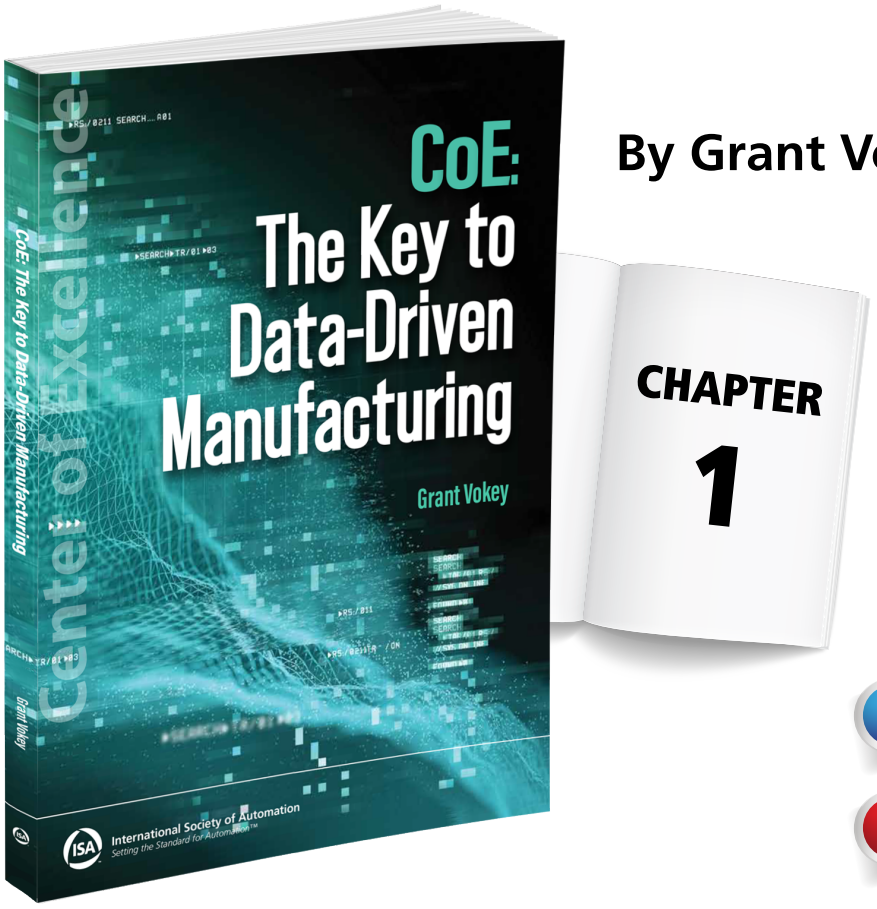
Chapter 1 of:
CoE: The Key to Data-Driven Manufacturing
Grant Vokey

# CoE: The Key to Data-Driven Manufacturing




## By Grant Vokey

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# CoE:
## The Key to Data-Driven Manufacturing

Grant Vokey

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ISA
3252 South Miami Blvd, Suite 102
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# About the Author

**Grant Vokey** is the principal consultant for Vokey Consulting. With 20 years of diverse manufacturing operations experience and an additional 15 years of integrating information technology (IT) systems into the manufacturing floor, he has developed a strong understanding of how manufacturing companies work and the information needed to operate at world-class levels.

Grant's experience, coupled with continuous training and 10 years as a Certified Operations Manager, has also provided him with an excellent understanding of industry best practices and best-in-class utilization of manufacturing execution systems (MES). Using this knowledge, he has been a subject matter expert for developing industry-leading MES applications/solutions, a program manager for multiple MES programs, and a lead consultant on implementations of MES in various verticals (electronics, industrial equipment, automotive manufacturing, and metal fabrication).

Grant has developed a reputation for providing sound, practical advice and direction that make a difference to his clients and the MES industry as a whole.

# Preface

During a youth leadership course I took many years ago, I was introduced to a game that was intended to show the importance of good communication (many of you probably remember it). The game involves a group of people, and one person quietly tells the first person a message. Each person, in turn, whispers that message to the next person until the last person is given the message. The last person shares the message they received with the group, and the group compares that message to the original one. Like others in the group, I was amazed at how much of a difference there was between the first and last versions of the message.

Over the years, I have noticed a pattern of that kind of miscommunication in manufacturing companies. I have observed these issues throughout the companies, on both the business side and the manufacturing side. These issues have had a significant effect on initiatives for implementing any aspect of change management. However, from what I've seen, manufacturing operations management (MOM) seems to have more than its fair share of potential scenarios for miscommunication.

Why does this scenario play out so often in companies?

The specific answer to each independent observation is, of course, too narrow to be of value in a general context. But when I have stepped back from any particular issue, I have found that there were questions that could be meaningfully asked in a more general context.

In this book, I present some of the more general issues I found on the manufacturing floor and offer some ways to avoid or correct them. I primarily provide direction in creating a team within Manufacturing Operations whose purpose is minimizing the occurrences of these issues. Is it a lofty goal for a book? Maybe. Or maybe I might surprise you.

# 1 Introduction and Overview

Anyone who works in manufacturing quickly learns that change management is a big deal in the industry, to such an extent that consulting in change management in different industry segments provides a more than reasonable income for many. Think about how many consulting companies specialize in the Lean, Six Sigma, ISO-9000, or Theory of Constraints change management methodologies. Not to mention the number of people employed in manufacturing companies whose sole focus is change management as it relates to continuous improvement (CI). Also note that each of the mentioned change management methodologies started in manufacturing and was then recognized as being of value to the rest of the company. All of this indicates the importance of change management to manufacturing in general.

Yet many manufacturing company executives have expressed frustration with their company's inability to sustain CI for longer than the period of the original initiative to implement one of these change management methodologies. In addition, many senior operations managers have expressed some disappointment in the results of implementing any of the change management methodologies (or at least they expected considerably more out of the implementation than was achieved). In industry surveys as recent as 2020, up to 70% of companies have been disappointed with the results of their CI programs.

No, this is not yet another book on CI. I'm not going to tell you about a *fantastic new methodology* or that any particular methodology is better than another. Each methodology has a particular scope of operations it is meant to help improve, and each has its place.

I will say that it is not the particular methodology that is important (sorry to burst the bubbles of all those consultants); it is the combination of methodologies and the correct coordination of resources that make a difference. And to properly coordinate those resources, you must provide them with the "tools" in a program management context to enable them to develop. However, that raises a question regarding *how* to coordinate those resources.

My first book, *MES: An Operations Management Approach* (co-authored with Thomas Seubert), discussed using a manufacturing execution system (MES) to coordinate production and production support activities from an operations management perspective, and we provided some guidance on using the ISA-95 standards as a template for MES implementation. I'm happy that the book is now being reviewed for use by universities in master's-level courses for industrial engineering (specializing in manufacturing engineering). After spending more than 20 years implementing MES, I am surprised at how little growth there has been in understanding how to tie MES implementation to a company's CI program and in the ability of companies to manage these programs to be sustainable.

In this book, I provide an overview of the different characteristics of manufacturing management at the production floor level, how to use those characteristics for operations management, and how many of the latest trends in analysis and access to real-time data are actually of value. I also explain how to develop a coordinated approach to use these characteristics and some general "operations management tools" to create a specialized team to lead manufacturing companies into a long-term sustained program for continued improvement in manufacturing capability. This is not a step-by-step instruction because the detailed implementation of any sustained program is specific to each company, and this is not a book about quality management (there are many good books that cover that topic). I do, however, provide guidance on implementing a sustained program and explain some of the characteristics of manufacturing processes that enable the guidance that I provided.

Although the problems of change management are common to many industries, manufacturing industries have particular concerns. Not only do changes have to be made in the way the business operates (the business processes), but the same types of changes are needed at the production floor level as well (the manufacturing processes). Because of the detail to which manufacturing processes must be defined, the interactions between business processes and manufacturing processes, and the effect on the quality of even seemingly small changes, change management in manufacturing operations management (MOM) has a deeper level of complexity.

Many companies that have been repeatedly successful in implementing required changes have attributed that success to first implementing a formal process management program and a formal team to manage the *normalization* of processes in general, and then managing *both* the *changes in process* and the *process of change*.

In this book, I look at process management from a MOM perspective and cover the structure and implementation of a process management team within that MOM context.

In this chapter, I use the term MOM in a general context. In later chapters, I will get into more detail about the definition of MOM from an industry point of view.

Also, within that same general MOM context, many manufacturing companies have found that MES can play a significant role in the effectiveness of the process management team and of MOM in general. For that reason, this book also includes a general overview of MES functionality and how it supports MOM in process management as well as production efficiency and CI, and how an MES is a major component of successful companies' Industry 4.0 initiatives. As part of the Industry 4.0 discussion, I explain why creating an Industry 4.0 strategy is vital to manufacturing and how using data provided by smart sensors, machine learning, and automation is an integral part of an Industry 4.0 initiative.

## Overview of Company Planning

To initiate planning, Operations senior management must understand their current state of affairs (capacity, process management capability, production planning, etc.). Hopefully, senior managers have been following the activity of the departments under them and already have that *current state* visibility. On a separate track of activities, Sales and Marketing will look at the company's current market position and work with Product Engineering to better understand the characteristics of the product line (current and upcoming), and they will determine what changes are needed to maintain or improve the market position. They will then develop an action plan for the company to achieve the desired changes in their market position. Once Sales and Marketing have their *plan of attack* for market gains and Operations understands the current state, it is time for them to come together for sales and operations planning (S&OP). They will determine what must change in the current state of operations over the course of the next year or more to support the sales and marketing plan, or they must determine what must change in the sales and marketing plan because of things Operations cannot support (e.g., as a result of capacity or resource issues). This is considerably

simplified, but the result of S&OP is a plan to either hold a current market position or to make the gains desired and an action plan to update operations capability to support the sales and marketing plan.

After the plans are developed and approved, they are flowed down to department managers who simply execute the plan. Right? *(Um… ya… ok, sure)*. The first rule of company planning is that a plan is only good up to the point of starting to execute it. When the department managers start to act on the plan, a multitude of things can (and will) go awry.

After S&OP has developed the operations and the sales and marketing plans to move forward, senior sales and marketing managers will begin to execute their side of the plan, and senior operations managers will work with operational department managers to plan the steps for fulfilling the changes defined during S&OP. Again, there may be issues at the department level that must be reconciled to achieve the plans. That is why S&OP is actually an iterative process.

During the year, in addition to day-to-day activities, senior managers support department-level activities (either as part of a steering committee or by sponsoring the finances or both) to achieve the expected changes. As the year progresses, things change. Assumptions made during S&OP are sometimes found to be false, the company's priorities may change because of local or global events (e.g., the devastating economic effects of a global pandemic), or internal changes may drive different activities.

Although things can also go wrong from a sales and marketing plan perspective and a product engineering perspective, these issues are not under the control of manufacturing operations and, therefore, are beyond the scope of this book. From a manufacturing operations perspective, there are a few issues that can create problems.

One of the first issues is the accuracy of the original current state understanding of operations capacity. With multiple production lines (or multiple plants) and ongoing changes in operations staff, equipment, and products, there is a lot of potential variation in production activities that can cloud (or downright confuse) the current state of understanding. In addition, implementing the changes in operations may be more complicated than originally thought or planned, and required resources may not be available when needed. This is especially true if the changes require coordinating multiple departments. And, of course, there is the ongoing issue that these departments must also keep up with their normal day-to-day activities to get products out the door.

## Overview of Operations Management for Manufacturing

The scope of operations management is very broad. It can include all aspects of a company's activities from receiving a customer's order through production, delivery, payment collection, after-market services and customer support (initial and long-term), warranty activities, and product servicing and upgrades while the customer is using the product. Within each of these overarching activities, a few functions become key to operations management in manufacturing. These functions include capacity management, inventory and resources management, control of execution of manufacturing, and assurance of the quality of the products manufactured or the services provided by the company. As resources (material, equipment, or people) are in limited supply (this is the basis of economics and business management), the ability to plan, allocate, and utilize resources efficiently differentiates successful companies from struggling companies. Companies must also execute change management with a high degree of efficiency. For an issue that requires change, Operations must determine the root cause, identify possible solutions, select the most effective solution, and quickly implement that solution, all of which takes resources (most of the time, the same resources used in day-to-day operations). The longer a problem exists, the more money a company is potentially losing. To anyone who has in-depth knowledge of operations management, this should not be new information.

A major concern that many operations managers have regarding executing the plans from S&OP and lower planning levels, as well as many of the daily decisions while executing these plans, is ensuring that they have the most up-to-date information available so that they are making well-informed decisions and accurately conveying the intended meaning of that information throughout the company. A key concept that is frequently overlooked is the relationship between the information used to make a decision and the accuracy and integrity of the data used to create that information. Some decisions can be made using information that is a few days old with little consequence. However, as processes become more complex, that relationship tends to become diluted, and (as introduced in the preface) the information being conveyed tends to drift from its intended message. This tendency becomes more significant as days-old data that one department uses to make decisions might be a couple of months old by the time the data is propagated throughout the company. In this regard, effectively collecting data and communicating the intended information in a timely manner can be paramount to a company's success.

In today's market, customers have become accustomed to highly customized products and the ability to change their orders at almost any time. Determining the details of which product to manufacture has become much more complex, and being able to

deliver products in a short enough time frame has become much more difficult. From the perspective of a manufacturing company, the effort to deliver quality products—with the correct options, on time, and in the right quantity—requires knowledge of customer orders and quick updates to accommodate sudden changes in capacity. In day-to-day operations, unexpected changes in available resources are difficult to manage, and adding change management execution to the mix amplifies the importance of having knowledge of capacity and resources in real time. Whether managing day-to-day activities or implementing changes, when a manufacturing manager is trying to make the most effective use of resources (people, equipment, or material), unexpected changes (good or bad) are bad for planning. Either capacity is not available when needed and activities cannot be completed, or resources sit idle. Idle resources cost money to maintain, and there is a loss of opportunity when idle resources could have been used elsewhere. So, if capacity and resources are not planned accurately, it will cost the company in lost sales (customers go to another supplier) when demand cannot be met, or invested money is wasted as the estimated demand (reflected in the plans) fails to provide the expected return, thereby increasing the cost of production or reducing profits.

Figure 1-1 provides an overview of the scope of MOM and how information is created and made available throughout the different groups within MOM. Some of the reports

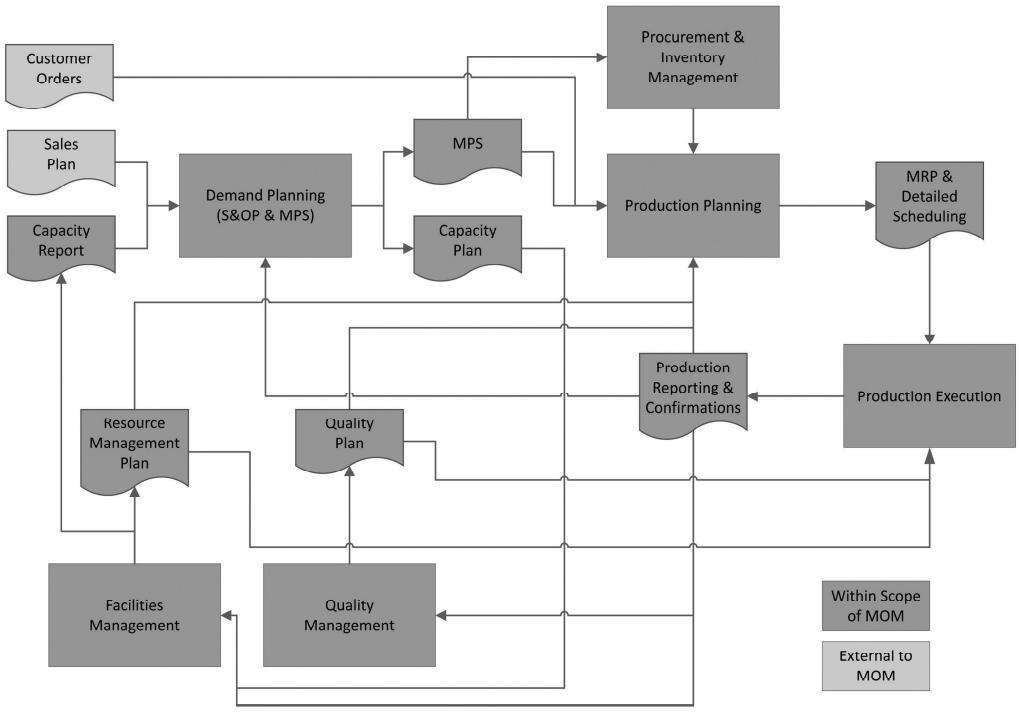


**Figure 1-1.** Scope of MOM and information transfer.

(or plans) that are used (e.g., the capacity report) do not have to be as current as others (the materials requirements planning—MRP, report and detailed schedule). Therefore, if the capacity report is a few days old (in some companies, it can be as much as a couple of months old), it may not have much of an impact on the capacity plan and the master production schedule (both are more long-range plans of change and scheduling) as an output of S&OP to facilities management or procurement. However, if the resource management plan (which likely includes personnel planning) used in production planning and at the MRP level is a few days old, equipment required for production may not be available (e.g., if it was inadvertently scheduled for maintenance or an upgrade), causing a major delay in production orders. Understanding how reports will be used, the data required for the reports, and the procedures for extracting the data and creating the reports are all important when looking at the timeliness requirement for the data and the cost associated with fulfilling that timeliness requirement (e.g., the cost of design for system interfaces).

## Tools of the Trade in MOM

As I discuss in more detail in Chapter 2, "CoE and Data-Driven Management," there are a few *management tools* that operations managers use to stay on top of issues and manage the complexities of MOM. These management tools include reporting from manufacturing process management, regularly publishing reports, and reviewing these reports in regular, monthly operational review meetings. To prepare for these meetings, personnel can spend up to a week collecting data and summarizing the data into reports. Decisions are made during the meetings, and action plans are devised and acted upon until the next meeting. Issues that arise in these meetings include the reliability of the aged data that was collected, the consistency and integrity of the reporting, and the diversity of issues that require action to resolve. Although managing manufacturing in this manner in today's environment of fast data and immediate reports may seem archaic, many companies still operate this way.

### *The Need for Standardization*

In addition to the concern about data (and its availability), there is also a need to minimize issues that require decision-making. A significant problem that operations managers face is being the sole person authorized (or able) to make decisions. This problem is further complicated when similar issues arise and must be re-evaluated, time and again, to ensure that the correct decision is made at that time. In some cases, this can result in "reinventing the wheel" as operations people reanalyze similar problems repeatedly to come up with more or less the same solution each time. As much as possible, the situations that require decision-making should be reduced either in the number of occurrences or in the complexity of the decisions to be made.

One way to solve this problem is standardization.

Standardization can take many forms, such as process standards, reporting standards, and standardized data collection. As a supplement to standardization, the production support team must develop the capability to record situational details whenever there are issues that the standard cannot support (e.g., the standard process must be changed for a specific issue); delays in recording those details can result in important information being lost.

### *Standardization Programs*

Whenever a company engages in a significant standardization effort, it is important to have a team that is focused solely on the standardization activities. Although it might be easy to assign these activities to the manufacturing or quality engineering staff, adding standardization responsibilities on top of their other duties frequently results in delaying or dropping the standardization to take care of day-to-day operations issues. In addition, if a company has multiple manufacturing engineering teams (as in multiple plants), the implementation of *standards* will not be *standardized*. This can create the same problems of reinventing the wheel and complex decision-making that standardization was supposed to fix.

When a major initiative like implementing standardization is undertaken, the best practice is to use some form of program management. Although there are a few different program management methodologies, the important part of any program is to establish the standardized processes, reporting, and data and to integrate the overall management of these activities into the day-to-day operations management processes for long-term support. In this regard, it is best to develop processes for maintaining standardizations that are integrated into everyday operations and brought under the normal operations management structure while still keeping the dedicated standardization team to maintain continued progress in standardization and improvement. As part of integrating standardization into everyday operations, managing the program must include training the management and staff who form the standardization team as well as the managers who will use the reports and information created by the team. Many programs fail because, although the team recognizes the need for the staff to be trained to use the program, they fail to educate management on the program's value and the need to support it, as well as the need to incorporate standardization activities into their operations management.

As with any program, planning and implementing a standardization program inevitably requires access to resources that, at the same time, must continue to run their

day-to-day manufacturing operations. As a result, companies typically hire a consultant to implement the program and get it running by developing the policies and procedures that define how to implement a standard process in general and developing a standardization team within the company to document, implement, and manage the standardization program. The team then ensures that the process collects the required data and publishes the information needed by operations management. Frequently overlooked during implementation is training operations management to use the reports and ensuring that there is a common understanding in interpreting the information the reports provide. After the policies and procedures are in place (and the knowledge becomes part of the normal operations management methodology), the consulting program manager is phased out, the standardization team becomes part of the operations management organization, and the operations manager becomes responsible for the growth of the program.

Although there are different titles for the team that manages standardization and process management, the term *Center of Excellence* (CoE) has taken hold in recent years. The function of the CoE can (and should) relate to all aspects of a company. However, this book focuses on the CoE function as it relates to MOM, and because an MES can be valuable to MOM, it also addresses the MOM functions that extend to implementing and using an MES.

## Introduction to the Center of Excellence

Why should a company create a CoE, and what does it do?

A CoE has two primary functions:

1. The first is to provide the capability to fully model and document any of the business or manufacturing processes used within a company (in this case, any of the MOM processes).
    - Modeling includes the process capability and fallout, the data going into the process, and information needed by all stakeholders coming out of the process.
2. The second is to be a central source of knowledge for all other departments regarding what processes already exist, how they are measured for effectiveness, and which data is used to manage that effectiveness. It is also to help create and support a management plan to ensure continued improvement in efficiency and reduced production costs.

As the CoE matures in capability and knowledge, there are other roles it can provide. These roles are discussed in detail in other chapters.

With the information derived from operational reports, it is the role of department managers, with the help of the CoE, to track and deeply understand the factors that are impacting the effectiveness of their departments and then to determine a course of action based on the reporting results and factors that align with the company's capacity plan from S&OP. The department managers then assign the task priorities back to the CoE to work on to improve their departments' effectiveness.

In many companies, the CoE is initiated as part of the information technology (IT) organization. (This is particularly true in the MES industry.) However, the role of the CoE in this context is usually to ensure the application supports the process requirements as defined by the manufacturing engineer, but not the optimization of the process in which the application is used. Because the IT department has a limited understanding of manufacturing or business process management, problems can arise when the CoE is limited to IT knowledge (more on this in Chapter 2). To ensure that processes move toward optimization and are then repeatable to other departments, other production lines (in the context of manufacturing specifically), or other plants, the CoE must include members who have a holistic knowledge of operations management and, specifically, knowledge of process management methodology.

In Chapters 2, 3, and 4, I outline the roles and skills needed for a CoE, and I explain how the CoE is needed to support all levels of operations management up to the chief operating officer.

To understand the full context of the CoE to MOM, I include a more detailed comparison of *business* and *manufacturing* process management and why they should be treated differently.

### *The CoE and Industry 4.0: An Introduction*

Part of the role of the CoE is to stay abreast of the changes in technologies that affect MOM. In Chapter 4, "Industry 4.0 and Data Mining," I describe using the CoE and MES as they pertain to Industry 4.0, data mining, and machine learning; I also explain why supporting these initiatives is important.

The main concept of Industry 4.0 is that a company's success depends highly on the effectiveness of processes used within the company. This effectiveness depends on

proper process management, the quality of the information going into the processes, and the quality and timeliness of the data and information coming out of the processes.

Two factors that are not included in many Industry 4.0 initiatives is the knowledge of how to interpret the information coming out of the processes and the quality of the decisions that are made as a result of that interpretation. In this area of company management, the CoE will likely be the main source of knowledge and training regarding correctly interpreting that information. Many manufacturing managers are trained in the general process and quality management methodologies. The training they receive (either in school or on the job) frequently does not include training in fundamental data mining techniques or in interpreting the statistical or probability information that is becoming available with Industry 4.0. Developing a strong CoE can go a long way to improving the knowledge and capability of management and operational staff to be successful in the data-driven manufacturing world of Industry 4.0.

In Chapter 4, I also discuss the details of using the production-level data that can be available and bridging that data from the operational technology (OT) and controls engineering perspective to the information technology (IT) and relational database perspective. The chapter includes examples of condensing raw OT data to be stored at the IT level as well as an example of using basic data mining to understand the production events that are reflected in that data. In addition, I provide an overview of IT data that has been maintained within a relational database containing manufacturing operations data and an overview of interpreting that data into events on the production floor.

Chapter 5, "The CoE in Maintaining MOM/MES," includes a detailed explanation of MOM from the perspective of the ISA-95 standards and of how the standard can be used to help manufacturing operations in general. This chapter also includes a detailed look at the key issues a CoE should take into consideration when selecting, implementing, and maintaining an MES.

In Chapter 6, "MOM and the Functionality of an MES," I discuss in some detail the general functionality of an MES, compare the functionality of an MES to enterprise resource planning (ERP), and explain some of the differences between the MES functions that have been designed to support *process manufacturing* and those designed to support *discrete manufacturing*. I also discuss the characteristics of *batch manufacturing* and how it compares to process and discrete manufacturing from a data and an MES perspective.

Other topics addressed include the following:

- Using an MES as a tool to support production and MOM as a whole
- Points of concern for implementation strategies for an MES
- Considerations for selecting an MES application
- Managing an MES configuration

Finally, in this chapter, I discuss some examples of integration management from an MES to the enterprise level and down to the shop floor equipment. I also address using the ISA-95 standards to guide that integration and provide some input on best practices for integration.

### *The CoE and Strategic Planning*

Chapter 7, "The CoE in Strategic Planning and Management," provides a high-level look at developing corporate strategy and a deeper discussion of fitting MOM into that strategy. As part of the deeper dive, I address the ways the CoE can (and should) play a significant role in developing a corporate strategy and in executing that strategy, at least at the MOM level.

As the CoE initiative matures and stabilizes within a company, the purpose and goals of the CoE will change as well. In Chapter 8, "Connecting the Dots," I look at how the CoE can be used as a source of knowledge and innovation. By understanding the importance of standardization and methodical management of improvement, the CoE can provide guidance and training to line-level manufacturing engineers on accessing the system information available to them via ERP, MES, or controls-level historians and on interpreting this information correctly. When this data is accessible, the CoE can then provide guidance on using the information to drive CI. In the chapter, I also illustrate that additional value can be driven by the CoE in a discussion on providing MOM-level analytics to senior management to be used for strategic planning.

It has been my observation over 40 years in manufacturing that many companies are not exploring all the opportunities available when using a properly developed CoE. Specifically in the manufacturing industry, a broad spectrum of skills is required, and efficiently coordinating these skills is critical to the successful operation of any manufacturing company and in executing initiatives such as Lean, CI, and business process management. Although coordinating skills and activities is important in any company, there is a complexity to this coordination that exists only at the manufacturing floor level within a manufacturing company.

It is my hope that people reading this book will gain an understanding of that complexity and some insight into how to effectively implement a CoE for the manufacturing floor, how to use the management and methodology tools that are available, and how to establish systems (people, processes, and technology) to successfully coordinate these skills and activities at the manufacturing floor level.

I hope you will find this book as informative to read as I have found it enjoyable to write.

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