integrators that set up new software technology for manufacturers, the SM Platform will greatly lessen the need for the physical IT infrastructure and decrease the physical effort of integration between the SM Platform and the factory operation*

This saves tremendous time and allows the integrators to focus more on the function of the data analytics and modeling — the aspects of technology that produce the results for manufacturing information (data) that will assist them with real-time decision making.

Benefits for the Customers

KNOW What They're Buying

> **"**
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> *Smart manufacturing is evolving the competitive landscape across nearly every industry. Instead of accepting the mass produced, consumers will be able to receive products that custom fit their needs. As smart manufacturing factories and demand-driven supply chains mature, customers will tell factories what car to manufacture, what computer to build, or how to tailor a pair of jeans.*
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> **"**

With more data collected and interpreted throughout the value chain, customers will be able to take advantage of that newfound information as well. As with the food manufacturer example, the customer can stay better informed about the original source of the product and make value decisions based on how and where the product is made.

Manufacturers can provide customers better pinpoint track and traceability when there are issues. In general, **customers become a strong voice** in establishing features and manufacturing processes so that the entire value chain needs to be responsive. When responsive, it becomes a competitive advantage for the manufacturer.

Increased Confidence & Personal Satisfaction

Now, with the ability to display more accurate information to consumers, customers will make better decisions using their purchasing power. Using the concept of demand dynamics, a more informed value chain is able to provide the products that the consumers are demanding. Knowing that their needs can be addressed quickly, customers are able to purchase with more confidence. Furthermore, this can benefit manufacturers as this type of customer-satisfaction driven focus can help build better brand loyalty.

Chapter 5:
The Business Case – Why Smart Manufacturing?

When talking about mastering the early phases and prototypes of Smart Manufacturing, Jim Wetzel (Director of Global Reliability at General Mills and Chairman of SMLC) recalled seeing results **immediately**.

And, he expects anyone taking the Smart Manufacturing route to experience the same type of quick increase in efficiency and data collection. Let's take a few steps back and analyze **how Wetzel and General Mills** were able to get to this point.

In a phone interview, Wetzel had this to say about the beginning stages of SM implementation:

> *It starts with culture. In a manufacturing world, knowing what's going on in your organization from the plant manager to the factory floor is transformational.*

Seeing results quickly with Smart Manufacturing is likely as its implementation allows you to **capture, gather and analyze data that your company never had** or wasn't previously able to access and contextualize.

> *Even if your facility is operating fairly well, the use of SM works like a new pair of glasses*. **You'll be able to see aspects of your business more clearly** *with quantitative and qualitative information that can lead to more confident business decisions.*

The culture of SM creates a huge shift in HOW your organization makes its decisions. If your facility shifts from having no smart technology to diving into the deep end of Smart Manufacturing, **a newer, quicker and more data-heavy culture will inevitably be established.**

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> *As soon as you move the culture from managing based on an opinion to managing based on facts, you'll have victories right at the beginning and so did we. As soon as we started being connected we had insight and that began the transformation.*
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> *"*

And this connection that Wetzel refers to is the synchronization of data-capturing devices and machines on the plant floor with an information system where your decision makers can act on quantitative data, rather than instinct.

Refer back to Chapter 3 where we discuss this in more detail.

For other determined manufacturers, Wetzel sees no reason why they shouldn't see results immediately, too. Furthermore, he states that the ROI should exceed their internal financial hurdles and they should be **expected to achieve anywhere from 20-30% ROI** after effectively implementing Smart Manufacturing.

Are SMMs Ready Now?

The reason why SMMs cannot dive in the deep end of Smart Manufacturing right now is due to the huge associated costs and risks that are barriers to even large companies. SMLC is in the process of developing an **Open Platform** that will be made accessible to small, medium and large companies alike.

For decision makers who are looking to use the principles of Smart Manufacturing within their organizations, Wetzel encourages them to start by asking **which employee will champion the SM integration?** He also advises that they learn how to **sustain** the transition and begin investing in smarter workplace technology that can collect information.

As much as the concept of Smart Manufacturing is paired with technology, a successful SM implementation must be focused on the **information extracted** from this technology.

In the meantime, smaller manufacturers are losing value with outdated technology that may not collect information.

> *"*
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> *And this is the first step for any organization waiting for the Open Platform: get the data. An SMM can do this by investing in devices, sensors and/or flow meters that can send data to your facility.*
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> *"*

Several options are coming to the marketplace, but **all that's necessary at the moment is that your technology is ethernet-capable**. "In the future, if you can't network your device, it's going to be more difficult to adapt to the new technology," warns Wetzel.

SMLC is driven to create a seamless experience with the SM Platform that's just as simple and intuitive as mobile phones and their operating system's app stores. In fact, the Platform's prototype is currently in development and is using *real industry cases*. This means **small companies are welcome to participate now** and learn more about the platform while it's still in its initial stages.

Once a desired app is found, a manufacturer will be able to download it, apply it to a line in their factory, leverage cloud technology (eliminates the need to add computers) and then, all one has to do is select applications just like it's done on smartphones today.

The Current Status of the Open Platform

To keep what's at stake in perspective, Wetzel offers this reminder:

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> *Smart Manufacturing isn't your goal.* ***Winning in business is your goal.*** *Smart Manufacturing is the method you use to achieve that goal.*
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> "

Some large companies such as **Praxair** and **General Dynamics** are accessing the tools that are currently being developed in the Open Platform. These companies and collaborating SMLC members see unprecedented value in Smart Manufacturing and see it as a way to continue generating profit, innovation, competitiveness and productivity.

However, the goal is that companies of *all sizes* will reap the benefits of Smart Manufacturing. Remember, SM is on the move now. **SMMs don't have to wait to get started**. Besides readying your equipment base for network communication as mentioned above, SM Platform development and SM test bed deployments are currently in place. One example is the SMLC $11 million grant to develop the nation's first open platform for industrial applications under the Department of Energy at two industrial test beds.

The SMLC is currently in its second year of the three-year grant and is in the process of building several other test-bed demonstrations with interested companies. Companies of all sizes are able (and are encouraged) to take part and shape the platform development and engage in test beds.

Chapter 6:
Reinvigorating the Manufacturing Workforce

Manufacturing in general faces challenges in securing the necessary educated, trained workforce needed to be successful. Contributing factors include an increase in emerging technologies, retirements, and fewer young people interested in manufacturing careers. Recognizing that these challenges directly impact their bottom line, employers are stepping up their workforce development programs to implement targeted, scalable solutions. Smart Manufacturing is part of those scalable solutions.

Smart Manufacturing will not only lead to increased productivity, efficient operations, sustainability and product innovation, but will also bring about beneficial changes to the existing and future workforce. In fact, adding more technology to the production floors can mean two things.

One, current employees will require additional education and training in order to fully maximize the potential and ROI of the new technology. Employers must first know existing proficiencies of their current workforce in order to develop the new competencies required.

And two, new and emerging technology in the manufacturing industry will help attract the next-generation workforce that is very comfortable with using web tools, rapidly evolving technology and the world of Big Data. SM can be the key to reinvigorating the manufacturing workforce, attracting and nurturing a younger talent pool that historically may not have considered a career choice in the manufacturing industry.

Future Manufacturing Careers

As the overall concept and blueprint of Smart Manufacturing continues to develop, the future looks bright for manufacturers who decide to embark on the SM path.

Once manufacturers embark on their journey to implement SM technologies, they will recognize the changes they need to make to achieve their optimum manufacturing operational strategy and meet performance and productivity requirements. New positions and capabilities are likely to emerge.

"Smart Manufacturing leverages the increasing amounts of information coming from Internet of Things capable devices. Every day we see the impact of new, improved or emerging technologies. Our challenge is to grab a hold of these new capabilities in ways that make sense to us and improve our lives.

The same thing is happening in our factories. What new technologies do we adopt and implement so that we can maximize the impact they have on our production capabilities? An educated, skilled and motivated workforce in an SM environment is necessary to help make these important decisions and take advantage of the new tools," explains Pam Hurt, Workforce Development Industry Manager at SME.

As far as future careers go, **any position that is able to leverage information within a manufacturing facility will become increasingly valuable**. Analytics and data management will become additional requirements for new manufacturing positions as these skills will become highly desirable to achieve SM.

Skills development, resource tools and techniques are needed to better integrate human factors and decisions into smart software tools. This integration would enable faster, more disciplined decision making on the plant floor and allow operators to become "knowledge" workers.

New Responsibilities for Manufacturers

While a common concern for those unfamiliar with Smart Manufacturing is that their facility may have to expand their workforce and hire new tech-savvy employees, this is not necessarily true. This is why the SMLC and its partners are researching heavily to identify existing or create new educational resources for current manufacturing employees.

Rather than adding a new department or bringing on new hires to your company, SM may bring about change in the form of existing jobs that transition to using new technologies as companies adopt new practices.

"Creating specialist roles may be appropriate in some situations, but it may be expensive and difficult to separate the traditional skill sets required in manufacturing from old to new roles," explains Hurt.

"More than likely, we will see the **emergence of blended hybrid job functions** that may require enhanced collaborative communication and problem-solving skills to properly apply the new tools for benefit."

Some of these new, blended job functions include managing data analytics, tracking products in the value chain using wireless devices (cell phones, tablets, etc.) and being able to pinpoint issues in the supply chain quickly should they occur.

While the head count can remain the same, SM adds new duties that can help the production of your manufacturing material. Think of it like a smartphone application. "Cell phone users are not necessarily concerned about how an app was created, **but rather need to decide which apps improve and enhance their experience [while] using the device."**

Welcome, Millennials!

Making such technological strides in a traditional industry opens the doors for a new demographic to enter your workforce — millennials.

Smart Manufacturing can bridge the gap between career choices and demographics to revitalize the industry. Millennials, with their tech-savvy abilities, creative-solution mindset and eagerness to contribute can quickly grasp and implement SM apps, capitalize on new opportunities and increase productivity.

Of course, new millennial hires will be integrated into their roles with an understanding of the company's specific goals, manufacturing expertise and job duties. "However, rather than emphasizing what and how they should perform on the job, companies should focus on the challenges, desired outcomes, and expected results.

Allowing new employees to bring their ideas to the table and exploring the SM landscape with leadership support and recognition could result in higher employee satisfaction, increased productivity and better job performance," explains the SME.

Attracting and integrating the millennials is not just a single effort. SMLC members have a variety of programs, products and services that directly target these students as they prepare to enter the workforce. SME targets high schools, community colleges and universities, including conferences, research endeavors and scholarship opportunities through a variety of initiatives.

An example is the PRIME program (Partnership Response in Manufacturing Education), an initiative that aims to build a network of industry, education and association partners that collaborate to help improve the quality of advanced manufacturing education in high schools on a local level.

"Companies embracing Smart Manufacturing will have a dynamic, flexible environment. And the workforce will match that as long as we prepare them. As the new generation comes onboard, they will help drive the transition for everyone to a more digitally capable workforce able to apply and use the advanced tools to operate the new technologies."

Supporting the Next Generation Workforce

Before a company invests in new technology, its leadership must clearly define their business goals and objectives and map out the expectations of their workforce. The changes that SM will bring depend on the individual business goals of the manufacturer.

Factors such as the rate of technology expansion and the time invested in training boils down to just how fast a manufacturer wants to (and is capable of) doing so — making SM not a race, but rather a growth-based initiative with clear deliverables and expected outcomes.

The competitive advantage of a company is often the reflection of a successfully trained and skilled workforce. In the manufacturing sector, both the current and future workforce are able to take advantage — take it from SME:

> **"**
>
> *The current workforce can enhance their existing skills by taking advantage of advanced training that can be applied on the job seamlessly when new apps and processes enter the marketplace. With the development of new skills, this workforce will become more efficient, ultimately resulting in increased productivity.*
>
> **"**

Resources such as Tooling U-SME provide comprehensive learning services that feature direct engagement with both companies and schools. A variety of delivery mechanisms are available for the education and training needed by companies and include: online classes, instructor-led training, pre/post assessments, certifications, custom content and digital books and videos.

The goal is to provide the current workforce with more "flexible and agile forms of learning." In short, a good amount of on-the-job training can be accomplished, and on an employee's own timetable.

Furthermore, joining organizations such as the SMLC has benefits to seamlessly help the workforce adjust to the changing work atmosphere. For instance, one's membership allows early-adopting companies to share their best educational and training practices should a manufacturer have trouble trying to educate their workforce.

"Future manufacturing talent will benefit from educational programs that adhere to industry standards. Collaborations between academia, manufacturing companies and industry organizations help build communities of skilled workers to meet the growing technical capabilities required today and in the years ahead," encourages Hurt.

Conclusion:
The Biggest Change is in People —not Technology

A major part in seeing success early has to do with the company culture and the commitment of team members. It's important to remember that all the integration and use of technology is rendered useless if it is combined with employees who don't fully understand how it will make their job easier, not harder. And just as crucial as employee support is needed for a successful SM path, it can also serve as the biggest hurdle in SM implementation.

> *For us, [the biggest hurdle] wasn't technology. It wasn't capabilities. It was changing what people did every day when they came into work. Instead of saying 'I'm going to go on gut feeling' — to saying 'I'm going to see what this information says and I'm going to use that as my guiding light. I'm going to let statistics guide my actions.'*

explains Jim Wetzel, Director of Global Reliability at General Mills and Chairman of SMLC.

As Smart Manufacturing is often discussed in terms of technology and innovation, Wetzel warns otherwise. "Technology is the enabler. It's not all about technology. The true challenge is getting people to behave differently."

Glossary of Terms

Apps
Software applications available as workflow based code modules that manufacturers can assemble into customized real-time SM application systems.

Big Data
Extremely large data sets that may be analyzed computationally to reveal patterns, trends, and associations, especially relating to human behavior and interactions.

Business Intelligence
Is the set of techniques and tools for the transformation of raw data into meaningful and useful information for business analysis purposes.

Certificate of Analysis
A document issued by Quality Assurance that confirms that a regulated product meets its product specification. They commonly contain the actual results obtained from testing performed as part of quality control of an individual batch of a product.

Cloud Computing (the cloud)
Defined as a type of computing that relies on sharing computing resources rather than having local servers or personal devices to handle applications.

Cyber-Physical Systems (CPS)
Are integrations of computation, networking, and physical processes. Embedded computers and networks monitor and control the physical processes, with feedback loops where physical processes affect computations and vice versa.

Cybersecurity
Is the body of technologies, processes and practices designed to protect networks, computers, programs and data from attack, damage or unauthorized access. In a computing context, the term security implies cybersecurity.

Demand Dynamics
The concept of a supplier providing materials based on customer demand. Ideally, this demand is taken into account throughout the value chain. It is determined using real-time data that's available to suppliers and customers alike so more accurate decisions can be made.

Industrial Internet

Refers to the integration of complex physical machinery with networked sensors and software. The industrial Internet draws together fields such as machine learning, big data, the Internet of things, machine-to-machine communication and Cyber-physical system to ingest data from machines, analyze it (often in real-time), and use it to adjust operations.

Industry 4.0

Is the network of physical objects or "things" embedded with electronics, software, sensors, and connectivity to enable objects to exchange data with the manufacturer, operator and/or other connected devices based on the infrastructure of International Telecommunication Union's Global Standards.

Interface/Interfacing

In computing, a shared boundary across which two separate components of a computer system exchange information. The exchange can be between software, computer hardware, peripheral devices, humans and combinations of these.

Interoperability

The ability of software and hardware on different machines from different vendors to share data.

IT Integrator

Is an individual or company that markets commercial integrated software and hardware systems for manufacturers.

Machine to Machine (M2M)

Refers to technologies that allow both wireless and wired systems to communicate with other devices of the same type.

Marketplace

A cloud based online store containing both toolkit libraries and Apps that can be selected and used to compose workflows, in addition to a variety of associated services.

Real-time data (RTD)

Denotes information that is delivered immediately after collection. There is no delay in the timeliness of the information provided. Real-time data is often used for navigation or tracking. Some uses of this term confuse it with the term dynamic >data

Redundancy

A part in a machine, system, etc., that has the same function as another part and that exists so that the entire machine, system, etc., will not fail if the main part fails.

Smart Manufacturing Leadership Coalition (SMLC)
Is a non-profit organization comprised of manufacturing practitioners, suppliers, and technology companies; manufacturing consortia; universities; government agencies and laboratories.

Smart Manufacturing (SM)
Smart Manufacturing is having the ability to solve problems – existing and future– within an open infrastructure that allows applications/solutions to be implemented at the speed business demands while creating advantaged value.

SM Application Systems
Customized real-time workflow application systems assembled from selected data management, modeling, analysis, display and interface Apps, which are constructed in the SM Platform to meet the needs of a specific company. They can be legacy systems and/or newly available through the Apps Marketplace.

SM Platform
An Advanced Manufacturing technology based on a cloud based, open architecture infrastructure that is currently under development by SMLC. Through hybrid cloud structures, a suite of cloud services, and an open source and commercial Marketplace, the SM Platform infrastructure makes it possible to integrate existing and future plant level data, simulations and systems across manufacturing seams and orchestrate business real-time action.

Test Beds
Specific use cases that are developed and deployed to address manufacturing challenges and opportunities through SM Platform infrastructure functionalities. These functionalities can be embedded for future use by others through the SM Platform.

Toolkits
Reusable workflows that contain a set of Apps orchestrated to achieve a specified function.

Workflows
Orchestrate discrete tasks needed to get the necessary data, contextualize it, analyze it and put it into actionable forms within a needed time frame. Workflow and App attributes are Meta pieces of information that allow a workflow to be analyzed in terms of overall properties and for the state of the workflow to be monitored during execution.