

## Why integrate MES and ERP? Because you can't afford not to!

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In the early 1990s, manufacturing execution systems (MES) were touted as the panacea for shop floor management problems, promising to do away with "islands of automation" and to seamlessly connect the plant floor with enterprise systems. Unfortunately, the early MES was much too vertical in scope. For example, there was a MES for silicon wafer assembly, one for chemicals, another for packaging, and so on – with dozens of companies specializing in finely honed products for vertical applications. The early MES did little to put an end to the islands of automation, and the seamless connections often required skilled coding to connect to ERP (enterprise resource planning) and process control systems.

In some respects, the concept of MES was ahead of its time. Networking systems and operating systems weren't quite ready to handle the degree of communication necessary between plant floor and enterprise systems. A potential solution to the communication problem - object-oriented communication – was developing in both PC-based OS (often used on the plant floor) and UNIX systems (typically used for enterprise systems), but definitions seemed to change with each new release of an OS. DCOM (Distributed Component Object Model) in Windows, and CORBA (Common Object Requester Broker Architecture) in UNIX never quite seemed finished and were in a constant state of flux. In addition, the inability of these object platforms to communicate with one another impeded progress.

Today, the availability of Web-based XML communications successfully bridges the gaps between these systems, allowing object-based communications to freely pass. Built on XML, the B2MML (business-to-manufacturing markup language) standard specifies accepted definitions and data formats for information exchange between systems, and facilitates information flow and updates between systems.

An MES brings together many functions that fall outside the realm of the plant floor control system. Some of these include plant maintenance, laboratory information management, standard operating procedures, document control, training documentation, raw materials management and corporate information flow. The MES pulls information from the ERP system concerning orders, bills of materials, work instructions, standard operating procedures, assets, assembly steps, etc., and creates a practical manufacturing plan based on prevailing factory floor conditions.

According to Robert S. Seeley in a 1997 MD&DI column, "The most compelling reasons for installing an MES are manufacturing productivity, efficient data gathering, and simpler, more accurate management of documentation, which can lead to lower manufacturing and regulatory compliance costs." Although these reasons for using an MES are still vital today, recent changes make the MES an ideal partner with both plant floor systems and the corporate ERP system.

When coupled effectively with an ERP system, today's MES tightly integrates plant floor events with business events, empowers plant personnel with real-time/near-real-time vision into relevant events and metrics, provides accurate manufacturing costs based on productivity, and shows how much value was added on the plant floor on a shift, daily, or weekly basis. Since past MES/ERP integration problems were often due to lack of definition as to the boundaries of each system, it's important to define the role of MES functionality in a specific application before deciding how an ERP system might complement it.

## Redefining the MES

While the MES has always promised to improve manufacturing agility – making it easier to introduce more new products, create smaller and specialized batches, and shorten lead times – it also satisfied requirements for electronic record keeping and traceability. But in today's global markets, other important considerations are redefining the implementation of a MES. Some of these include global markets and production facilities, product quality and safety, production efficiency, and product genealogy. Today's manufacturing execution systems can help answer the following questions producers ask:

- Can I prove that the product I'm shipping is safe?
- What is the actual performance against performance targets?
- Which pallets have been contaminated by raw materials?
- How effectively is my organization using its assets?
- Which HACCP alerts have occurred during a production shift?
- Why is my capacity idle or non-productive?
- Are resources being used efficiently for the products actually produced?
- What is the economic impact of operational inefficiencies?
- How much revenue was lost due to these inefficiencies?
- Why do two teams that appear to be equal, produce products that are so different?

Also helping to redefine the role of the MES is the ISA SP-95 Enterprise-Control System Integration specification, an international standard agreed upon by a consortium of manufacturers, system suppliers, and opinion leaders. ISA's Enterprise-Control System Integration, Part 1: Models and Terminology provides standard terms and a consistent set of concepts and models for integrating control systems with enterprise systems that will improve communications between all parties involved. The models and terminology emphasize good integration practices of control systems with enterprise systems during the entire life cycle of the systems. Part 2: Object Model Attributes contains further details and examples to help explain and illustrate the Part 1 objects, while Part 3: Activity Models of Manufacturing Operations Management presents models and terminology for defining the activities of manufacturing operations management. Part 3 outlines four operational pillars: maintenance operation, production operation, quality operation, and inventory management. Part 3 has been approved as an ANSI standard and joins Parts 1 and 2. Parts 4-6, which cover object models and attributes of manufacturing operations management activities, business-to-manufacturing transactions, and manufacturing operation transactions will be the next issues for consideration as ANSI standards.

The ISA SP-95 model breaks down business to plant floor operations into four levels. Levels 1 and 2 include batch, continuous, and discrete control (Figure 1). Level 3 (the MES layer), includes manufacturing, operations management, dispatching production, detailed production scheduling, reliability assurance, etc. Level 4 (ERP) defines business planning and logistics, plant production scheduling, operational management, etc.

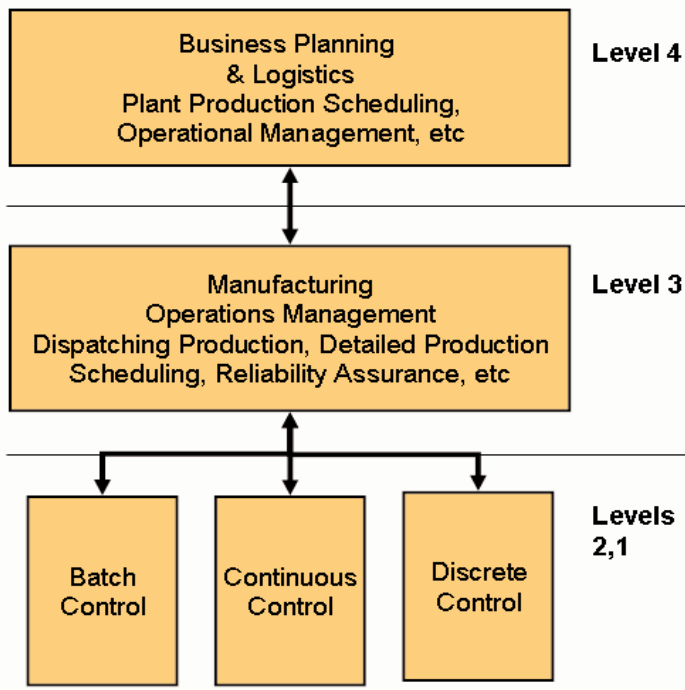


Figure 1

According to the ISA SP-95 specification, Level 4 activities include:

- Collecting and maintaining raw material and spare parts usage and available inventory
- Providing data for purchasing of raw material and spare parts
- Collecting and maintaining overall energy use and available inventory and providing data for purchasing of energy source
- Collecting and maintaining overall goods in process and production inventory files
- Collecting and maintaining quality control files as they relate to customer requirements
- Collecting and maintaining machinery and equipment use and life history files necessary for preventive and predictive maintenance planning
- Collecting and maintaining manpower use data for transmittal to personnel and accounting
- Establishing the basic plant production schedule
- Modifying the basic plant production schedule for orders received, based on resource availability changes, energy sources available, power demand levels, and maintenance requirements
- Developing optimum preventive maintenance and equipment renovation schedules in coordination with the basic plant production schedule
- Determining the optimum inventory levels of raw materials, energy sources, spare parts, and goods in process at each storage point. These functions also include material requirements planning (MRP) and spare parts procurement.
- Modifying the basic plant production schedule as necessary whenever major production interruptions occur
- Capacity planning, based on all of the above activities

ISA SP-95 Level 3 activities include the following:

- Resources allocation and control. Resources include: machines, tools, labor skills, materials, other equipment, documents and other entities that must be available for work to commence and be completed
- Dispatching production to specific equipment and personnel in form of jobs, orders, batches, lots and work orders
- Collecting and maintaining area data on production, inventory, manpower, raw materials, spare parts and energy usage
- Quality management: providing real time measurements collected from manufacturing and analysis. It includes SPC/SQC functionalities, management of off-line inspections and analysis in laboratory information management systems (LIMS)
- Process management: production monitoring, automatic corrections, and decision support for manual corrections
- Production planning and tracking including recording of production information to allow forward and backward traceability of components and their use within each product
- Performance analysis: up-to-the-minute reporting on resource utilization and availability, product unit cycle time, conformance to schedule, and performance to standards
- Operations and detailed scheduling: sequencing based on priorities, attributes, characteristics, and production rules associated with specific production equipment and specific product characteristics
- Document control
- Labor management: personnel status at up-to-the-minute time frame, certification tracking, indirect functions tracking (e.g. material preparation)
- Maintenance management

### Building an ISA SP-95 compliant MES

With an ERP system at the enterprise level (top) and the control layers at the plant floor (bottom), an ISA-compliant MES will need to communicate data in both directions to help managers answer the questions how to produce, what can be produced, when and what to produce; and when and what was produced (Figure 2). In the ISA model, a B2MML layer provides connectivity between the ERP system and the MES. At the bottom, OPC (OLE for Process Control), which began as part of Microsoft's COM/DCOM object model, connects data from the control system to the MES.

The B2MML layer provides protocols for product definition, production capability, production schedule, and production performance. Product definition protocols bring data from the MES Product Definition Management module to the ERP. Production capability protocols are used to pull data from the MES Production Resource Management module, and Production performance protocols deliver data to the ERP from the MES Production Tracking System. Meanwhile, production schedule protocols send data from the ERP system to the Detailed Production Scheduling module in the MES. The MES also consists of several other interconnected modules including Production Dispatch, Production Execution, Production Data Collection, and Production Performance Analysis. Of these, the Production Definition Management, the Production Execution, and the Production Data Collection modules connect through OPC to the control system.

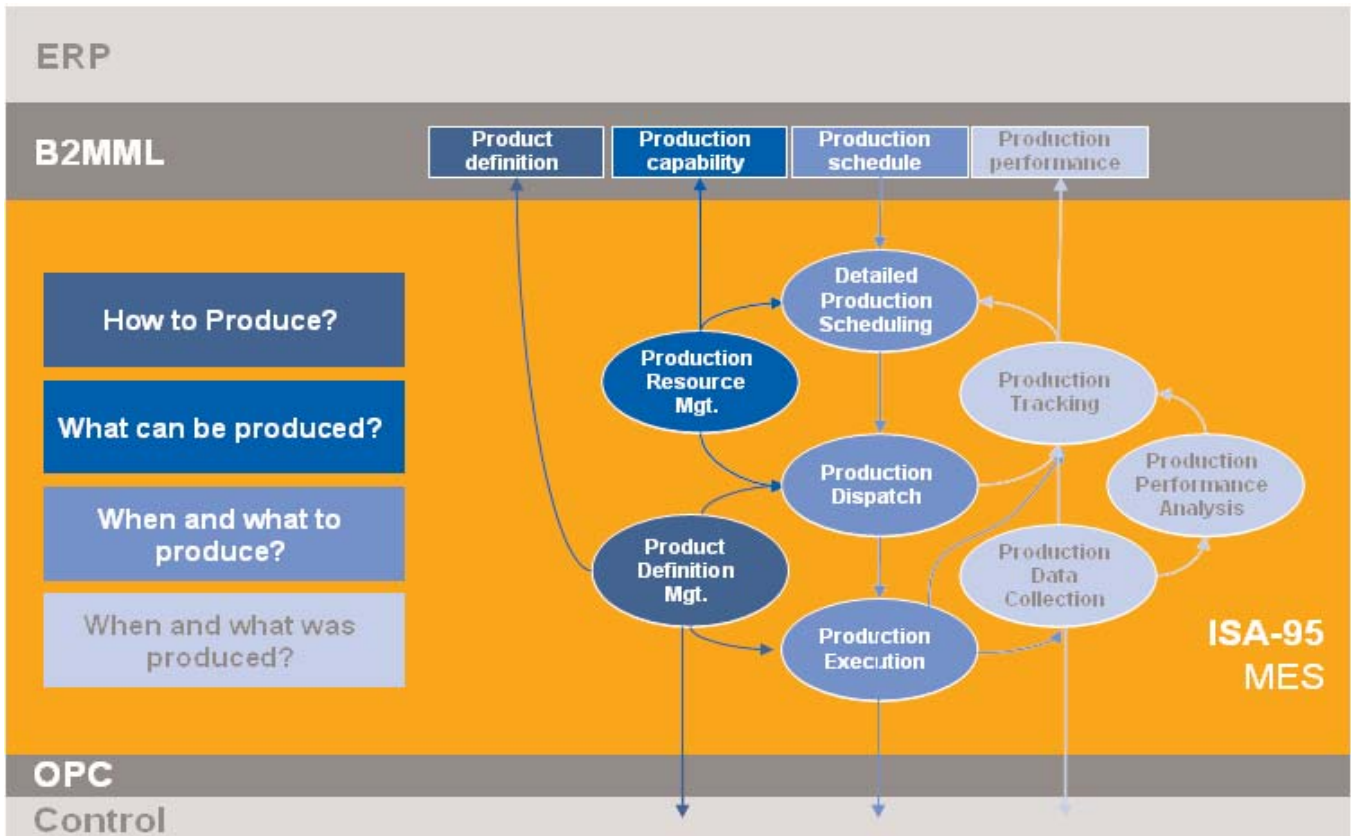


Figure 2

### Improving on the ISA Model

To make this ISA model provide real-time, dynamic, rule-based behavior to a real-world, flexible manufacturing system, some further steps help make the system perform better and provide an easy-to-operate user interface (Figure 3). First, a Data Integration Service (DIS) sub-layer bridges the MES to the ERP system (encapsulates transactional data) using B2MML. Second, to bring data from the OPC layer, a real-time, fully-redundant data server feeds data to the MES and back to the control systems. It encapsulates data from the plant floor to make it easy for the MES to handle. In addition, the ISA Production Resource Management module can be expanded to include an Equipment Manager, Material Manager, and Personnel Manager. The Production Dispatch module can be changed to a Production Order Manager, and the ISA Production Tracking module can be expanded to include a Material Manager, PPA, and a Personnel Manager. In addition, a Historian replaces the ISA Production Data Collection module, while the ISA Production Performance Analysis module's duties have been expanded to include a Plant Performance Analyzer. While these modules cover information flow, two additional systems provide the flexibility for engineers to configure the system. A Report Manager provides necessary data that plant managers will need to run the plant, and a Client Application Builder allows engineers to design and build the MES.

Additional features that go beyond ISA SP-95 specifications provide more flexibility for MES system designers. For example, rules coordinate and synchronize machines, applications and people. The system accommodates third-party software products and devices, as well as laboratory information systems and specification management systems, which assist users in managing and formulating product specifications for raw materials, semi-finished, and finished products, as well as for packaging materials. These systems can also distribute information across the company and throughout different departments (sales, purchasing, logistics, production, quality control, etc.) in a clear, concise, and controlled manner. Finally, a data engine provides fully redundant 100 ms closed-loop interlocks.

### Make Programming and Configuration Simpler

A framework approach to building an MES can eliminate trial-and-error spaghetti coding. For example, a graphical modeling environment as well as a strict separation between the production model and the operating components will provide better transparency and flexibility than a traditional approach to building an MES.

Just as object-oriented programming reduces "reinventing the wheel," an MES containing a hierarchy of reusable libraries can

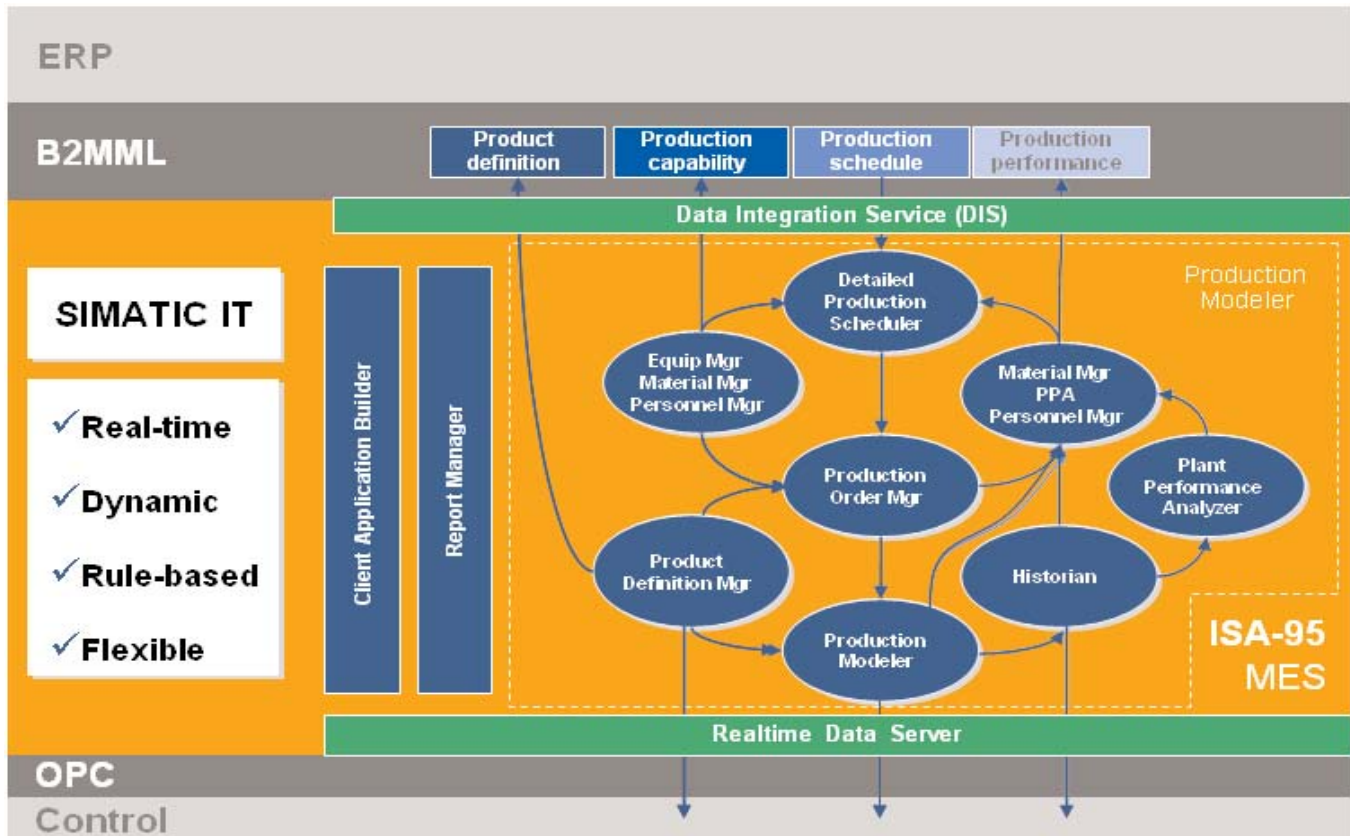


Figure 3

significantly reduce project costs and risks. A project can be built on an industry library template and make use of customer libraries and partner industry libraries. Built-in cross industry libraries allow manufacturers to test candidate libraries. Examples include filling/packaging, batch, assembly, equipment, maintenance, logistics, inventory, quality, and orders.

Last, but not least, the MES Client Application Builder, with built-in Web server, allows engineers to create and publish custom ASP.Net Web pages on a range of devices – from laptop to industrial displays to handheld computing devices. Data sources include the production modeler, MES components, database, and real-time data server.

### Benefits of a Fully Integrated ERP/MES System

An ERP system provides business planning and logistics, plant production scheduling, operational management, etc., all Level 4 activities. An MES (ISA Level 3) provides manufacturing operations management, dispatching production, detailed production scheduling, reliability assurance, etc. In the past, a complaint against ERP systems was that they tried too hard to provide what an MES does. Thus, when integrated with an MES, there were often overlapping functionalities that manufacturers couldn't use or didn't need. And in many cases, any "MES functionality" provided within an ERP system was anything but

comprehensive. At the same time, many early MES attempted to provide modules that were normally part of a well-seasoned ERP system. Also, in many cases, these MES modules didn't measure up to the level of performance that ERP systems provided.

Today, it's completely possible to integrate MES with ERP where systems are complementary and don't overlap. Besides providing an integrated workflow management at the business level of an enterprise, ERP systems can also provide supply chain and customer relationship management, as well as product lifecycle management. MES manage workflow at the plant level of an enterprise, working with PLCs, distributed control systems, and batch control systems. Manufacturers can't afford not to integrate these systems if they have both in house.

Businesses need to understand their combined manufacturing workflow before they start on the path toward MES/ERP integration. Business and production processes can be presented as a single workflow, where each step represents functionality of a machine, application, or person (Figure 4). Each step is naturally more business or process oriented, and can, therefore, be plotted on a functionality allocation chart. ERP functions can be represented on the top half and MES on the bottom half – divided by a horizontal line. B2MML boxes on the chart represent communication/control channels between ERP and MES functions. Moving the borderline changes the balance of

responsibility for functionality and workflow. For example, raising the borderline and leaving more functions below the center line (in the MES region) reflect an MES-biased implementation. Lowering the centerline reflects a more ERP-biased implementation. Manufacturers will need to go through this process to determine their own application needs. This will involve a meeting of the plant staff, the IT staff, and management, each reviewing the process and the information flow from the plant floor to the enterprise level.

### Does it Work?

A leading food company in Spain prepares and packages top-quality dairy products. Its seventeen plants employ 4,000 people and create an annual turnover of €875.5 million. It needed to improve genealogy, tracking and traceability of its products; and it wanted to increase the efficiency of its filling lines - that is, decrease downtime, reduce processing time, and improve availability. It also needed to provide for personnel management and production reports. The company also wanted a Web interface for the MES, as well as the ability to connect the MES to its ERP system.

The company installed an MES – the Siemens SIMATIC IT Production Suite, Historian, Report Manager, and Server – which provides a direct interface to the ERP. The results were positive and met their requirements, plus in many cases went beyond the basic needs. The integrated MES/ERP system provides a common solution for all plants, as each is based on a standardized product. The system provides full traceability of products and ingredients, improved production efficiency and flexibility, manages key performance indicators (KPI). With the ERP system, the company has enterprise-wide visibility of data integration, reduced errors, and managed equipment, labor, personnel, and production orders.

Another Spanish manufacturer, who makes electro-welded mesh and reinforcing joints (annual turnover of €90 million), has also seen the results of a combined and integrated MES and ERP system. It needed to enable real-time visibility of all its production operations, enable the real consumption of raw material, increase the control of resources (equipment and operators), obtain the total traceability of product lots, and increase the reliability of its data. The results of an integrated SIMATIC IT Production Suite, Historian, an interface and ERP system, reduced the company's downtime by 20%. The successful integration made it possible to trace the real consumption of raw material, improve the efficiency and equipment of operators, and provide production status for managers.

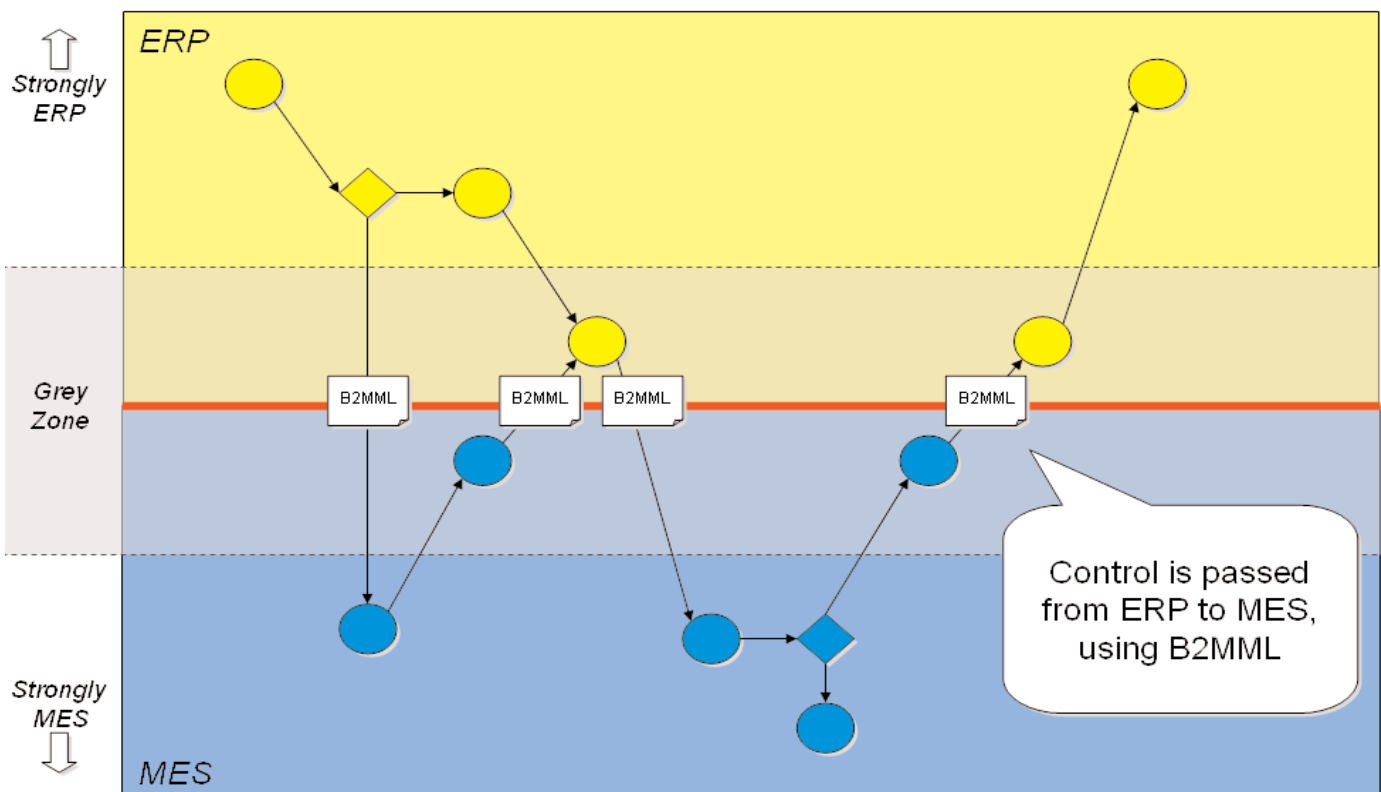


Figure 4

## Conclusion

The benefits of MES-to-ERP integration go far beyond the rudimentary integration efforts. To become agile and responsive, manufacturers must gain vision into their operations to enable them to make decisions based on real-time information, understanding both the impact of those decisions and the alternatives that may be available to them. Joining manufacturing with planning systems is the first step toward that agility.

Today, there really is no lack of communication mechanisms to constrain the successful integration of MES – and with standards

such as ISA 95, and ANSI's version of the ISA specification, an MES that conforms to those standards can greatly ease the efforts of that development. It also assures that the terminology, functionality, and communication capabilities are consistent.

Finally, an integrated system will show real returns: from the ability to monitor – in real time – key performance indicators on productivity, quality, yields, and throughput; to managing inventory locations and raw materials; through remediation processes to isolate and or rework nonconforming products. Integration, rather than merely a blending of two discrete systems, becomes the key enabler for a more profitable, responsive business.

