EVOLVING TO THE ENTERPRISE PRODUCTION SYSTEM (EPS)

By

Michael McClellan
President
MES Solutions, Inc.
Terrebonne, Oregon 97760
541 548 6690

Applying information system technology to assist in the execution of production has been a rapidly growing trend for a number of years. Beginning in the early fifties the original driving force behind these systems was the financial side of the business. The primary objective was to better control or at least understand the investment in inventory. The original functionality included what are now considered basic production planning tools:

Master Schedule	Material Requirements Planning	Purchasing
Inventory Control	Costing Data	Shop Floor Control

These systems have evolved through various stages of functionality including Material Requirements Planning (MRP), Manufacturing Resources Planning (MRPII), Manufacturing Control Systems (MCS), and currently, Enterprise Requirements Planning or Enterprise Resource Planning (ERP). Their impact has grown from simple calculation methods to determine inventory quantities into sophisticated global enterprise management tools that today involve every aspect of the corporation

When manufacturing needed information to guide their efforts it was necessary to make do with what was previously designed for financial analysis. Early MRP runs were provided monthly based on data gathered manually from production control departments. Originally this information might be gathered during the last week of the month. During the first week the reports were run and printouts (sometimes 12" thick) were delivered to production management indicating requirements for the upcoming month. Can you imagine a unit of a major corporation receiving a month of expected production needs that then must be converted into daily production schedules for the month? Obviously, there was room for improvement.

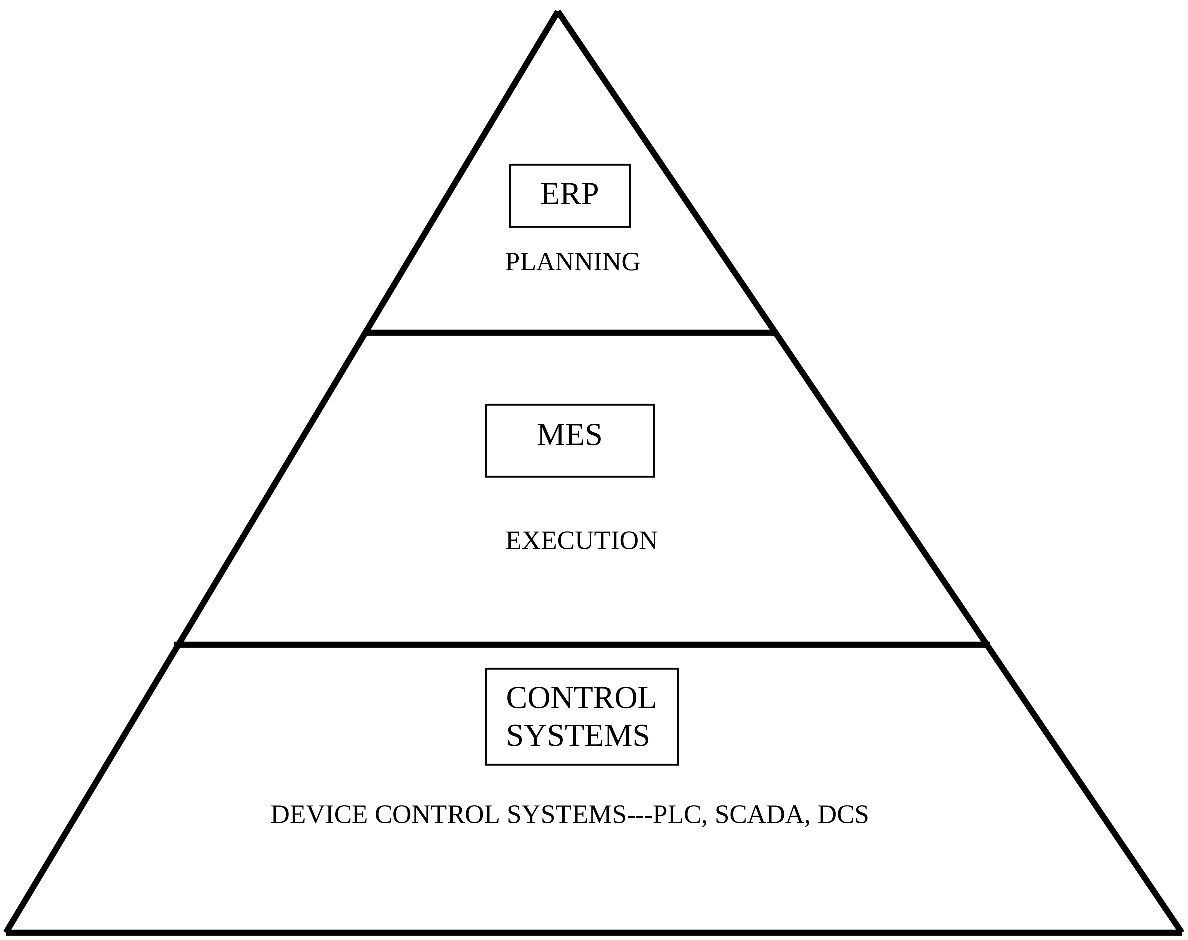
Because the MRP run was very difficult to work with, manufacturing management mostly ignored it. The data was generally incorrect, always late, and nearly incomprehensible when it came to making daily or even weekly decisions. Even when the time horizon was shortened to one week (most MRPII systems) the process did not improve much. The data was collected on Thursday and Friday, entered into the computer over the weekend, and reports were printed and distributed on Monday for review on Tuesday. You can quickly see production management now had information that was only five days old, much better than one month old, but still not a very effective tool.

Beginning in the early 1980s a new concept emerged that began to provide some direct assistance for manufacturing as what are now called manufacturing execution systems came on the market. This was a big step forward because for the first time the system was designed for the specific use of manufacturing management. Some of the early functionality focused on work orders and data collection providing information to make choices focusing on orders that had been released by the MRPII system into weekly time buckets. With early MES systems, work-in-process tracking was (and in many cases still is) where management effort centered. The focus was to improve the management of the orders in the short-term queue and to assign resources (primarily manufacturing equipment) to get improved throughput. Typical functionality included the ability to visually view open orders, combine orders into larger lot sizes, or prioritize orders to improve set up time requirements.

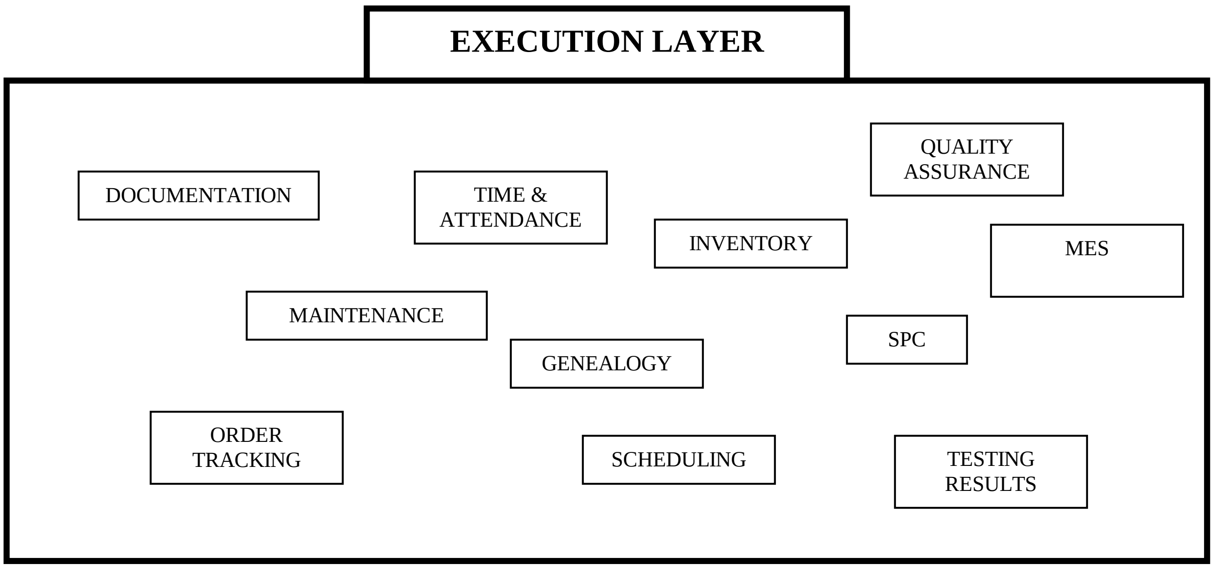
At this same time more software products were being developed to address other aspects of the plant. These included maintenance management systems, quality assurance, time and attendance, statistical process control, documentation management, and genealogy. Although there have been plantwide models such as those developed by the Manufacturing Execution Systems Association, the vendor community has generally not provided systems that go beyond specific traditional department functionality.

The evolution of technology has also been continuing on the plant floor. We have come a long way since the first programmable logic controllers were first used to replace relay logic control panels that measured conditions and controlled devices used to accomplish production processes. We are now at the point where SCADA systems are common and industrialized computers are used to monitor and direct production device networks.

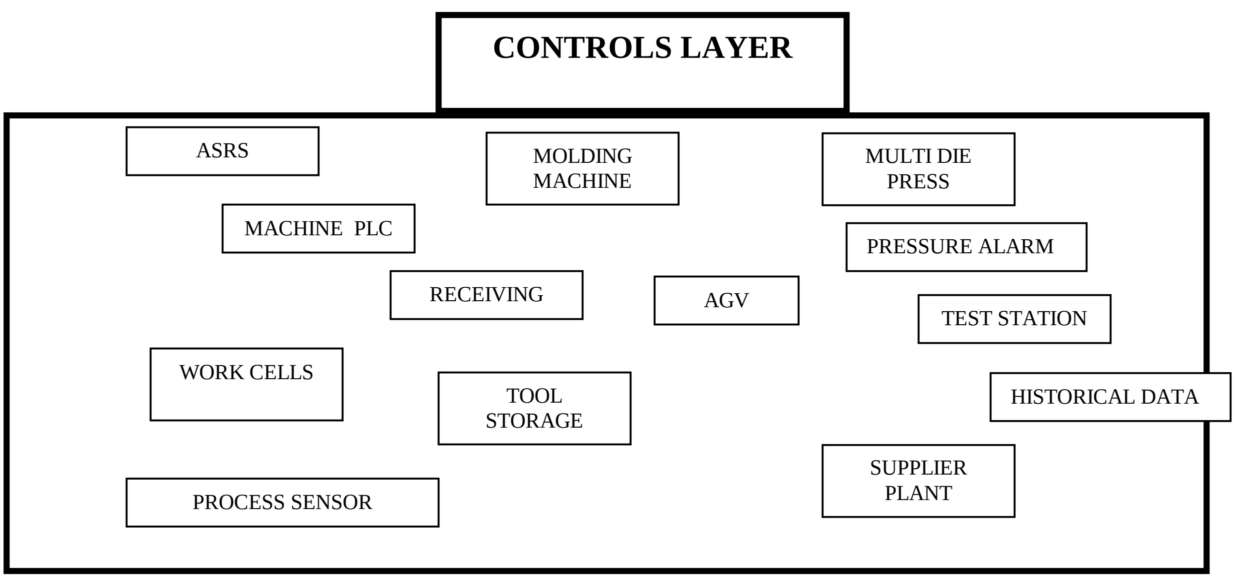
For many years these systems have been pictured using the three-tier model as shown below:



With all that has been developed, we are just getting started. There are new opportunities to use technology in manufacturing that will make previous accomplishments look as weak as we might currently think about early MRP system capabilities. These opportunities will not come from generating more data as we are overflowing with data already but through a better job of integrating the information into more usable forms for more widespread use. To provide a better understanding of where this is going we will more closely examine the functions within the manufacturing infrastructure in the execution and control system layers.



On the plant floor the process and equipment control systems were separately designed and managed based on methods from a tradition of motor control and process sensors.



These are the two layers that make up the manufacturing process. Although software systems exist for most functional requirement they still remain islands of information. Today's opportunity is to integrate these various islands of automation/information into a **HOLISTIC** seamless system with the ability to accomplish production and provide current and correct information to all users.

Some possible examples of improved integration:

1. The scheduling system is updated by events on the plant floor as they occur with a resulting revised schedule that is presented to all affected system users in near real time via the network, intranet, or internet.
2. Quality assurance testing data is analyzed on line with immediate go/no go decisions. The order rework requirements and routings are reinserted into the schedule and new genealogy information is recorded and attached to the production order that has been divided into sub lots.
3. An out of tolerance condition has been detected in an oven. What is the correct response?
4. Where is a specific lot of received material? If it is available for assembly, initiate the delivery to the assembly line. If not available, select alternate material and make note of the substitution in the genealogy information.
5. A truckload of material from a just-in-time supplier has arrived at the receiving/unload station. Scan the driver information, confirm the order and quantity, perform quality assurance test, and take into inventory.
6. Assembly and test information is constantly updated and maintained in the corporate product documentation system. As an order is released for manufacture the information necessary to each manufacturing operation is delivered to the affected workstations either upon request by the operator or automatically in response to material being delivered.
7. When an operator signs on to a workstation the system compares the qualifications of the operator to the work scheduled in the current time period. The operator identification is made a part of the production record.
8. When a recipe is assigned to a production order the equipment settings are revised and inventory is committed and delivered to the production stations.
9. As orders are released to production inquiries are made into the production systems of key JIT suppliers to confirm their readiness.
10. A key customer has increased their order quantity by 100% and would like to keep the current shipping date four days out. Review scheduling, inventory, maintenance, and available manpower skills on line and respond within 5 minutes with a go/no go decision and a revised plant floor schedule.

Having the ability to answer these conditions required significant interaction between individuals or a very large investment in programming to integrate the various computer systems. The new approach is to combine the real-time and near real-time data generation and use into an integrated system through the use of an integration layer or framework. The first step is to think of the business as having two types of systems. One system is ERP, the overall corporate management and planning resource. The other system is the Enterprise Production System (EPS) made up of the MES or execution infrastructure layer and the control system layer. The EPS, by definition, includes all software and control systems logic used to manage the plant floor functions and processes. This includes equipment and process sensors, equipment and process programmable controller logic and any and all software used to control or influence production such as scheduling, maintenance, genealogy, tracking, etc.

Enterprise Requirements Planning
(corporate system)

Financial Reporting Customer Relations Master Schedule
Purchasing Global Inventory MRP Costing
Human Resources Product Design & Documentation
Supply Chain Mgt Corporate Guidelines & Strategy

Enterprise Production System
(Each production facility or group of facilities)

Maintenance Time & Attendance SPC Quality Assurance
Local Inventory Warehouse Management Genealogy
Process Data Exception Management Material Movement
Process Control Work Stations/Cells Scheduling Testing
Performance Analysis Machine Control ASRS CNC
Scanners/sensors Plant Computer and Network PLCs
Receiving Manufacturing Execution System Product Data

There are good business and system design reasons to support this approach.

1. This more clearly divides the systems into planning (decision support) and execution (transaction processing).
2. This will usually fit the physical separation of the corporate view and the local plant view although there will be some overlap and the systems are mutually supporting.
3. This allows a corporate wide strategy separated from localized production facility systems.
4. This provides a better environment for system improvement and upgrade (either corporate or local).

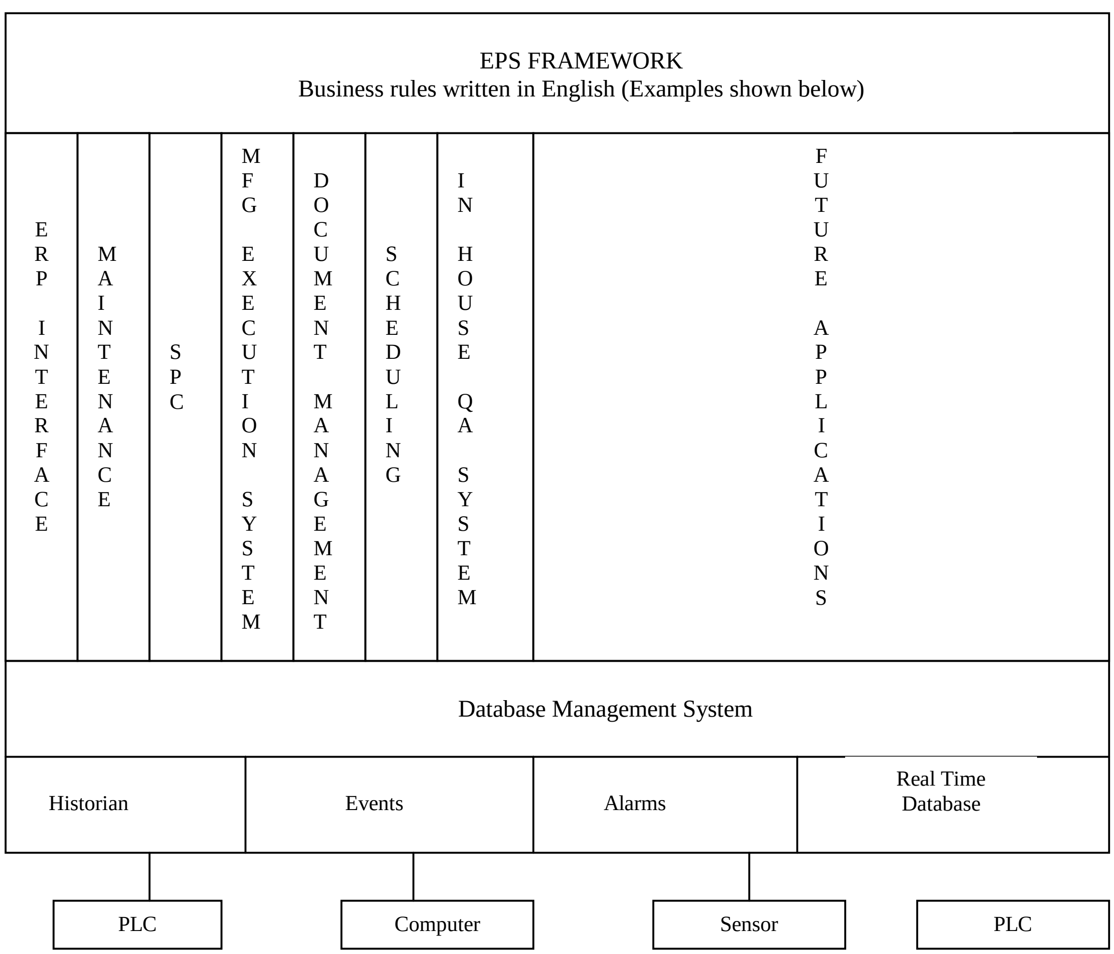
Besides the cultural and development history there have been technical and practical reasons that have brought us to where we are. The most significant roadblock to a seamless system has been the cost and complexity of integration of various data sources and/or software packages. The staggering complexity can be seen considering the simple requirements of integrating three separate typical plant software systems such as scheduling, maintenance, and a manufacturing execution

Typical problems include:

1. Obtaining the source code for each package with the ability to make revisions.
2. Designing and developing the drivers to enter and receive data from each package.
3. Designing and developing the various data passing and logic conditions as well as the identifying clean data issues.
4. Whenever any changes are made the entire system will again require a detailed analysis to ensure system functionality is not compromised.
5. Change documentation and testing must always be current or there will be no way to debug or rely on revisions.

The problem compounds. Three packages each require their own revision plus the revision of two others. In a typical plant there could be twenty or more systems (PLC control systems and system software). Revising each of these and making upgrades is nearly impossible—consequently integration is usually NOT done.

There are some new ideas and software coming to market that makes this process much easier. The idea is to develop a framework and a common database structure along with easily developed business rules that **LINK** (key word) existing or new applications. This arrangement begins with a database that maintains data necessary for the integrated portions of the EPS. This diagram shows how various applications are linked.



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The system operation is based on the idea of using functional applications and data generated by sources internal or external to the EPS. When certain events occur they are recognized as triggers causing a corresponding business rule to be followed within the EPS integration layer.

Business rules are the response to certain events or actions that occur within the system and define the actions or responses to system stimuli. Typical business rule applications would look much like the following:

1. When a vendor shipment arrives at receiving scan the purchase order number to retrieve the issued purchase order number documentation. If the purchase order is valid, retrieve receiving inspection instructions from the product data system, set a receiving priority established through the scheduling system and advise ERP that the shipment is on site.
2. A workstation is scheduled for use in production. Check the maintenance schedule to confirm that downtime is not planned within the current planning horizon.
3. When a worker scans into a workstation (signs on) confirm with the human resources system skills information to ensure the worker is qualified to perform the tasks required.
4. When the pressure on tank one exceeds xxx advise quality assurance and increase monitoring to every 30 seconds. If pressure exceeds xxxx sound alarm and advise maintenance to schedule cleaning method 4.
5. When an order has completed packaging collect genealogy data, SPC information and exception reports. Print the information on the shipping label and send quantity information to updates the warehouse management system and the ERP. When the order is finished, calculate the piecework compensation for contributing employees based on the current shift formula in the personnel system.
6. Retrieve temperature monitoring information from each machine PLC and append to the genealogy file of each order every 20 minutes. When an order is completed send the temperature file and the MES work-in-process rework history to the customer order system.
7. Every 30 minutes dial the schedule monitoring system of ABC supplier. When there is a deviation from previous data, advise production area 10 a delay has been received and post this to all level one supervisors as a class two alarm. Send the data to the ERP system to append to the vendor file.
8. Whenever an inventory shortage effects a released order, place a standing order for the part number or numbers with receiving and incoming material test systems. Advise scheduling when availability can be determined.
9. When an engineering change order is received check all outstanding work-in-process and completed orders in the warehouse management system. Advise scheduling of all lots requiring rework and advise customer service. Advise ERP of inventory changes.

It appears there is no question that the current islands of information are only one early step in the evolution toward a fully integrated system of manufacturing management. The functional needs of specific departmental applications are being accomplished but this is not enough. Any preferred method requires as much flexibility as possible without sacrificing individual plant needs and methods. The LINKING concept allows a version of “plug and play” with limited connection costs while providing flexibility to use existing purchased or in-house developed applications and new applications when required.

Whether you use linking, software programming, or sneaker-net, closer **integration** of all data sources and data users is where this technology is going, providing a more effective Enterprise Production System.