MES Software Evaluation / Selection

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Purpose

The purpose of this white paper is to assist manufacturers and associated support organizations in evaluating and selecting Manufacturing Execution System (MES) software. Various definitions portray MES as an integrated suite of products with dynamic interaction and real-time responsiveness. MES software can be complex because it involves the integration of multiple functions and these functions may not be available from a single vendor. This paper provides a process along with suggestions for arriving at an informed decision when choosing from the myriad of specialized and/or integrated packages offered.

The following white papers published by MESA International define MES and the benefits that can be expected:

- "The Benefits of MES: A Report From the Field"
- "MES Functionalities and MRP to MES Data Flow Possibilities"
- "The Controls Layer: Controls Definition and MES to Controls Data Flow Possibilities"

The above papers, as well as those published by well known manufacturing consulting organizations, share a common theme that plant floor systems provide greater benefits if they are integrated and have a common information infrastructure. Integrated execution software is multi-functional and naturally requires a different sort of evaluation than is involved in evaluating software designed for a single manufacturing function. A simple functions checklist does not fit the bill. The selected MES product must be suitable, or adaptable to, the manufacturer's business over a broader range of functions. The manufacturing organization must be prepared for this new technology, and the software must integrate well with existing business planning and controls level systems. Customers are demanding more agility and mass customization from manufacturers. The MES must not only enable agility and continuous improvement in manufacturing operations, but *the MES software itself must be agile and easily improved.* The final MES may be a single software product with or without customization, or it may be a combination of software packages. The evaluation and selection process involves selecting the software and also the vendor(s) and/or system integrator.

This white paper lays the groundwork for evaluating and selecting integrated MES packages. The process includes the following steps:

- MES Analysis
- Evaluation / Selection Team
- High Level Requirements
- Initial Product / Vendor List
- Requirements Document and/or RFP
- Vendor Meetings
- Selection Results

A list of MESA members who participated in the development and review of this white paper will be found in Appendix C.

Contents

Introduction to the Evaluation and Selection Process

The MES software evaluation/selection process is intended to help manufacturers shorten the time to evaluate and select MES software. This process is provided as a guideline and does not address any particular industry. The focus of the process is on MES software. MES software is unique in that it is multi-functional (or cross-functional), has broad organizational impact, is very interactive, and is applied differently over multiple industries. The steps in the process help the manufacturer know who to involve, what should be done, and how to communicate with the software vendors. The process helps the manufacturer include the proper level of detail needed to make a good selection in a timely manner.

The overall time required to complete the process depends on the scope of the requirements, the number of vendors, and the experience of the evaluation/selection team. It is not uncommon for software evaluation and selection to take from six months to one year. If the proper time is committed to following the process and the steps recommended in this paper are scheduled well in advance, MES product selection can be shortened to take place within *two to six months* (six months or more if multiple point solution integration is involved).

The level of detail to consider in determining requirements and evaluating vendors is critical to timely selection. Too much detail can lead to very cumbersome evaluations and comparisons with confusing results. Sometimes extra detail is the result of trying to define requirements in terms of existing systems rather than business processes. Too much detail may also be the result of trying to *design* a system rather than identifying business requirements. The process contained within this paper provides examples of the level of detail required.

MES solutions can be single software packages, or a combination of packages from different vendors. Solution comparisons can be between single and/or multiple packages. The process does not differentiate, but more time may be required to select solution sets versus single products.

A process flow diagram that graphically represents the evaluation and selection process is provided on page x. Although the steps appear sequentially, some elements may overlap. Preparation for one step may take place while the previous step is in process.

MES Analysis

Manufacturing and Information Technology management must first understand what MES is and why it is needed. They must provide a mission statement which can be translated into MES objectives and requirements. The mission statement and objectives must be communicated to the entire organization in order to set expectations and prepare the organization for change.

Objectives are easier to define if the manufacturer analyzes typical “drivers” for change in manufacturing organizations:

- Increased customer demand for custom products at mass production prices
- Uncompetitive lead times
- Government regulations
- Product liability
- ISO 9000 compliance requirement
- Increased complexity and combination of operations and resources
- Excessive work-in-process inventory
- Poor quality
- Under-utilized capacity
- Excessive paperwork
- Lack of timely information
- Lack of process control
- No correlation of process data to products produced.

In the past, manufacturers implemented “point” solutions to address the above areas one at a time. Point solutions often require the same information and redundant data to be entered into disparate information systems. In fact, MES evolved from industries that emphasized one operational functional area or another. For example, the highly complex semiconductor industry processes and their need to closely monitor product and process variances eventually led to enhanced point solutions that included product tracking and cost accounting. Systems evolved similarly for heavily regulated industries. In the pharmaceutical industry, tracking controlled substances was supplemented with the retention of other production-related information, such as proof of compliance to procedures (as in FDA regulations, ISO 9000 and QS 9000).

In any case, understanding MES requirements is dependent on understanding what is driving the need for change. These needs vary from industry to industry and, if possible, should be translated into a mission statement along with clear objectives and measurable goals. Ultimately, keeping the objectives and goals in front of people will facilitate the process of MES requirements gathering.

MES goes beyond the point solution mentality; it permeates the entire organization. Because they affect the entire organization, MES implementations are not trivial. For example, data from one area may be used to make decisions in another area; if that data is not timely or accurate, poor decisions may result in the related area. It is mandatory that the whole organization is committed to understanding the "big picture" of what is needed. Participation and/or proper representation in the evaluation and selection process helps assure successful implementation.

The process for evaluating and selecting MES software is based on the assumption that the need for MES has been established. However, there may be reasons to *not* proceed with the evaluation and selection of software. Some of these include:

- Lack of participation, representation, or understanding from the areas affected by MES (manufacturing, quality, engineering, and/or information technology groups)
- Lack of organizational preparation or readiness to change
- No senior manager *driving* the project
- No budget commitment (for example, a software budget of x, hardware budget of 1.5x, and integration/ implementation services of 3 x)
- Lack of a planning (MRPII, ERP) system in place (unless such a system is being developed concurrently).

Understanding the roles and responsibilities and forming the team is discussed next.

Evaluation and Selection Team

After the need for MES has been analyzed and the company leadership understands how MES affects the entire organization, the MES software evaluation/ selection team can be formed. The people who will benefit from the system, the prospective users, are also the experts who are qualified to evaluate its capabilities. People from representative functional areas should be a part of the evaluation and selection team. The team should be prepared to be involved for a period of *two to six months*, depending upon the complexity of the requirements and the experience of the people. Six months would be optimistic if multiple products are being integrated and a process such as the one provided is not adhered to. The process can be shortened if experienced consultants and/or systems integrators are added to the team.

Because computer software is involved, or because the "new" systems have to be interfaced to existing systems, manufacturing management has been inclined to let the Information Systems department evaluate and select systems. Information Systems should be represented, especially to assess the compatibility with existing information infrastructure, but also to evaluate future requirements. However, due to advances in information technology, more of the configuration and "look and feel" of the newer information systems are defined by the users of the system, and the users, or representative manufacturing management, need to actively participate in the evaluation/selection process.

MES encompasses multiple areas of expertise and the initial preparation, selection, and implementation of MES software are events in which most companies have no previous experience.

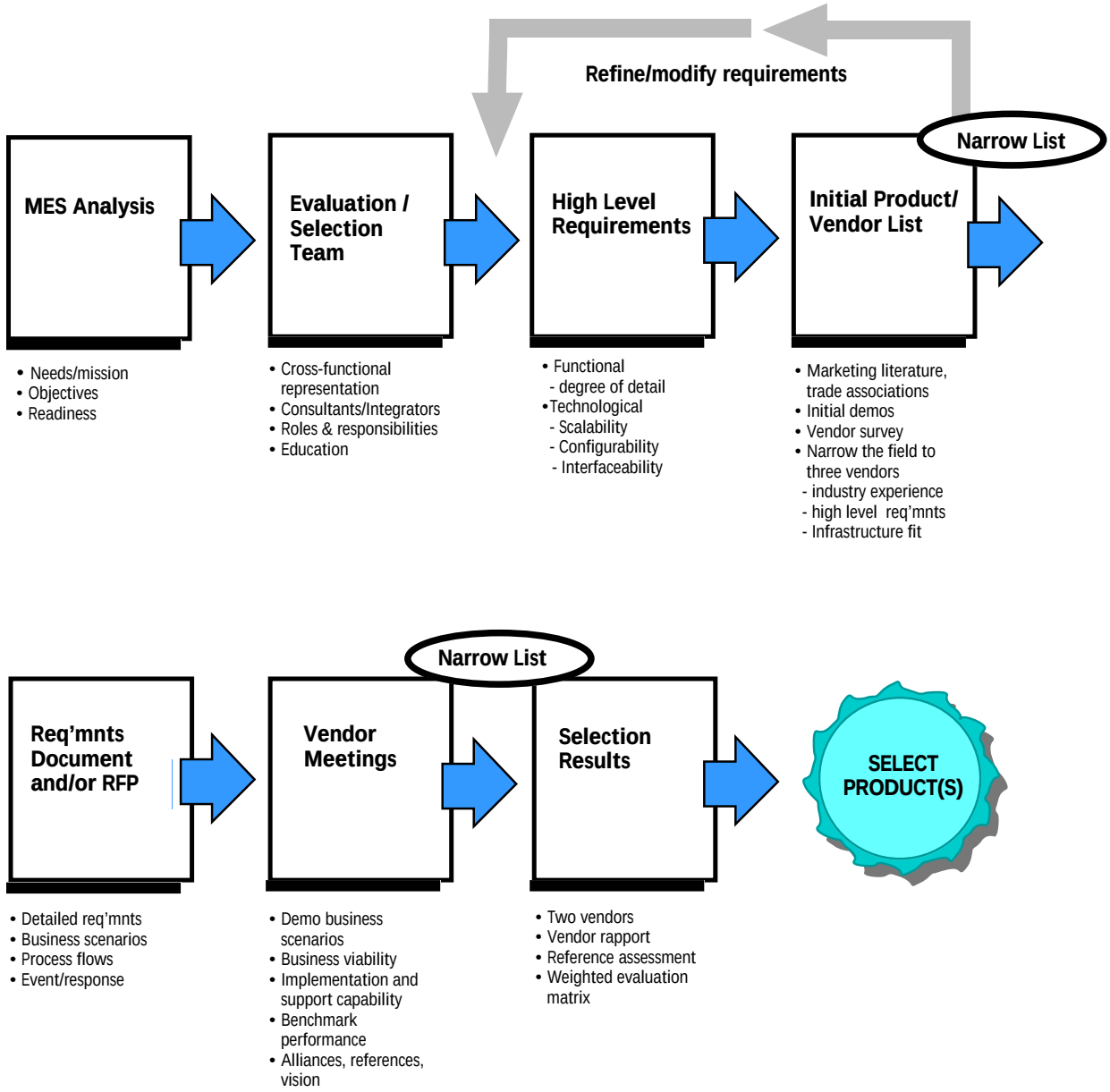
Experienced consultants and/or systems integrators should be a part of the team. Manufacturing consultants can provide an outsider's experienced perspective in analyzing business process improvements. They also can assure that the new system's requirements are driven by the entire organization's requirements and not just individual departmental needs. Systems integrators can assess prospective systems as to whether or not they will accomplish the performance objectives set forth by the organization. Specifically, systems integrators can assist in evaluating integration requirements, responsiveness, flexibility, and delivery and retention of critical information.

Both consultants and integrators can provide experience in methodologies and processes as well as a knowledge of software and hardware vendors.

The evaluation/selection team can be broken into two groups: 1) the oversight or review team and 2) the evaluation/selection team.

The two groups are differentiated by number of people,

MES Software Evaluation/Selection Process



areas of expertise, responsibilities, and time commitment as follows:

MES Oversight Team
People and commitment:
- 5-6 people representing various manufacturing functional areas
  - Production area Foremen, or equivalent
  - Knowledge of own areas plus experience in other areas
  - Team players, comfortable with new technology
- 1-2 people from Manufacturing leadership; Plant Manager, Production Supervisor, etc.; the emphasis depends on industry (note: in a small to medium size company, the Executive Vice President, Vice President of Manufacturing, or Director of Manufacturing should be included)
- 2 to 4 hours one time per week

Responsibility:
- Review progress of Selection team
- Assure that the evaluation/selection process is being followed
- Provide functional area expertise as needed
- Approve the final decision

MES Selection Team
People and commitment:

- 3-4 Full time representatives;
  - (1) Manufacturing Information Systems (MIS)
  - (1) Production; General Supervisor or equivalent
  - (1) Production Control or Scheduling expert
  - (1) Quality Assurance or Process Engineering expert
- 1 Outside consultant/systems integrator; 1-2 days/week
- 1 Full time Project Leader
  - Knowledge of entire plant floor operations with experience in more than one functional area
  - Needs to manage the level of detail
  - Excellent communications, coordination, and conflict resolution skills
  - Connections/contacts throughout the organization
  - Responsible for arranging the team's meetings, trips, presentations
  - Acts as single point of contact for vendors

Responsibility:
- Determine high level requirements
- Create initial vendor list
- Review/evaluate products, survey vendors
- Prepare Requirements Document and/or RFP
- Meet with vendors
- Compile results and select the product (make the final decision)

The "team" needs to begin with some level of knowledge of MES. Of course, the series of MESA International white papers is a good starting point. Beyond that, experienced consultants and/or systems integrators are essential in helping prepare the team. Often, team members attend one or more product overviews to form a knowledge base for comparing products.

High Level Requirements

After the selection team has been formed and has familiarized themselves with the organization's MES objectives as provided by management, they can begin to develop the high level requirements for the new system.

High level requirements are fairly general statements that define the bounds of the system, the interfaces to it, the functionality contained within it, and the type of technological environment that is desired. The cross-functional team members should be responsible for providing functional requirements, and the information systems members should be assessing the infrastructure required. The team must make some decisions as to what legacy business and expert systems will be retained, and which will require interfacing or integration into the new system. Some examples of high level requirements follow:

Bounds of the system: interfaces: the MES

- receives released orders from the corporate Order Management System.
- receives changes in machine status from the Plant Production Monitoring and Control System.
- provides resource, labor, and material status and usage to the corporate Planning/Costing System.
- provides order status to Customer Service representatives

[Consider all areas that could benefit by increased access to shop floor information and visibility; also consider what extra information, from either the upper level planning systems or the lower level controls systems, might benefit production operations.]

Functionality: the MES

- schedules the work load at each machine center based
- provides traceability of product to raw material batch numbers.
  on machine, tooling, material, and labor availability; utilizes upstream visibility to group products that can

share critical setups.
- verifies and logs the work procedures (by revision level) used by the machine operator.
- notifies Maintenance Management personnel of resources that require preventive maintenance and their schedule availability.

[Refer to Appendix A: MES Functionalities for other possibilities. In addition, there may be industry specific functions the system is expected to perform; these should be listed up front to save the team and vendor from wasting time because of any potential eventual disqualification.]

Technological/Usability features: the MES

- must provide the means for an operator to continue entering data, while continuing to track work completion, even though a file server and/or interface to another system may be temporarily disabled.
- must graphically display production parameters to machine operators; the system should be capable of highlighting exception or alarm conditions.
- needs to handle 80 plant floor work stations for operators to receive work instructions, enter job status and relevant data, and monitor production processes; 20 office and supervisory personnel must have access to configure routes and recipes, monitor performance, and produce related ISO 9000 reports.
- allow user configurable reports/screens via a graphical interface and standard query language (SQL) access to the MES database.
- must allow the creation of new Routings, including Bills of Material, by copying and modifying existing ones.

*[*Many companies have standards for open architectures, preferred Graphical User Interfaces, preferred hardware platforms, preferred communication protocols, etc.; these should be itemized here also. Also consider performance requirements including the "dynamics" (real-time vs. batch), configurability, and flexibility features. Some companies prefer that products use state of the art "object oriented" techniques so that functional modules may be inserted or removed at will without re-coding.]

As shown in the "*MES Software Evaluation/Selection Process*" chart at the end of the Purpose section, defining requirements is an ongoing process. Requirements may be modified or refined as the team learns more about MES from consultants, integrators, available literature, and product demonstrations. This learning process is covered more in the next section, "Inital Product/Vendor List."

Initial Product / Vendor List

As high level requirements are being defined, the evaluation/ selection team can be creating a list of products and vendors that meet the general, high level requirements. Reading about various products, attending product overviews, demonstrations and the like, afford the team a chance to review requirements in light of what other manufacturers are accomplishing. As the learning proceeds, requirements can be deleted, modified, or enhanced to suit the team's new vision.

Consider the following sources for information for creating the initial vendor list:

- Attend trade and professional shows (APICS, MESA, SME/AutoFact, etc.)
- Review trade and professional journals (APICS, MESA, SME, plus various manufacturing and factory automation publications such as *Managing Automation, or Manufacturing Systems)*
- Obtain directories of manufacturing systems software (e.g., *Directory of MES* by Thomas Publishing)
- Contact specific industry consortiums (i.e., aerospace and defense, automotive, chemicals, electronics, food, metals processing, pharmaceutical, semiconductor, etc.)
- Refer to manufacturing consultant publications (AMR and Gartner)
- Tap the experience of a systems integrator and/or manufacturing consultant, many of whom have already participated in evaluations, selections, and implementations
- Seek referrals from manufacturers in the same or similar industries
- Check with current hardware/software vendors for alliances and/or references

As a cautionary note, keep in mind that the functions of MES can be considered to overlap both the Enterprise Resource Planning (ERP) or MRP II systems, and Process Monitoring and Controls, including Man Machine Interface (MMI) systems, and Supervisory Control And Data Acquisition (SCADA) systems. Often, because of this overlap, some publications list these packages along with MES packages. One of the goals of the team should be to identify those systems that combine as many of the required MES functions (see Appendix A) as possible into one package. The value of integrated packages still needs to be compared to what might be sacrificed in best-in-class point solutions.

The team should create a Vendor Survey form to solicit vendor responses to questions that normally are not Appendix B for representative topics to include on this survey. Questions related to the manufacturer's industry should be included in order to check the vendor's experience in this area. Various MES products have evolved with unique industry related strengths that may or may not support the high level requirements the team has selected.

Hopefully, after comparing the high level requirements to what is available, by looking for vendor experience in specific industries, and by sticking to a preferred technological architecture, the list of possible products can be reduced to three or four. If the list is any larger, the team should consider refining requirements to reduce the list further.

Requirements Document and/ or RFP

Unfortunately, not many packaged execution systems "drop" in without modification. Detailed requirements help the manufacturer and the vendor identify and estimate the cost of those areas that might need customization. The more concise and complete the documented requirements are to begin with, the less risk exists for future cost overruns and delays. Vendors and systems integrators, as well as customers, appreciate being able to accurately plan their resources in advance of implementation. With the ultimate goal of selecting a single integrated MES package, or possibly a set of packages that are complementary, the manufacturer should minimally prepare a Requirements Document. This document is submitted to the final list (not more than three, if possible) of vendors for their responses. A more formal alternative is to submit a Request For Proposal (RFP) that contains a Requirements Document but includes more information and seeks more in return from the vendor. In the context of this paper, the acronym RFP is used to cover both types of documents even though some companies may prefer to select an MES product without requesting proposals from vendors.

The RFP should contain three elements: 1) a description of the business and the areas to be addressed, 2) a detailed list of functional and technical requirements, and 3) a representation of events that occur in the shop floor environment and the responses that the system is expected to generate. The vendor is requested to address the second section, point by point regarding whether or not the package complies, or requires custom work. The third section sets the stage for the vendor to provide a "conference room" demonstration of compliance so the user can obtain an actual sense of how the system would operate. Following is more information on each of these sections.

1. Description of the business and the areas to be addressed:

This section should identify the business, the industry, and how the products are produced, from the point at which orders enter the shop to the point they are ready to be shipped. A current situation analysis should describe what is driving the company to change and what the objectives are in implementing an MES.

The areas to be addressed by the MES can be listed with brief descriptions of each of the functions; this can be taken from what was already developed as high level requirements.

A one page "context" diagram can be helpful in communicating the interfaces to the system. The MES is shown as a central circle with arrows representing inputs and outputs from and to external systems and users of the MES. The arrows are labeled with high level descriptions of the data they represent. Refer to MESA International White Paper Numbers 2 and 3 for data flow possibilities when interfacing to Enterprise Resource Planning (ERP) and Controls Systems.

2. A detailed list of functional and technical requirements:

The detailed list of functional and technical requirements is generated by adding detail to the high level requirements.

Some of the functional detail can be derived from the definitions of MES functions as shown in Appendix A. For example, when detailing the requirements for *Product Tracking and Genealogy*, some of the detail could include such line items as:

N.0 Product Tracking and Genealogy

N.1 must associate material ID of material consumed with lot ID

N.2 must keep track of serial numbers of components within lots

N.3 must be capable of attaching comments (up to 100 at 80 characters each) to lot ID

N.x etc.

Technical or technological requirements are intended to specify any constraints or preferences, such as in hardware or software, that will have a bearing on the system selection. They should also indicate such requirements as expected volumes and timings of data transactions, number of user interfaces, communication protocols, mode of data collection, and expected response times. Other, more subjective, factors include usability, scaleability, and configurability. The Information Systems and system integrator members of the team can be invaluable in contributing requirements for this category.

Requirements should be enumerated so that the vendor can cross reference the requirements by number in the response, and so that the user can verify that all critical requirements have been addressed in the vendor's response.

3. Business scenarios and/or event/response tables: This section provides some typical business scenarios that must be managed by the system. Some of the basic elements of these scenarios include:

- The name of the process or function and its objective:
  e.g., Final Assembly; To fasten Assembly A to Assembly B forming finished product C
- Inputs to, and outputs from, the process:

e.g., In: Assembly A, Assembly B, (3) fasteners Out:Product C

- Processing performed:

e.g., Record start of operation; verify operator is certified to perform
Obtain assembly instruction, system verifies rev. level
Record completion
Test; record by serial number, Pass or Fail
If Fail, send to rework or scrap

Event/response tables may be used to communicate detailed expectations:

Event:	***Response:***
Operation complete	Request for test results (data collection)
Test Complete	Scan serial numbers of failed parts and indicate disposition

Responses to the RFP may vary widely as may estimates of the costs to implement. Some vendors, upon better understanding the requirements, may decline to bid. In either case, vendor responses (or lack thereof) may provide the opportunity to narrow the list of potential products further before proceeding into the next stage, Vendor Meetings.

Vendor Meetings

At this point, the MES RFP (or detailed requirements document) has been submitted to the vendors, the vendors have responded to the RFP, and the list is down to about two to three vendors. There have probably been some prior meetings with the vendors as they endeavored to learn more about the business (plant tours, question/answer sessions, etc.), but now the manufacturer needs to learn more about the vendor, and the vendor's response to the RFP, before a final selection can be made.

The following goals should be accomplished by meeting with the vendor:

1. To understand the vendor's response to the RFP and clarify issues from either party:

Any misunderstanding in the RFP or the vendor's response could lead to major cost ramifications at a later date if the vendor is selected. Take this opportunity to make sure the vendor understands the requirements and clarify issues.

2. To assess the vendor's viability as a business partner:

The vendor is supplying a product that is a major investment and will become an integral part of your business. Check into the following:

- the vendor's financial condition
- the vendor's vision; is it in line with the company's direction? Is a decent percentage (15% or over) of revenues returned to R&D?
- international support; if overseas locations are involved, will the vendor be able to support them?
- is the vendor cooperative?

3. To assess the vendor's capability in modeling the business:

Can the vendor model, with the MES product, the business scenarios that were presented in the requirements document?

4. To understand roles and responsibilities of the vendor, the systems integrator, and the manufacturer:

Determine or verify the responsibilities as to who leads, who supports, and who reviews each step of the processes from design, custom development, configuration, testing, implementation, acceptance, and support of the system.

5. To set up visits to reference sites (if required):
References can provide invaluable information about the vendor and the product. The vendor should be able to provide references in the same or similar industry as the manufacturer. A visit to such a site can afford the opportunity to:

- verify estimated implementation times and effort involved
- assess vendor reliability and cooperation
- witness ease of product use and responsiveness
- assess vendor post-sale product support.

Some more vendors may be dropped from the selection process as a result of these meetings. Assuming there is more than one vendor remaining (ideally, only two to choose from), the next step is to put it all together and make the final decision!

Product Selection

There is not a simple "one size fits all" solution to making the final decision. There are multiple factors to consider, and depending on a company's vision, industry focus, organizational readiness, and plant floor personnel level of acceptance, the choice will be different for different companies. Plus, the vendor meeting has added another dimension to consider: the vendor's viability as a long term partner.

Three major areas of the evaluation should be used in the final selection:

1. The functional aspects of the product; does the product meet the functionality required?
2. The technical aspects of the product; is the product technically sound and compatible with the technological direction of the company?
3. The business aspects of the product and vendor; is the price of the product and the cost for on-going support acceptable? Will the vendor be easy to work with?

One suggestion is to start by creating a scoring matrix for the requirements (functional and technical) as listed in the requirements document. Two aspects to the scoring should be considered:

1. The relative weights of the various functions (or requirements);
2. The absolute score of the extent to which the vendor meets the requirement.

A very brief representation of this scoring is shown in the table below. Note that the final score a vendor receives is the sum of the absolute scores after they have been multiplied by a relative weighting factor.

Relative Requirement Weight: (1-3)

1 = nice to have
2 = should have
3 = must have

Vendor Score: (0-5)
0 = doesn't meet requirements
1-4 = partially meets
5 = completely meets

The relative weights should be assigned with involvement and consensus by the whole team such that all areas are represented fairly. This will also help to assure that the results are accepted by all.

Standards and/or examples should be created for the scoring such that it is done consistently. The range of scores (0-5 in the example) may be increased or de-

Requirement Number/Description	Relative Reqmt. Weight	Vendor A		Vendor B		Vendor C	
		Score	*X wt.*	*Score*	*X wt.*	*Score*	*X wt.*
N.1 Assoc. mat'l ID w lot ID	3	5	15	5	15	5	15
N.2 Keep track of serial num.	3	5	15	1	3	5	15
N.3 Attach comments to lots	2	3	6	5	10	0	0
N.4 xxxxxxxxx xxxxx	1	3	3	5	5	0	0
N.5 xxxx xxxx xxxxx	1	3	3	5	5	0	0
TOTALS			42		38		30

creased as per the team's preference and ease of use.

A similar method may be applied to the other, more subjective, aspects of the evaluation, namely the business aspects of the product and vendor, but these are difficult to score. Ultimately, the more subjective areas may be used to eliminate some vendors from contention, or to make the final decision assuming all else is relatively even. Whether scored in a tabular format or not, here are some other "subjective" items to consider in making the final decision:

- Was there good vendor rapport? Was the vendor cooperative in providing a product demonstration?
- Did the vendor references provide favorable responses?
- Has the product under consideration actually been released and installed at a customer site, or is it still being developed?
- Does the vendor have a vision for its product that matches the customer company's vision? Is the vendor putting adequate revenues back into its product through Research and Development in order to keep pace with technology?
- If major customization is required, does the vendor provide assistance? Is the vendor organization large enough to provide this support? What are the vendor's fees for this "expert" service?
- If not all functionality can be supplied by one vendor, does the vendor have alliances with other vendors that can fill the gaps with proven products?

The underlying assumption in this paper is that the evaluation/selection has been for one MES product. There may be a need to compare one product set to another, or to compare a product suite (two or more products integrated by one or more vendors) to an integrated package. In either case, more consideration would be required for integration and interfacing costs and on-going maintainability and support costs.

The final decision should be documented in a summary format that identifies the criteria used and the results found. The functional groups should give their stamps of approval since they are the ones that will have to live with the solution. Ideally, they will have been involved throughout the entire evaluation/selection process and they will be reassured that the process was thorough and the results meaningful. Plus, they will have a reinforced view of the organizational-wide benefits possible, and thus be anxious to start and support the implementation.

Appendix A: 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, color sequencing, or other characteristics that, when scheduled in sequence properly, minimize set-up. It is finite and it recognizes alternative and overlapping/parallel operations in order to calculate, in detail, exact time of equipment loading adjusted 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 the 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 the 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 might also include the control and integrity of environmental, health and safety regulations, and ISO information such as Corrective Action procedures. Storage of historical data is provided.

5. Data Collection/Acquisition: This function provides an interface link to obtain the inter-operational production and parametric data that populate the forms and records that 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 an 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 from a 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 inter-operational and focus specifically on machines or equipment being monitored and controlled, as well as intra-operational, which is tracking the process from one operation to the next. It may include alarm management to make sure factory personnel are aware of process changes that are outside acceptable tolerances. It provides interfaces between intelligent equipment and MES, possibly 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. Also provides the response (alarms) to immediate problems. It maintains a history of past events or problems to aid 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 results. Performance results include such measurements as resource utilization, resource availability, product unit cycle time, conformance to schedule and performance to standards. It may include SPC/SQC. Performance Analysis draws on information gathered from different functions that measure operating param-

eters. These results may be prepared as a periodic report or presented on-line as current evaluation of performance.

Appendix B: Vendor Survey Topics

Following is a suggested list of topics for inclusion in the Vendor Survey:

Vendor contact, title
Organization background
- Date established
- Total number of employees; number supporting MES products
- Company ownership; private or public
- Percent of business in USA; list other areas and percentages also

Financial Information
- Annual sales
- Annual net income
- Current ratio (current assets / current liabilities)
- Net worth
- Annual sales applicable to MES
- % of MES toward software licensing
- % of MES toward hardware sales
- % of MES toward consulting/implementation support
- % of total revenues put back into MES research and development

Alliances/partnerships
- Interfaces developed for other software (ERP, controls, data collection, reporting, other MES functions)
- Software from other vendors integrated into the MES product
- Alliances with hardware/operating system vendors and systems integrators

Product support
- Help desk support?
- 24 hour hot-line?
- Maintenance agreements and costs?
- What types of training available?
- What documentation provided?

Product information
- Number of customers; number of installations; notable customers by industry
- Frequency and types of releases?
- Major product functions
- Applicable industries (discrete-lot, discrete-repetitive, batch process, continuous process)
- Development languages used
- International languages provided
- Product pricing; by user? site license? high/low/average

Technical architecture
- Hardware platforms; current plus future (six months to one year)
- Operating systems; current plus future (six months to one year)
- Databases used
- Graphical User Interface (GUI)
- Network protocol
- Client/server?

Industry experience
- Representative customers in same or like industry
- Capability to configure industry specific processes (provide examples; e.g., serialized parts, coil slitting and tracking, etc.)

Miscellaneous:
- Security
- Ad hoc reporting capability
- Case tools utilized
- Application Program Interfaces (APIs) available?
- Is source code available?
- Quality assurance procedures

Appendix C: Participation

The following members of MESA International participated in this work:

Individual	*Company*
Bernard Asher	RWT Corporation
Mike Brennolt	Effective Management Systems, Inc.
Tim Ferkel	EDS
Bill Hakanson	MESA International
Bob Johnson	EDS
Gordon Kilgore	Digital Interface Systems, Inc.
Mike McClellan	MES Solutions
Maryanne Steidinger	Allen-Bradley Company
Bill Schaefer	HK Systems
Sandy Towle	Camstar Systems, Inc.

Manufacturing Execution
Systems Association

MESA International
303 Freeport Road
Pittsburgh, PA 15215 USA
+1 412.781.9511
FAX: +1 412.781.2871
E-mail: info@mesa.org
http://www.mesa.org