MES Functionalities & MRP to MES Data Flow Possibilities

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Background

MES and MRP: Complimentary Systems for Operations Management

In today's complex manufacturing environment, it's hard to imagine managing without computer systems and software. Most of these systems and software, however have only come on the scene during the past two or three decades. Despite the growing number of "integrated systems" on the market, most companies find themselves with a mixture of new and legacy systems, which must be linked together.

In manufacturing, many of these legacy applications are Manufacturing Resource Planning (MRPII) systems which have been installed within the last fifteen years or so, and probably have not been completely implemented. In the standard scenario for an MRPII implementation, the planning and material management modules are installed and used (more or less well).

However, operations management and the factory floor have a very limited system involvement. Even with limited success with MRPII, many companies cling doggedly to their systems, largely because they have a tremendous investment in the data that the systems contain or because someone built his or her career on the "success" of the MRPII system. The folks on the shop floor are left to fend for themselves, as they have always done.

In the past few years, a new class of systems, Manufacturing Execution Systems (MES), has come to the market. These systems offer the manufacturer the opportunity to provide the shop floor with a look it can use to really manage production, while breathing new life into the MRPII system. Not only is understanding how MES and MRPII can function together a key to a successful implementation of the MES, but it also provides the opportunity for the MES to extend and enhance the functions performed by the MRPII.

MESA International

MESA International was formed in 1992 as a trade association representing developers and vendors of MES software and related products and services. As such it is in a unique position to create and disseminate information of the type found in this white paper. Its member companies are on the leading edge of MES development and application and have installed systems throughout North America and around the world.

This paper is part of MESA's aggressive research and analysis program designed to support developers/vendors of MES technology and manufacturers who use the technology or are planning to use it. Through a series of industry surveys, studies, reports, published articles and papers, and throughout industry events such as the MES Roundtables, the association is helping to advance a technology that will have a profound impact on manufacturing into the next century.

Contents

While it's important to analyze the benefits these technologies offer, it's also critical to understand the history of the computerization of manufacturing operations. Basically, its history can be divided into four significant phases:

1. Accounting systems and simple inventory management systems;
2. MRPII systems that emphasized a material planning approach;
3. Niched systems for Job Shop, Repetitive, Process, etc.;
4. Functional extensions and new information technology as embodied in Manufacturing Execution Systems.

Because accounting systems were so well defined and established, they were one of the first business applications to be automated with computer systems. In fact, the first manufacturing applications occurred as a by-product of the computerization of accounting, which often included components for inventory accounting. The need for software specifically designed for manufacturing, rather than financially oriented information used to solve operations problems, led to the eventual development of MRPII and a variety of software packages currently on the market.

MRPII concepts, or closed-loop manufacturing systems, reached their zenith during the late 1970s and early 1980s. Essentially, they are designed to integrate all the operational functions for a manufacturing organization from engineering through production, and replace a reactionary management culture with top-down planning disciplines., These systems were and still are successful for companies that are really determined to change. For the most part, discrete manufacturers with deep bills of material (BOM) realized the great benefit of MRPII, simultaneously reducing inventories while improving customer service.

Typical MRPII systems are designed to support the traditional manufacturing organizational structure with three core functions:

1. Production definition - describes and quantifies the relationships between raw materials, purchased parts, fabricated parts, sub-assemblies, and finished products. Also known as a bill of material, it includes engineering control capabilities to manage product introduction and changes. This also contains a part master that includes lead times and other departmental information, including cost, order policy, quality, material control, and customer service. The result is a common database for the entire enterprise.

2. Material control - provides basic capabilities to allow inventory transactions to maintain material balances, and provide inventory cost accounting.

3. Material planning - functions to analyze supply and demand for all planned parts. Forecasts and master schedules may be used. MRP generates a supply order quantified by order policy, which is back scheduled from the due date using a lead time calculation whenever projected inventory balances are negative or demand exceeds supply. This function simply provides "What, how much, and when" for developing material plan.

MRPII systems employ planning techniques that improve communication both inside and outside the manufacturing enterprise. Manufacturers that have implemented these systems have made major improvements in coordination of cross-functional activities to identify potential customer's shipment and vendor receipt problems. Where MRP has fallen short is in the development of a realistic schedule for the shop tied to a factory communication and tracking network. Dispatch lists produced by MRPII systems are rarely followed. This happens for many reasons, the least of which are that MRP systems assume infinite resources; and updates to and from the floor are not in real time.

As MRP technology has matured, other functions have been added to provide routing definition, shop floor control, and capacity planning. These functions provide expanded cost definition, generate production order paperwork and track job status. Without finite capacity scheduling and real-time feedback, however, the generated dispatch lists typically are not very useful.

By the mid-1980s companies began applying JIT (Just in Time) to solve many of their manufacturing problems. Powerful new concepts, such as "push versus pull," ricocheted throughout the industry, and MRP software developers scrambled to make their systems appear orderless. Manufacturing systems provided functionality to support Kanban environments. Practitioners and consultants alike learned to reduce lot sizes to one in an effort to achieve immediate productivity gains. Quality was king. Then two words, "cycle time," entered into manufacturing as a focus for competition and a measure of production success.

MES applications provide companies with the tracking capability to monitor the floor activities with greater resolution (hour/minute), and integrated with finite capacity scheduling to provide fast reaction to changes. It must also continually analyze activities in order to be responsive to events as they occur on the shop floor.

Much of the manufacturing applications software now on the market has capitalized on many of these technology advances, and software producers have added refinements. One of the breakthrough ideas that has occurred within manufacturing software is the emergence of synchronous manufacturing systems, MES coupled with a scheduling module. To better understand these systems, let's look at a basic definition of manufacturing — the process of transforming material through the application of labor of machine resources. Manufacturers want software that enables them to concentrate on continually improving this particular process. Common improvement measures used by manufacturers include quality, cost, and cycle time. MES helps manufacturers affect these measures by improving the scheduling of all direct resources that control throughput, synchronize support resources, and identify and eliminate wasted time and materials. MES synchronized with scheduling allows companies to efficiently manage time and resources, which are keys to realizing significant productivity gains.

By incorporating an MES approach, a company can create an environment that streamlines the manufacturing flow and increases the velocity of production, while maximizing the added efficiency (touch time/cycle time). This manufacturing environment reduces queue time and analyzing and addressing the causes of queue time. It also identifies support resources from the activity path and incorporates ways to identify problems. The goal is to accelerate the flow of work throughout the shop.

Four areas where MRPII environments foster and perpetuate significant problems are 1) incorrect bill of material structuring: 2) obsolete routing time standards; 3) unrealistic lead time definition; and 4) unrealistic schedules as a result of no real-time feedback from plant operations.

MES cultivates a more realistic process model, provides material definition linked to consuming operations, and generates lead-time accuracy based upon actual execution times, which improves inventory control. Precise capacity models tied to metrics (measurements) of actual versus scheduled times can be used to refine process models and help them more accurately represent the real behavior of the plan.

MES is particularly well suited for manufacturers looking for ways to turbocharge existing MRPII systems. Manufacturers can now work with achievable shop floor plans. The result is reduced cycle times.

MES produces information to support the material requirement of executing a manufacturing plan. They also contain all constrained resources necessary. Support activities are part of the critical manufacturing path and coordinated so that the entire organization follows one coherent, workable plan. The planning resolution (hour/minute) is more precise than a stand-alone MRPII system.

MES compliments MRPII applications and extends their capabilities by incorporating an execution-driven approach. Together these solutions provide companies with more realistic schedules that compress cycle time, reduce work in process, and improve the value added time while maximizing return on assets. Collectively, these benefits enable companies to achieve significant productivity improvements, improved customer satisfaction and provide an overall competitive advantage in the marketplace.

Why MES

Automated MES systems not only assist production people to schedule precisely but provide an electronic network for performance improvement. MES includes functions for finite operational scheduling, resources management, the dispatching of production units (jobs, batches, lots or whatever.) MES will supply automated data collection and the delivery of detail documents such as instructions, recipes, drawings and part programs to the work station. MES will also record production details and analyze performance (see Figure 2 - MES Functionalities.) What "Planning" handles superficially in batch, MES handles continuously, up-to-the-minute and on the spot.

What about the proverbial bottom line? What are the real, demonstrated benefits of MES? Here's what happened to a variety of manufacturers who used MES systems:

Reduced Manufacturing Cycle Time

Sixty-six percent (66%) of the manufacturers responding reported a reduction in manufacturing time of 45% or greater.

Reduced Data Entry Time

Sixty-six percent (66%) of the manufacturers responding reported a reduction in entry time of 75% or better.

Reduces Work in Progress

Fifty-seven percent (57%) of the manufacturers responding reported a reduction in WIP of 25% or better.

Reduces Paperwork Between Shifts

Sixty-three percent (63%) of the manufacturers responding reported a reduction in paperwork between shifts of 50% or better.

Reduced Lead Times

Sixty-three percent (63%) of the manufacturers responding reported reduction in lead time of 35% or better.

Improvements in Product Quality/Reduces Defects

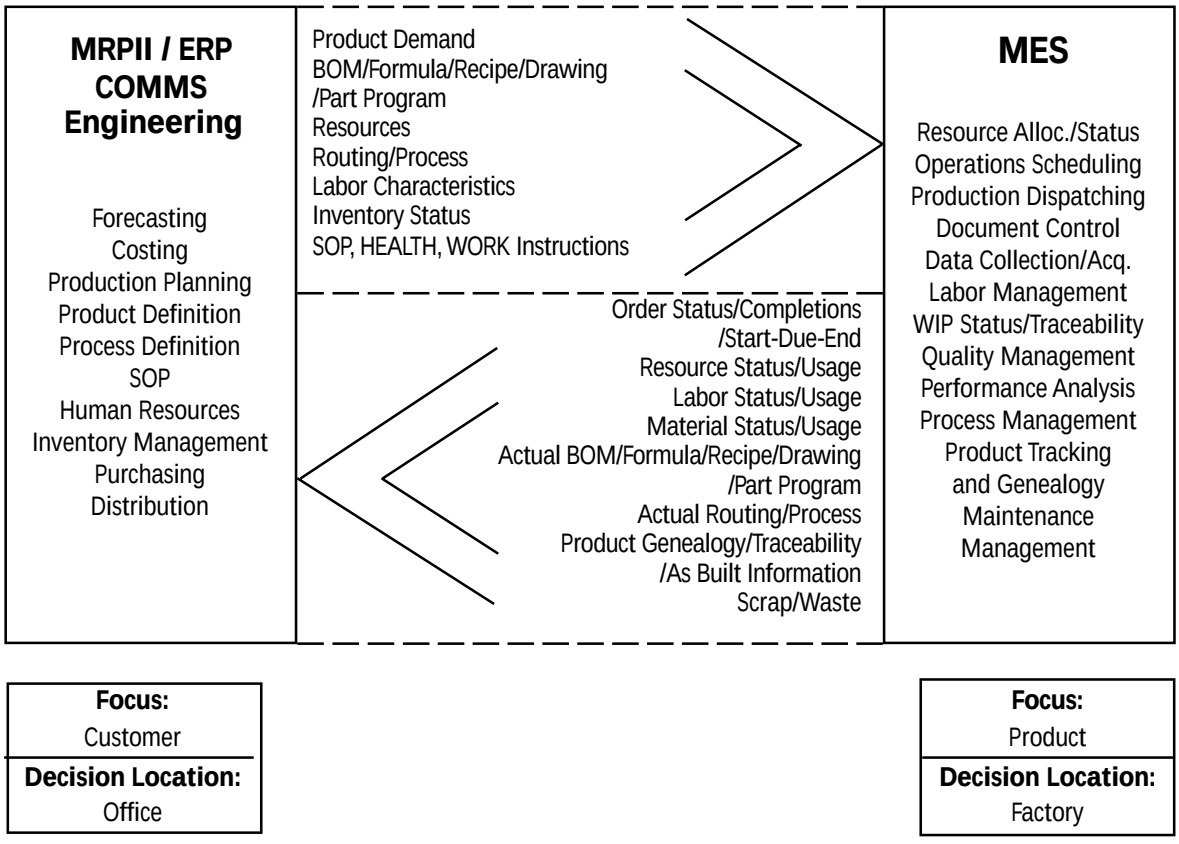
Reduces/Eliminates Lost Paperwork/Blueprints

Return On Investment/Payback Period (14 Months Average)

Experience has shown that MES needs information not generally found in office systems. In those cases where planning systems provide some information, MES must define additional data elements in order to organize manufacturing operations on a realistic basis. Such deviations and improvements by the MES system also means that there must be constant feedback to the planning program so that purchasing is aware of any changes in required materials.

MES provides the basic interface between planning and execution systems that benefits both the front office and the factory floor. The payoff is even bigger when MES is oriented towards "real time" production and scheduling. The expanded interface has information flowing both ways with factory floor information aiding the office system in job costing, payroll, lot control, inventory and

Figure 1: MRPII to MES Data Flow Possibilities



other factors on work actually being performed (see Figure 1: Data Flow Diagram).

MES systems bring up-to-the-minute communications with the factory floor. The vital link can present, electronically, the setup, or configuration/drawing information critical to the task at hand. Part programs and recipes required by machine tools can be electronically down-loaded.

MES becomes increasingly important during the production process. It can monitor production in real time; provide information for lot control; and generate labels for identification of the products, information on scrap, machine down time and parametric data on the state of the process is made available as needed and as wanted. An MES could report container quantities as they come off the production line, generate bar-coded identification label, assign serial numbers and provide parametric data as the containers are filled.

MES—Manufacturing Execution Systems —do one thing exceedingly well. They leap over that gap between front office and factory floor, and empower production employees with a down-to-earth, easy-to-use system that supplements the office oriented system. MES, in conjunction with current Planning systems, is easy to install and employees are quick to learn its benefits without starting from scratch. MES makes sure that the game plan devised in the office is a winner on the floor.

Figure 2: MES Functionalities

1. Resource Allocation and Status
Manages resources including machines, tools labor skills, materials, other equipment, and other entities such as documents that must be available in order for work to start at the operation. It provides detailed history of resources and insures that equipment is properly set up for processing and provides status real time. The management of these resources includes reservation and dispatching to meet operation scheduling objectives.

2. Operations/Detail Scheduling
Provides sequencing based on priorities, attributes, characteristics, and/or recipes associated with specific production units at an operation such as shape of color sequencing or other characteristics which, when scheduled in sequence properly, minimize setup. It is finite and it recognizes alternative and overlapping/parallel operations in order to calculate in detail exact time or equipment loading and adjust to shift patterns.

3. Dispatching Production Units
Manages flow of production units in the form of jobs, orders, batches, lots, and work orders. Dispatch information is presented in sequence in which the work needs to be done and changes in real time as events occur on the factory floor. It has the ability to alter prescribed schedule on the factory floor. Rework and salvage processes are available, as well as the ability to control the amount of work in process at any point with buffer management.

4. Document Control
Controls records/forms that must be maintained with the production unit, including work instructions, recipes, drawings, standard operation procedures, part programs, batch records, engineering change notices, shift-to-shift communication, as well as the ability to edit "as planned" and "as built" information. It sends instructions down to the operations, including providing data to operators or recipes to device controls. It would also include the control and integrity of environmental, health and safety regulations, and ISO information such as Corrective Action procedures. Storage of historical data.

5. Data Collection/Acquisition
This function provides an interface link to obtain the intra-operational production and parametric data which populate the forms and records which were attached to the production unit. The data may be collected from the factory floor either manually or automatically from equipment in an up-to-the-minute time frame.

6. Labor Management
Provides status of personnel in and up-to-the-minute time frame. Includes time and attendance reporting, certification tracking, as well as the ability to track indirect activities such as material preparation or tool room work as a basis for activity based costing. It may interact with resource allocation to determine optimal assignments.

7. Quality Management
Provides real time analysis of measurements collected from manufacturing to assure proper product quality control and to identify problems requiring attention. It may recommend action to correct the problem, including correlating the symptom, actions and results to determine the cause. May include SPC/SQC tracking and management of off-line inspection operations and analysis in laboratory information management system (LIMS) could also be included.

8. Process Management
Monitors production and either automatically corrects or provides decision support to operators for correcting and improving in-process activities. These activities may be intra-operational and focus specifically on machines or equipment being monitored and controlled as well as inter-operational, which is tracking the process from one operation to the next. It may include alarm management to make sure factory person(s) are aware of process changes which are outside acceptable tolerances. It provides interfaces between intelligent equipment and MES possible through Data Collection/Acquisition.

9. Maintenance Management
Tracks and directs the activities to maintain the equipment and tools to insure their availability for manufacturing and insure scheduling for periodic or preventive maintenance as well as the response (alarms) to immediate problems. It maintains a history of past events or problems to aide in diagnosing problems.

10. Product Tracking and Genealogy
Provides the visibility to where work is at all times and its disposition. Status information may include who is working on it; components materials by supplier, lot, serial number, current production conditions, and any alarms, rework, or other exceptions related to the product. The on-line tracking function creates a historical record, as well. This record allows traceability of components and usage of each end product.

11. Performance Analysis
Provides up-to-the-minute reporting of actual manufacturing operations results along with the comparison to past history and expected business result. Performance results include such measurements as resource utilization, resource availability, product unit cycle time, conformance to schedule and performance to standards. May include SPC/SQL. Draws on information gathered from different functions that measure operating parameters. These results may be prepared as a report or presented online as current evaluation of performance.

Purpose and participants

• To review work done to date in the analysis of the information flow between Planning systems and MES.

• To develop an original MESA MES Functionality Overview, Information Flow Diagram and to advance the state of work for use in educating potential users of MES.

MESA members participating in this work were:

Individual	*Company*
John Leibert, Chairman	MDSS, Inc.
Mark Muroski	ABB Industrial Systems Inc.
Julie Fraser*	AMR
Tony L. Davis	BBN
Sanborn Towle	Camstar Systems, Inc.
Peter Tebbenhoff*	Consilium
Scarlett Navarro-Robertroy	EDS
Dennis Huff	Harnischfeger Engineers
Curtis Chance*	Honeywell
Mike Wells*	ICC
Craig Woods	IBM
Dale Kukla	MDSS, Inc.
Bill Hakanson	MESA International
Steve Zailyk*	RWT Corp.

** Individuals no longer affiliated with companies indicated.*

Members reviewed the current models from both AMR and Gartner Group and the fine work both organizations had started in this area. The meeting continued with a discussion about whether separate models were needed for Batch Process, Discrete and Continuous Process types of industries and agreed the objective would be to develop one model that would apply to all three.

Newly developed flow diagrams were presented by Chair Leibert as a starting point which indicated categories of information that flow from COMMS to MES and back. During review of these diagrams it was determined that clearer definitions of the MES functionalities were needed before an agreed upon MESA Information Flow Diagram could be developed. As a result of this realization, the meeting became the focal point for a MESA-originated document to clarify the MES functionality as the basis for the flow diagram.

Manufacturing Execution Systems Association

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