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Manufacturing Domain Task Force
RFI-3
Manufacturing Execution Systems(MES)

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1. Introduction

The Manufacturing Execution Systems(MES) and Machine Control(MC) Working Group within the OMG's Manufacturing Domain Task Force (MfgDTF) is attempting to define a reference architecture based on industry experience within the MES scope(those aspects of manufacturing related to production). This reference architecture will guide the issuance of a series of Requests for Proposals (RFPs) that seek to define interface specifications for MES functionality as well as MES interoperability with other functional elements of manufacturing systems. The group anticipates that submitters to the RFPs, employing new technologies, will propose solutions in their responses that advance this model.

The Working Group, through this RFI, invites input from individuals and organizations with insight or information in the any of the following areas:

- Validating definition of MES
- How to functionally partition MES solutions for standardization
- Examples, case studies and problems of interactions between MES solutions
- Examples, case studies and problems of interactions between MES and other contexts in manufacturing(eg: ERP, PDM, MC)
- Validating selection of SIMA reference model for scoping RFPs
- Appropriate standards for MES
- Roadmap for issuing RFPs

Responses to this RFI will be instrumental in determining the structure of the reference architecture and the scope of the requirements enumerated in the forthcoming MES RFP(s). It is important that the reader recognize that responses which elaborate on functions, patterns or systems will be helpful to the group regardless of whether the response addresses a wide range of MES functions or a range which is very tightly focused.

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2. Context and Scope of the RFI

A business need within the manufacturing community has been stated for a more agile business environment that can be quick in its response to change. A primary requirement of this new environment is that manufacturing applications are capable of interoperating with one another. The OMG's Manufacturing Domain Task Force has active groups working in the following functional areas:

- Product Data Management
- Manufacturing Execution Systems
- Machine Control
- Enterprise Resource Planning

This RFI is intended to help scope the Manufacturing Execution System(MES) area of manufacturing.

2.1 Manufacturing Execution Systems: A definition

While many definitions of a MES - a Manufacturing Execution System - exist, the OMG Manufacturing Domain Task Force has adopted the following from MESA International, a trade association of leading MES software suppliers.

> "Manufacturing Execution Systems (MES) deliver information that enables the optimization of production activities from order launch to finished goods. Using current and accurate data, MES guides, initiates, responds to, and reports on plant activities as they occur. The resulting rapid response to changing conditions, coupled with a focus on reducing non value-added activities, drives effective plant operations and processes. MES improves the return on operational assets as well as on-time delivery, inventory turns, gross margin, and cash flow performance. MES provides mission-critical information about production activities across the enterprise and supply chain via b-directional communications." [MESA97b]

2.2 High Level MES Context within Manufacturing

Manufacturing Execution Systems are but one key element of an information system supporting a manufacturing facility. According to MESA International [MESA97b], there are five other key functional groupings with which a MES must interface in order to effectively manufacture product. The following figure indicates these functional groupings and their interfaces:

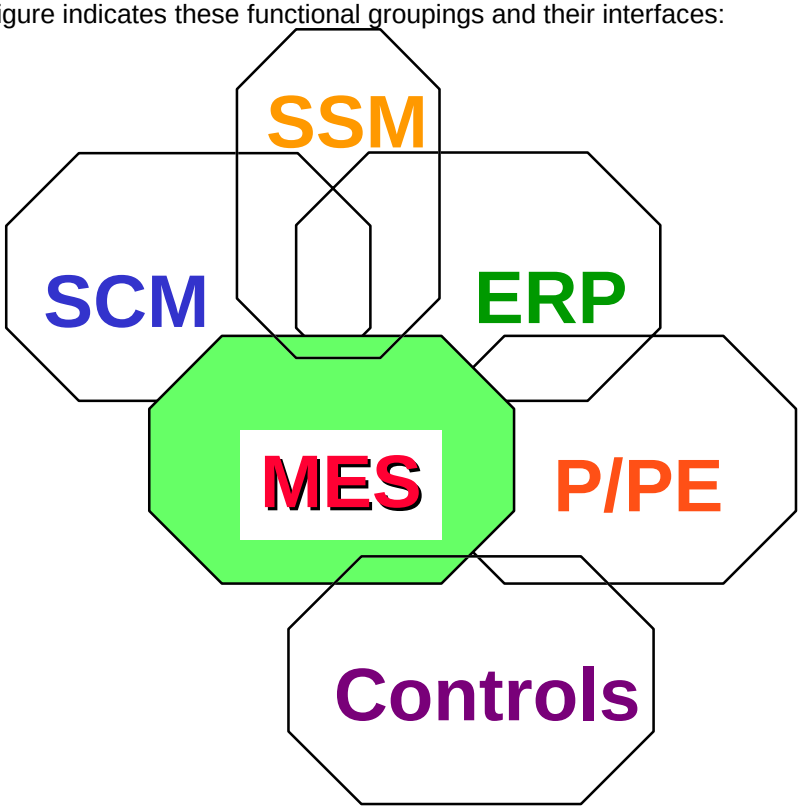

Figure 1. MESA MES Context Model [MESA97b]

These environments need to interoperate with a Manufacturing Execution System(MES) environment to help manufacturing meet their needs within certain manufacturing business processes in the production area. A description of these functional groupings are below.

SALES & SERVICE MANAGEMENT(SSM)

Sales and Service Management (SSM) comprises software for sales force automation, product configurations, order management, service quoting, product returns, and post-sales service.

SUPPLY CHAIN MANAGEMENT(SCM)

Supply Chain Management (SCM) includes functions such as forecasting, distribution and logistics, transportation management, electronic commerce, and advanced planning systems.

PRODUCT AND PROCESS ENGINEERING(P/PE)

Product and Process Engineering (P&PE) includes computer aided design and manufacturing (CAD/CAM), process modeling, and product data management (PDM). PDM supports information sharing in a distributed environment that can cross company boundaries. The industrial enterprise has a special dependency on its product model information (product data).

This product data includes definition of the products that will be manufactured. CAD systems are involved in designing a product or a facility to build a product. At this time CAD systems utilize drawings and specification documents to maintain the design information.

CONTROLS

Controls are usually hybrid hardware/software systems such as distributed control systems (DCS), programmable logic controllers (PLC), distributed numerical control (DNC), supervisory control and data acquisition (SCADA) systems, and other controls designed to automate the way in which the product is being manufactured.

ENTERPRISE RESOURCE PLANNING(ERP)

Enterprise Resources Planning (ERP) consists of those systems that provide financial, order management, production and materials planning, and related functions. The modern ERP systems focus on global planning, business processes and execution across the whole enterprise (intra-enterprise systems), with an accrued recent importance of aspects like supply chain planning and the whole supply chain management aspects and extending to include the whole inter-enterprise supply chain.

2.3 More Detailed Level MES Context within Manufacturing

Previous sections of this RFI have provided a context for MES within an automated manufacturing enterprise by describing how it relates to other functions. A more complete understanding of the scope of MES can be created by looking at a formal model of manufacturing activities and identifying those activities which are performed by Manufacturing Execution Systems. Portions of such an activity model have been provided for this purpose.

The models used are from the “SIMA Reference Architecture Part 1: Activity Models” [SIMA96] which were created as part of the Systems Integration for Manufacturing Applications(SIMA) project at the National Institute of Standards and Technology (NIST). The objective of the SIMA project was to facilitate the implementation of integrated manufacturing systems through the use of a formal systems approach. The focus of SIMA and its activity model was on the technical aspects of the product realization process (a process that begins with product conception and ends with a manufactured product).

The modeling technique used for the SIMA activity models was IDEF0 [FIPS183]. IDEF0 diagrams model activities, flows and resources. Activities are functions performed by humans, hardware/software systems or both (interactively) and are represented by a box in IDEF0 diagrams. An activity may have a refinement on a later page, which is a decomposition of the activity showing its component activities. Flows correspond to information units or materials produced and/or consumed by activities and are represented by lines between activity boxes. Resource flows, which are needed to perform activities, are represented by lines which intersect the bottom of activity boxes. Constraint flows intersect the top of the activity boxes.

To understand the relationship of MES within the full manufacturing business process context the following SIMA diagrams are provided. The first Level 0 diagram for A0 of SIMA is:

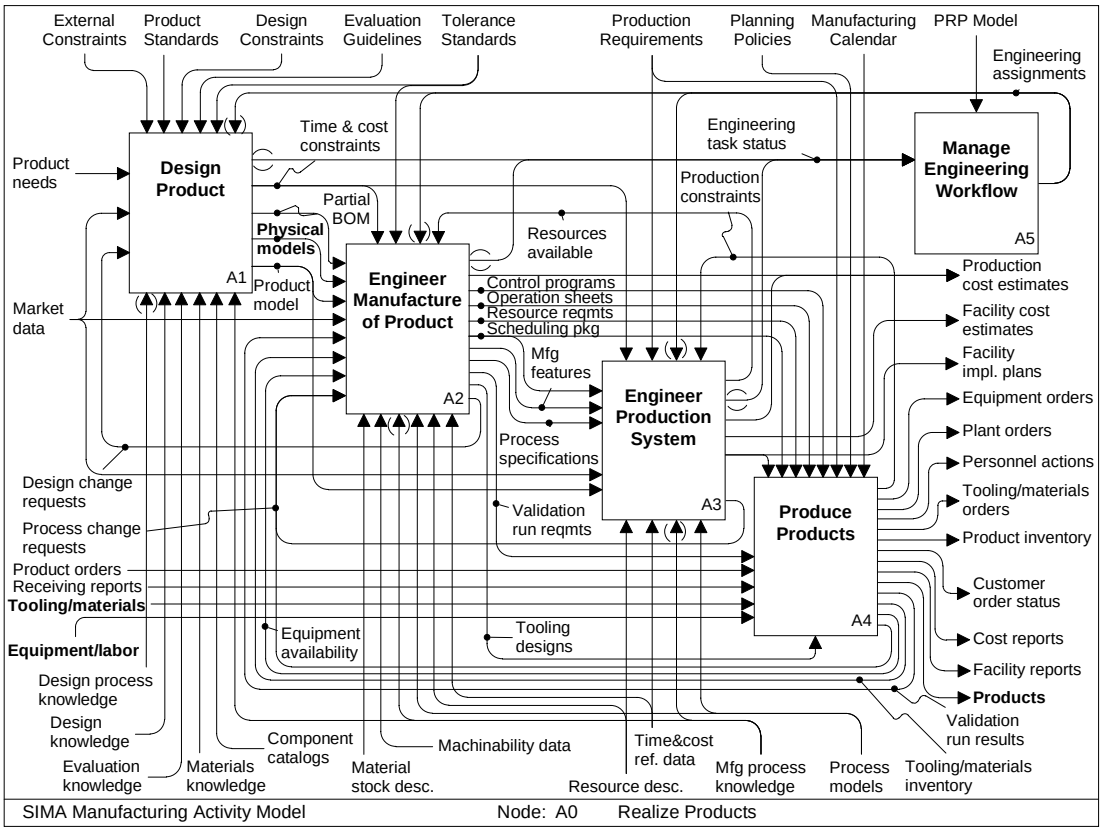

Figure 2. NIST SIMA *Realize Products* activity diagram

Within the SIMA manufacturing activity model most of the MES-related activities are within the [A4 Produce Products] activity SIMA level 1. A refinement of this activity is below:

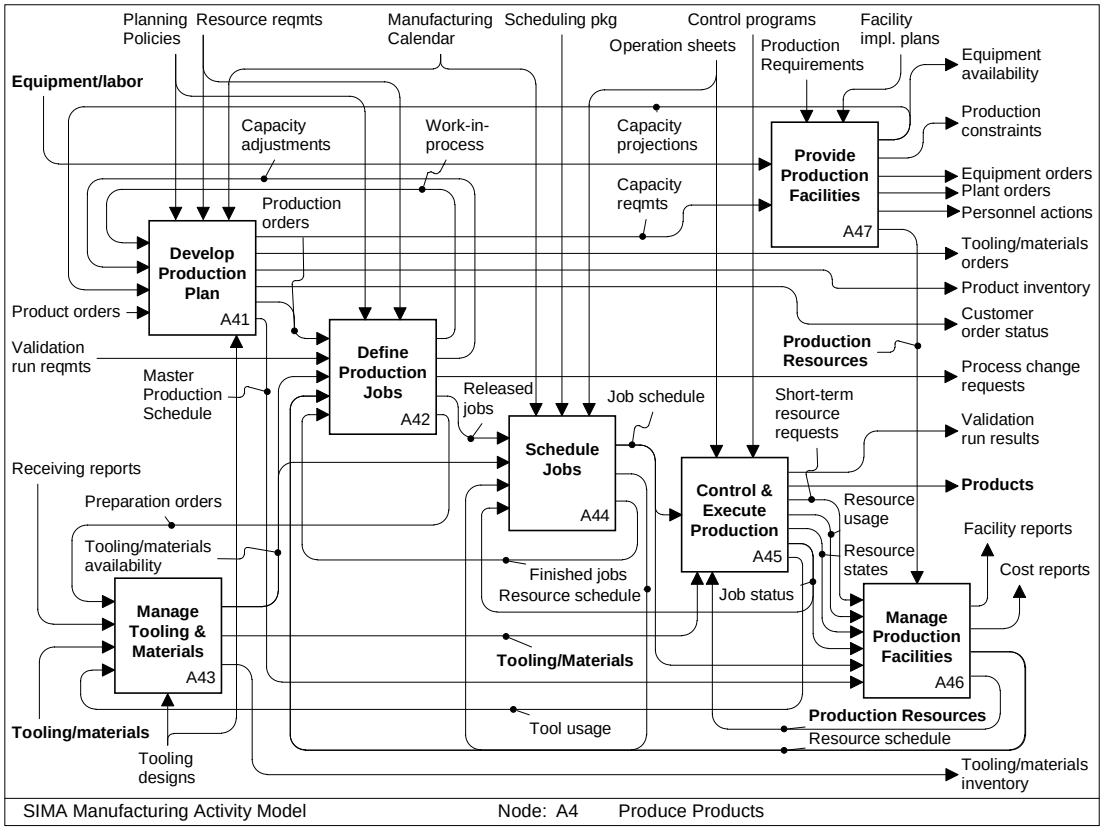

Figure 3. NIST SIMA *Produce Products* activity diagram

The following table provides a view of the [A4 Produce Products] activities within the SIMA manufacturing activity model that are applicable to the MES related area:

SIMA Level 1	SIMA Level 2	Applicable	Objects/Entities
[A41] Develop Production Plan	[A411] Create Master Schedule	ERP	Manufacturing Calendar; Resource Requirements; Planning Policies; Product Orders; Master Production Schedule; Capacity Projections; Capacity Requirements; Work-in-Process; Product Inventory; Tooling/Materials orders; Production Orders Tooling Designs
	[A412] Define Capacity Requirements	ERP	
	[A413] Create Production Orders	ERP	
	[A414] Monitor Production Orders	MES	
[A42] Define Production Jobs	[A421] Define Jobs	MES	Planning Policies; Released jobs; Capacity adjustments; Production Orders; Job disposition; Preparation Orders; Resource Schedule; Tooling/Materials availability; Process change request; Work-in-Process
	[A422] Generate Tool/Stock Orders	MES	
	[A423] Release Jobs	MES	
	[A424] Monitor Job Completion	MES	
[A43] Manage Tooling & Materials		MES	
[A44] Schedule Jobs	[A441] Generate Job Schedule	MES	
	[A442] Generate Operations Schedules	MES	
	[A443] Generate Delivery Schedules	MES	
	[A444] Track Jobs	MES	
[A45] Control Production	[A451] Direct Personnel & Machines	MES	
	[A452] Control & Monitor Jobs	MES	
	[A453] Coordinate Equipment Groups	MES	
	[A454] Control equipment	MC	
[A46] Manage Production Facilities		MES	
[A47] Provide Production Facilities		ERP	

Figure 4. Applicable contexts of NIST SIMA activities

2.4 Different Viewpoints of MES

Overall, the MES environment's objective is to make products to specifications and enable the work surroundings in plant operations to produce the product effectively and efficiently. Throughout the industry, differing viewpoints have been defined for the MES environment. Comparing these differing viewpoints, it is apparent that they are similar in activity scope, but vary in how the functionality has been grouped together. The only consensus on what the MES environment includes is anything in the operations and maintenance lifecycle of a manufacturing facility that is not in an Enterprise Resource Planning and Machine Control environment.

Industry definitions of MES interoperability vary as well as those for environments. It is the intent of this RFI to clarify these MES definitions to assist the process of developing, through an RFP process, specifications for MES functionality and interoperability. In order to help scope MES, five different industry viewpoints of what an MES environment could include are provided in this RFI: the SIMA manufacturing activity model, addressed in the previous section, and the four models presented in Appendix A.

The MfgDTF has made an initial selection of the SIMA manufacturing activity model as the reference model to guide its issuance of RFPs. As with the other models presented, it provides an implementation independent scoping model. However, as a business activity-based model, it is broader in scope than any of the other models and another step removed from traditional packaging of MES solutions. The last point is crucial to the group's goal of not imposing solutions and bears repeating. The SIMA model is not intended to define the design architecture of MES systems, whereas the other models, in presenting functional groupings, are a minor but no less first step in that direction.

The four other models in Appendix A are included as examples of anticipated proposals received in response to this RFI.

The MfgDTF is anxious to receive industry comment on the selection of the SIMA model. If it is felt that a better reference model exists, or that one of the other four models should be chosen, then a recommendation of the proposed model and the reasons for employing it are sought. If the task force does not receive any recommendations to the contrary, it will proceed with its choice of the SIMA model as its reference architecture.

2.5 MES Interoperability

In order to help a business with their overall organizational and business objectives, a MES environment must interoperate with other work environments, such as Machine Control(MC), Computer Aided Design(CAD), Product Data Management(PDM), Enterprise Resource Planning(ERP), etc.

The top view of a manufacturing operation is the corporate planning system, where most overall operational decision-making takes place, using Manufacturing Resource Planning(MRP-II) or Enterprise Resource Planning(ERP) applications. These applications focus on accounting functions and enforce top-down planning and infinite scheduling. Some areas of interoperability with ERP environments and MES environments includes such areas as purchasing (Raw Materials, Energy, Equipment parts, etc.); financials; orders and schedules(e.g.: outages); workflow management; labor contracts, costs, organization, etc.

The bottom view of a manufacturing operation is the level where actual plant controls exist in the form of hardware and/or software that physically controls the machines involved in the manufacturing tasks. These Machine Control(MC) applications such as man-machine interface(MMI) and supervisory control and data acquisition(SCADA) systems communicate directly with devices like programmable logic controllers(PLC) and other devices to maintain plant

operations. Some areas of interoperability with MC and MES environments includes such areas as: Operator interface; real-time event-driven messaging of events, alarms and activity steps; security; equipment instructions, performance analysis and diagnostics, etc.

MES resides between these two views of controls and enterprise planning and is where the entire manufacturing process comes together. Here, information about production order status, production flow, and materials on-hand matches up with available human and machine resources, which can result in a finished product that leaves a lot of scrap or only a little, has quality defects or meets specifications, or is either late or on-time. In the area of materials management, MES environments interact with MRP-II for quantities and PDM for material specifications.

Although there are many areas defined within the manufacturing plant that need to act together within a MES environment, they all revolve around and need some of the same data and specifications that are currently encompassed within all the plant's Process & Instrumentation Diagrams(P&IDs), Process Flow Diagrams(PFDs), procedures, etc. Therefore, in order to ensure that each area is acting on the same plant situation it is necessary to ensure that each of the MES areas are relying on the same version of data for all this information and when changes are made to this data it is understood across all MES areas. This is the role of the Product Data Management and Production History Management environments. Based a plant-floor aspect, the MES solutions should obtain documents from the PDM environment as needed. The PDM environment owns product tracking from an enterprise-level, organization-capability standpoint, whereas the MES environment tracks products as they are built from the plant-floors viewpoint.

There are many areas in MES that must interact within manufacturing in order to help a business with their overall organizational and business objectives. A MES environment must interoperate with other work environments, such as machine control, product data management and enterprise resource planning to facilitate these objectives.

2.6 Why Standardize on MES Interoperability?

Within a MESA survey on benefits of MES to manufacturing, some of the most important MES benefits cited were "flexibility to respond to customer demands" and "provides agile manufacturing". MES is considered to be a key technology set in the drive to improve manufacturing performance capability in the fiercely competitive global marketplace. While corporate management is naturally concerned with long-term objectives, there is a growing realization that MES can have considerable short-term impact on mission and performance as well [MESA97a]. Unfortunately, some manufacturers are unable to capitalize on this short-term impact due to the high integration costs and long integration time of MES systems within the plant environment. Sometimes the integration costs far outweigh any cost benefits the manufacturer is able to gain from the individual MES system. Standardizing the interfaces between MES and other elements of a manufacturing system could help relieve these high integration costs.

3. Objectives of the RFI

The Manufacturing Execution Systems(MES) and Machine Control(MC) Working Group within the Manufacturing Domain Task Force (MfgDTF) of the OMG is attempting to define a reference architecture that provides a concise and effective framework. This reference architecture will guide the issuance of a series of Requests for Proposals (RFPs) that seek to define interface specifications for MES functionality as well as MES interoperability with other functional elements of manufacturing systems. The Working Group, through this RFI, invites input from individuals and organizations with insight or information that could provide a basis for work in this area.

Responses to this RFI will be instrumental in determining the structure of the reference architecture and the scope of the requirements enumerated in the forthcoming MES RFP(s). It is important that the reader recognize that a response which elaborates on functions, patterns or systems will be helpful to the group regardless of whether the response addresses a wide range of MES functions or a range which is very tightly focused

Responders may address any or all of the following subjects.

3.1 Validate definition of MES

Comments are welcome on the definition of MES that has been presented in this RFI.

3.2 Validate Selection of Reference Model

Provide comments on the usage and validity of the SIMA activity reference model as a scoping mechanism for RFPs in MES. If the SIMA activity model is unacceptable, then propose some other scoping mechanism for MES within manufacturing.

3.3 Partitioning of MES solutions

MES solutions are designed and partitioned into different categories. Describe, in general, a proposed functional partitioning and how it maps to the SIMA activity model or an alternative reference model. Some examples of the level of granularity of the functional partitioning are provided in Appendix A.

3.4 Examples and Case Studies within MES

Examples and/or case studies of MES dependencies within other MES areas, either in terms of problems encountered or proposed solutions to those problems.

3.5 Examples and Case Studies external to MES

Examples and/or case studies of MES dependencies with areas outside of the MES environment(e.g.: ERP, PDM), either in terms of problems encountered or proposed solutions to those problems.

3.6 Appropriate Standards

Identify any industry standards that should be considered within the MES area and indicate where within the MES area the standard should be utilized

3.7 Roadmap

Propose a roadmap for issuing RFPs to develop interface specifications for MES functionality and interoperability.

3.8 Additional Information

Responders are also welcome to provide any additional information that they feel is relevant to this effort.

4. Who Should Respond

4.1 General

Responses are welcome from any supplier, user, systems integrator or knowledgeable person with MES experience. Responses are also welcome from organizations who feel they have experience in interfacing with and integrating MES systems.

Interfaces which result from the work of the Manufacturing Domain Task Force will reflect the object oriented context of OMG. This object-oriented context may affect the impact of the contributions made by RFI responders on the activities of the task force. Understanding this, a responder still may choose any form for his or her response; some examples include UML diagrams, Entity-Relationship diagrams, process models or plain text.

Respondents also are not required to be familiar with OMG's adopted or proposed technology. However, to assist respondents not already familiar with OMG's specifications, Appendix C and D provides (1) an overview of OMG's Object Model Architecture (OMA), (2) a summary of CORBAservices that fit in the so-named block on the OMA , and (3) a summary of CORBA facilities that fit into the so-named block on the OMA and (4) an overview of the OMG process.

4.2 Standards and Research Organizations

Some organizations have already specified standards or guidelines for identifying MES concepts that span specific or multiple manufacturing industries. Such standards and guidelines are sought as a base for the architecture.

4.3 Suppliers and Vendors

There are many different products within MES. Suppliers of MES software and services are invited to provide insight into how interoperability in this area and between other environments such as PDM and ERP can be defined. Any guidelines for an architecture are sought.

4.4 Manufacturing customers

For many of the MES areas, there are various in-house developments or MES criteria that manufacturing sites need or are utilizing. Any interoperability needs or criteria of functionality in the MES area are sought.

5. Instructions for Responding to this RFI

5.1 General

Organizations responding to this RFI shall designate a single contact within that organization for receipt of all subsequent information regarding this RFI, RFI responses and the forthcoming series of RFPs. The name of this contact will be made available to all OMG members. Note that this single contact name can be changed at a later date.

Responses to this RFI must be received at OMG no later than 5:00 PM EST (22:00 GMT) March 2, 1998. Documentation submitted in response to this RFI will be distributed to all of the members of the Manufacturing Domain Task Force.

5.2 Format of RFI Responses

The following outline is offered to assist in the development of your response. You should include:

1. A cover letter -- the cover letter must include a brief summary of your response.
2. Your response to any or all of the RFI objectives and subjects listed in Chapter 3.

Although the OMG does not limit the size of responses, you are asked to consider that the OMG will rely upon volunteer resources with limited availability to review these responses. In order to assure that your response receives the attention it deserves, you are asked to consider limiting the size of your response (not counting any supporting documentation) to approximately 25 pages.

If you consider supporting documentation to be necessary, please provide one copy to the Manufacturing DTF Desk at OMG. Please indicate which portions of this supporting documentation are relevant to this RFI.

NOTE: According to the Policies and Procedures of the OMG Technical Committee, proprietary and confidential material may not be included in any response to the OMG. Responses become public documents of the OMG. If copyrighted, a statement waiving that copyright for use by the OMG is required and a limited waiver of copyright that allows OMG members to make up to at least twenty-five copies for review purposes is required.

5.3 How to Submit

OMG requests that one hard copy and an electronic copy of the response in IBM PC machine-readable format (typically ASCII, Word or Acrobat PDF format) be sent to the Manufacturing DTF Desk at OMG. If you are submitting supporting documentation, one hard copy and an electronic copy of the supporting documentation must be sent to the Desk at OMG.

Responses to this RFI (and other communication regarding this RFI) should be addressed to:

Manufacturing Domain Task Force Desk
Object Management Group Inc.
Framingham Corporate Center
492 Old Connecticut Path
Framingham, MA 01701-4568
USA

Phone: +1-508-820 4300
Fax: +1-508-820 4303
Email: mfg@omg.org

Responses to this RFI must be received at OMG no later than 5:00 PM EST (22:00 GMT) March 2, 1998. The outside of packages/envelopes containing submissions or any other communication regarding this RFI should be clearly marked "MANUFACTURING DTF RFI #3 RESPONSE". When presentations are made of the responses, 25 paper copies of the response should be available for attendees at the OMG meeting.

NOTE: Your organization should be prepared to handle requests for additional copies of your response and should be prepared to handle requests for additional copies of supporting documentation.

5.4 Reimbursements

The OMG will not reimburse submitters for any costs in conjunction with their responses to this RFI.

6. Response Review Process and Schedule

Responses to this RFI are to be reviewed by the Manufacturing Domain Task Force (DTF) for the following express intention: providing OMG with technical information and guidance in writing the forthcoming series of RFPs in the area of object-oriented manufacturing software components.

6.1 RFP Process

The OMG membership, specifically the Manufacturing DTF will review responses to this RFI. Based on those responses, the Manufacturing DTF will prepare one or more RFPs. These RFP(s) will be presented to the entire OMG DTC for acceptance. The accepted RFP(s) will be issued to the public.

As a forewarning to organizations who intend to respond to the initial RFP(s) when they are issued, please note that responding to an RFP requires:

A Letter of Intent signed by an officer of your organization signifying your intent to respond to the RFP and a statement of your organization's willingness to comply with the OMG's requirements (e.g., your willingness to license the proposed technology openly).

The technology submission described in accordance to the RFP. Any technology adopted by the OMG must be commercially available from a Corporate Member. A statement describing how the submission meets this commercial availability requirement is required with the submission.

Section 6.3 provides a timetable listing the tentative dates when these documents will be due for the first RFP(s). Please consult the OMA Guide for a complete description of the OMG's requirements, policies and procedures for technology submissions.

6.2 Clarification of Responses

To fully comprehend the information contained within a response to this RFI, the Manufacturing DTF may seek further clarification on that response. This clarification may come in the form of verbal communication over the telephone; written communication; electronic; or a request to make a presentation of the response to the Manufacturing Domain Task Force.

6.3 Schedule

The schedule for responding to this RFI is as follows. Please note that early responses are encouraged.

MfgDTF recommends issuing the RFI	December 2, 1997
RFI issued by DTC	December 5, 1997
RFI responses due	March 2, 1998

The tentative schedule for the RFI evaluation process is:

Review of RFI responses	March 31, 1998
Revise MES model	June 8, 1998
Revise MES roadmap	June 8, 1998
Final Draft MES RFP	June 11, 1998
Issue MES RFP	July 31, 1998

Note that this schedule is subject to change based on the number of RFI responses received.

6.4 Questions and Further Information

Questions concerning the Manufacturing DTF RFI should be directed to:

Manufacturing Domain Task Force Desk
MES/MC Working Group
Object Management Group Inc.
Telephone: +1-508-820 4300
Facsimile: +1-508-820 4303
Internet: mfg_mesmc@omg.org

APPENDIX A. Viewpoints of MES

MESA International's MES and Integrated MES

MESA International was formed in 1992 by most if not all of the leading MES software vendors. MESA is a not-for-profit trade association providing a legal forum for competitors to work together to expand awareness and use of manufacturing technology, particularly MES and all of the related products and services required by the modern manufacturing enterprise. By working together in MESA, its members can do a much better job communicating the benefits of the products and services they offer.

Early MES were introduced within specific plant areas to assist in a specific plant function. These systems were often called point solutions because they addressed a single "point" in a plant operation such as scheduling, machine maintenance, or quality management. The problem with point solutions is that they usually became owned by individual departments, using separate networks and incompatible databases. Even if a plant operations software application identified a problem, it existed apart from the resources needed to correct that problem. As a result, it was nearly impossible for managers to view the production process as a whole or respond in real time to what was happening on the plant operations.

MES is similar to Materials Resource Planning (MRP) or Manufacturing Resource Planning(MRP-II) environments. However, the differences are within the MES functionality necessary to react to the dynamic plant environment in day-to-day activities versus MRP environments that are focused on monthly numbers, planning and forecasting. There are points of overlap between MES and MRP systems within the data, but MES systems rely on the daily and/or minute values to react versus MRP systems analyze the weekly or monthly values. In addition, each environment has a different viewpoint on the same information. For example, the MES environment is planning and scheduling the use of specific production resources(e.g.: machines, tools, material lots, people) to accomplish the production of specific product lots. The MRP environment is targeted for planning product volumes and order fulfillment and planning aggregate availability and usage of resources against statistical expectations of capacity, availability and yield.

Today, some of these early MESes are expanding into what is called "integrated" manufacturing execution systems. Integrated Manufacturing Execution Systems (also called Integrated MES) unite a plant's operations around a common distributed database accessible from anywhere on a company's network. Integrated MESes capture feedback from actual production data, analyze the big picture in real-time, and make instant decisions regarding priority changes when necessary. Integrated MES functional groupings as defined by MESA International include:

- resource allocation and status
- operations/detail scheduling
- dispatching production units
- document control
- data collection/acquisition
- labor management
- quality management
- process management
- maintenance management
- product tracking
- performance analysis.

SEMATECH CIM Framework

Another functionality grouping is from the SEMATECH's CIM Framework [SEMA97]. SEMATECH, the R&D consortium for the U.S. semiconductor manufacturing industry, has spent several years in the development of a specification for a MES framework. This work has been performed in conjunction with semiconductor manufacturing suppliers and end-users. It should be noted, however, that an evaluation by the Manufacturing DTF indicated that over 95% of the functionality covered by the specification could be extended into other facets of manufacturing.

The scope of MES functionality covered by this specification is categorized by what SEMATECH refers to as *functional groups*. A functional group roughly corresponds to MES product packaging as it exists today. It should be noted, however, that SEMATECH's CIM Framework employs a component-based architecture and as such finer grained functionality can be identified at the component level.

For the purposes of this RFI, SEMATECH's view of the scope of MES functionality is presented by its functional groupings. The groups defined within SEMATECH's CIM Framework focus primarily on factory operations; equipment integration; and material management and movement. The complete range of application functionality grouping encompassed by the CIM Framework includes:

- Factory management and operations
- Labor management
- Material management
- Process specification
- Machine control
- Process control
- Material movement
- Job management

Managing Automation's Product Categories

Managing Automation is a trade magazine which provides a buyers guide to manufacturing software. Below is Managing Automation's full list of the functional groups of manufacturing product categories on their *1996 MES/MMI/SCADA/Quality Directory and Comparison Guide* [MANGUIDE]:

- Resource Management
- Finite Scheduling
- Maintenance Management
- Process/Routing Simulation
- Manufacturability Analysis
- Engineering Process Development Tools
- Computer-Aided Process Planning and Documentation
- Electronic Document Management, Delivery & Tracking
- SCADA
- Supervisory/Cell Control (SCADA)
- Man Machine Interface
- Simulation
- Data Acquisition
- Recipe and NC Program Management
- Computer-Aided Operator Support
- Data Collection, Information Management and Reporting
- Quality Documentation
- Supplier Management
- Process Control
- Inspection and Testing
- Statistical Process Control and Quality Control
- Laboratory Information Management Systems (LIMS)
- Nonconformance and Corrective Action
- Statistical Analysis
- Product Handling and Service
- Cost of Quality
- System Interfaces

This is just one example of how a marketing and distribution company will group MES and related manufacturing functionality. Each marketing and distribution company has their own way of grouping MES functionality. In addition each user environment currently has their own way of grouping MES functionality.

Gartner Group's Manufacturing Operations Management

Gartner Group, Inc., is an independent advisor of research and analysis to business professionals making information technology (IT) decisions, including users, purchasers, and vendors of IT products and services. Its primary business consists of research and analysis of significant IT industry developments and trends, the packaging of such analysis into subscription-based products called personal advisory services, and the distribution of such products through various print and electronic media. [Gartner]

Gartner Group's definition of MES was derived as a subset of a full Manufacturing Operations Management(MOM) environment [Gart94]. MOM is an integrated system used by the plant to bring the key seven areas of manufacturing into balance in real time to facilitate the efficient use of resources in fulfilling production orders. MOM is a superset collection of seven MES groupings defined around business processes, business roles and business drivers. The seven areas of MOM are provided below.

MES grouping	***Key business roles***	***Key business processes***	***Business drivers***
Production Orders	Production order planner; Production order scheduler; Maintenance scheduler; Operations manager	Schedule production; Determine production order status; Optimize resources	Optimize production order costs; Reduce production order cycle time
Equipment	Equipment manager; Maintenance planner; Maintenance scheduler; Maintenance supervisor; Maintenance contractor	Manage equipment; Performance/diagnostics; Manage equipment utilization; Manage equipment maintenance	Reducing equipment downtimes due to failures or preventive maintenance; Optimizing equipment performance; Reducing fluctuations in equipment performance
Labor	Labor scheduler; Labor planner	Manage labor training; Manage labor deployment; Manage contractual obligations	Optimization of resources; Training compliance
Operations	Operations Manager; Production team; Shift teams	Perform production; Manage work instructions	Optimize the efficiency of operations; Reduce cycle time
Materials	Materials manager; Logistics manager	Manage Work-In-Process; Inventory tracking; Analyze material performance	Economic optimization of material usage; Verification of material availability; Performance measurements of material specifications.
Quality	Quality manager; Sampler; Lab assistant; Engineering Analyst; Chemist	Improve production process; Predict process failure; Predict product failure	Reduce off-spec product; Reduce process fluctuations in product characteristics; Reducing downtime due to failures.
Health, Safety & Environmental Regulation	Environmental monitors; HS&E manager; Regulatory information provider; Regulatory information managers; Safety coordinators	Monitor environmental performance; Provide OSHA/SARA/EPA regulation information; Manage OSHA/SARA/EPA regulation information	Ensure OSHA, SARA and EPA compliance in the areas of training, reporting and procedures.

The key driver for MOM systems is that each area is “proactive” within its area of expertise for identifying problems and integrated with the other areas to understand their impact on the execution of the plant in order to fulfill production.

MOM and Integrated MES includes Production History Management(PHM) systems which support the storage and access of archived production process measurements and events. A collection of these production process events and measurements is called a production history. The difference

between a Product Data Management environment and a Production History Management (PHM) environment is that the PDM works to define what the manufacturing facility *is to make* and how each of the facilities are *designed to build the product*, whereas the PHM environment works to collect and provide information on *what products were made* and *how well the facility was performing* [Gart96].

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Appendix C. Background on the Object Management Group and its Manufacturing Domain Task Force

OMG is dedicated to producing a framework and specifications for commercially available object-oriented environments. The Object Management Architecture (OMA) Guide provides an architecture with terms and definitions upon which all supporting interface specifications are to be based. Part of this architecture is the Reference Model which identifies and characterizes the components, interfaces, and protocols that compose the OMA.

Figure 1 shows the five major elements of the OMA Reference Model. Each is summarized below. Readers unfamiliar with the Reference Model are encouraged to refer to [OMG RM].

- The *Object Request Broker (ORB)* enables objects to make and receive requests and responses.
- *CORBAservices* is a collection of services with object interfaces that provide basic functions for realizing and maintaining objects.
- *CORBAfacilities* is a collection of interfaces and objects that provide general purpose capabilities useful in many applications.
- *Application Objects* are specific to particular end-user applications, such as a manufacturing scheduling system.
- *CORBAdomains* embrace objects that are specific to vertical markets, such as the notion of “machine”.

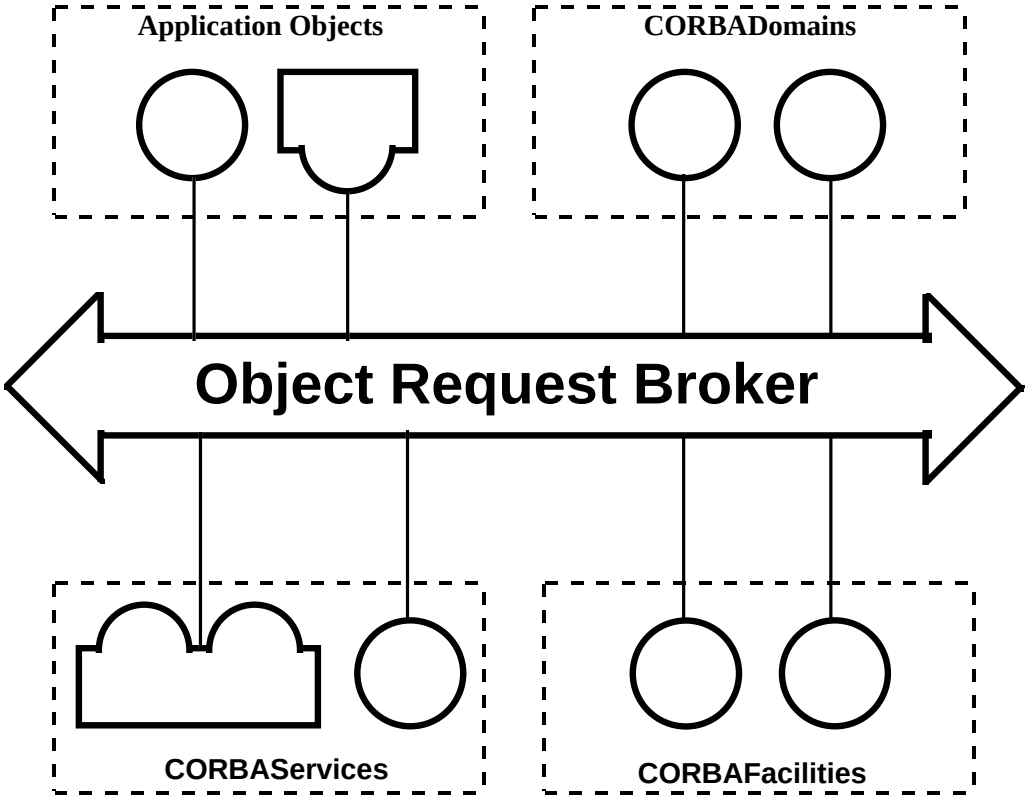

Figure 1: OMA Reference Model

Through a series of RFPs, OMG is populating the OMA Reference Model with detailed specifications for each of its components and interfaces. The OMA's Object Model describes what an object is and what constructs are generally available for defining OMG objects. The Common Object Request Broker Architecture (CORBA) specification [OMG ORB] defines the OMG ORB - a mechanism which allows clients to issue requests to, and receive responses from conforming objects (Figure 2).

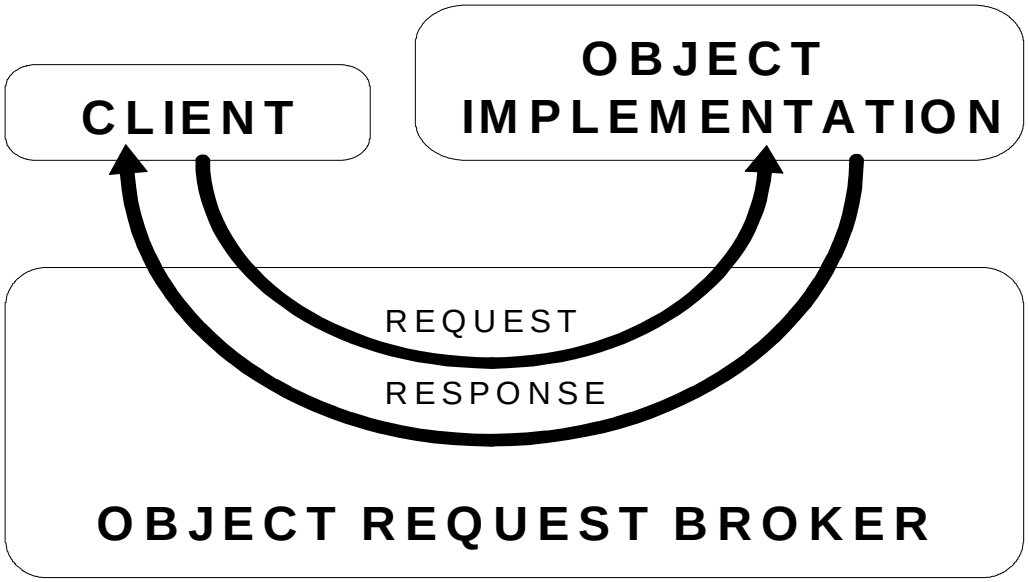

Figure 2: Common ORB Architecture

Using the ORB, requests for an object's services are made without regard to the location or implementation of the object providing the service, i.e., without regard for the mechanisms used to represent, store, manage, invoke or communicate with the object. Objects made available through the ORB publish their interfaces using the Interface Definition Language (IDL) as defined in Chapter 4 of the CORBA specification. The IDL provides a language-independent way of specifying an object's operations and attributes.

To construct inter-working, portable clients and object implementations, there must exist a set of basic CORBAservices which provide functions for realizing and maintaining objects. CORBAservices provide the basic operations for logical modeling, naming, lifecycle, managing and physically storing objects. For example, CORBAservices define the operations used to create, find, move and delete objects, as well as the operations used to define an object and its implementations.

Figure 3 and 4 offer brief summaries of the OMG CORBAservices and CORBAfacilities[OMG CF] and their status.

Service	*Definition*	*Status*
Naming	Manages the naming of objects within defined naming contexts	Adopted in CORBAservices
Event	Manages channeling of events between event producers and consumers.	Adopted in CORBAservices
Persistence	Enables objects to persist beyond the completion of the process that creates them.	Adopted in CORBAservices
Life Cycle	Manages the creation and destruction of objects.	Adopted in CORBAservices
Externalization	Supports export and import of object state information.	Adopted in CORBAservices
Relationships	Manages bi-directional associations between objects.	Adopted in CORBAservices
Transaction	Manages atomic units of work involving operation invocations.	Adopted in CORBAservices
Concurrency	Manages concurrent access to shared objects.	Adopted in CORBAservices
Security	Defines interfaces for authentication and authorization of operations on objects.	Adopted in CORBAservices
Licensing	Manages licensing agreements between objects.	Adopted in CORBAservices
Properties	Manages dynamic named attributes associated with objects.	Adopted in CORBAservices
Query	Provides SQL-like access to sets of objects.	Adopted in CORBAservices
Time	Provides a standard representation to time and the services for manipulating time. Also supports time-related events.	Adopted in CORBAservices
Collections	Supports groupings of objects.	Adopted in CORBAservices
Trader	Enables clients and servers to match services with needs.	Adopted in CORBAservices
Startup Service	Supports sequences of requests issued on ORB startup and shutdown to establish predictable server configurations on startup and restart.	In Progress
Change Management	Provides versioning and composition of objects that change over time.	In Progress

Figure 3: CORBAservices

Facility	*Definition*	*Status*
Compound Interchange and Presentation	Provides for document presentation and interchange services	Adopted in CORBAfacilities
Time Operations	Supports time synchronization in a global distributed system.	Adopted in CORBAservices
Internationalization	Provides support for character sets and language differences of international applications.	Adopted in CORBAservices
Data Interchange	Supports exchange of information between dissimilar objects.	In Progress
Automation	Enables actions triggered by events.	Adopted in CORBAservices
Scripting	Provides management of scripted series of actions.	In Discussion
Rule Management	Supports constraints and event-action rule services.	Adopted in CORBAservices
Mobile Agent	Manages autonomous agents.	In Progress
Repositories	Manages extensible metadata and management of object schemas	Adopted in CORBAservices

Figure 4: CORBAfacilities

The Manufacturing Domain Task Force

The OMG Manufacturing Domain Task Force was chartered as a forum for ensuring the consideration of manufacturing vertical market (industry specific) requirements in the evolution of OMG technologies.

The mission of the Manufacturing Domain Task Force is four-fold:

- Identify and promote extensions to OMG CORBAfacilities and CORBAservices that are specific to the manufacturing vertical market.
- Continue to promote manufacturing requirements in the evolution of the Common Object Request Broker Architecture (CORBA).
- Cooperate with other OMG groups in promoting common requirements for all OMG technologies.
- Increase the industry's awareness of the benefits of object technology.

More information on the Manufacturing Domain Task Force can be obtained via the Internet at:

http://www.omg.org/mfg

For More Information

More information on the Object Management Group can be obtained via the Internet at:

http://www.omg.org/

OMG provides a document server. Send e-mail to **server@omg.org** with a message body:

```
help
get docs/doclist.txt
```

Appendix D. OMG Process

OMG adopts specifications for interfaces, based on existing technology, by explicit vote on a technology-by-technology basis. The specifications selected each fill in a portion of the OMA Reference Model. OMG bases its decisions on both business and technical merit.

The OMG Platform Technical Committee (PTC) and Domain Technical Committee (DTC) provide technical guidance to the OMG in making decisions about specifications. The PTCs efforts are focused on the development of the plumbing - horizontal enabling technology specifications for wide interoperability between components, applications and objects. The DTC efforts focus on leveraging platform technology to support vertical application domains (e.g., manufacturing). Each committee is composed of representatives from OMG member companies and is managed by a full-time OMG staff member (as opposed to being an employee of a member company). The Manufacturing Domain Task Force is organized under the DTC. Any OMG member or invited guest may attend any task force meeting. However, a member must be at the appropriate Contributing Member level in order to have voting privileges for the relevant Technical Committee. Influencing and Government Members may vote at the task force level.

The Architecture Board (AB) is responsible for ensuring architectural integrity of all OMG specifications, Request for Proposals, and other relevant OMG documents. In essence, the AB is the keeper of the flame for the Object Management Architecture. Currently, the AB is composed of elected representatives from OMG member companies and is managed by a full-time OMG staff member.

Both committees, DTC and PTC, operate primarily in a Request for Proposal mode, requesting technology to fill open portions of the OMA Reference Model from international industry. The responses to such a proposal, taken within the specific RFP response period, are evaluated by the issuing task force. The full committee then votes on a recommendation to the Architecture Board. After review, the AB forwards the recommendation to the OMG Board of Directors (BoD) for final approval. If a recommendation passes at all levels, it becomes a specific addition to the set of OMA specifications. Once a specification (a technology, not source or product) has been adopted by the BoD, it is promulgated to the industry through a variety of distribution channels.

Another process, the Request for Comment (RFC), is the OMG's fast track that allows for more expedient adoption of technology in the case where an existing OMG compliant specification exists and there is likely to be no competition.

The Request for Information (RFI) is the OMG process for procuring information prior to issuing RFPs. Responses to this RFI will be reviewed by the Manufacturing Executions System/Machine Control Working Group of the Manufacturing Domain Task Force. The group’s intent is to survey the industry to obtain information about object oriented software components for manufacturing which will be used in the preparation of forthcoming RFPs.