6. THE INDUSTRIAL ENGINEER IN THE MES ARENA

"The real success of Industrial Engineering is not in developing a creative and effective recommendation for a system, or in arranging the most effective operation of this system after installation. It is in effectively bringing together the necessary people, organizations, and resources for developing the system specifications and operating arrangements to increase significantly the likelihood that the most effective recommendations will be adopted and implemented." (Handbook, 1991:4)

To investigate the role of the Industrial Engineer within the MES arena, the general nature and scope of Industrial Engineering are discussed in the first instance and then applied to roles played within the MES arena.

CONTENTS OF THIS CHAPTER

6. 1. THE INDUSTRIAL ENGINEER

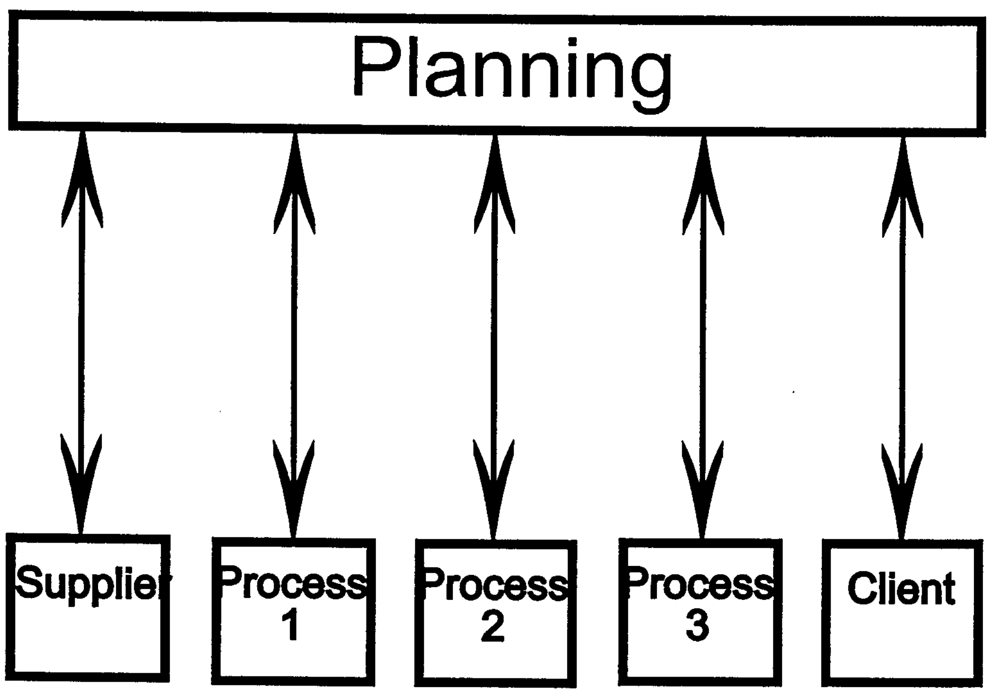
"The proliferation of engineering branches resulted a century ago from a lack of efficiency and integration of all factors into an effective total system. As the technologies needed to cope with these problems started to emerge, the Industrial Engineering profession developed." (Handbook, 1991:4).

6. 1.1. THE INDUSTRIAL ENGINEER AND MES

The role of the Industrial Engineer in the MES arena has emerged together with the evolution of MES technology and the need for MES integration. Vertical integration between control and planning layers is established through the development and implementation of MES by electronic engineers and information technologists (as indicated in *Figure 17*).

Figure 17

Vertical integration between planning and control



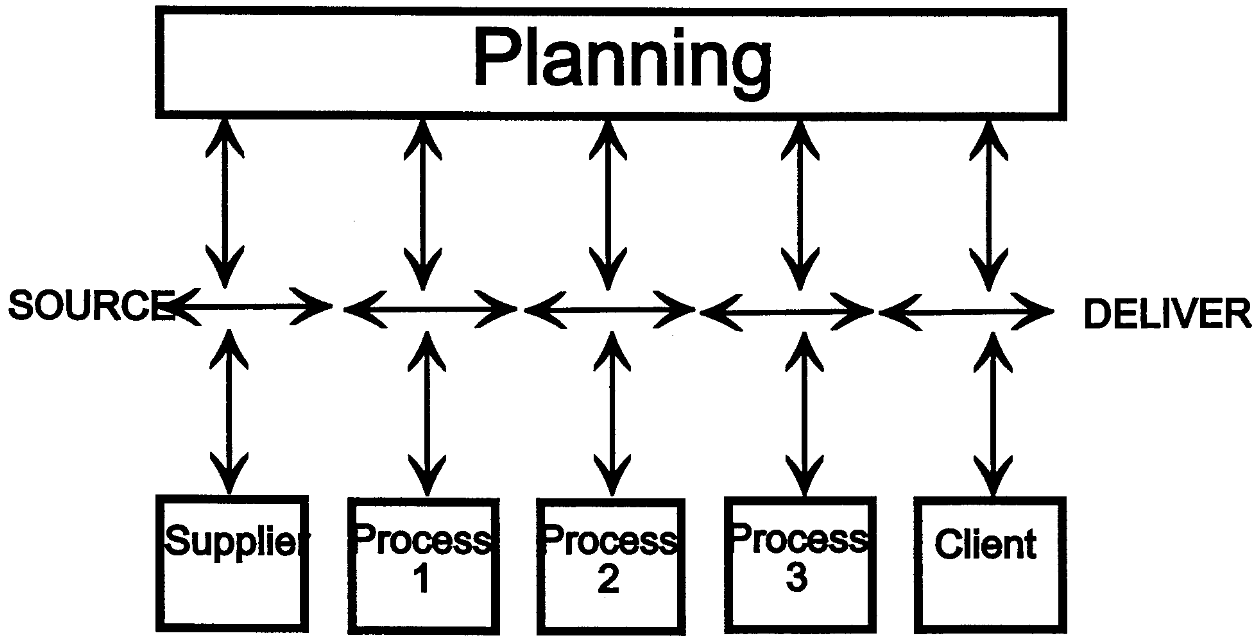
According to Digital Basestar (1998: www.asia-pacific.digital.com/info/manufacturing/integr.htm), real-time data collection from shop floor devices and personnel, real-time data processing and validation, real-time data sharing, and real-time application interoperability suffer, even in the most automated plants, from the islands of automation syndrome. In *Figure 17* it is shown how vertical integration may occur, while no integration is established between these "islands of automation".

The Object Management Group (1998:6) supports the need for horizontal integration between workstations and plants:
"Many machines and controllers are standalone and are not networked or integrated with other systems. Manufacturing facilities are seeing the need to network these controllers and machines, as businesses need to become more flexible to business directions and organizational changes. In most cases, controllers at this time are unable to understand each other's constraints, targets and assumptions to ensure the control model is valid."

The role that the Industrial Engineer has to fulfill is becoming increasingly important, as the technologies to enable vertical and horizontal execution integration throughout the enterprise and supply chain evolves (*Figure 18*).

Figure 18

Vertical and horizontal execution integration throughout the enterprise



6. 1.2. THE INDUSTRIAL ENGINEER AND MES IN SOUTH AFRICA

The development of the Industrial Engineering profession within the MES arena is portrayed in statistics of two of the leading MES developers and integrators in South Africa as indicated *Table 35.*

Table 35

Industrial Engineers within South African MES companies

Name of company	Background on company	Industrial Engineers within company
KEOPS-ISIS	The following background is given on the homepage of Keops Isis (www.keopsisis.co.za): "Keops Isis Industrial Information Systems (Pty) Ltd.: (Keops Isis) is a leading South African systems developer and systems integrator that specializes in providing solutions for Manufacturing Execution Systems (MES). Keops Isis is vendor independent. Thus they do both MES development and integration.	When this company emerged in the MES field a few years ago, the project team member consisted out of electrical and mechanical engineers as well as information technologists. In 1999 the second Industrial Engineer was appointed, which increases the percentage of Industrial Engineers in relation to other engineers to 20%. Approximately the same number of Information Technologists as Engineers is employed at this company. Keops-Isis is planning to employ even more Industrial Engineers, since Industrial Engineers have proved to interact excellent with their clients. (Theron,13 May 1999).
BKS Hatch	The vision of Hatch is to be the world's pre-eminent supplier of technical and strategic services including Consulting, Information Technology, Engineering, Project Management and Construction to the Mining and Metallurgical industries. Hatch's Advanced Systems group has extensive experience designing and installing MES and ERP systems. (www.hatch.co.za)	In 1998 the first (and only ever since) Industrial Engineer was employed at BKS Hatch, South Africa.

A sample size of two is small an insignificant to allow generalization. Conclusions on the involvement of Industrial Engineers in the MES arena, should not be derived directly.

6. 1.3. TRAINING OF THE INDUSTRIAL ENGINEER WITH REGARD TO MES

Röhrs (1996) developed a training model for Industrial Engineers as illustrated in *Figure 19* on the next page.

The vertical axis (systems axis) represents the continuum of types of systems. The top of this axis represents abstract systems (information), while concrete systems (equipment) are represented at the bottom. These systems can either be human driven (left) or technique driven (right) as indicated by the process (horizontal) axis. The Industrial Engineering areas of expertise are indicated in the relevant positions on this model.

The scope of Industrial Engineering (as derived from *Figure 19*) can be brought into context with MES through the MES Function Matrix (Chapter 4). This is done in *Table 37*, following *Figure 19*. Some of the Industrial Engineer's areas of expertise (such MRP, MRPII or automation) fell within the scope of planning or control systems and not execution. It is, however, indicated on this matrix, since expertise with regard to the other levels of systems is needed to establish optimal integration.

Figure 19

Training model for Industrial Engineers

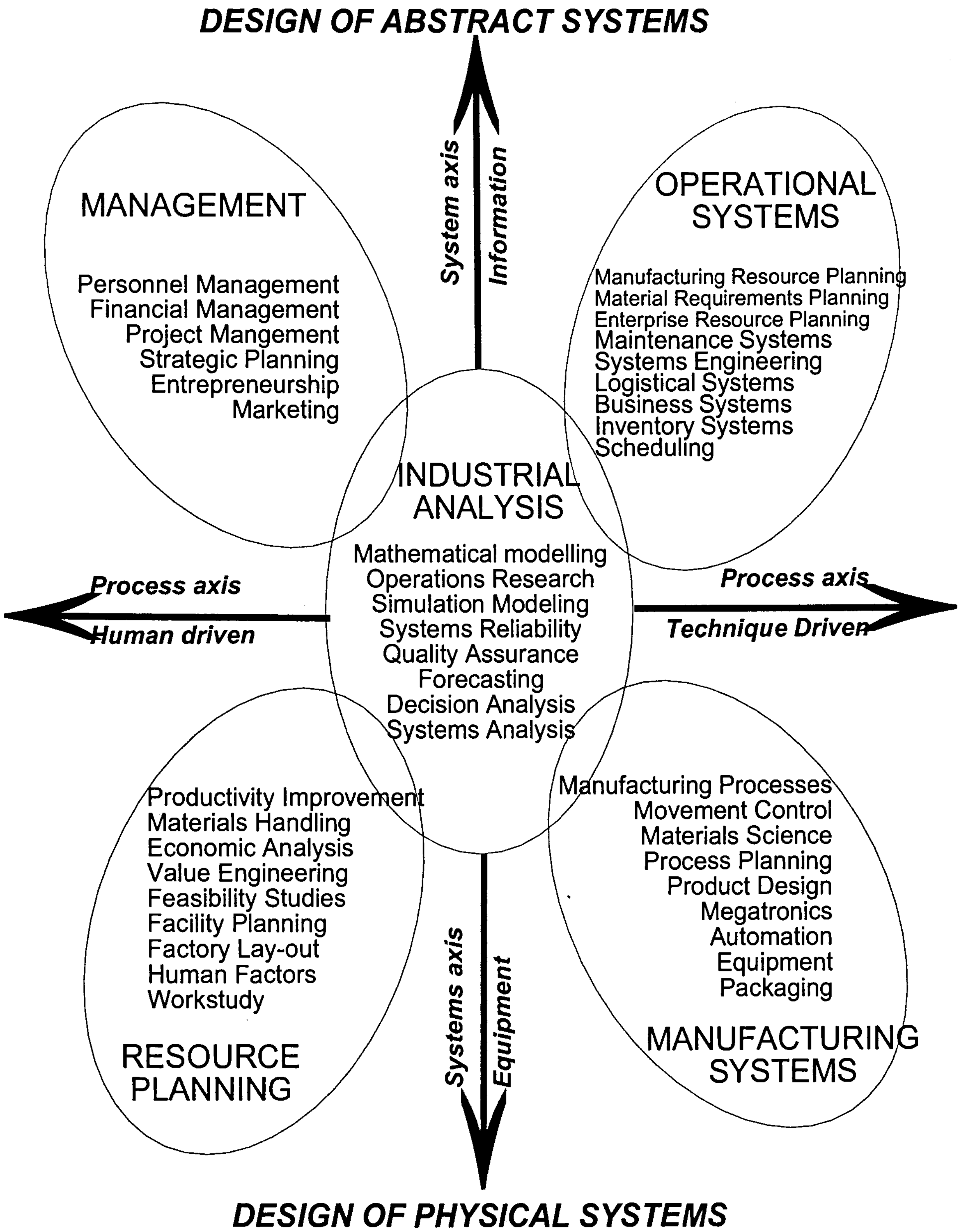


Table 37

The expertise of the Industrial Engineers within the scope of Manufacturing Execution Systems

	GUIDE/ COORDINATE	INITIATE/ READY	ANALYZE	REACT
MATERIAL/ PARTS/ PRODUCT	• MRP/ MRPII • Logistical Systems • Inventory Systems • Scheduling	• Logistical Systems • Materials Handling	• Mathematical Modeling • Operations Research • Quality Assurance • Materials Handling • Materials Science	• Scheduling • Quality Assurance • Decision Analysis • Materials Handling
LABOUR/ PERSONNEL	• Personnel Management • Scheduling	• Personnel Management • Human Factors	• Personnel Management • Mathematical Modeling • Human Factors	• Personnel Management
EQUIPMENT/ TOOLS/ FIXTURES	• Scheduling • Automation	• Maintenance Systems • Automation	• Maintenance Systems • Mathematical Modeling • Operations Research	• Maintenance Systems • Decision Analysis
WORK INSTRUCTIONS/ SPECIFICATIONS/ PROCEDURES	• Value Engineering • Manu-facturing Processes	• Value Engineering • Product Design • Manu-facturing Processes	• Operations Research • Economic Analysis	• Decision Analysis
WORK ORDERS	• Logistical Systems • Scheduling	• Logistical Systems • Scheduling	• Mathematical • Modeling • Forecasting • Economic Analysis	• Scheduling • Decision Analysis

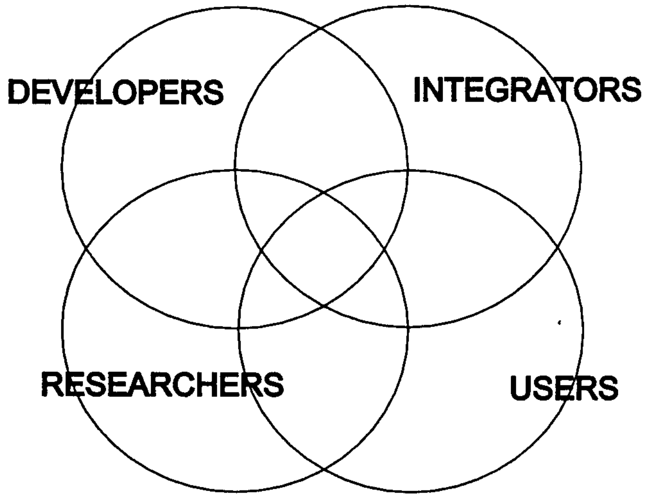
Areas of expertise, such as project management, marketing and systems engineering do not appear in *Table 37*, but it are related to the roles played within the MES arena. It is evident that the Industrial Engineer possesses important skills to assists in the development, implementation and use of MES.

6. 2. ROLES WITHIN THE MES ARENA

Within the MES arena 4 roles are identified as indicated in *Figure 20.*

Figure 20

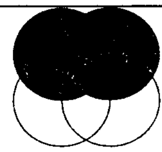
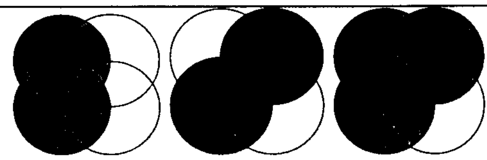
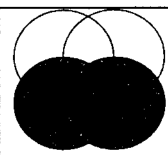
The roles played within the MES arena

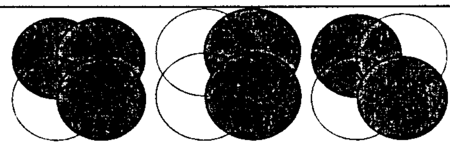
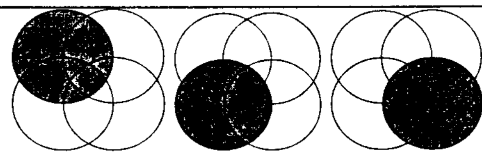


These roles may overlap in some way or another, as explained in *Table 38.*

Table 38

Overlapping of roles played with regard to MES

It often happens that one company is both developing and integrating certain MES products.	
Both developers and integrators may be involved in research on MES.	
Some manufacturers (users) – such as the semiconductor industry (Sematech, 1999, http://www.sematech.org) – often engaged in research on the application of MES within their industry or business.	

Users may also work together with developers and/or integrators to develop an Manufacturing Execution System solution for that business. Due to the duration and strategic nature of MES implementation, it is normal for a user organization to engage in a partnership with an integrator organization. (HATCH Africa,1998:1)	
In most instances users of MES are not involved in the development of MES and some institutes (such as MESA International) have the sole purpose of promoting MES through research. Some vendors may also only focus on the development of a product, but integrators never work in isolation.	

6. 2.1. ROLES FULFILLED BY THE INDUSTRIAL ENGINEER

According to the Handbook of Industrial Engineering (1991:4), "Industrial Engineering will be recognized as the leading profession whose practitioners

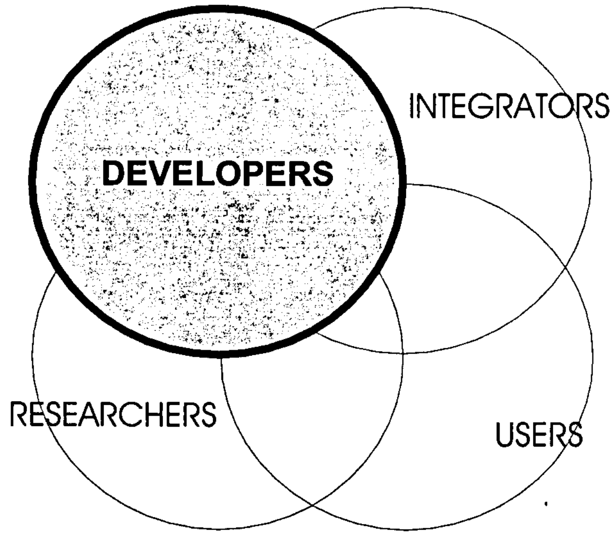
- plan, design,
- implement, and
- manage integrated production and service delivery systems that assure performance, reliability, maintainability, schedule adherence and cost control. These systems may be socio-technical in nature, and will integrate people, information, material, equipment, processes, and energy throughout the life cycle of the product, service, or program."

The roles of system

- development (plan, design),
- integration (design, implement) and
- use (manage)

can be identified from this definition. Each of these roles, together with the research role, is investigated in the remainder of this chapter.

6. 3. THE INDUSTRIAL ENGINEER AS MES DEVELOPER



"Information Engineering" is sometimes suggested as a substitute name for the Industrial Engineering profession. It refers to the combined hardware and software aspects of systems improvement. The profession will draw on artificial intelligence, expert systems technology, data base systems, and computer chip concepts to supplement its current set of techniques and tools to achieve the information engineering status. Computer-integrated manufacturing systems, software systems development, decision support systems, expert systems, enterprise wide information systems, project control systems, and economic analysis systems illustrate the prospective results of this thrust." (Handbook,1991:26)

From a comprehensive list of typical roles played by an Industrial Engineer (Handbook of Industrial Engineering,1991:18), the roles related to the development of software solutions are the following:

1. **Designer/ Planner**
   - Produces the solution specifications and serve as advocate of the solution through the implementation phase.
2. **Innovator/ Inventor**
   - Seeks to produce a creative/unique/advanced technology solution and advocate its use all the way through implementation.

These roles are related to the development of an Manufacturing Execution System.

6. 3.1. DESIGNER/ PLANNER

"An Industrial Engineer produces the solution specification and serve as advocate of the solution through the implementation phase." (Handbook, 1991:18).

According to Forstedt (1998:www.consilium.com/Publications/ics.htm) the trend is away from writing software internally in favour of sticking with core competencies, and looking for software vendors to provide the cost to develop, support and enhance. The Industrial Engineer is in an excellent position to identify the functions needed and translate the need to specifications, which would enable vendors to develop software to attend to this need.

6. 3.2. INNOVATOR/ INVENTOR

"An Industrial Engineer seeks to produce a creative/ unique / advanced technology solution and advocate its use all the way through implementation."
(Handbook, 1991:18).

Code development arrangements are not uncommon between manufacturers and software providers when there is no software product that meets the user requirements. With the emphasis today being on quality and reliability, more demands are being placed on software vendors to become ISO 9000 registered, to provide better product testing and documentation, and to participate in the enhancement process with their partners the manufacturers (Anonymous, 1998:4A). The average information technologist does not have sufficient knowledge regarding manufacturing management or concepts such as ISO9000. The Industrial Engineer should thus be involved in the development process.

6. 3.3. CONCLUSION

The Industrial Engineer can make a significant contribution towards the development of MES. Since Industrial Engineers is to a great extent concerned with integration, even greater contributions should be made regarding MES integration, as discussed in the next section.

6. 4. THE INDUSTRIAL ENGINEER AS MES INTEGRATOR

"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 integrators should be a part of the team. Manufacturing consultants can provide an outsider's experienced perspective in analyzing business process improvements.

(MESA International, 1996: www.MESA.org/html/main.cgi?sub=29)

From the same list used to define roles related to software development (Handbook, 1991:18) roles, related to the integration of products, are selected:

1. **Boundary/ Spanner**
   - Bridge the information/style/interests gap between the developer and user/client/adopter.
2. **Facilitator/ Coordinator**
   - Provide appropriate purposeful activity approach guidance and structure to a group.
3. **Analyst**
   - Separate a whole into parts and interactions and examine them to explore for insight and characteristics.
4. **Project Manager**
   - Operate, supervise, and continuously evaluate the usually large scale and complex project structure or system.
5. **Chairperson**
   - Be responsible for a project and manage and facilitate the team/group/task force.
6. **Decision Maker**
   - Select a preference from alternative possibilities for topic of concern.
7. **Trainer/ Educator**
   - Have people involved learning the skills and knowledge of Industrial Engineering and the various approaches to purposeful activities.

6. 4.1. BOUNDARY/ SPANNER

"An Industrial Engineer bridges the information/style/interest gap between the developer and user/client/adopter" (Handbook, 1991:18)

Swanton (1998:www.amrresearch.com/repac) explains that, with technical backgrounds, vendors and plant users tend to miss important business and political realities when advocating system projects. According to BKS Hatch Africa (1998:1) - one of the leading MES integrators in South Africa - the needs, which address the business vision, must be identified and met, through the implementation of an Manufacturing Execution System. The affected business processes must be characterized and evaluated, and sometimes changed. The readiness within the business to successfully implement the systems must be assessed and developed. Forstedt (1998:www.consilium.com/Publications/ics.htm) highlights the opportunity to reengineer manufacturing processes and documentation when implementing an Manufacturing Execution System.

Swanton (1998:www.amrresearch.com/repac) listed some questions, which need to be answered when an Manufacturing Execution System is implemented:

- What changes are driving my industry? Top executives have a clear picture of changes necessary to stay competitive, and the project must further these goals.
- Will it enhance ERP and supply chain projects? These same executives have already bet their careers on expensive enterprise-level projects. To get corporate backing a plant project must demonstrate enhancement or, even better, necessity for plant success.
- What are my fundamental business processes? Though much has been made of corporate business processes such as "order to cash," similar processes exist in the plant.
- How will I sustain a competitive advantage? Many plants judge themselves on a static bar such as production efficiency and cost.

The Industrial Engineer is in the position to answer these questions and present it in a way, which can be understood by vendors and plant users with a technical background.

6. 4.2. FACILITATER/ COORDINATOR / CHAIRPERSON

"An Industrial Engineer provides appropriate purposeful activity approach, guidance and structure to a group and is responsible for an Industrial Engineering project and the management and facilitation of the team/group/task force. (Handbook, 1991:18)

MESA International (1996:www.MESA.org/html/main.cgi?sub=29) explains that MES implementations affects the entire organization. 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, therefor, mandatory that the whole organization be committed to understand the big picture of what is needed. Participation and/or proper representation in the evaluation and selection process helps assure successful implementation. MES integrator must assure that the entire organization's requirements and not just individual departmental needs drive the new system's requirements.

Heini Wellman (1998:www.foodexplorer.com), who holds a master's degree in mechanical and industrial engineering, heads a multi-functional team which studies the replacement of Nestle's current factory-based ERP systems and its integration with the MES systems for Nestle's manufacturing plants. Wellman explained his facilitation/ coordination role as MES integrator:

"For MES, we formed a special interdisciplinary working group, under an interdisciplinary steering committee. The steering committee includes people from manufacturing systems, information systems, engineering (plant automation), and quality management. The special working group has representatives from these same areas. The project is lead by people concerned with manufacturing systems: Manufacturing systems people are not information systems people, but people who think about our manufacturing systems and methods. That's what I'm responsible for. I serve on the steering committee, and I organize the special working group, which is headed by a manufacturing systems person. For balance, the head of engineering chairs the steering committee."

The Industrial Engineer is thus equipped to facilitate and coordinate the company-wide implementation of an Manufacturing Execution System.

6. 4.3. ANALYST

"An Industrial Engineer separates a whole into parts and interactions and examine them to explore for insight and characteristics." (Handbook, 1991:17)

Systems integrators can assist in evaluating integration requirements, responsiveness, flexibility, and delivery and retention of critical information (MESA International, 1996:www.MESA.org/html/main.cgi?sub=29). According to Swanton (1998:www.amrresearch.com/repac) the potential of MES, as an analyzing tool, is not exploited optimally by MES users. The Industrial Engineer has the ability to make sure that this business process is not neglected when an Manufacturing Execution System product is chosen and integrated.

6. 4.4. DECISION MAKER

"An Industrial Engineer selects a preference from among alternative possibilities for topic of concern." (Handbook, 1991:18)

The Automation Research Council (1998:www.arcweb.com/ARCsite/MktStudies/mktstudies.htm) highlights the fact that the installation of production management systems is a lengthy and costly process (often taking a year-and-a-half or longer in large plants). Because production management software projects involve extensive system integration services, manufacturers need to be careful in selecting a supplier. Supplier selection is particularly important because most production management software companies are small. Manufacturers selecting production management vendors would like assurance that their prospective partner will be capable of an ongoing relationship, available to solve problems and update the system.
The Industrial Engineer is trained in the making of decisions such as these.

6. 4.5. PROJECT MANAGER

"An Industrial Engineer operates, supervises, and continuously evaluates the usually large scale and complex project structure or system." (Handbook, 1991:18)

Each MES implementation project varies from one another. Project differences relates to:

- the type of industries,
- existing systems,
- budgets,
- scope of projects and
- available information technology.

Although no generic implementation strategy exists, the project manager (such as an Industrial Engineer) should consider the following:

According to Theron (1998), change management is especially important in converting existing legacy or manual systems to an integrated MES. Aspects that need to be taken into consideration are:

- Participation, representation and understanding from all areas affected by the MES
- Organizational preparation for change
- Senior management supporting/managing the project
- Budget commitment
- Existence of other complementing systems (SCM, ERP, Control)

Valstar (1998: www.valstar.co.uk/MES/MESprod.html) is using the following strategy to implement their MES:

1. Investigation of manufacturing environment by integrator
2. Testing of system by key users
3. Configuration of hardware and software on grounds of the suggestions by key users
4. Testing of system to determine key data collection points, events and external interfaces
5. Installation of production system and initialization of production database
6. Maintenance and long term support.

Due to the long duration and strategic nature of MES implementation, it is normal for an user organization to engage in a partnership with an integrator organization. (HATCH Africa,1998:1). The Industrial Engineer - not being a technical specialist - is ideally suited with appropriate experience to fulfill the role of project manager.

6. 4.6. TRAINER

Despite all of its functionality, MES still faces two notable barriers to success. One is the attitude of people in production and the other barrier is their comfort level working with real-time information systems. MES must be embraced by

- *managers, supervisors, and*
- *others on the shop floor to be effective.*

(Forger,1997:www.manufacturing.net/magazine/mmh)

(a) TRAINING/ EDUCATION OF "MANAGERS AND SUPERVISORS"

According to Leibert (1995:7) the vision to implement a factory floor-based workflow system is often derailed up front, during the evaluation stage. Top-level management frequently closes its eyes to situations they don't want to acknowledge. They also might not be aware of the barriers to effectively evaluating a workflow system. The reasons for ineffective evaluations have to do with the misunderstanding of system capabilities and the lack of understanding about how employees will be affected through a new way of working. Good system changes often require business changes that occasionally can be in conflict with the status quo found at middle and lower management levels.

(b) TRAINING/ EDUCATION OF "OTHERS ON THE SHOP FLOOR"

Charles Klee (Forger,1997:www.manufacturing.net/magazine/mmh) explains that the biggest challenges in implementing MES and in obtaining satisfactory results are related to people. In order to get all of the employees to think and act together after so many years of independent activities, a steering committee including top management was formed to break down the barriers between departments. By using live data and making it available to multiple departments, people must dispense with the informal information systems they have relied on in the past. In turn, that changes the way work gets done. Resistance to that shift will disappear, as people become more comfortable with the new method of operating.

It is also important to analyze the degree of control necessary, which will depend on, among other things, how well trained/educated the production personnel are and whether or not they are computer literate (Forstedt,1998:www.consilium.com/Publications/ics.htm).

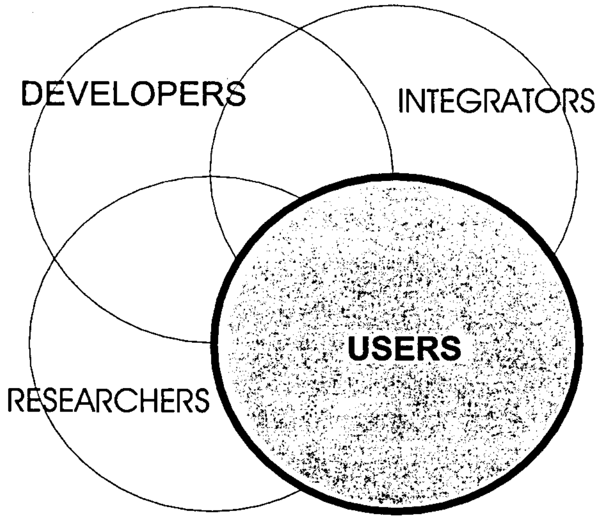
The Industrial Engineer has knowledge of both organizational behaviour and the contents of suggested training and can assist in the development of an MES training program.

6. 4.7. CONCLUSION

"Automation of manufacturing, professional, and office systems and activities will accelerate. Paradoxically, the importance of human beings in these systems increases as greater skills are needed to design and operate the systems while the number of people employed goes down. No office computer, robot, automated cell, or computerized manufacturing system will ever be able to contribute, as can the people who remain. Socio-technical systems are needed to accommodate the multiple perspectives of reality. The Industrial Engineering will be called on to provide the facilitating abilities, change processes, technology understanding, and human factors knowledge to produce the breakthroughs and continuing improvements in them" (Handbook,1991:26)

The expertise of the Industrial Engineers described above is needed for optimal integration of MES. MES can furthermore be applied by the Industrial Engineer to obtain continuous improvement, as discussed in the following chapter on the users of MES.

7. USERS OF MES



The users of MES is categorized in this chapter on according to the following categories:

1. Industry sectors
2. Companies
3. Individual users within companies

CONTENTS OF THIS CHAPTER

7. 1. THE USE OF MES WITHIN INDUSTRY SECTORS

According to Consilium (1998:www.consilium.com/Publications/why.htm) the following industry sectors represent the vast majority of the total packaged integrated MES installed base:

- Semiconductor
- Electronics
- Aerospace and defense,
- Pharmaceutical and health care products, and
- Chemical industries.

The need for traceability, together with complex or unstable processing and heavy governmental regulations, within these industry sectors, is believed to be the common driver for the growth of MES products.

7. 1.1. INDUSTRY SECTOR UTILIZATION OF RELATED SYSTEMS

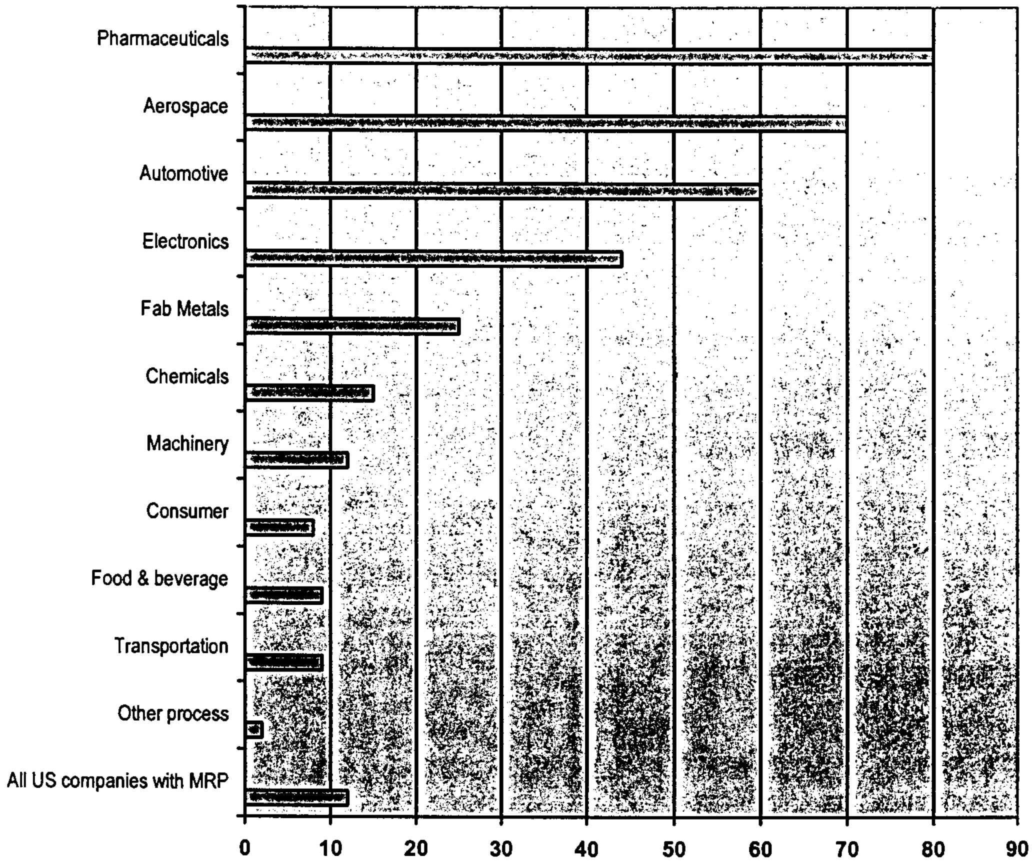
These industry sectors corresponds to a great extend with companies who have taken the lead on the field of MRP and MRPII. *Figure 21* shows the percentage of companies in the United States that have installed MRPII-type systems (Chase:1995:589).

7. 1.2. INDUSTRY SECTOR UTILIZATION OF MES WITHIN SOUTH AFRICA

The automotive and fabricated metals industries rank high on the MRPII list, but are not present on the list of industries with high implementation of MES. It is, however, interesting to note that the metals industry is the focus of the two of the most significant South African MES integrators (KEOPS-ISIS and BKS Hatch). These two companies also do some MES implementations in the automotive industries.

Figure 21

Percentage of Companies in 11 Industries (within the USA) with installed MRPII systems



In a resent survey by South African Instrumentation and Control Journal (1999:8-12) thirty software integrating companies in South Africa were given the choice of highlighting (in five words), their integration expertise. The industry sectors covered by these integrators were also added to this survey. Nine of these thirty companies have chosen MES as to describe their integration expertise. The feedback from these nine companies is summarized in *Table 39*, on the following page.

The scope of projects undertaken by these companies is unknown and MES integrators interviewed for purposes of this dissertation is not part of this list. An accurate ranking of the MES utilization within South Africa can therefor not be provided.

Table 39

South African MES integrators

INDUSTRY SECTOR	Alstom Industrial Systems	DLRA Projects	Gemsys	ICIS	ISI (Industrial Systems Integrators)	Quad-SI	S&P Poroject Engineering	Tradex	Warthog Industries
	COMPANIES WITH MES EXPERTISE								
Food & beverage	■	■	■	■	■	■	■	■	■
General manufacturing	■	■	■	■	■	■	■	■	■
Materials handling	■	■	■	■	■	■	■		■
Mining & Metals	■	■	■	■	■	■	■		
Power generation & distribution	■	■	■	■	■	■	■		
Water & wastewater	■	■	■	■	■	■	■		
Pulp&paper	■	■	■	■	■		■		
Transportation	■	■	■	■		■	■		
Automotive manufacturing	■		■	■			■		■
Petrochemical		■	■	■	■		■		
Sugar		■	■	■		■	■		
Environmental control & monitoring		■	■		■		■		
Warehousing & storage	■		■	■		■			
Pharmaceutical	■			■			■		
Rubber and plastic	■					■	■		
Marine	■		■						
Textiles							■		

7. 1.3. DRIVERS WITHIN INDUSTRY SECTORS

Manufacturing Execution Systems provide similar benefits regardless of the industry they are applied to. However, there are also unique drivers within industries that emphasize specific MES capabilities over others depending on the manufacturing environment. According to Marks (1997:http://www.industry.net/nmw97/MES1.htm), these business drivers have important ramifications on how MES systems are viewed, funded and implemented by companies in different manufacturing industries

Consilium (1998:http://www.consilium.com/Publications/why.htm) listed some of these industry drivers (*Table 40*).

Table 40

Drivers of change towards MES within industry sectors

Industry	Drivers of Change
Aerospace & Defense	Government Compliance Tractability Product Quality Work Track by Contract
Chemicals	Safety Environmental Requirements Service Responsiveness
Electronics	Vendor Quality Quality Trends Warranty Time-to-Market
Pharmaceuticals	Government Reporting Electronic Batch Records Electronic Data Collection Recipe Management
Semiconductor	Complex Materials Plans Lot Tracking Yield/ Quality Time-To-Market Finite Capacity Scheduling Resource Utilization
Food Processing	Yield Quality Lot Tracking Government Compliance

According to Forstedt (1998: http://www.consilium.com/Publications/ics.htm), MES packages are gaining wider acceptance as more and more industries are faced with customers demanding better delivery performance and higher levels of quality at lower cost.

7. 1.4. MES FOR DISCRETE MANUFACTURING AND PROCESS MANUFACTURING

McClellan (1997:22) explains that the idea of MES is being applied to all manufacturing environments, from discrete-part manufacturing to process manufacturing such as a chemical plant, a pharmaceutical plant or brewery. He suggests the following industry classification regarding the use of MES within industry sectors:

- Discrete part
- Repetitive discrete part
- Batch process
- Continuous Process

In Chapter 4 the suggestion is made the MES Function Matrix is used as framework to develop an MES checklist for a specific industry. The statement is made that the elements of manufacturing and the elements of execution (as defined for purposes of the MES function matrix in Chapter 4) are related to the type of industry. To support this statement, the differences between process manufacturing and discrete manufacturing is discussed according to some elements of manufacturing (*Table 41*) and some elements of execution (*Table 42*). Both of these tables appear on the next page.

Table 41

The differences between discrete manufacturing and process manufacturing on grounds of elements of manufacturing used to develop the MES Function Matrix.

Discrete Manufacturing	**Process Manufacturing**	**ELEMENTS OF MANUFACTURING**
Stored in containers	Stored in tanks, silos, bulk	• ***Material***
"Discrete manufacturers add value by machining, fabricating, and assembling parts. All material is usually input at the beginning of the manufacturing process. This process produces one output unit (i.e., a completed subassembly or finished product). This type of manufacturing process can be modeled using the bill of materials and routing files in a discrete MRPII software package."(Luber,1991:319)	Process manufacturers add value by using energy, equipment, and other resources to blend or separate ingredients and cause chemical reactions. The manufacturing process consists of multiple steps or stages. Each stage may require ingredients and resources to be input, and each stage may yields multiple outputs such as co-products, by-products, waste, energy, and recyclable materials. (Luber,1991:319)	• ***Material*** • ***Work Order*** • ***Speci-fications***
Tight specifications Bill of Materials	Wider specifications Formula	• ***Speci-fications***
Categorized by item number	Categorized by product number	• ***Work order***
Discrete manufacturers can often increase capacity by hiring additional workers, buying or leasing more machines, or subcontracting work to external suppliers.	Process manufacturers generally must work within the constraints of fixed capacity. Short of building and additional plant. There is often little that a process manufacturer can do to increase capacity.	• ***Equipment***

Table 42

The differences between discrete manufacturing process manufacturing on grounds of elements of execution used to develop the MES Function Matrix.

Discrete Manufacturing	**Process Manufacturing**	**ELEMENTS OF EXECUTION**
Easy and accurate to measure (count)	Difficult to measure (volume etc)	• ***Analyze***
Consistent and predictable quality	Quality is unpredictable and time variant	• ***Analyze***
Predictable yields	Inconsistent Yields	• ***React***
Initial MRP concepts (which still dominate many application designs, focussed on the needs of discrete manufacturers	Despite the rapid growth in the ERP market over the pas few years, the process segment remained relatively untapped from 1995 to 1996. According to the AMR, ERP in process industries are expected to increase.	• ***Coordinate***

7. 1.5. INDUSTRIES OTHER THAN MANUFACTURING

The term *Manufacturing* Execution Systems implies that it is a concept focussed on manufacturing industries. MES principles and products can presumably be applied to service industries too. Further discussion does not fall within the scope of this dissertation.

7. 2. COMPANIES AS USERS OF MES

According to McDonough (1995:http://mfginfo.com/htm/MESi-artical.htm) the cost of an MES is not strongly linked to the size of a plant or the volume of a foundries production. MES systems that run on large mainframe / mini-frame types of hardware have significant costs and support issues that have a life all their own, independent of the MES software running on them.

Only a small fraction of manufacturing businesses can afford the cost of installing and maintaining an integrated MES solution. When a Manufacturing Execution System is integrated into an existing business system, maintenance and integration costs incur. According to NIST (1998:http://www.atp.nist.gov/atp/focus/tima.htm) these costs contribute to the fact that total integrated MES are not feasible for small and medium enterprises.

Examples of South African plants at which Manufacturing Execution Systems are implemented, are listed below:

- Alusaf Hillside Smelter (KEOPS-ISIS)
- Royal Swazi Sugar Corporation (KEOPS-ISIS)
- Delta corporation (KEOPS-ISIS)
- Scaw Metals (KEOPS-ISIS)
- Saldanha Steel (KEOPS-ISIS)

These manufacturing plants are considered to be large. The main reason for the lack of smaller manufacturers, making use of MES, is not necessarily the cost of the systems. It does, however, support the statement that current MES are only affordable to larger manufacturers. In South Africa the growth of the manufacturing industry sector is to a great extent in the hands of small and medium sized manufacturers. Thus, it would be to the benefit of the country if MES could be made affordable to these manufacturers. Together with the physical software, the training regarding the use of this product, as well as underlying concepts, need to be provided to these manufacturers. One of the suggestions by Willemse (1999) - regarding market positioning of the product DIAMES - is to develop this product into a product accessible to medium and small manufacturers.

7. 3. THE USE OF MES WITHIN COMPANIES

"By moving execution capabilities out to the operators, manufacturers can create a pull environment on the shop floor, creating a process that contains nothing but value-added activities. Support activities would be done in parallel to manufacturing activities so they do not constrain the creation of value. Activities that do not create value for the manufacturer or its customers are eliminated." These key players are subsequently described (MESA International, 1996:www.MESA.org/html/main.cgi?sub=32)

7. 3.1. SHOP FLOOR OPERATORS

Execution-driven applications provide operators with real-time dispatch lists that show work orders in priority sequence. This job sequence information is continuously adjusted as actual manufacturing operations take place – or as priorities change. As information of the work order completion is provided by the operator, availability for the next operation is shown.

Shop floor operators have access to detailed work order status screens that provide them with support requirements for each job, including engineering drawings, programs, tooling, materials and special instructions. Actual work order status is communicated in real-time to production control personnel and to the scheduling system. Information on jobs in queue, set-up, run and problem states can be entered and communicated continuously. Real-time communication of problems to production scheduling and support functions expedites problem resolution.

7. 3.2. PRODUCTION SCHEDULERS

Scheduling personnel are able to easily change order priority, routings and schedules (due to alternate routings, engineering changes, quantity changes, rework and cancellations) and communicate these changes to the shop floor instantaneously. Schedulers have the capabilities to override the schedule and change an order's place in the job sequence, or group similar jobs to save set-up time. Work orders and routings can be downloaded from MRP systems or entered manually. Support function resource requirements, such as tools, documents and fixtures, can be easily imported into the system for communication directly to work center operators. Job status information facilitates their working with customer service; managers and supervisors to prioritize schedule changes. "What if" simulation capability allows them to test alternative scenarios prior to finalization of changes.

7. 3.3. SUPPORT GROUPS : STOCK ROOM, TOOL ROOM, MAINTENANCE ENGINEERING

The manufacturing management system provides work order priority, location and requirements on a real-time basis to all support functions in order to maximize manufacturing throughput. The system supplies each support function with detailed plans of what to do and when to do it, on a minute-by-minute basis. Real-time alarms identify problem situations occurring on the shop floor, allowing support personnel to respond quickly. Support groups can input in advance when they are unable to meet scheduled requirements, providing information that automatically revises schedules.

7. 3.4. CUSTOMER SERVICE AND SUPERVISORS

The execution system provides customer service, supervisory and other personnel the work order status for any functional area within the plant. The system offers them multiple views of production status information including historic, current and projected data. Customer service personnel can use production information to make sure new customer commitments can be met without impacting previous promise dates.

Supervisors can use the information to make decisions on whether to employ alternate machines or work centers to relieve shop floor bottlenecks, and to identify problem order and material shortages.

7. 3.5. MANAGERS & MANUFACTURING ENGINEERING

The system provides detailed data on individual work centers and tools for identification of performance improvement areas. Complete backlog analysis and trending, input/output control and throughput calculations provide the information needed to identify production bottlenecks. It also enables detailed analysis of queue, set-up, run and problem times so that the best opportunities for cycle time reductions can be pinpointed.

7. 4. MES AS TOOL FOR THE INDUSTRIAL ENGINEER

"Compared with MRPII/ERP and SCADA products, MES still are not well understood primarily because manufacturing was long viewed as a necessary evil rather than the core of the business. However, the current business climate is forcing corporations to focus on manufacturing practices in order to continuously improve and achieve new so-called stretch goals." (Forstedt:1998:www.consilium.com/Publications/ics.htm)

The Industrial Engineer coordinates continuous improvement. According to the Handbook for Industrial Engineering (1991:18), the manager of a continuous improvement program is someone who operates and supervise the program for continuing search for change and improvement in the organization. The use of MES in the continuous improvement process as well as the implementation of quality standards are discussed accordingly.

7. 4.1. CONTINUOUS IMPROVEMENT

"Continuous improvement seeks continual improvement of machinery, materials, labor utilization and production methods." (Chase, 1995:180)

(a) CONTINUOUS IMPROVEMENT THROUGH THE ELIMINATION OF WASTE

The so-called "Seven Wastes of Manufacturing" are often used to identify areas for continuous improvement. Schroer (1998:87) identified ways of overcoming each of these wastes through continuous improvement. These wastes - as well as possible causes identified by Schroer (1998:88) – are listed below:

(1) Overproduction
- Policy; Management decisions; Batch scheduling systems

(2) Waiting and searching
- Waiting for materials; Poor layout; Wrong tool; Unexpected problems

(3) Transportation
- Poor layout; Available storage area; Large lots

(4) Processing
- Improper fixtures/ tools; Insufficient standards;

(5) Motion
- Poor layout; Lost items; Poor work arrangement Misunderstanding Poor standards

(6) Defects
- Poor manufacturing methods; Damaged/ Lost goods; Poor training

MacDonald, (1998:www.consilium.com/Publications/roi.htm) explains how MES can contribute to the reduction in cost related to the elements of manufacturing. The information provided by Schroer (1998:86) and MacDonald is combined to illustrate the potential of continuous improvement through MES. (*Table 43* on the following page).

Table 43

The use of MES to reduce wastes and contributes to Continuous Improvement

Engineering data collection	Company wide planning	Intelligent dispatch	WIP tracking	Wastes of Manufacturing
Greatly improved control of production process through tight control of vital engineering and production data.	Greatly improved production planning through visibility into history and current backlog.		Ability to implement JIT procedures Reduce WIP buildup due to greatly enhanced control. Reduce the level of finished goods due to reduced need to build excess stock to cover or hide problems in manufacturing execution.	**(Over) production and Inventory**
Reduced machine downtime by invoking automatic preventive maintenance.		Improved equipment utilization and on-time delivery and increased overall plant throughput by real-time balancing of the production lines.	Reduction of WIP cycle time.	**Waiting and searching**
			Reduce WIP buildup due to greatly enhanced control.	**Trans-portation**
Reduce problems in engineering plans by assisting in analysis and troubleshooting. Statistical quality control. Improved performance to specification.	Better decision making on products, equipment, facilities, labour loading, shutdowns and use of subcontractors.	Achieving better control of product release to the shop, minimizing excessive setups and reducing operation cycle times and their variability.		**(Over) Processing**
				Motion
Reduced scrap and rework through early identification of negative trends. Quicker resolution of quality control problems.			Reduce scrap and rework due to yield improvement and fewer operator errors Improved worker productivity through tight control of work instructions, materials and processes.	**Defects**

Table 43 (Continued)

The use of MES to reduce wastes and contributes to Continuous Improvement

	Wastes of Manufacturing					
	(Over) production and Inventory	**Waiting and searching**	**Trans-portation**	**(Over) Processing**	**Motion**	**Defects**
Resource tracking		Reduced equipment/labour downtime.	Improved equipment utilization and control through ability to analyze equipment performance.	Improved labour productivity.		
Cost accounting				Faster and more effective decision making through greater visibility.		Reduced waste through assistance in identifying and removing.

(b) MES FUNCTION MATRIX RELATED TO THE DEMING CYCLE

From *Table 43* it is clear that except for the waste of motion, MES can definitely contribute towards the continual elimination of these wastes - thus accomplishing improvement. To support the use of MES as continuous improvement tool, the Deming cycle for continuous improvement is related to the MES Function Matrix (developed in Chapter 4).

The Deming cycle is a method that can aid management in stabilizing a process and pursuing continuous, never-ending process improvements and conveys the sequential and continuous nature of the continuous improvement process (Gitlow, 1995:107). The MES Function Matrix (developed in Chapter 4) is brought into relation with this cycle in *Table 44* on the next page.

Table 44

The Deming cycle for continuous improvement related to the MES Function Matrix

Deming Cycle (Gitlow, 1995,107-109)	MES Function Matrix (Chapter 4)
STEP 1 : PLAN	**ELEMENT OF EXECUTION : Coordinate/ Guide**
The collection of data about process variables is critical when determining a plan of action for what must be accomplished to decrease the difference between customer needs and process performance. A plan must be developed to determine the effects(s) of manipulation process variables upon the difference between process performance and customer needs.	Based on data received from controls. This is used to update the schedules and other attributes in such a way that the difference between what is planned and process performance can be decreased. The effects of these alternation also need to be evaluated
STEP 2 : DO	**ELEMENT OF EXECUTION : Initiate/ Ready**
The organization must educate everyone involved with the planned experiment so that they understand the relationship between the manipulated variables and the proposed decrease in difference. Secondly everyone must be trained so that they understand how their jobs will be influenced.	People and equipment are informed on the changes in plans and how it effects them.
STEP 3 : STUDY	**ELEMENT OF EXECUTION : Analyze**
The result of the "DO" phase is answered to determine if the manipulated process variables behave according to plan and if the downstream effect creates any problems or improvements.	"The traditional data analysis tasks focus on determining the root cause of production problems. Most MES reporting is geared to these needs, but often at too low a level of detail. AMR This analysis function represents a key method for plants to continue improvement. All of these functions are handled today informally or with personal spreadsheets, but we believe they need to be incorporated into the formal plant architecture. However, a clear distinction between generating the information and using it to make decisions is required" *(Swanton,1998:www.amrresearch.com/repac/)*
STEP 4 : ACT	**ELEMENT OF EXECUTION : REACT**

(c) TOTAL QUALITY MANAGEMENT (ISO9000)

Continuous improvement is part of the Total Quality Management philosophy. To elaborate on the use of MES as tool to accomplish continuous improvement and total quality management, the way in which MES can be used to establish quality standards, is discussed.

ISO9000 is a series of standards that outlines the requirements for a quality management system. The need to comply with ISO9000 (and other) standards is regarded as an important reason why companies choose to implement a Manufacturing Execution System. Unlike most standards, ISO9000 does not provide product certification, but it specifies the minimum system requirements to ensure that good manufacturing practices are followed. "After implementation a Manufacturing Execution Systems can be used to ensure that manufacturing is performed in conjunction with the policies and procedures set out by ISO900O, recording where exceptions occur and acting as a key source of data for demonstrating conformance during audits."

Golovin (1998:www.consilium.com/Publications/iso.htm) evaluated the abilities of MES against the 20 points of the ISO 9000 standards. The MES Function Matrix is used as structure to discuss this analysis (*Table 45* on the next page).

7. 5. CONCLUSION

MES has the potential to enhance manufacturing efficiency and effectiveness in any manufacturing industry sector. The approaches towards the implementation and use of MES may vary, however. The Industrial Engineer can contribute to the use of MES in any industry sector and MES can be used as tool to accomplish continuous improvement.

Table 45

The establishment of ISO9000 standards through MES

	GUIDE/ COORDINATE	INITIATE/ READY	ANALYZE	REACT
MATERIAL/ PARTS/ PRODUCT	ISO 9000 requires that data captured according to the procedures defined in the Inspection and Testing clause be associated with the product parts and be accessible.	In requiring product identification and tractability, ISO 9000 expects an auditor to be able to identify the current status and past history of a product part within the manufacturing process.	ISO 9000 requires that some form of statistical charting be used during the manufacturing process, in accordance with defined procedures.	ISO 9000 requires that nonconforming product - product that does not meet the specification - is handled according to predefined procedures.
LABOUR/ PERSONNEL	ISO 9000 specifies those training materials and classes are developed that all personnel are trained using these, and that these personnel should then be certified to perform tasks that require that level of training.			
EQUIPMENT/ TOOLS/ FIXTURE	ISO 9000 demands that the equipment used for performing inspections and testing are fully calibrated in accordance with defined procedures.			
WORK INSTRUCTIONS/ SPECIFICATIONS/ PROCEDURES	ISO 9000 requires control not over the creation of documentation, but over its approval, release, and use on the shop floor. ISO 9000 demands that within a processing operation, procedures be defined and followed for controlling the manufacturing process.	ISO 9000 specifies that training materials and classes be developed, that all personnel be trained using these, and that these personnel should then be certified to perform tasks that require that level of training.	ISO 9000 requires that internal quality audits be supported within the quality system.	ISO 9000 demands that when errors during manufacturing, procedures be defined and followed to correct those errors.
WORK ORDERS	According to ISO 9000, when material is received from a customer for inclusion in final product, the product must be separately identifiable and procedures for receiving and manufacturing this material must be followed.			

8. MES RESEARCHERS

"Now that the MES model and functions has been redefined, the next step is to continue educating manufacturers and vendors. Educating needs to be done so
(1) people recognize what these systems are,
(2) what capabilities they have and
(3) what benefits users can achieve." (Fulcher,1997:26)

The role of the Industrial Engineer with regard to the development, integration and use of MES was explained in the previous chapters. The role of the Department of Industrial and Systems Engineering (University of Pretoria) with regard to MES research and education is investigated in this chapter. Information on existing MES research initiatives is evaluated and suggestions is made concerning a local research initiative.

CONTENTS OF THIS CHAPTER

8. 1. CURRENT MES RESEARCH INITIATIVES

A number of research initiatives, which participates in some way or another in MES research, was identified. With the exception of the South African Production and Inventory Control Society (SAPICS) all of these initiatives are international or from foreign countries.

The names of these initiatives are listed below:

- Advanced Manufacturing Research (AMR Research)
- Manufacturing Execution Systems Association (MESA)
- National Institute of Standards and Technology (NIST)
- American Production and Inventory Control Society (APIÇS)
- Automation Research Corporation (ARC)
- National Center for Manufacturing Sciences (NCMS)
- South African Production and Inventory Control Society (SAPICS)
- Object Management Group (OMG)
- Semiconductor Manufacturing Technology (SEMATECH)

The activities and nature of these research initiatives are discussed within the following pages. A discussion, regarding a proposed MES research initiative, is done thereafter.

8. 1.1. ADVANCED MANUFACTURING RESEARCH (AMR Research)

Main Business and Research Fields	AMR Research is an industry and market analysis firm specializing in enterprise applications and related trends and technologies. Tracking more than 400 leading software and service providers, AMR Research helps Global 1000 companies evaluate, select, and manage new systems for every part of the enterprise, including logistics and supply-chain management, Enterprise Resource Planning (ERP), Manufacturing Execution Systems (MES), and electronic/Internet commerce. Through a working partnership, AMR Research helps companies navigate through each phase of the IT life cycle: Research fields includes : **MANUFACTURING STRATEGIES** Analyst from Manufacturing Strategies specialize in specific vertical industries and have a thorough knowledge of all elements of the plant architecture, including controls and automation, Manufacturing Executives Systems (MES), and plant level ERP. This

	service approach also balances the needs of the plants with their role in the broader enterprise and supply chain. **SUPPLY CHAIN STRATEGIES** This service provides research on Supply Chain management, including demand/development planning systems, warehouse automation, customer asset management, electronic commerce, related technology, and industry trends. **SAP ADVISORY PROGRAM** This product serves the user who has already selected SAP as its ERP vendor. - *Market Analysis and Review Service* Software companies use this service to drive business planning, and aid in developing specific sales and product plans. Industrial companies use this information to provide a detailed overview of vendor performance. Investors and the financial community use this service to provide a concise and authoritative overview of dynamic growth markets. - *Enabling Technology Strategies* Provides research and analysis on the key enabling technologies for manufacturing and supply chain applications.
MES Specific Research	The term MES was coined and the Three-Layer-Model is developed by AMR Research. The latest MES related output from this institute is the development of the REPAC model.
Physical Location	Boston (USA)
Non-Profit ?	Although not explicitly mentioned, the assumption can be made that AMR Research is a profit-driven company.
Date founded	1986
Research Studies and publications	AMR Research's Reports and Alerts are available to clients via hard copy, electronic delivery, and AMR Research's web site. Through a key word or topic search, clients can quickly find the research they require in real-time. Non-clients can get access to executive summaries of these reports. The Executive View is a monthly letter that analyzes the business impact of enterprise applications for senior executives.
Web site	The address of the web site is http://www.amrresearch.com. Non-clients have limited access.
Analysts designated to company	Each client is assigned one client research manager who serves as a central point for all of our services. This approach streamlines the inquiry process for the clients and speeds response time to research needs.
Conferences Trade Shows, Meetings and Roundtables	AMR Research's semi-annual Executive Conferences are where hundreds of IT executives and solution providers gather to hear real-world case studies from leading industry users and market insight from AMR Research analysts. These conferences are the premier gathering of top-level decision-makers. Meetings are organized for clients

8. 1.2. MANUFACTURING EXECUTION SYSTEMS ASSOCIATION (MESA)

Main Business and Research Fields	The leading manufacturing execution system (MES) software vendors formed MESA. 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 the related products and services required by the modern manufacturing enterprise. MESA membership is corporate. Each member company is represented by one "delegate," and can have any number of "alternate" representatives as it wishes.
Physical Location	USA
Non-Profit ?	Non-Profit
Date founded	1992
Research Studies and publications	**Educational Materials & White Papers** MESA International publishes educational materials and offers them free of charge to manufacturing executives around the world. Included in the package are a member directory, which lists all members, the markets they serve, and complete write-ups on the products and services members offer. Complete information on all individuals who request MES information are forwarded to all members every month. **MESA International's MES Magazine Supplements** The Performance, Manufacturing Systems, Managing Automation and Industry Week are some of the major publications in which MES Supplements have appeared. Featuring articles on the benefits of MES, successful installations, and vendor listings.
Web site	http://www.MESA.org
Conferences Trade Shows, Meetings and Roundtables	**MES Roundtables - organized and sponsored by MESA International.** These Roundtables include a conference program which features users as well as vendors and vendor product demonstrations. **Trade Show Participation - MES Pavilions.** To gain greater attention for MES, MESA International members exhibit together in trade show pavilions at the leading manufacturing shows. Organizers of these shows typically offer extra promotion for MES Pavilions. Members participate in the pavilions and gain special promotion as exhibitors.

8. 1.3. NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

Main Business and Research Fields	The National Institute of Standards and Technology was established "to assist industry in the development of technology needed to improve product quality, to modernize manufacturing processes, to ensure product reliability and to facilitate rapid commercialization of products based on new scientific discoveries." Main Research Areas in NIST Labouratories • Building and fire research • Chemical science and technology • Electronics and electrical engineering • Information technology • Manufacturing engineering • Materials science and engineering • Physics
MES Specific Research	The program on Technologies for the Integration of Manufacturing Applications (TIMA) particularly focuses on the integration of and Interoperability among MES. The TIMA program focuses on developing and validating technologies, methods and infrastructures that reduce dramatically the cost and time needed to integrate manufacturing execution systems into a manufacturing enterprise. The Framework Project will provide industry with tests and methods for analyzing and validating emerging manufacturing information standards and technologies. Work will be focused on information models for manufacturing, software application interface definitions, object-oriented class hierarchies, data access protocols, scheduling and control strategies, integration mechanisms, and communication architectures.
Physical Location	Throughout the United States of America
Non-Profit ?	Not-for-profit
Research Studies and publications	Information on projects described above is distributed through: • NIST Technical Publications Database, NIST Virtual Library , NIST Journal of Research, General Publications • Fact Sheets; Press Releases and Newsletters; Guide to NIST; Selected General Publications; Strategic Planning and Economic Analyzes Program Specific Links • Publications Pages from NIST Programs; FIPS - Federal Information; Processing Standards; Fire Research Information; Service Standards Publications
Web site	http://www.nist.gov
Conferences, Trade Shows, Meetings and Roundtables	NIST Conferences and Workshops is held regularly.

8. 1.4. AMERICAN PRODUCTION AND INVENTORY CONTROL SOCIETY (APICS)

Main Business and Research Fields	APICS is recognized globally as • The source of knowledge and expertise for manufacturing and service industries across the entire supply chain in such areas as materials management, information services, purchasing and quality. • The leading provider of high-quality, cutting-edge educational programs that advance organizational success in a changing, competitive marketplace a successful developer of two internationally recognized certification programs, Certified in Production and Inventory Management (CPIM) and Certified in Integrated Resource Management (CIRM) a distribution center for hundreds of business management publications and Educational materials a source of solutions, support, and networking local chapters, workshops, symposia, and the annual APICS International Conference and Exposition.
MES Specific	No specific MES research/education project exists. MES are, however one of the concerns of APICS. The only published book on MES thus far was an initiative of APICS. (McClellan:1997)
Physical Location	United States of America
Non-Profit	Not-for-profit
Date founded	1957
Research Studies and publications	APICS membership means valuable direct benefits. Each year, APICS members receive free publications valued at several times the cost of Society and chapter dues. • APICS--The Performance Advantage • Production & Inventory Management Journal • APICS Buyer's Guide • APICS Dictionary • APICS Bibliography • International Conference Proceedings APICS Business Outlook Index
Web site	http://www.apics.org
Conferences and Trade Shows, Meetings and Roundtables.	Annual conferences are held by APICS. Various APICS chapters exist worldwide. Chapter seminars is frequently held.
Educational ProgramMES	APICS is marketing itself as the educational society for resource management Education is established through: • In-House Training and • Applied Manufacturing Education (AMES) • Chapter Certification Review Course Schedule

8. 1.5. AUTOMATION RESEARCH CORPORATION (ARC)

Main Business and Research Fields	Providing advice and market intelligence to manufacturing companies and their automation suppliers
MES Specific	Although no specific MES program or project is launched, the ARC is concerned with MES.
Physical Location	International
Non-Profit	Although not explicitly mentioned, the assumption can be made that AMR Research is a profit-driven company.
Date founded	1986
Research Studies and publications	ARC is the premier provider of market data, forecasts, and reports for a wide range of enterprise application solutions and automation products and systems. ARC's studies and reports are recognized worldwide for their accuracy and detailed analysis. This accuracy and analysis is a direct result of our experienced staff, who on average each bring over fifteen years of direct industry experience to ARC. In addition to our experienced staff, ARC maintains an in-depth database on the enterprise and automation marketplace. It contains the latest information on technologies, standards, and the products and capabilities of hundreds of companies. With offices worldwide, we provide the best perspective on the global market with detailed analysis of regional markets as well. Our extensive global network of contacts is the reason ARC Market Studies are considered the most reliable source of market intelligence available.
Web site	http://www.arc.com
Analysts designated to company	Upon purchasing a report from ARC, analyst directly responsible for this report may be contacted to discuss our research findings, analysis, and conclusions. ARC's Advisory Services deliver a comprehensive portfolio of knowledge-based products and services that will keep you ahead of the latest developments in enterprise applications and industrial automation.
News Letter	Only for Clients

8. 1.6. NATIONAL CENTER FOR MANUFACTURING SCIENCES (NCMS)

Main Business and Research Fields	The National Center for Manufacturing Sciences provides the legal and logistical framework under which member companies and other partners can participate in pre-competitive manufacturing R&D. Through the NCMS collabourative process — tested on hundreds of programs over a decade — companies can team on research projects that would be too large, costly or time-consuming for them to accomplish on their own. They can also tap into a wide array of services and support to help them meet their individual Program objectives. There are currently no major research collections outside NCMS devoted to all aspects of manufacturing. The Manufacturing Information Resource Center (MIRC) has developed a library comprehensive in all areas of manufacturing research. Particular strengths of the collection include resources on quality, manufacturing processes, and environmental issues. Among the major research topics covered are: • Business and marketing – information on markets, products, companies, and technologies, economic data and financial news. • Computers - user interfaces, connectivity issues and software information. • Defense - contracts and awards, research in progress, and aerospace markets and tchnologies. • Law and government - Commerce Business Daily, the Federal Register, legislation and Congressional reports, and Capitol Hill news. • Materials science - engineered materials, both conventional and unconventional, and the technologies and processes involved. • Patents, trademarks, and standards - for both the United States and abroad. • Science and technology - manufacturing engineering, electronics packaging, and telecommunications.
Physical Location	North America
Non-Profit	Non-profit
Web site	http://www.ncms.org/
Conferences and Trade Shows, Meetings and Roundtables	NCMS Technical Conferences provide opportunities for companies to partner on pre-competitive manufacturing research projects, network with firms representing a diverse array of industries, see the highly successful NCMS collabourative process model at work, and learn about current and emerging trends in usiness and industry. The NCMS Annual Technical Conference, held each spring, is the consortium's major public forum for highlighting past, current and anticipated collabourative programs. As an adjunct to this event, NCMS hosts a Fall Workshop Series where companies can hear about, and take advantage of, emerging project offerings.

8. 1.7. SAPICS (EDUCATIONAL SOCIETY FOR SUPPLY CHAIN MANAGEMENT)

Main Business and Research Fields	The mission of SAPICS is to be the leading provider of knowledge and continuous improvement in production, Operations and supply chain management in Southern Africa.
MES Specific	The MES Special Interest Group of SAPICS has the following mission: To improve global competitiveness in the Southern African manufacturing industry through MES.
Physical Location	South Africa (Kempton Park)
Non-Profit ?	Not-for-profit
Date founded	1996
Web site	http://www.cy.co.za/sta/sapics
Conferences and Trade Shows	The following services is provided by SAPICS • Workshops and Two Day Seminars • Annual Conferences • SAPICS Newsletter
Roundtables and meeting	Open
News Letter	The newsletter send out to members, is also published on the World Wide Web.
Educational Program	MANUFACTURING - PRODUCTION AND INVENTORY MANAGEMENT • Basic Principles of Production and Inventory Management Course • Principles of Production and Inventory Management Course CERTIFICATION in PRODUCTION and INVENTORY MANAGEMENT (CPIM) • CPIM Basics of Supply Chain Management • Inventory Management • Just-in-Time • Material and Capacity Requirements Planning • Production Activity Control • Master Planning • Systems & Technologies CERTIFICATION in INTEGRATED RESOURCE MANAGEMENT (CIRM) REVIEW COURSES - CIRM • Enterprise Concepts and Fundamentals • Identifying and Creating Demand • Designing Products and Processes • Delivering Products and Services • Integrated Enterprise Management MATERIALS MANAGEMENT • Stores & Stock Control Course • Effective Supply, Warehousing & Distribution Course • Fundamentals of Materials Management Course • Executive Education SUPPLY CHAIN MANAGEMENT - EXECUTIVE OVERVIEW WORKSHOP

8. 1.8. OBJECT MANAGEMENT GROUP (OMG)

Main Business and Research Fields	The OMG was formed to create a component-based software marketplace by hastening the introduction of standardized object software. The organization's charter includes the establishment of industry guidelines and detailed object management specifications to provide a common framework for application development.
MES Specific Research	The MES/MC workgroup is part of the manufacturing special interest group. This working group is concerned with the definition of interfaces to enable flexible integration and interoperation of computerized systems which support manufacturing production (as contrasted with the focus of other MfgDTF working groups on design, engineering and planning). We expect these interfaces to be applicable to a wide range of industries, which perform discrete, batch and/or continuous processing.
Physical Location	The OMG is headquartered in Framingham, MA, USA and has international marketing offices in Australia, Bahrain, Brazil, Germany, India, Italy, Japan and the UK, along with a government representative in Washington, D.C.
Non-Profit ?	Not-for-profit
Date founded	April 1989
Research Studies and publications	The Working Group issued a Request for Information (RFI) December, 1997 which invited input from individuals and organizations with insight or information in the any of the following areas: • Validating the group's 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 (e.g.: ERP, PDM, MC) • Validating selection of SIMA reference model for scoping RFPs • Appropriate standards for MES Based upon the assessment of these responses, the following MES roadmap items have been identified: Request for proposals 1: • Manage Resource and Track Product Resource Allocation and Status; Labour Mgmt; Maintenance Mgmt; Product Tracking and Genealogy (tracking perspective); Material Storage and Transport (material perspective) Request for proposals 2: • Manage Resource and Track Product (continued) Resource Allocation and Status; Operations / Detail Scheduling; Dispatching Production Units; Product Tracking and Genealogy; Material Storage and Transport Request for proposals 3: • MES follow-on Process Mgmt; Quality Mgmt; Performance Analysis; Health, Safety and Environment Management
Web site	Information can be accessed at http://www.omg.org by clients and non-clients
Conferences, Trade Shows, Meetings and Roundtables	OMG Technical Meetings are held every six to eight weeks at various locations worldwide. These conferences include the Object World at COMDEX/ Enterprise series of events worldwide, Software Development East & West, and a variety of industry specific events.

8. 1.9. SEMICONDUCTOR MANUFACTURING TECHNOLOGY (SEMATECH)

Main Business and Research Fields	SEMATECH is a technology development consortium of U.S. semiconductor manufacturers. Its development programs include: • Interconnect • Front end processes • Assembly and packaging • Design systems Manufacturing methods
MES Specific	The first MES's was developed for the semi-conductor industry. This industry still takes in many ways the lead with regard to MES technology and concepts. No specific MES program or project exists, but due to relationship between developments in the semi-conductor industry and MES, this institiute is significant.
Physical Location	Austin, Texas
Non-Profit ?	Not-for-profit
Date founded	1987; International SEMATECH is a wholly-owned subsidiary of SEMATECH that began operations in April 1998.
Web site	http://www.sematech.org
Conferences and Trade Shows	An annual Advanced Equipment Control / Advanced Process Control (AEC/APC) conference is held by SEMATECH.

8. 2. PROPOSED ENVIRONMENT FOR RESEARCH INITIATIVE

The acceptance of the term MES to describe a system, which enables manufacturing execution, is growing throughout manufacturing industries. Since one company (AMR Research) started to use and promote this term, thousands of companies started to use it. The majority of information on MES provided on the World Wide Web is presented by companies as part of their effort to promote MES products and services.

The situation often occurs in this promotion material - as well as academic documents - that the meaning of MES (Manufacturing Execution Systems) is written in brackets next to the accronymn, while in the same paragraph a term such as ERP (Enterprise Resource Planning) or JIT (Just-in-Time) occurs, without any explaination. The conclusion can be drawn that the term MES is commonly accepted, but to commonly understood by all users and potential users.

In the remainder of this chapter the feasibility of a new research initiative is discussed. It is proposed that this MES research initiative is hosted by *the Department of Industrial and Systems Engineering* at the *University of Pretoria* in *South Africa*. Each of these three (underlined) environment aspects will subsequently be discussed.

8. 2.1. MES RESEARCH INITIATIVES *IN SOUTH AFRICA*

Since many research institutes which focuses on MES already exist, the question may arise if a research center within South Africa is needed. The following arguments are offered in favor of a South African based research center:

- Due to South Africa's geographical isolation, it is not feasible for smaller manufacturing companies to attend international conferences, meetings and presentations on a regular basis.
- Access to business analysts and research by institutes such as AMR Research is not within reach of most South African manufacturers due to the unfavorable exchange rate. Only one company within South Africa is currently a full client of AMR Research.

- Unique circumstances exist within South Africa, regarding technological infrastructure, as well as resource and labour utilization.
- All of these institutes were founded within the past 15 years. The youth of all of these research institutes underlines the growing need for research in this field. The risk of duplication of research by more than one institute is low.

8. 2.2. RESEARCH INITIATIVES AT THE *UNIVERSITY OF PRETORIA*

The mission of the University of Pretoria is to:

- create knowledge through research
- distribute knowledge through education and to
- apply the knowledge through service to the community and industries

Through the hosting of a research initiative all of these objectives are met:

- Various RESEARCH projects could be undertaken. Within one research initiative these projects could complement each other.
- Users, developers, integrators and potential users, developers and integrators are EDUCATED regarding the benefits, abilities, disabilities and trends of Manufacturing Execution Systems and related topics.
- By providing information regarding MES and by focussing projects on the solving of specific problems, the industry (COMMUNITY) is SERVED.

8. 2.3. RESEARCH INITIATIVE HOSTED BY THE *DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING*

"The Department of Industrial and Systems Engineering is at present the largest Industrial Engineering department in South Africa and plays a leading role in the education, development and promotion of the profession. The educational philosophy is aimed at emphasizing understanding and insight and to develop a scientific thought process rather than the rote learning of facts. In this way our Industrial Engineers are able to handle future changes in the technology and economy well into the next century. The emphasis is on a system approach to problem identification and solution while an

entrepreneurial and client orientation is stressed. An effort is made to provide graduates with a balanced education, thus maximizing their market value to as many companies in South Africa as possible." (Department of Industrial and Systems Engineering: http://ie.up.ac.za)

The infrastructure for teaching and research on field related to Industrial Engineering already exists at the department. A MES research initiative will contribute towards the mission of the department, namely the training of world class Industrial Engineers.

8. 3. SCOPE OF THE PROPOSED RESEARCH INITIATIVE

8. 3.1. RESEARCH FIELDS

Of all of the institutes discussed in section 8.1, MESA International is the only one of these institutes, which focusses exclusively on MES. Although the proposed initiative will be known as an MES research initiative, related research such as supply chain management (SCM), statistical process control (SPC) and labouratory information systems (LIMS) should not be excluded, as long as it is complementary to the research field of MES. The focus should, however, remain on MES.

8. 3.2. FUNDING

The majority of initiatives are marketed as non-profit organizations. Funds need, however, to be generated from some source or another to support activities. Three types of funding are identified from existing initiatives:

- Industry Sponsorships
- Fees for services
- Government

Funding possibilities for the proposed research institute are explored accordingly in *Table 45*. Two or even all three of these types may be the source of funds of some of the institutes (which were discussed in the first part of this chapter). Only the most prominent examples are given.

Table 45

Types of funding available for research initiative

Type of funding	Examples from current industries	Possibilities with regard to the proposed research initiatives
INDUSTRY SPONSOR-SHIPS	The Manufacturing Execution Systems Association (MESA International) and Semiconductor Manufacturing Technology (SEMATECH) is supported to a great extent by companies benefiting by the research.	This type of funding will be easier to exploit once the research initiative is established and some credibility is obtained.
SERVICES	Funds is generated through services rendered by AMR Research, Automation Research Council (AMR), APICS and the National Center for Manufacturing Sciences (NCMS).	• Broader research results can by made available at a certain fee. • Through contract research companies can fund a specific project. • Business analysis and consultation can be provided at specific fees.
GOVERN-MENT	Government funding is provided to the National Institute of Standards and Technologies (NIST) as well as the Object Management Group.	• In South Africa government subsidies is allocated with respect to research outputs, in the form of articles within accredited journals. • Research councils distribute government funds indirectly through awards. South African funding oppertunities through the National Research Foundation (NRF) is subsequently discussed in more detail.

(a) GOVERNMENT FUNDING THROUGH THE NRF

The objective of the National Research Foundation (NRF,1999: www.nrf.ac.za) is to support and promote research through funding, human resource development and the provision of the necessary research facilities, in order to facilitate the creation of knowledge, innovation and development in all field of science and technology.

(b) JOINT FUNDING BY GOVERNMENT AND INDUSTRY THROUGH THRIP

The Technology and Human Resources for Industry Programme (THRIP) is a joint venture between industry, research and educational institutions and government, that was established in 1991. The programme supports the development of technology and appropriately skilled people for industry to improve South Africa's global competitiveness. THRIP performs this task by providing resources and mechanisms in support of collabourative research in the areas of science, engineering and technology. (NRF,1999: http://www.nrf.ac.za/programmeareas/thrip).

THRIP will consider contributing R1 for every R2 invested by the private sector in SET research projects of which the project leader and project are based at a higher educational institution, according to the following criteria:

- The research must be of a high standard.
- A project must have clearly defined technology outputs.
- At least one higher education institution and one industrial partner should be involved.
- At least one student must be involved in and trained through the research.
- Only financial contributions are considered for THRIP matching support and commitment from the industrial partner/s must be clearly communicated.
- Only contributions from South African or South African-based industry partner/s are considered for matching support.
- The industrial partner/s must give a clear indication that the project will directly benefit the specific companies.

- Arrangement for the ownership and exploitation of intellectual property arising from a project must be agreed upon between the academic and industrial partners, prior to commencement of the project.

The project, which is used for purposes of the case study in Chapter 5, is funded through this scheme.

8. 3.3. COORPORATION WITH INTERNATIONAL INSTITUTES

The Manufacturing Execution Systems Association (MESA International), has announced in 1996 a partnership with its counterpart MESA of Europe, headquartered in Cheshire, England, to expand the awareness and implementation of manufacturing execution systems (MES) and related products and services.
(Hakason,1996:www.MESA.org/html/main.cgi?sub=15).
Similar partnerships can be pursued to explore possibilities in Southern Africa.

Contact was established with the AMR Research. Since negotiations are still in progress, this is not discussed in this dissertation.

8. 3.4. SERVICES PROVIDED

Based on services provided by current research institutes, the following services are identified as services that can be provided by the research initiative:

(a) RESEARCH STUDIES

Since the proposed research center is initiated from the University of Pretoria, it would be ideal to use the formal research structures of the university.
Depending of the scope of the project, research can be conducted through:

- an Honors degree project (approximately 125 man hours),
- a masters degree project (approximately 250 man hours),

- a masters degree dissertation (approximately 1000 man hours) or a
- PhD doctorate.

Research teams consisting of a combination of people enrolled for various degrees can attempt larger projects. Personnel from the University responsible for mentoring and research could act as project leaders.

Research studies on market or technology issues are conducted and presented through research documents, by almost all of the institutes. Depending on the specific research institute and type of study, these studies are either

- made (partially) available to anyone without any fee;
- made (partially) available to anyone against a specific fee or
- made available to members/clients only.

The guideline of the University of Pretoria with regard to intellectual property rights will have an influence on the mode by which the research outputs is sold. By distributing outputs from these projects through articles, the mission of the University of Pretoria is accomplished and the initiative is promoted.

(b) EDUCATION

The aim of MESA (Manufacturing Execution Systems Association) International is to educate the manufacturing society. This is done through the distribution of white papers as well as roundtable meetings. APICS - which calls itself the educational society of Resource Management - is providing international courses in Production and Inventory Management (CPIM) and Integrated Resource Management (CIRM). APICS, MES SIG and AMR hold conferences on a regular basis.

Educational courses on MES can be made available through the structures of the University of Pretoria on the following levels:

- Post graduate courses
- Short certificate courses

- A subject as part of a structured program

These courses will be directed either at

- Industrial Engineers in need of knowledge and skills regarding enterprise integration through MES, or at
- Information managers and technologists, requiring insight on manufacturing management.

(c) CONFERENCES AND MEETINGS

Representatives from this research initiative will take part in South African conferences related to MES. The most significant of these would be the

- annual conference held by SAPICS and
- the conference of the Southern African Institute for Industrial Engineering.

Until a specific need for a conference is identified, this research initiative will not embark on the organizing of conferences. Meetings should, however, be organized between users, developers and integrators of MES. The purpose of these meetings should be to

- expand the MES network,
- share information on the latest technologies and concept and
- identify research projects.

(d) ACCESS TO INFORMATION THROUGH THE WORLD WIDE WEB

Each of the institutes investigated are making use of the internet through the hosting a web site. MES related information (which is not necessarily the product of a formal research study) is accessible through the World Wide Web. Keeping in mind the high degree of information technology related to MES research, the assumption can be made that very few - if any - institute, will not utilize internet information technology. The establishment of a web site as service by this research initiative is taken further for purposes of this dissertation.

8. 4. THE ESTABLISHMENT OF A VIRTUAL RESEARCH FRAMEWORK

This virtual research framework consists of a

- web site (distributing information from one source) and a
- list server (a multi-source information forum).

8. 4.1. POTENTIAL USERS OF THIS SERVICE

Although it is not possible to derive specific numbers regarding users and publishers, it is clear that the World Wide Web is a popular communication forum for manufacturers and industrialists. It is also common knowledge that the use of the WWW is growing exponentially

The South African Internet search engines, Ananzi (www.ananzi.co.za) and Aardvark (www.aardvark.co.za) have both directories for manufacturing and engineering. Ananzi-TecNet (www.tecnet.co.za) is promoted as the exclusive engineering, industry, mining and manufacturing directory.
The focus of this initiative is om

- South African Industries and
- foreign companies with an interest in MES are also potential users of this web site.

This web site can also be used as communication forum between project partners.

8. 4.2. SPECIFICATIONS

The aim of the web site is to provide a forum from which the following MES information can be shared:

- History of MES and future trends.
- Theory on business models and functions.
- New developments and products.
- Links to MES related web sites.
- South African specific
  - Implementation projects
  - integrators and service providers (integrators, consultants etc.)
  - events.
- Past, current and proposed research projects of this research initiative.

The suggestions of Mara (1995:199,200) on how to establish a web presence is followed as explained in *Table 46* on the next page.
Space is available on the Internet server of the Department of Industrial and Systems Engineering. A unique account is dedicated to the MES web site at the following address:
http://maui.ee.up.ac.za/~mes

Table 46
The establishment of a web presence (Mara:1991:200)

Register at search engines	This web site is registered at the following search engines: South African • Aardvark (science:engineering / business:manufacturing and packaging) • Web-chart (science and engineering : industrial engineering) • Zebra • Webcrawler (businees and commerce:manufacturing) International • Google • Excite • Euroseek • Infoseek
Trade URL-postings with related servers	It was decided not to use this option, while the web site is still under construction.
Advertise through the appropriate newsgroup	Messages are send periodically to the following newsgroups to advertise the web site: • alt.manufacturing.misc • clari.biz.industry.manufacturing.releases • git.manufacturing.prc • sci.engt.manufacturing • za.misc • za.edu.comp
Advertise through non-internet media	The address of this web site is added to all documentation on projects of this initiative.

8. 4.3. LIST SERVER

Mailing lists enable users to broadcast e-mail to groups of other e-mail users who share a common interest. These lists serve as forums for questions and answers, announcements, discussions and often spirited arguments (Rosenfeld,1995:24). A List server is an e-mail distribution list. When an e-mail message is sent to a list server, the message is distributed to all the e-mail addresses of people subscribed to the specific list server.

Users may subscribe to individual list servers via electronic mail, in which case the articles will be forwarded to the recipient via electronic mail. Users subscribing to individual list servers, may request the information in various formats, e.g. each article as a separate electronic mail message or all articles for a specific day concatenated into a single message. A specific list server covers only one topic of interest, albeit different categories of the specific topic (University of Pretoria, 1998, http://www.up.ac.za).

An MES list server is created (to serve as virtual communication forum) for developers, integrators, users and researchers with the focus on South African industries. This server is marketed through the MES web site. Users can subscribe to this list server by sending an e-mail - without a subject - to mes@kendy.up.ac.za. The following should be written in the body of the e-mail:
Subscribe mes

8. 5. CONCLUSION

Based on the evaluation of a number of institutes, currently facilitation MES research, the following mission statement is compiled for a proposed MES research initiative at the University of Pretoria:

The VISION of the Research Initiative for MES is to enable and enhance the creation and transfer of knowledge regarding MES.

The following **GOALS** and **OBJECTIVES** are set to accomplish this vision:

Provide the infrastructure to initiate and coordinate research projects for the benefit of integrators, developers and users of MES.

- Identify research projects for the benefit of MES integrators, users and developers and facilitate the accomplishment of these projects.
- Select and supervise postgraduate and final year undergraduate students to undertake research projects for the benefit of MES integrators, developers and users.
- Generate funds to enable the accomplishment of research projects through industry sponsorship, government funding and official scholarships and bursaries.

Obtain industry credibility and maintain a network of parties concerned with Manufacturing Execution Systems

- Establish and maintain a web site serve as information archive and communication forum.
- Publish articles on projects completed by the initiative in national and international accredited journals.
- Present papers on projects and other MES related topics at national and international conferences.
- Facilitate conferences and business meetings.
- Establish links with similar international initiatives, such as AMR Research and Manufacturing Execution Systems Association (MESA) International.

9. CONCLUDING CHAPTER

The purpose of this dissertation is to determine and establish the role of Industrial Engineering in the development, implementation and use of MES.

On grounds of this purpose and within the scope of the study, the following propositions (and objectives) were set:

PROPOSITION 1: The concept of MES is valid (The concept of MES is used by and useful to manufacturing industry).	
Objectives	**Questions**
Integrate literature regarding MES business models and applications.	• What are Manufacturing Execution Systems? • Where does the concept of MES originate and in which direction is it evolving? • In which industry sectors (and to which extent and with how much success) are MES implemented?
Integrate opinions of South African role players throughout the literature study	• To which extent is the concept of MES accepted by South African manufacturing industry? • What is the view of South African developers, integrators and users.
Develop a new or combined model to be used as MES evaluation tool (if current models prove to be insufficient).	• Can current MES function models be used as tool to evaluate MES products and environments? • How should an appropriate evaluation model look?
Demonstrate the validity of the newly developed MES model - as well as the validity of MES as concept - through a case study (DIAMES).	• How does DIAMES perform as a Manufacturing Execution System and what developments are required? • Does an evaluation exercise - using the newly development MES model - prove that the product DIAMES can indeed be marketed as a manufacturing execution system? • In which other ways can the newly developed MES model be used to analyze MES products and environments?

PROPOSITION 2: The Industrial Engineer has a contribution to make, regarding MES	
Objectives	**Questions**
Relate MES to Industrial Engineering by integrating literature on Industrial Engineering.	• How are Industrial Engineers trained? • How are Industrial Engineers practically involved in industry? • Which roles are to be played in the MES arena and to which extent can the Industrial Engineer fulfill these roles?
Initiate a research program for MES at the Department of Industrial and Systems Engineering (University of Pretoria).	• What other MES research initiatives exists? • What should the focus and scope be of such an initiative?

9. 1. CONCLUSIONS ON GROUNDS ON OBJECTIVES

The purpose of this chapter is to conclude this research effort and to evaluate the extent to which these propositions are supported. This is done according to each of the 6 objectives:

9. 1.1. INTEGRATE LITERATURE REGARDING MES BUSINESS MODELS AND APPLICATIONS

The term Manufacturing Execution Systems (MES) was created by Advanced Manufacturing Research (AMR) in 1990. The term is used to describe the suite of software products, which enables the execution of manufacturing through the integration of the planning and control systems of an enterprise.

As manufacturing strategies evolves, so is the way by which manufacturing is planned and controlled. Manufacturers adopt integrated MES software packages for the same reason they turned to MRP II in the 1970s, namely to gain competitive advantage in world markets. MES products were first adopted in industries with high value products, complex or unstable processing, or heavy governmental regulations. Included in this group are semiconductor manufacturers, prime contracts in the aerospace and defense industries and makers of pharmaceuticals. MES packages are gaining wider acceptance as more and more industries are faced with customers demanding better delivery performance and higher levels of quality at lower cost.

The concept of MES is well established and is integrated inextricably within planning and control systems. However, developers of planning systems are continuously adding MES functions to their products, as are developers of control systems. It can thus be anticipated that the market served by vendors and integrators exclusively focussing on MES are narrowing.

9. 1.2. INTEGRATE OPINIONS OF SOUTH AFRICAN ROLE PLAYERS THROUGHOUT THE LITERATURE STUDY

A survey from the South African Instrumentation and Control Journal proves that MES is a concept used and accepted by South African systems integrators. Views of South African MES developers, integrators and users were integrated throughout this dissertation. The sample size of South African MES developers, integrators and users is, however, small. Research, regarding the status quo of MES in South Africa, is thus not representative and should not be used as baseline. The conclusion from this objective can, however, be used as hypothesis for further research.

9. 1.3. DEVELOP A NEW OR COMBINED MODEL TO BE USED AS MES EVALUATION TOOL

As contribution towards the evolution of MES business models, the MES Function Matrix was developed. This MES Function Matrix is not a checklist or an MES module breakdown, nor is it meant to replace existing models. It is rather a framework to contextualize and assess MES products and environments. This matrix can (amongst others) be used to:

- Identify the strengths, weaknesses, opportunities and threats regarding a specific MES product.
- Identify the areas in a business not benefiting optimally from MES and relate the benefits of MES in terms of return on investment (ROI).
- Identify common MES attributes related to certain industries and environments.
- Explain the relationship between MES and other business applications and functions.
- Evaluate MES products and relate it to a specific environment.
- Indicate interfacing or integration within an MES environment.

The MES Function Matrix was also used in this dissertation to relate MES to the Industrial Engineering training model, as well as continuous improvement.The validity of this model was supported through the comparison with existing models, as well as a case study application.

9. 1.4. DEMONSTRATE THE VALIDITY OF THE NEWLY DEVELOPED MES MODEL - AS WELL AS THE VALIDITY OF MES AS CONCEPT - THROUGH A CASE STUDY

DIAMES was used as case study to demonstrate how the MES Function Matrix can be used as MES assessment tool. DIAMES was not evaluated in isolation. The MES environment of Abedare Cables (where DIAMES is used) was also investigated. Through this, the validity of MES as concept was supported.

9. 1.5. RELATE MES TO INDUSTRIAL ENGINEERING BY INTEGRATING LITERATURE ON INDUSTRIAL ENGINEERING

Four types of role players are active in the MES arena:

- Developer
- Integrator
- User
- Researcher

The role of the Industrial Engineer, regarding all for of these roles is increasing. The greatest contribution can be made regarding integration, although the contribution towards MES development can not be ignored. MES provide vertical communication between planning and control systems. The expertise of the Industrial Engineer is needed to facilitate this vertical integration, but especially the horizontal integration between shop floor stations and planning functions.

MES have the potential to enhance manufacturing efficiency and effectiveness in any manufacturing industry sector. The approaches towards the implementation and use of MES may, however, vary. The Industrial Engineer can contribute towards the use of MES in any industry sector and MES can be used as tool to accomplish continuous improvement.

9. 1.6. INITIATE A RESEARCH PROGRAM FOR MES AT THE DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING (UNIVERSITY OF PRETORIA).

The term MES was created to describe the systems, which enables the execution of manufacturing. MES may be just another acronym in the vocabulary of the Industrial Engineer. The relationship between the roles to be played within the MES arena and the Industrial Engineer can, however, not be ignored. The discrepancy between the relationship and the current involvement on South African Industrial Engineers in the MES arena, is the drive behind the MES research initiative at the Department of Industrial and Systems Engineering of the University of Pretoria. A web site is created for this purpose.

9. 2. CONTRIBUTION OF THIS DISSERTATION

Through this dissertation the MES concept was evaluated and explained within the scope of Industrial Engineering.

According to MacDonald (1998:*www.consilium.com/Publications/roi.htm*) the evolution of MES started long before the term was coined in 1990, and it is still evolving:
"An Manufacturing Execution System is not something new or something only large, complex manufacturers need. If you have a manufacturing plant, you already have a Manufacturing Execution System"

However, by defining and modeling these systems - and by relating it to a certain area of expertise - a better understanding is nurtured, regarding the way in which these systems can enhance effectiveness and efficiency in a business or industry.