A HANDBOOK ON MASTER PLANNING AND IMPLEMENTATION

FOR ENTERPRISE INTEGRATION PROGRAMS

APPENDICES

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June 1996

(Current Edition February 2001)

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Appendix I - Generic List of Macro-Functions

As emphasized in Chapter 1, the overall applicability of the Purdue Enterprise Reference Architecture depends to a great extent on the development of a set of generic tasks, functions and macro functions to describe an enterprise integration system or indeed any enterprise.

The Purdue Reference Model for CIM [81] developed two such lists, one based on the Scheduling and Control Hierarchy View and another based on the Data Flow Diagram View of the Reference Model. It then proceeded to show the correlation of these two apparently widely different lists by cross-referencing the task titles used and their point of application in each view. For the sake of completeness of this Guide, that material will be reproduced here, along with considerable related material on the architecture.

This appendix will show the correlation between the Purdue Enterprise Reference Architecture and the Vendor Reference Model for CIM.

Scheduling and Control Hierarchy Diagram

The Scheduling and Control Hierarchy View from the Reference Model [81] as mentioned above is shown in Figure AI-1. It is a Type 1 architecture developed to categorize the tasks carried out by the industrial control system for a complete plant or company. Figure AI-2 shows that this same diagram with modifications only for the names of the functions involved will characterize the control tasks of either a continuous or discrete manufacturing industry plant. Figure AI-3 expands the earlier diagrams to cover a company with multiple plants.

This diagram correlates to the Purdue Enterprise Reference Architecture as noted in Chapter 1 in that:

1. All functions and operations on the left-hand (manufacturing) side of the Purdue Reference Architecture Diagram can be represented as relating only to Level 0 of the Purdue Scheduling and Control Hierarchy view of the CIM Reference Model [81].
2. Conversely all functions and operations shown on the right-hand (information) side of the Purdue Reference Architectural Diagram relate only to Level 1 and higher of the Purdue Scheduling and Control Hierarchy view.

Functional Block Diagram

Another example of these architectural views is the functional block diagram of Figure AI-4. It will be used along with the hierarchy diagram in the discussion to follow as another way to indicate the relationship of the several sub-architectures to each other.

Management and staff functions as defined here include all the usual functions such as finance, procurement, etc. Research and development and sales are shown on each side of marketing since marketing often serves as an interface between these two functions. Manufacturing as defined here includes all of its subsidiary functions such as maintenance and its management, shipping, waste treatment, etc.

Note: It was just mentioned above that the Factory Scheduling and Control System block of Figure A1-4 represents Levels 1 to 4A of Figure A1-1 and A1-2 of the Purdue Scheduling and Control Hierarchy and the Manufacturing System block represents Level 0 of the hierarchy presented there. Also the remainder of the diagram (Management and Staff Functions, Sales, Marketing, Research and Development, and Engineering) represents those personnel not directly involved in the day-to-day operations of the manufacturing plant, i.e. Level 4 of Figure A1-1 and A1-2 and Level 5B of Figure A1-3.

A few words are appropriate on the definitions of the staff functions represented on Figure AI-4. Engineering is represented in terms of its two major functions, those related to products on the one hand (Product Design and Process Planning) and facilities on the other (Facilities Design and Process and Facilities Improvement). These two functions operate on two different time scales (because of the differing nature of their missions). Process Engineering prepares process plans for the production of desired products as these plans are needed by manufacturing or when new or revised products are developed by the Product Design function. Likewise Facilities Engineering is responsible for the engineering of facilities maintenance as needed by Manufacturing and for the design of new or modified manufacturing facilities.

Marketing's task is the determination of the Customers' needs for the product or service which the Enterprise offers at present or should offer in the future. These involve determining *what, where* and in *what quantity*. Also involved are *cost/quality tradeoffs* and *delivery capabilities*.

The Sales organization makes the services of the Enterprise available to the Customer through customer contacts, advertising, collection of orders and negotiation of sales contracts. Research and Development converts Marketing requests into proposed new or improved products or services of the Enterprise and works through Engineering to convert these to viable designs and process plans for their production.

Figures AI-5 and AI-6 describe the relationship of the Information Architecture and the Manufacturing Architecture to each other. The reader should review Figures AI-8 through AI-11 versus Figures AI-12 through AI-18 for the corresponding cases in the structural diagram of the Purdue Enterprise Reference Architecture. Note that these diagrams can represent either the definition (functional) or the specification (implementation) case. Figures AI-7, AI-8 and AI-9 show the idealized relationships of the Information Systems, Manufacturing Equipment and Human and Organizational Architectures to each other. In contrast to Figures AI-5 and AI-6 these represent only the implemented case. These do not coincide with the corresponding divisions of the functional networks in the definition phase of the Architecture as do Figures AI-5 and AI-6 because of the assignment of tasks from both of these areas to the Human and Organizational Architecture as described in Chapter 1. Figures AI-10 and AI-11 show the division of the Human and Organizational Architecture with its functions assigned to either the Information Architecture or the Manufacturing Architecture of Figures AI-7 and AI-8.

Relationship of PERA Block Diagram and Structural Forms

Figures AI-12 to AI-18 further classify the block diagram form of the Architecture by comparing the figures just presented to corresponding ones showing the structural form of the PERA Architecture. Despite their simplistic form, the figures are included to prevent any misunderstanding of the meaning of the block diagram form of the Architecture and its correspondence to the structural form. The block diagram form has several important uses as will be seen in the remainder of this text. It must be mentioned early that the lists of functions to be discussed here represent only the tasks included in the Scheduling and Control block of the architecture as represented in the Factory Scheduling and Control block of Figure AI-4. The other blocks of the Information Architecture as shown on that figure are not yet listed in terms of the tasks involved. Such a list for the Manufacturing Architecture would be much more difficult to prepare because of the relative lack of generality in manufacturing systems compared to scheduling and control functions.

APPENDIX I – Generic Macro-Functions

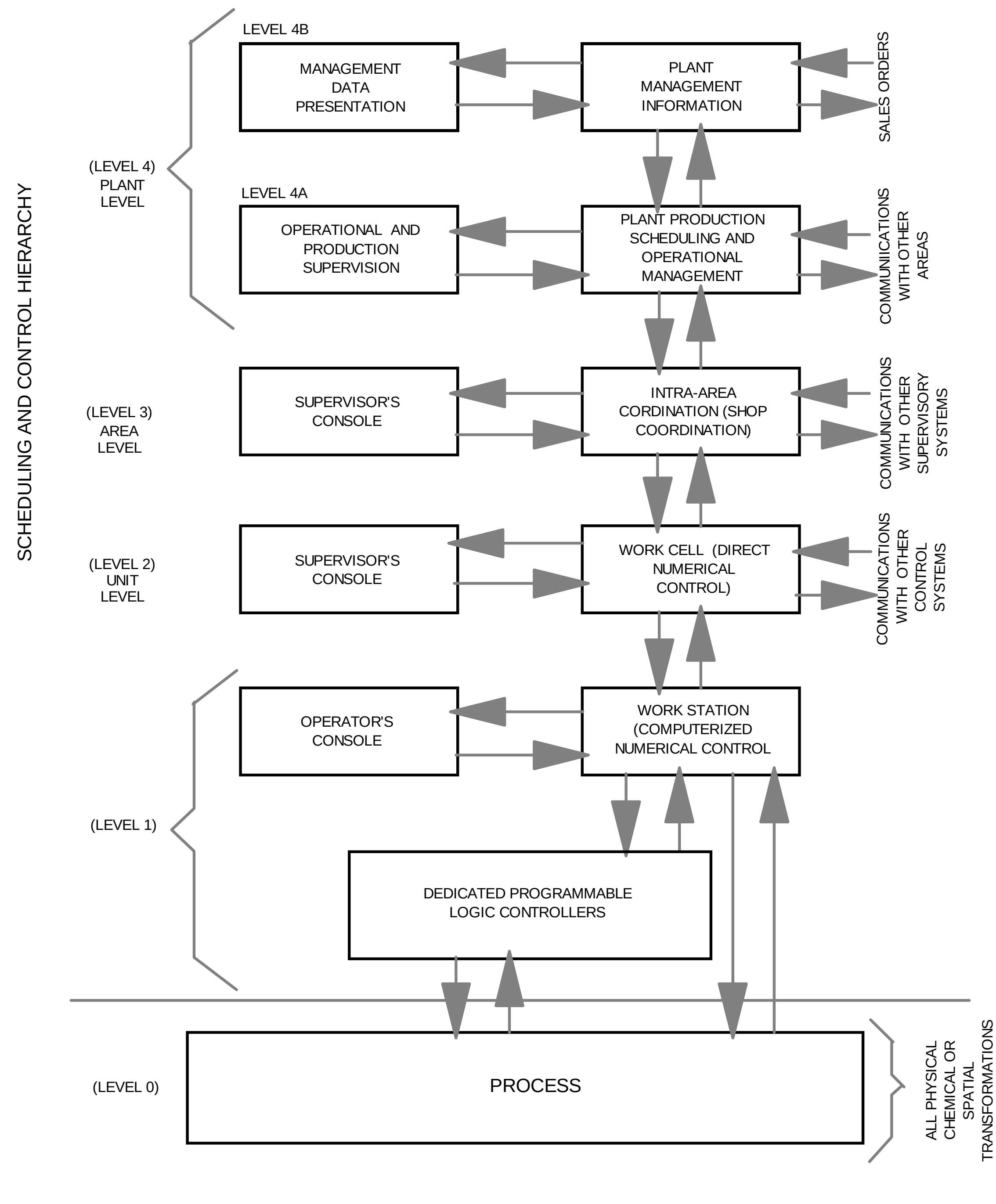

FIGURE AI-1 ASSUMED HIERARCHICAL COMPUTER CONTROL STRUCTURE FOR A LARGE MANACTURING COMPLEX (Computer Integrated Manufacturing system –CIM)

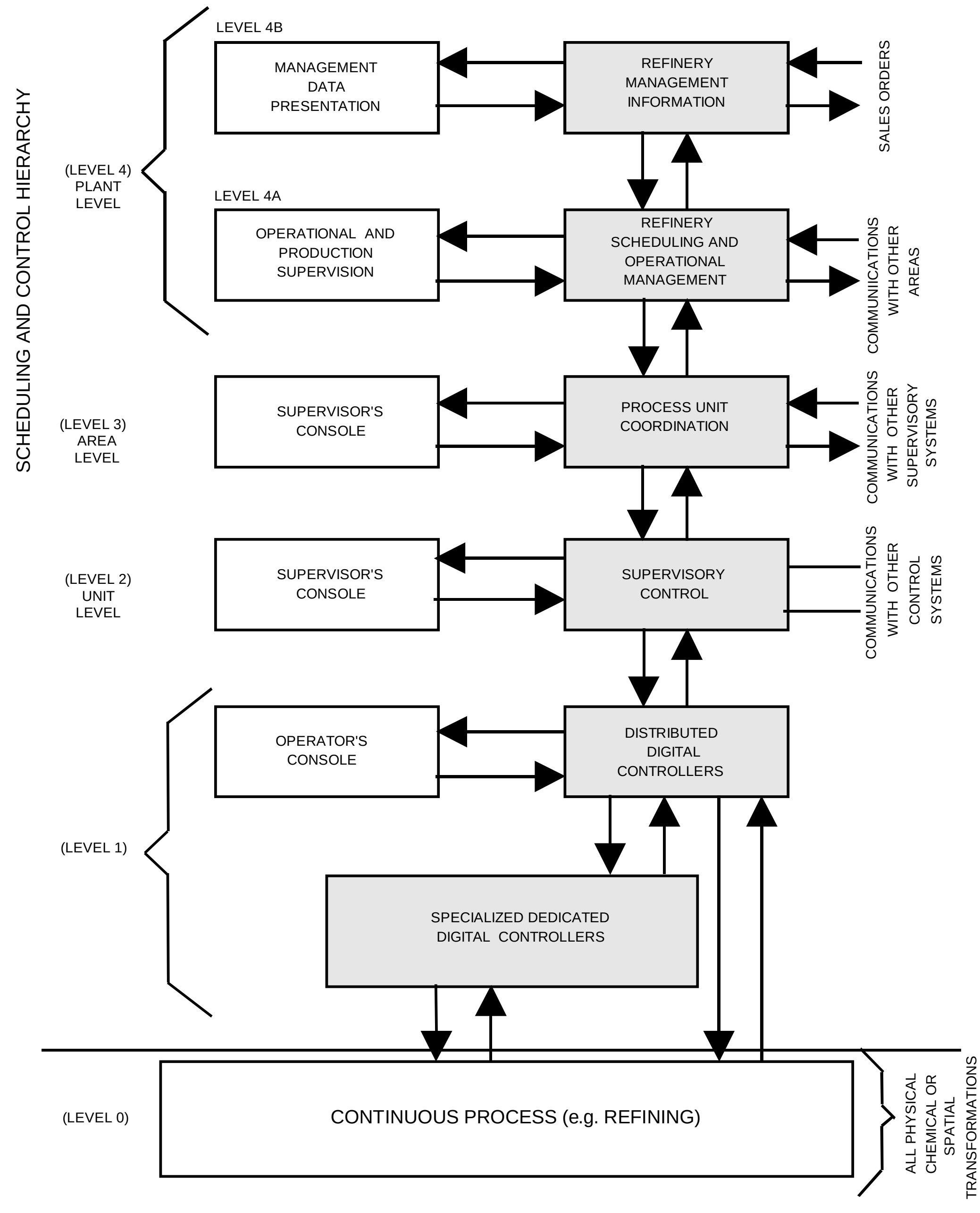

FIGURE AI-2 ASSUMED HIERARCHICAL COMPUTER CONTROL STRUCTURE FOR A CONTINUOUS PROCESS PLANT (such as Petrochemicals)

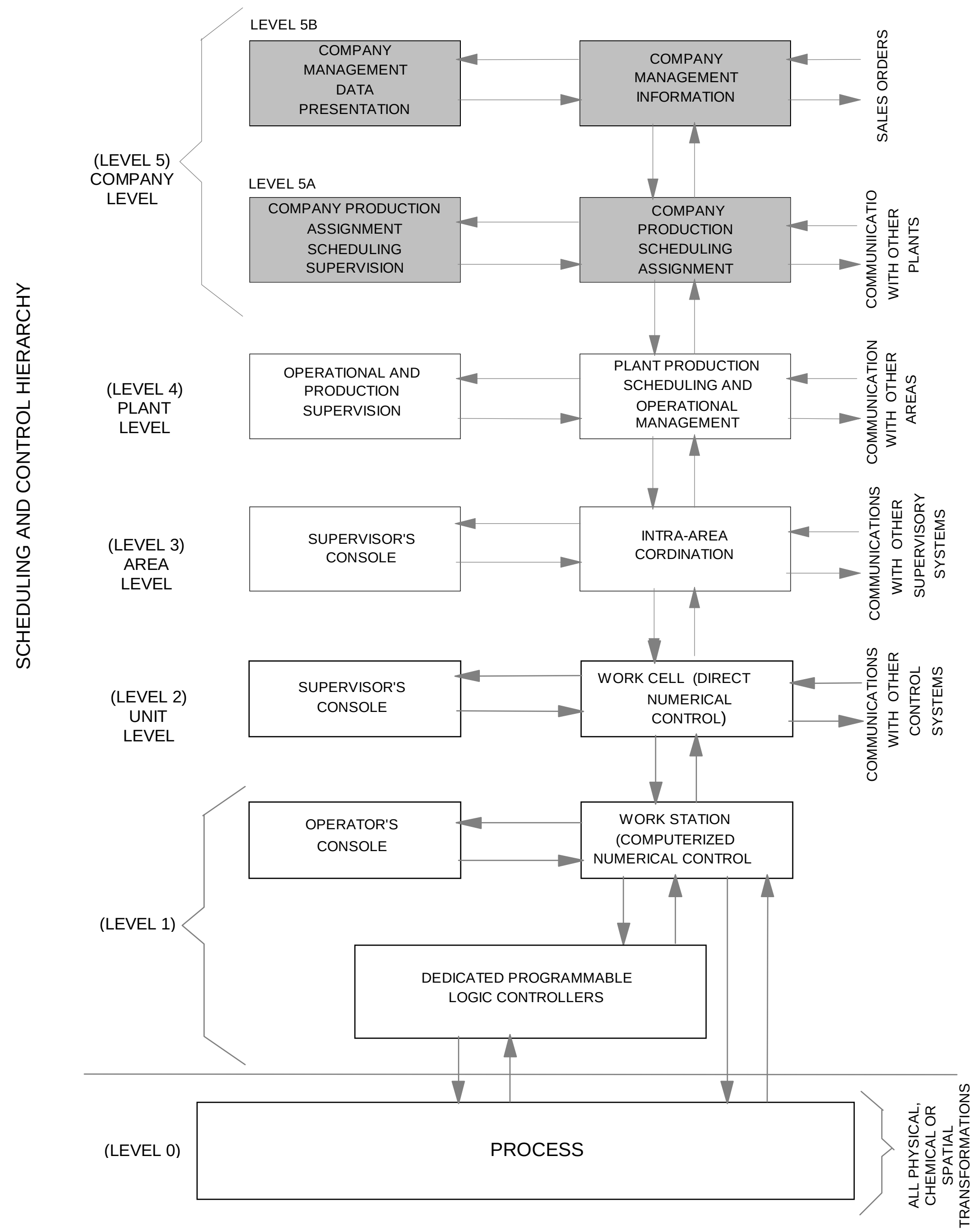

FIGURE AI-3 ASSUMED HIERARCHICAL COMPUTER CONTROL STRUCTURE FOR AN INDUSTRIAL COMPANY (MULTI-PLANT) TO SHOW LEVEL 5 AND ITS RELATIONSHIP TO THE REVISED LEVEL 4

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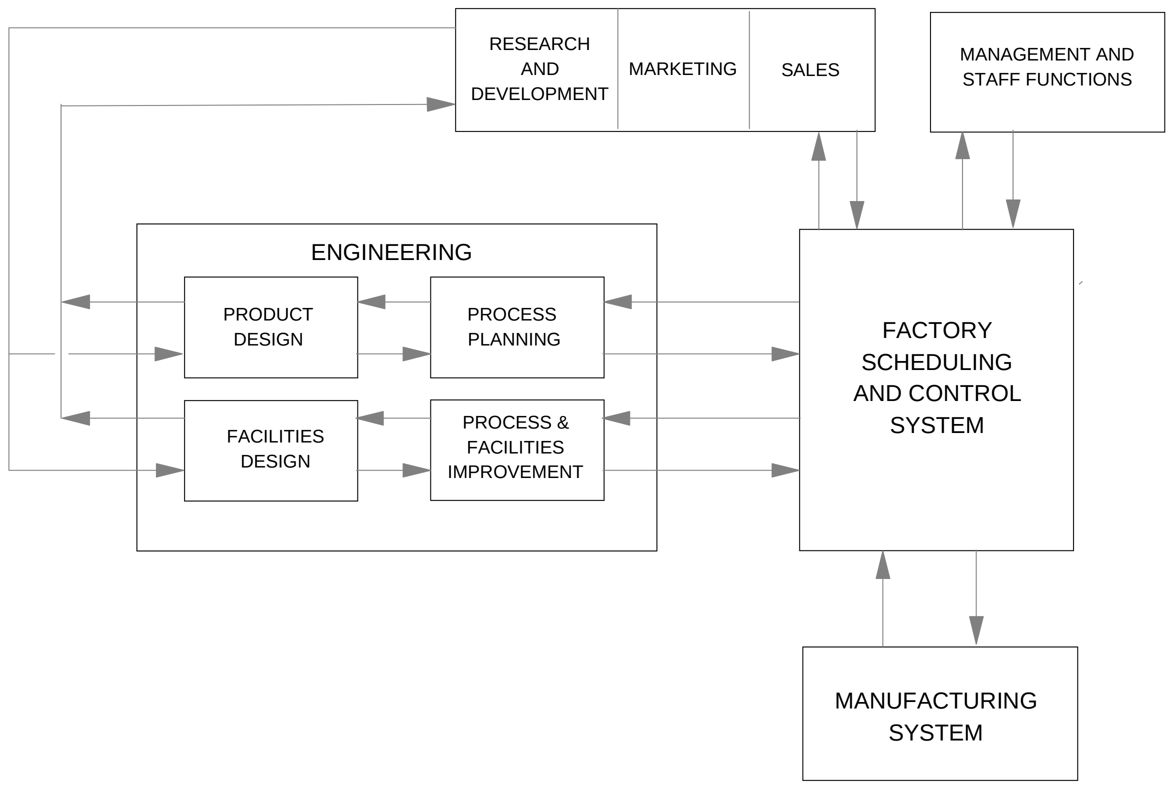


FIGURE AI-4 BLOCK DIAGRAM OF AN OVERALL ENTERPRISE INTEGRATION SYSTEM (FOR REPRESENTING THE VARIOUS ARCHITECTURES DESCRIBED HEREIN)

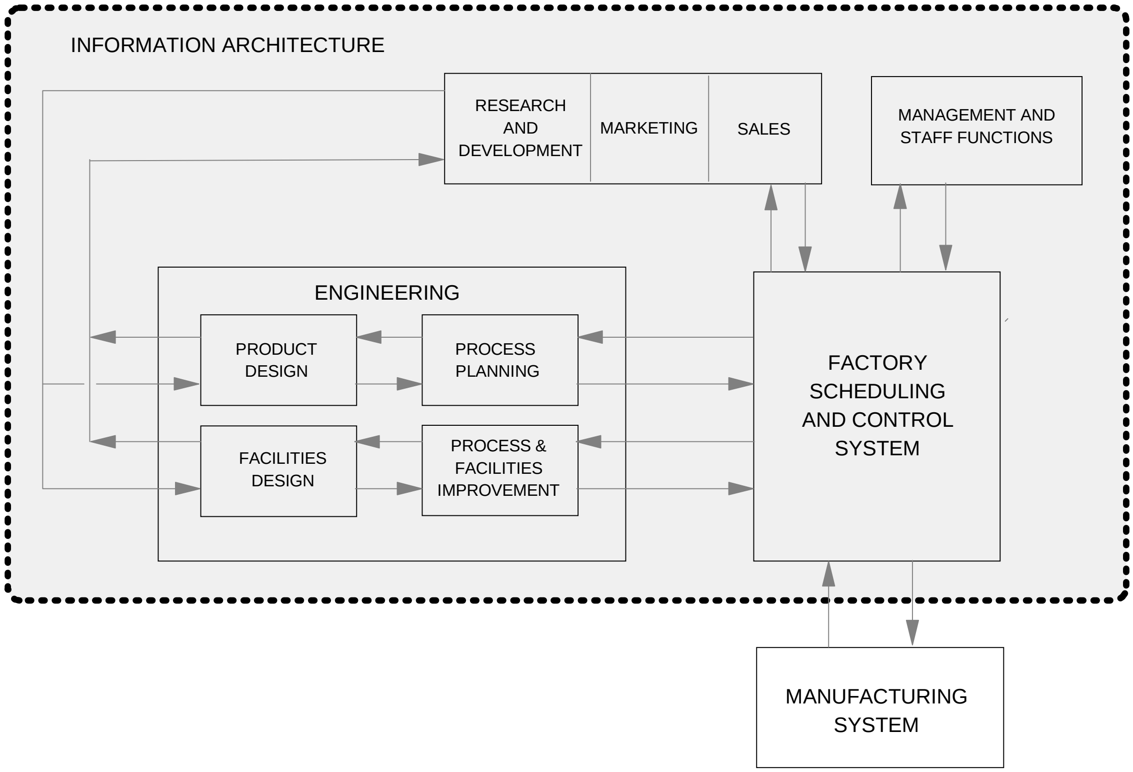


FIGURE AI-5 THE INFORMATION ARCHITECTURE ALSO FUNCTIONALLY REPRESENTS THE INFORMATION FUNCTIONAL NETWORK

APPENDIX I – Generic Macro-Functions

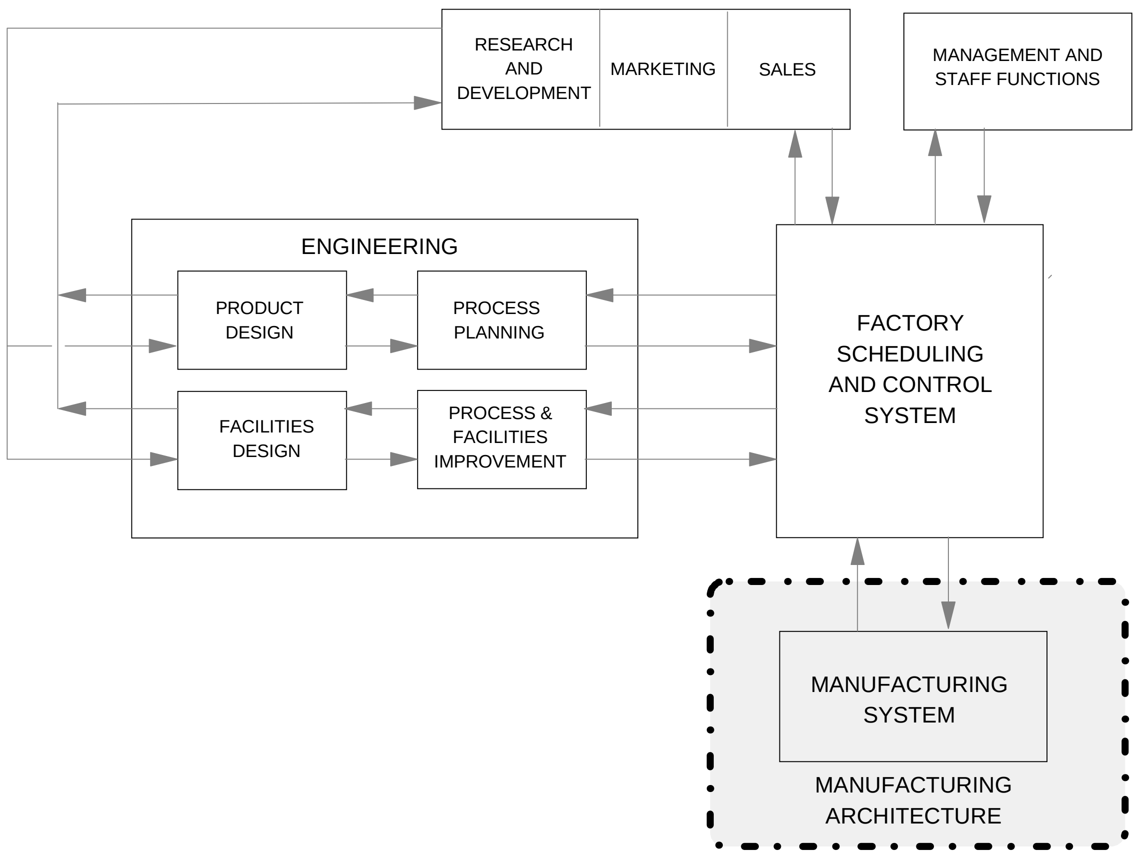


FIGURE AI-6 THE MANUFACTURING ARCHITECTURE ALSO FUNCTIONALLY REPRESENTS THE MANUFACTURING FUNCTIONAL NETWORK

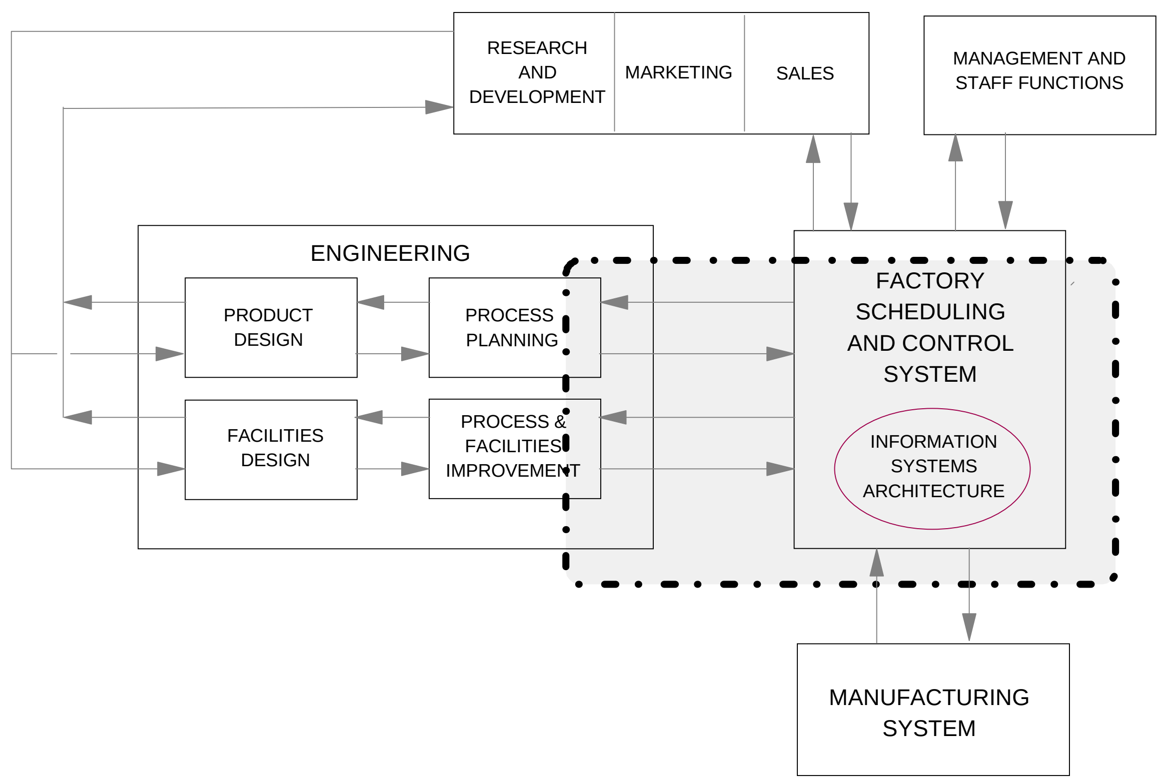


FIGURE AI-7 THE INFORMATION SYSTEMS ARCHITECTURE

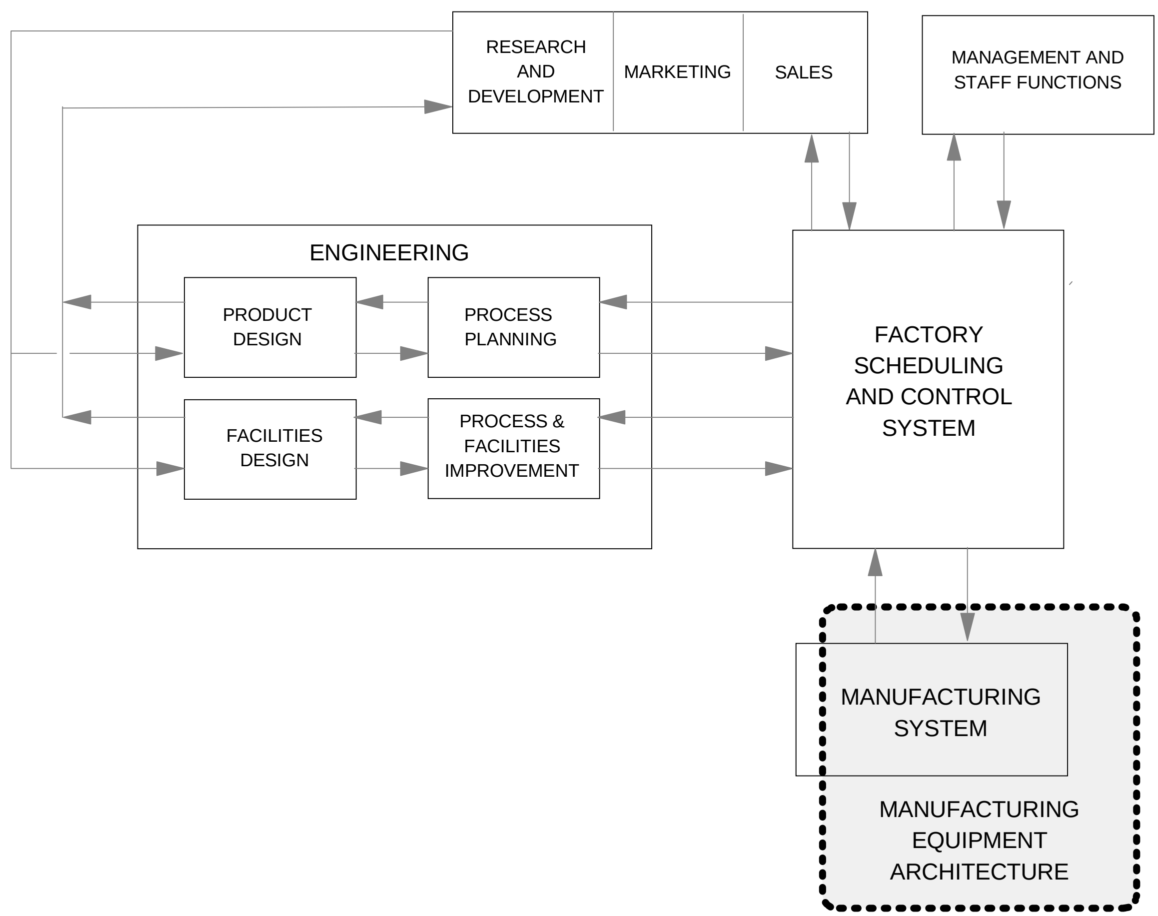


FIGURE AI-8 MANUFACTURING EQUIPMENT ARCHITECTURE

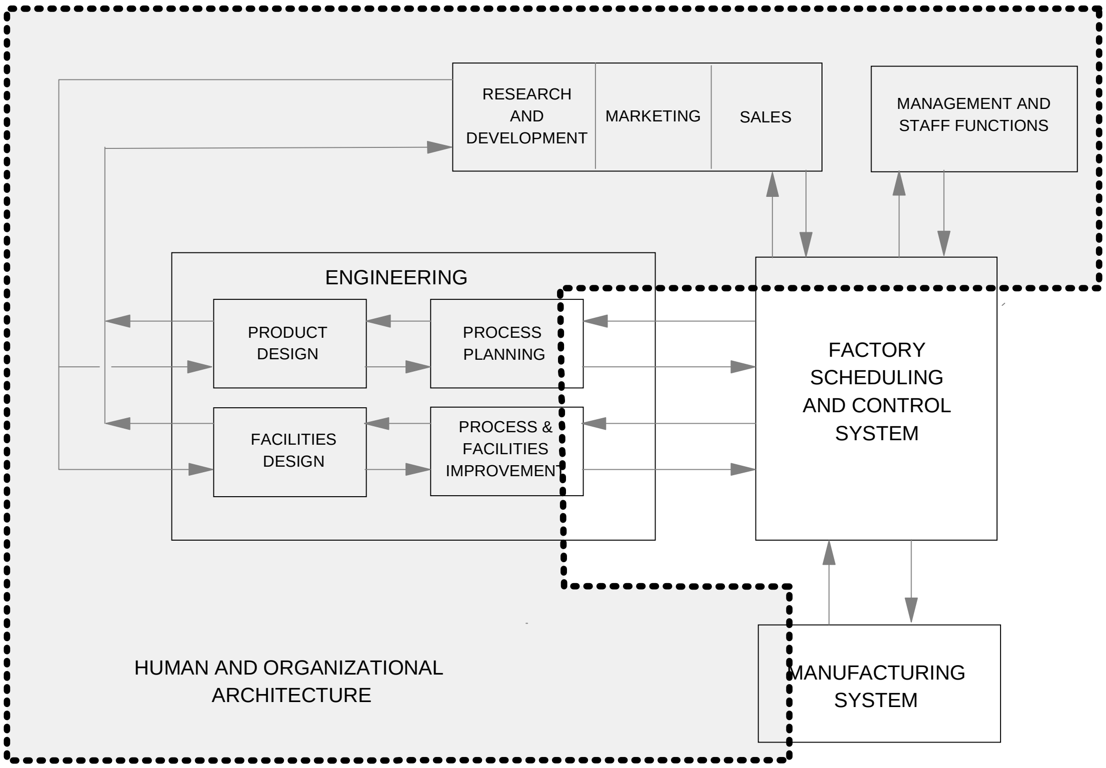


FIGURE AI-9 HUMAN AND ORGANIZATIONAL ARCHITECTURE

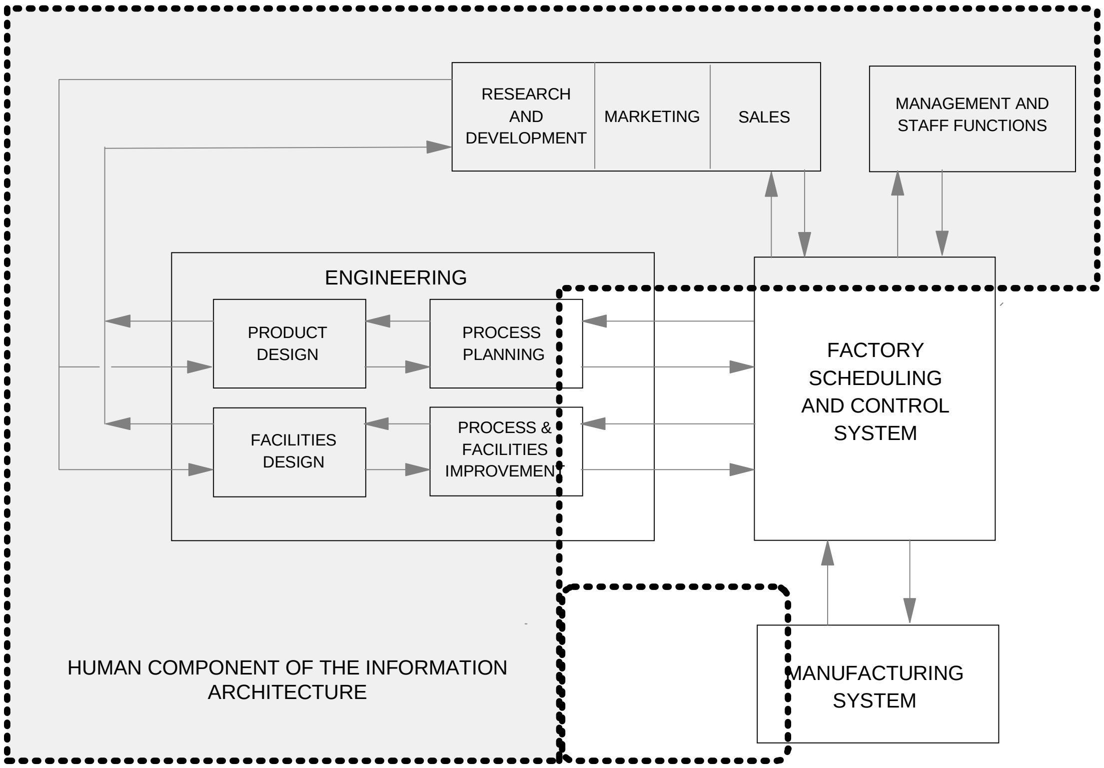


FIGURE AI-10 HUMAN AND ORGANIZATIONAL ARCHITECTURE SHOWING THE HUMAN COMPONENT OF THE INFORMATION ARCHITECTURE

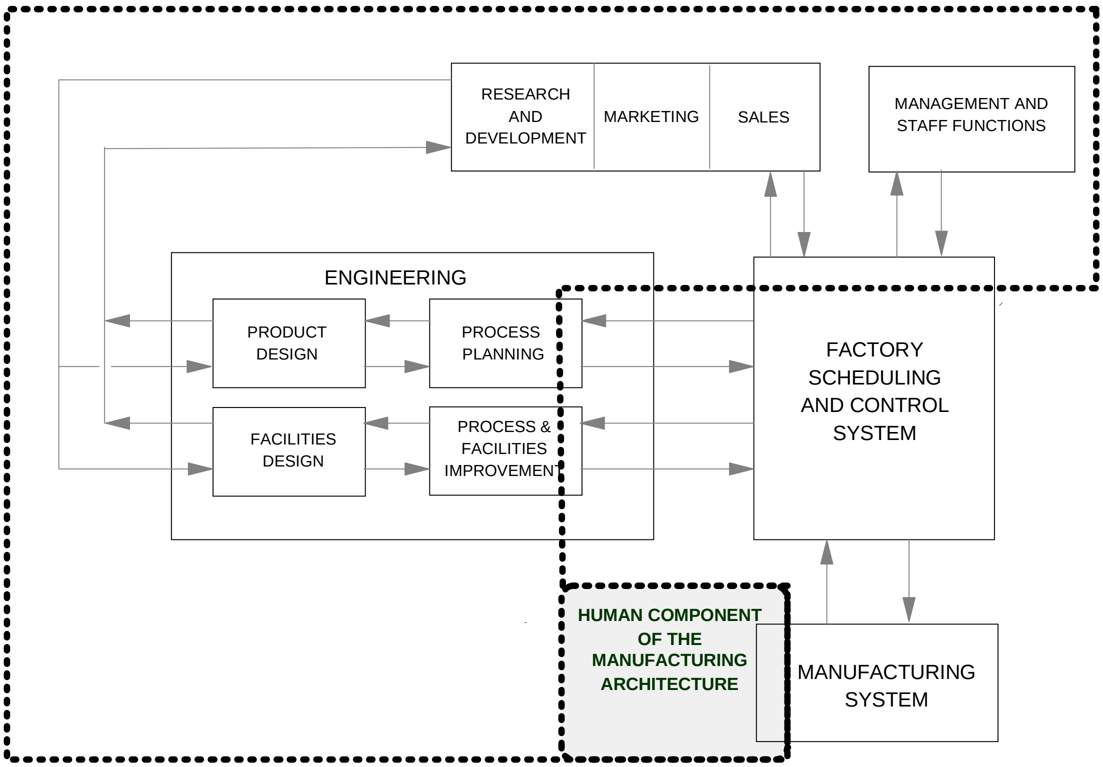


FIGURE AI-11 HUMAN AND ORGANIZATIONAL ARCHITECTURE SHOWING THE HUMAN COMPONENT OF THE MANUFACTURING ARCHITECTURE

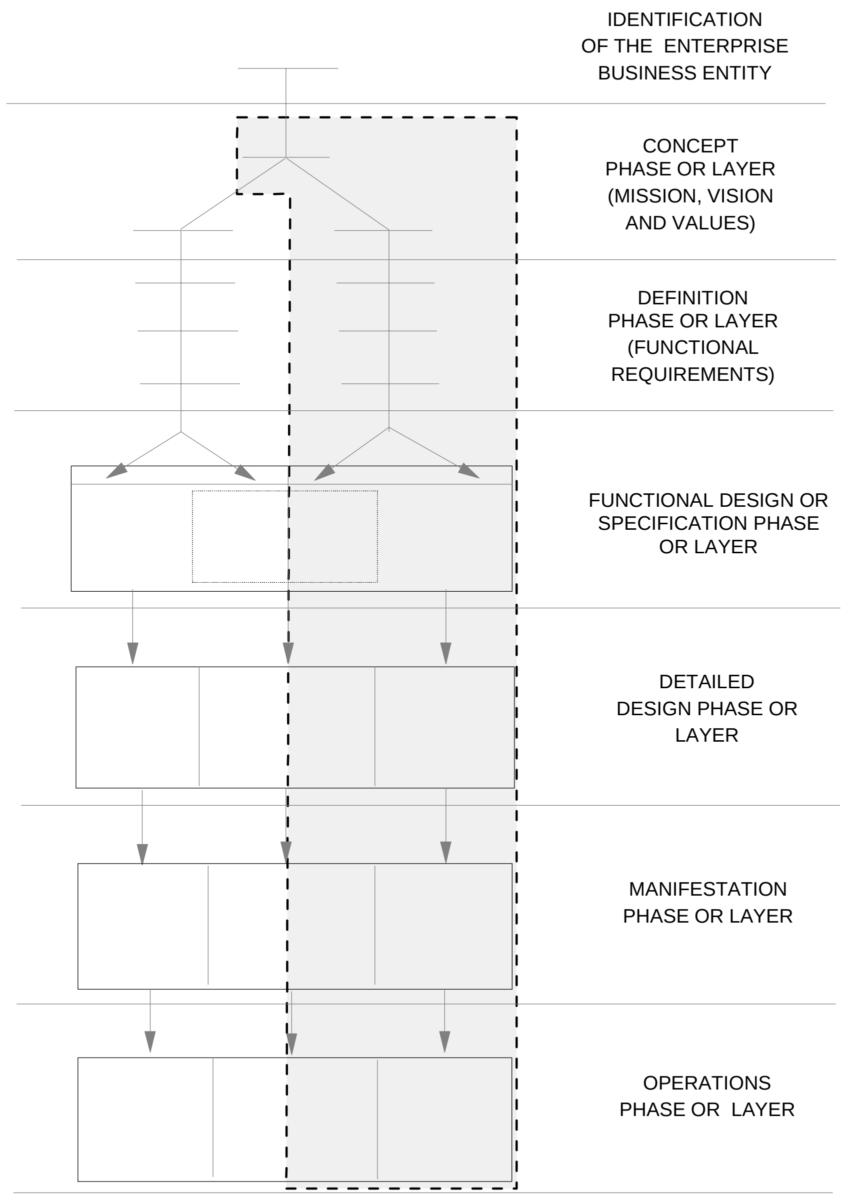


FIGURE AI-12 INFORMATION SIDE OF THE ARCHITECTURE
(CORRESPONDS TO FIGURE AI-5 OF THE BLOCK DIAGRAM FORM)

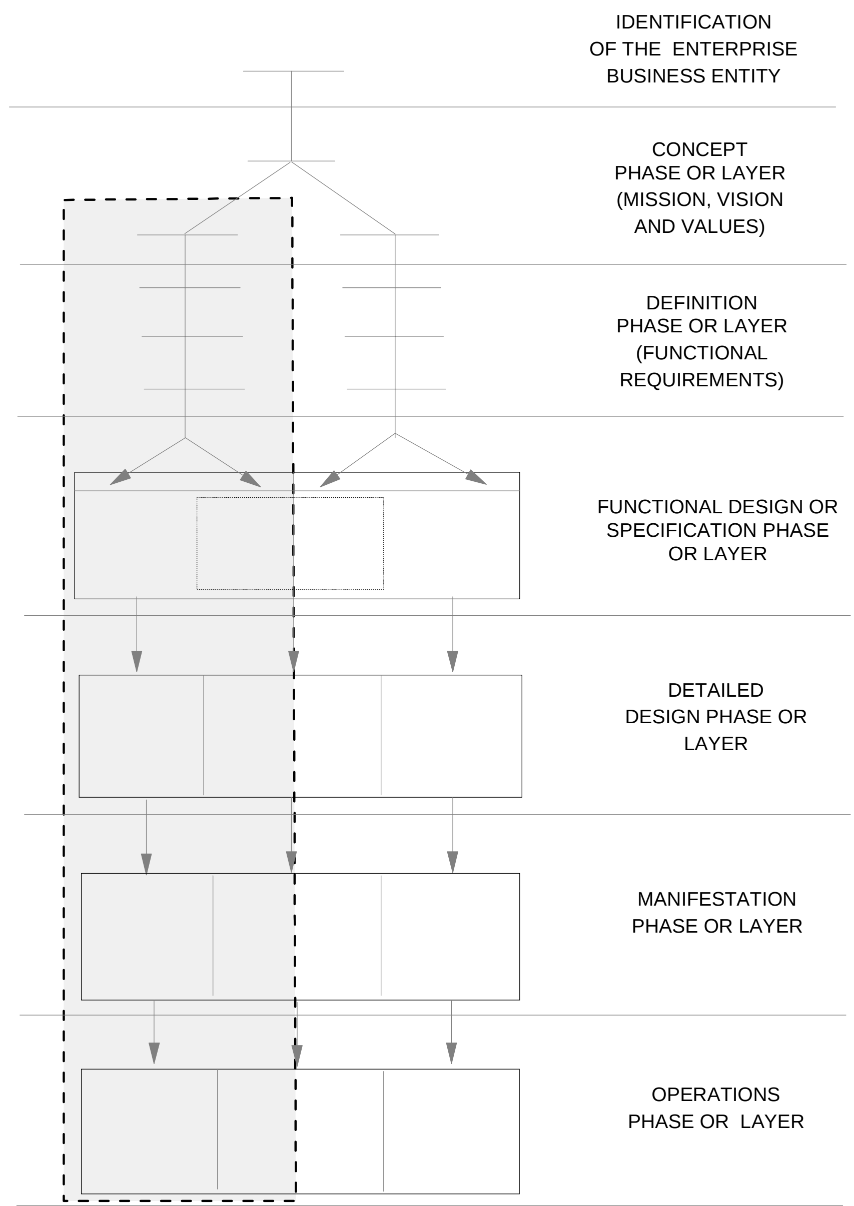


FIGURE AI-13 THE MANUFACTURING SIDE OF THE ARCHITECTURE
(CORRESPONDS TO FIGURE AI-6 OF THE BLOCK DIAGRAM FORM)

APPENDIX I – Generic Macro-Functions

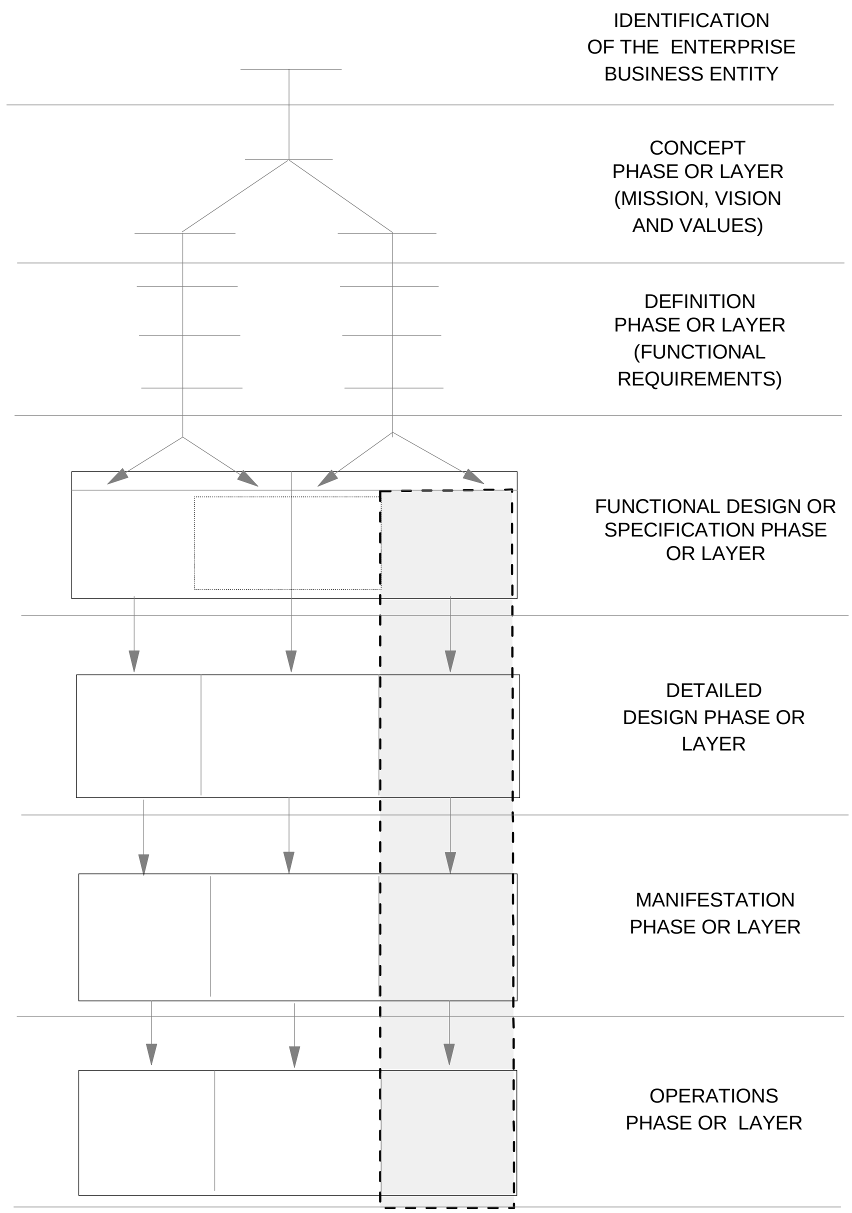


FIGURE AI-14 THE INFORMATION SYSTEM ARCHITECTURE
(CORRESPONDS TO FIGURE AI-7 OF THE BLOCK DIAGRAM FORM)

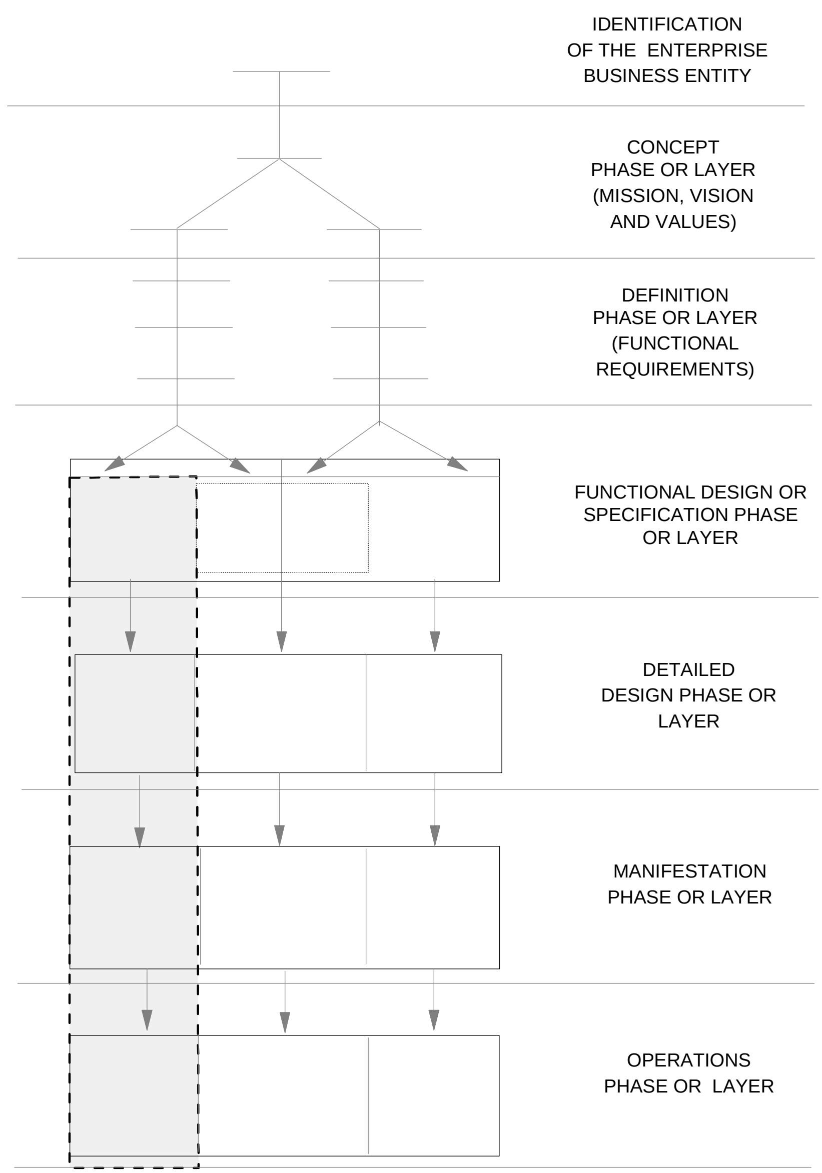


**FIGURE AI-15 THE MANUFACTURING EQUIPMENT ARCHITECTURE
(CORRESPONDING TO FIGURE AI-8 OF THE BLOCK DIAGRAM FORM)**

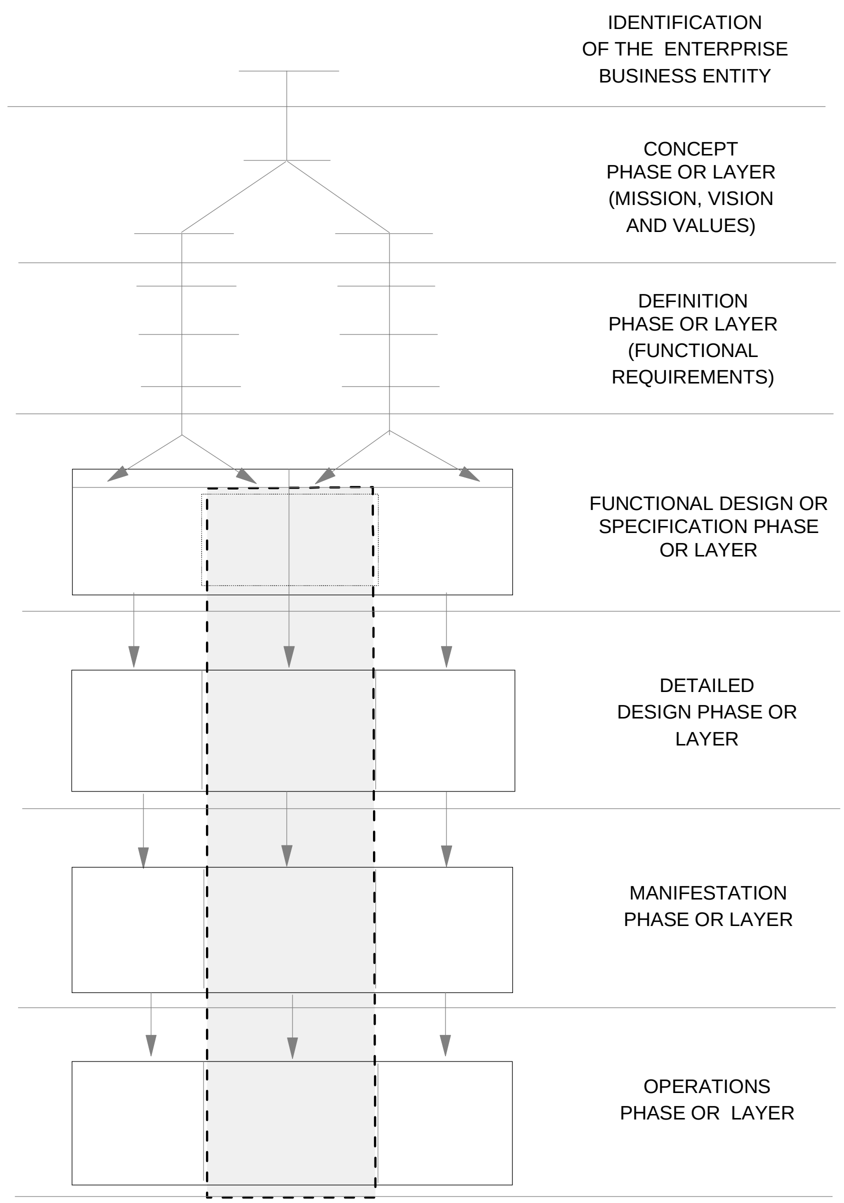


FIGURE AI-16 THE HUMAN AND ORGANIZATIONAL ARCHITECTURE
(CORRESPONDING TO FIGURE AI-9 OF THE BLOCK DIAGRAM FORM)

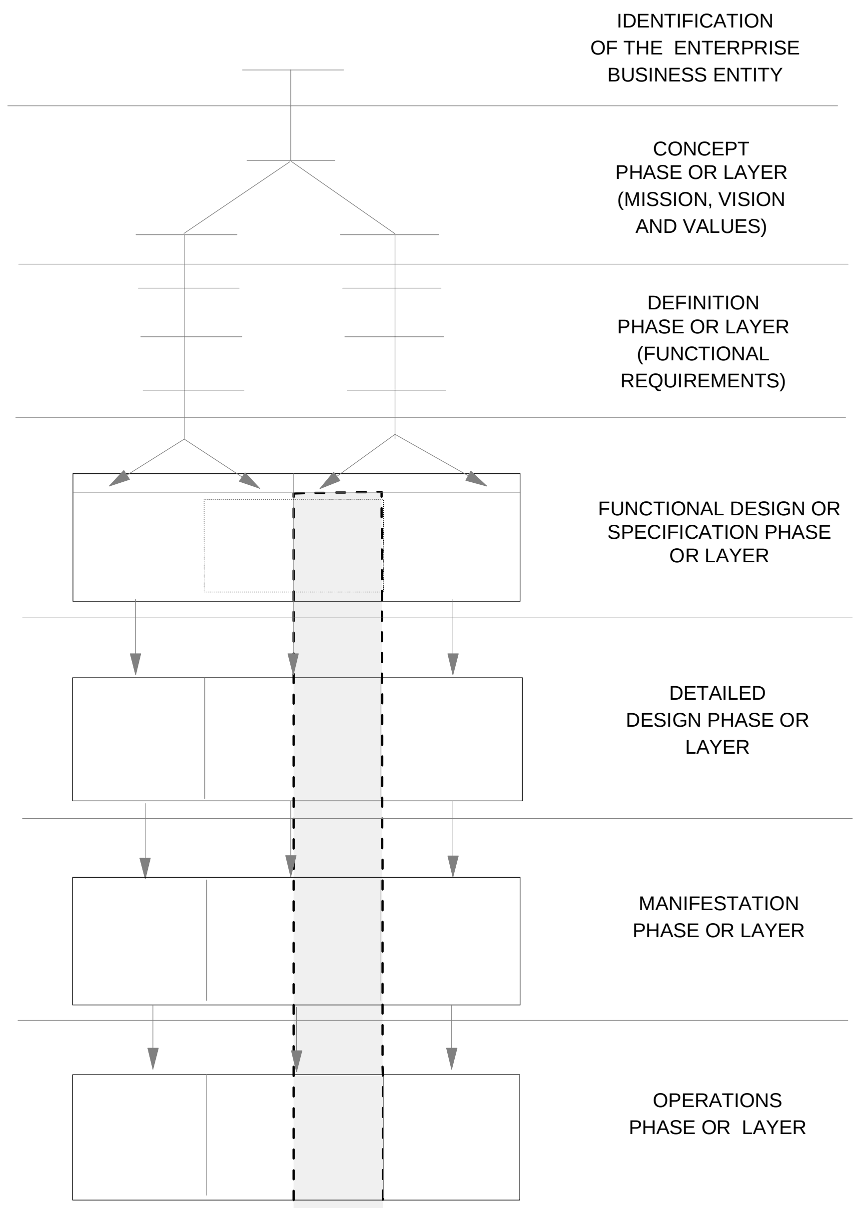


FIGURE AI-17 THE HUMAN COMPONENT OF THE INFORMATION ARCHITECTURE (CORRESPONDING TO FIGURE AI-10 OF THE BLOCK DIAGRAM FORM)

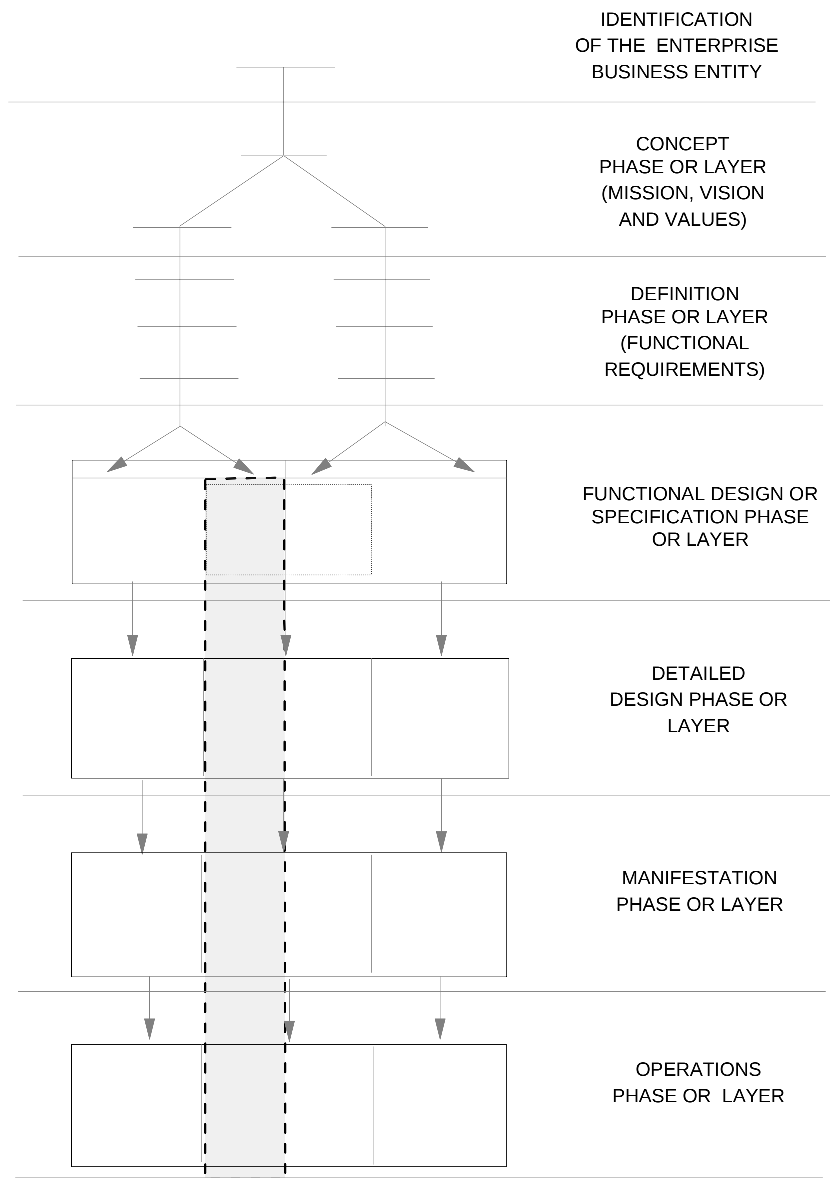


FIGURE AI-18 THE HUMAN COMPONENT OF THE MANUFACTURING ARCHITECTURE (CORRESPONDING TO FIGURE AI-11 OF THE BLOCK DIAGRAM FORM)

APPENDIX I – Generic Macro-Functions - Tasks

Generic Tasks of a Plant-Wide Scheduling and Control Hierarchy

Overall automatic control of any large modern industrial plant, regardless of the industry concerned, involves each of the requirements listed in Table AI-I.

Thus the automation of any such industrial plant becomes the managing of the plants' information systems to assure that the necessary information is collected and used wherever it can enhance the plants' operation - true information systems technology in its broadest sense.

Another major factor should also be called to our attention here. It has been repeatedly shown that one of the major benefits of the use of digital computer control systems in the automation of industrial plants has been in the role of a <u>control</u> <u>systems</u> <u>enforcer</u>. In this mode, one of the control computer's main tasks is to continually assure that the control system equipment is actually carrying out the job that it was designed to do in keeping the units of the plant production system operating at some best (near optimal) level. That is, to be sure that in the continuous process plant, for instance, the controllers have not been set on manual, that the optimal set points are being maintained, etc. Likewise, it is the task of dynamic control to assure that the plant's production schedule is carried out, i.e., to enforce the task set by the production scheduling function.

Often the tasks carried out by these control systems have been ones which a skilled and attentive operator could have readily done. The difference is the degree of attentiveness to the task at hand which can be achieved over the long run.

As stated earlier, all of this must be factored into the design and operation of the control system which will operate the plant, including the requirements for maximum productivity and minimum raw material and energy usage. As the overall requirements, both energy and productivity based, become more complex, more sophisticated and capable control systems are necessary.

While the above tasking list is truly generic for any manufacturing plant - continuous or discrete - it is necessary to rearrange it in order to come up with a more compact set of tasks for further discussion.

Therefore, what is needed is an overall system for any manufacturing plant which has the capabilities shown in Table AI-II.

In view of Item 2 of Table AI-II, Table AI-III presents some observations of the differences in process improvement technologies (i.e., near optimization) for continuous versus discrete optimization.

Because of the ever-widening scope of authority of each of the first three requirements in turn, they effectively become the distinct and separate levels of a superimposed control structure, one on top of the other. Also in view of the amount of information that must be passed back and forth among the above four "tasks" of control, a distributed computational capability organized in a hierarchical fashion would seem to be the logical structure for the required control system. This must be true of any plant regardless of the industry involved.

As just noted, a hierarchical arrangement of the elements of a distributed, computer-based, control system seems an ideal arrangement for carrying out the automation of the industrial plant just described. Figures AI-1, AI-2 and AI-3 lay out one possible form of this distributed, hierarchical computer control system for overall plant automation.

In the context of large industrial plants or of a complete industrial company based in one location, the detailed tasks that would be carried out at each level of the hierarchy can be readily described. These tasks are easily subdivided into those related to production scheduling, control enforcement, systems coordination and reporting, and reliability assurance (Table AI-IV).

TABLE AI-I

DUTIES AND TASKS (FUNCTIONAL REQUIREMENTS) OF ALL INTEGRATED INFORMATION AND AUTOMATION SYSTEMS, A GENERIC LIST

1. A system for the automatic monitoring of a large number of different plant variables operating over a wide range of process operations and of process dynamic behavior. Such monitoring will detect and compensate for current or impending plant emergencies or production problems.

2. The development of a large number of quite complex, usually nonlinear, relationships for the translation of some of the above plant variable values into control correction commands.

3. The transmission of these control correction commands to another very large set of widely scattered actuation mechanisms of various types.

4. Improvement of all aspects of the manufacturing operations of the plant by guiding them toward likely optima of the appropriate economic or operational criteria. Results may be applied to the control correction commands of Item 2 above and/or to the plant scheduling functions of Item 8 below.

5. Reconfiguration of the plant production system and/or of the control system as necessary and possible to assure the applicable production and/or control system for the manufacturing situation at hand.

6. Keeping plant personnel, both operating and management, aware of the current status of the plant and of each of its processes and their products including suggestions for alternate actions where necessary.

7. Reduction of plant operational and production data and product quality data to form a historical database for reference by Plant Engineering, other staff functions and Marketing.

8. Adjusting the plant's production schedule and product mix to match its customers' needs, as expressed by the new order stream being continually received, while maintaining a high plant productivity and the lowest practical production costs. This function must also provide for appropriate plant preventive or corrective maintenance functions.

9. Determination of and provision for appropriate inventory and use levels for raw materials, energy, spares, goods in process and products to maintain desired production and economics for the plant.

10. Assuring the overall availability of the control system for carrying out its assigned tasks through the appropriate combination of fault detection and fault tolerance, redundancy, and fail-safe techniques.

11. Maintaining interfaces with the external entities which interact with the plant production system such as Corporate Management; Marketing; Accounting; Corporate Research, Development and Engineering; External Transportation; Suppliers and Vendors; Purchasing; Customers; and Contractors.

TABLE AI-II
AN OVERALL PLANT AUTOMATION SYSTEM MUST PROVIDE

1. An effective dynamic control of each operating unit of the plant to assure that it is operating at its maximum efficiency of production capability, product quality and/or of energy and materials utilization based upon the production level set by the scheduling and supervisory functions listed below. This thus becomes the Control Enforcement component of the system. This control reacts directly to compensate for any emergencies which may occur in its own unit.

2. A supervisory and coordinating system which determines and sets the local production level of all units working together between inventory locations in order to continually improve (i.e., optimize) their operation. This system assures that no unit is exceeding the general area level of production and thus using excess raw materials or energy. This system also responds to the existence of emergencies or upsets in any of the units under its control in cooperation with those units' dynamic control systems to shut down or systematically reduce the output in these and related units as necessary to compensate for the emergency. In addition, this system is responsible for the efficient reduction of plant operational data from the dynamic control units, described just above, to assure its availability for use by any plant entity requiring access to it as well as its use for the historical database of the plant.

3. An overall production control system capable of carrying out the scheduling functions for the plant from customer orders or management decisions so as to produce the required products for these orders at the best (near optimum) combination of customer service and of the use of time, energy, inventory, manpower and raw materials suitably expressed as cost functions.

4. A method of assuring the overall reliability and availability of the total control system through fault detection, fault tolerance, redundancy, uninterruptible power supplies, maintenance planning, and other applicable techniques built into the system's specification and operation.

TABLE AI-III

SOME NOTES REGARDING OPTIMIZATION (IMPROVEMENT) OF MANUFACTURING EFFICIENCY

- In discrete manufacturing optimization (improvement) is generally carried out in scheduling.
- In continuous manufacturing optimization (improvement) is generally carried out both in control and scheduling.

TABLE AI-IV

SUMMARY OF DUTIES OF CONTROL COMPUTER SYSTEMS

I. Production Scheduling

II. Control Enforcement

III. Plant Coordination and Operational Data Reporting

IV. System Reliability and Availability Assurance

Item I of the above Table (Production Scheduling) corresponds to Item 3 of the list of Table AI-II.

Item II of the above Table (Control Enforcement) corresponds to much of Items 1 and 2 of the list of Table AI-II.

Items III and IV of the above list require the cooperative operation of all items of the list of Table AI-II. The Plant Coordination part comprises the detailed interpretation and expansion of the overall Production Schedule of Item 3 of Table AI-II.

It is our contention that such Duties can be broken down into lists of standard tasks that can be carried out in any industrial plant, particularly at the upper levels of the hierarchy. Details of how these operations are actually carried out may vary drastically, particularly at the lowest levels, because of the nature of the actual process being controlled. We all recognize that a distillation column will never look like or respond like an automobile production line. But the operations themselves remain the same in concept, particularly at the upper levels of the hierarchy.

Thus it is our further contention that despite the different nomenclature in different industries the major differences in the control systems involved is concentrated in the details of the dynamic control technologies used at Level 1 and the details of the mathematical models used for optimization at Level 2.

The differences are thus concentrated in the details of the control and operation of the individual production units (the application entities) of the factory. Commonality is in the support functional entities (computational services, communications, database technology, management structure, etc.). Sensing and communication techniques are exactly the same in both systems. The same optimization algorithms can be used. Computer systems technology and programming techniques should be the same and production scheduling technology should be identical to name only a few.

Thus the duties of the hierarchical computer system can be established as outlined in Table AI-IV and in Figure AI-19. Therefore Levels 1, 2, and 3 will concentrate on performing Task II of Table AI-IV, Levels 3 and 4 will carry out Task I and all will be involved in assuring the implementation of Task III and the integrity of Task IV, overall reliability and availability.

Possibilities of major reduction in the costs, development manpower effort, and time required to produce an integrated industrial control system then devolves upon the factors listed in Table AI-V [81].

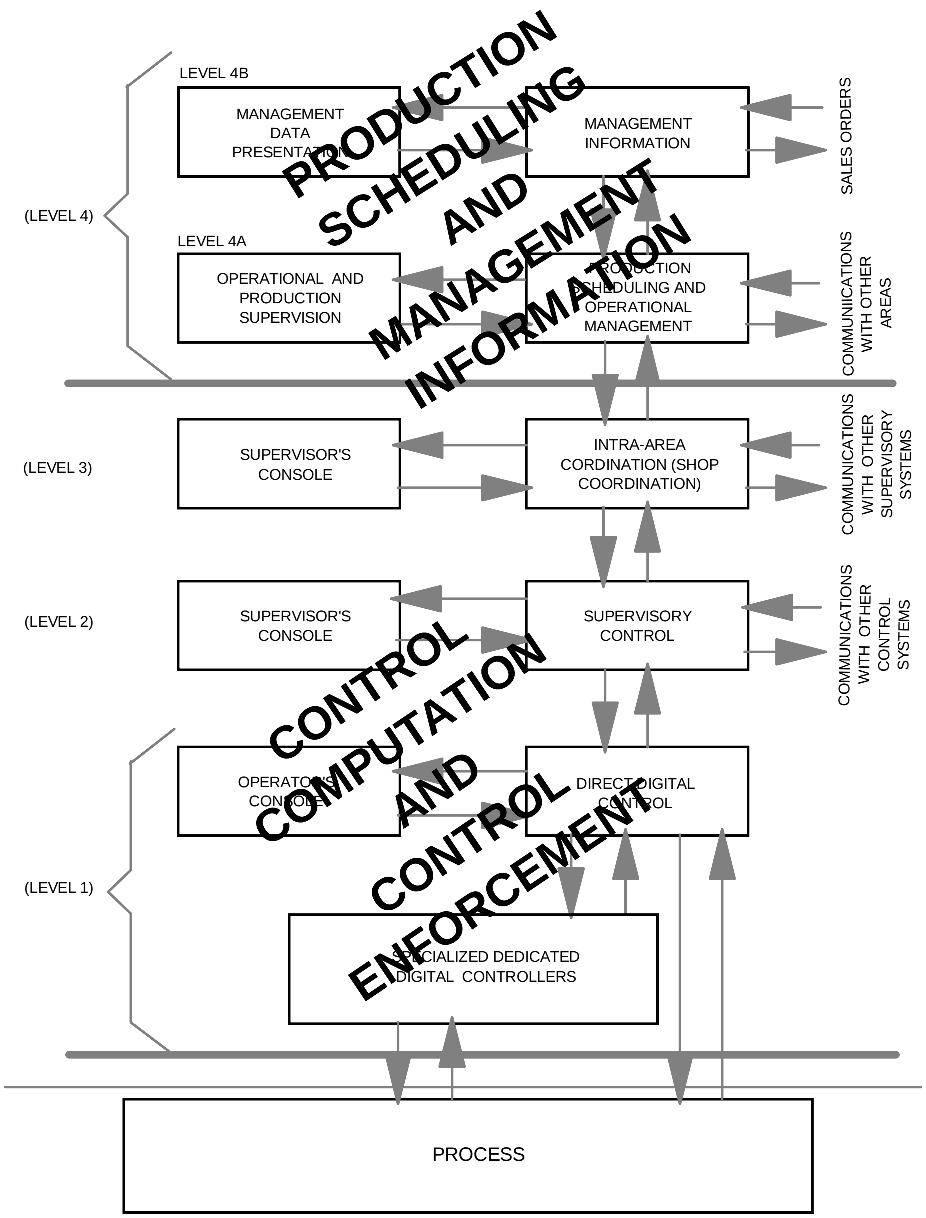


FIGURE AI-19 DEFINITION OF THE REAL TASKS OF THE HIERARCHICAL COMPUTER CONTROL SYSTEM

TABLE AI-V

POTENTIAL FACTORS FOR FACILITATING INTEGRATED CONTROL SYSTEM DEVELOPMENT AND USE

1. Potential commonality of control system structure in terms of the:
   - A. Computer systems,
   - B. Communications systems,
   - C. Database organization,
   - D. Relationship to plant management and operational structure (personnel).

2. Commonality of the techniques of application of:
   - A. Software engineering and programming,
   - B. Communications
   - C. Database management,
   - D. Control systems engineering
   - E. Production scheduling
   - F. Operations research and optimization

TABLE AI-VI

DUTIES AND TASKS OF THE COMPANY MANAGEMENT INFORMATION SYSTEM (LEVEL 4B OF FIGURE AI-1 OR 2 OR LEVEL 5 OF FIGURE AI-3)

I. **N/A**

II. **N/A**

III. **Plant Coordination and Reporting**

1. Maintain interfaces with:
- A) Plant and company management
- B) Sales and shipping personnel
- C) Accounting, personnel and purchasing departments
- D) Production scheduling level (Level 4A)

2. Supply production and status information as needed to:
- A) Plant and company management
- B) Sales and shipping personnel
- C) Accounting, personnel and purchasing departments
- D) This information will be supplied in the form of:
  - 1) Regular production and status reports
  - 2) On-line inquiries

3. Supply order status information as needed to sales personnel

IV. **Reliability Assurance**

4. Perform self-check and diagnostic checks on itself

Note 1 There are no Production Scheduling (Numeral I) or Control actions (Numeral II) required at this level. This level is solely for use as an upper management and staff level interface.

Note 2 Numerals of subdivisions (Duties) of Tables AI-VI to AI-X correspond to the same numerals of Duties listed in Table AI-IV.

TABLE AI-VII

DUTIES AND TASKS OF THE PRODUCTION SCHEDULING AND OPERATIONAL MANAGEMENT LEVEL (LEVELS 4A OR 5A)

I. Production Scheduling

1. Establish basic production schedule
2. Modify the production scheduling for all units per order stream received, energy constraints, power demand levels, and maintenance requirements.
3. In coordination with required production schedule develop optimum preventive maintenance and production unit renovation schedule.
4. Determine the optimum inventory levels of raw materials, energy sources, spare parts, etc., and of goods in process at each storage point. The criteria to be used will be the trade-off between customer service (i.e., short delivery time) versus the capital cost of the inventory itself, as well as the trade-offs in operating costs versus costs of carrying the inventory level. This function will also include the necessary material requirements planning (MRP) and spare parts procurement to satisfy the production schedule planned. (This is an off-line function.)
5. Modify production schedule as necessary whenever major production interruptions occur in downstream units, where such interruptions will affect prior or succeeding units.

II. N/A

III. Plant Coordination and Operational Data Reporting

6. Collect and maintain raw material and spare parts use and available inventory and provide data for purchasing for raw material and spare parts order entry and for transfer to accounting.
7. Collect and maintain overall energy use and available inventory and provide data for purchasing for energy source order entry and for transfer to accounting.
8. Collect and maintain overall goods in process and production inventory files.
9. Collect and maintain the quality control file.
10. Collect and maintain machinery and equipment use and life history files necessary for preventive and predictive maintenance planning.
11. Collect and maintain manpower use data for transmittal to personnel and accounting departments.

12. Maintain interfaces with management interface level function and with area level systems.

IV. System Reliability & Availability Assurance

13. Run self-check and diagnostic routines on self and lower level machines.

Note: There are no control functions (Numeral II) required at this level. This level is for the production scheduling and overall plant data functions.

TABLE AI-VIII

DUTIES AND TASKS OF THE AREA LEVEL (LEVEL 3)

I. Production Scheduling

1. Establish the immediate production schedule for its own area including maintenance, transportation and other production related needs.
2. Locally optimize the costs for its individual production area while carrying out the production schedule established by the production control computer system (Level 4A) (i.e., minimize energy usage or maximize production for example).
3. Along with Level 4A modify production schedules to compensate for plant production interruptions which may occur in its area of responsibility.

II. N/A

III. System Coordination and Operational Data Reporting

4. Make area production reports including variable manufacturing costs.
5. Use and maintain area practice files
6. Collect and maintain area data queues for production, inventory, and manpower, raw materials, spare parts and energy usage.
7. Maintain communications with higher and lower levels of the hierarchy.
8. Operations data collection and off-line analysis as required by engineering functions including statistical quality analysis and control functions.
9. Service the man/machine interface for the area.
10. Carry out needed personnel functions such as:
    - A) Work period statistics (time, task, etc.)
    - B) Vacation schedule
    - C) Work force schedules
    - D) Union line of progression
    - E) In-house training and personnel qualification

IV. Reliability Assurance

11. Diagnostics of self and lower level functions

Note: No control actions (Numeral II) are required here. This level handles detailed production scheduling and area coordination for the major plant subdivisions.

TABLE AI-IX

DUTIES AND TASKS OF THE SUPERVISORY LEVEL (LEVEL 2)

I. N/A

II. Control Enforcement

1. Respond to any emergency condition that may exist in its region of plant cognizance.
2. Optimize the operation of units under its control within limits of established production schedule. Carry out all established process operational schemes or operating practices in connection with these processes.

III. System Coordination and Operational Data Reporting

3. Collect and maintain data queues of production, inventory, and raw material, spare parts and energy usage for the units under its control.
4. Maintain communications with higher and lower levels
5. Service the man/machine interfaces for the units involved

IV. Reliability Assurance

6. Perform diagnostics on itself and lower level machines
7. Update all standby systems

Note: This level and those below it carry out the necessary control and optimization functions for the individual production units to enforce the production schedule set by Levels 4A and 3.

Note: There are no Production Scheduling actions (Numeral I) required at this level.

TABLE AI-X

DUTIES OF THE CONTROL LEVEL (LEVEL 1)

I. N/A

II. Control Enforcement

1. Maintain direct control of the plant units under its cognizance.
2. Detect and respond to any emergency condition that may exist in these plant units.

III. System Coordination and Reporting

3. Collect information on unit production, raw material and energy use and transmit to higher levels.
4. Service the operator's man/machine interface.

IV. Reliability Assurance

5. Perform diagnostics on itself
6. Update any standby systems

Notes: It has repeatedly been shown that one of the major benefits of the use of digital computer control systems in the automation of industrial plants has been in the role of a Control Systems Enforcer. In this mode, one of the control computer's main tasks is to continually assure that the control system equipment is actually carrying out the job that it was designed to do in keeping the units of the plant production system operating at some best (near optimal) level.

That is, to be sure that in the continuous process plant, for instance, the controllers have not been set on manual, that the optimal set points are being maintained, etc. Likewise, it is the task of dynamic control to assure that the plant's production schedule is carried out, i.e., to enforce the task set by the production scheduling function.

In the Purdue Reference Model definition there are no Informational Transformations at Level 0.

a) Sensors determine the state of the physical equipment or the material being transformed therein. All operations on the resulting data are informational. Sensor outputs are considered part of Level 1. Examples only of Level 1 control requirements are shown in Figures AI-6, 8, 9 and 10. There would be similar dynamic control systems required for each Level 2 unit.

b) Actuators are considered part of Level 0 - commands to them are considered as Level 1.

Summary of Duties and Tasks for Each of the Levels of the Hierarchy

In the context of any large industrial plant, or of a complete industrial company based in one location, the tasks that would be carried out at each level of the hierarchy are as described in Tables AI-VI to AI-X. Note that these tasks are subdivided within each table into those related to production scheduling, control enforcement, systems coordination and reporting, and reliability assurance (Table AI-IV). As was mentioned above, these tables outline the tasks which must be carried out in any industrial plant, particularly at the upper levels of the hierarchy.

Figures AI-20 to AI-26 present another form of the same information as presented in the tables listed just above to show the relationships and the interaction of the tasks given. Figures AI-27 to AI-32 show the application of the Scheduling and Hierarchy View to a variety of industries showing also that the computer control system discussed here is pyramidal as well as hierarchical. Figure AI-32 is an entirely different appearing diagram as originally developed by the Cincinnati-Milacron Company [81]. However with the current CIM hierarchy levels imposed it can be readily seen that this diagram converts directly to the others.

Figures AI-27 to AI-32 also bring out an important aspect of this model in relation to those proposed by some other developers, that is, inventories and associated material handling equipment in relation to the manufacturing processes themselves are treated just like any other process. Thus they are considered to have process control inputs and outputs and their dynamic behavior can be modeled mathematically in order to develop the appropriate overall control system for the functions served by the inventory and its associated material handling equipment.

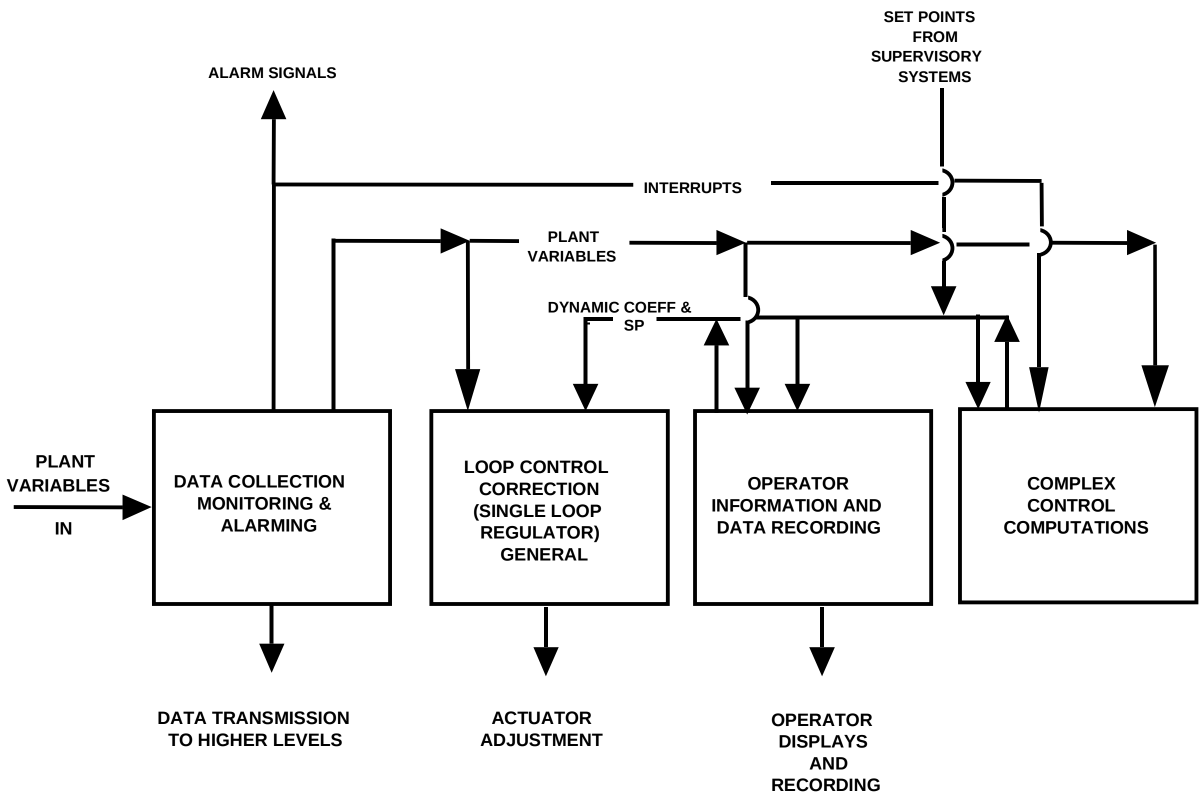


FIGURE AI-20 A BLOCK DIAGRAM OF A GENERALIZED PRIMARY LEVEL (LEVEL 1) CONTROL SYSTEM

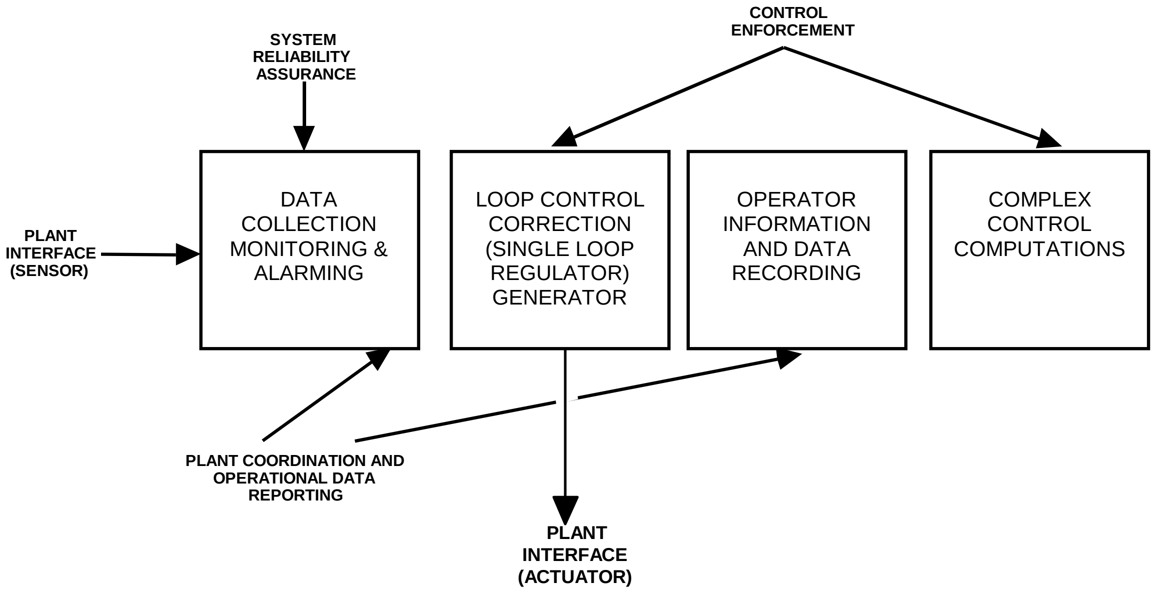


FIGURE AI-21 EXPLANATION OF THE TASKS OF HIERARCHICAL LEVEL 1 VERSUS MATERIAL OF TABLES AI-IV, AI-VI - AI-X AND FIGURE AI-19

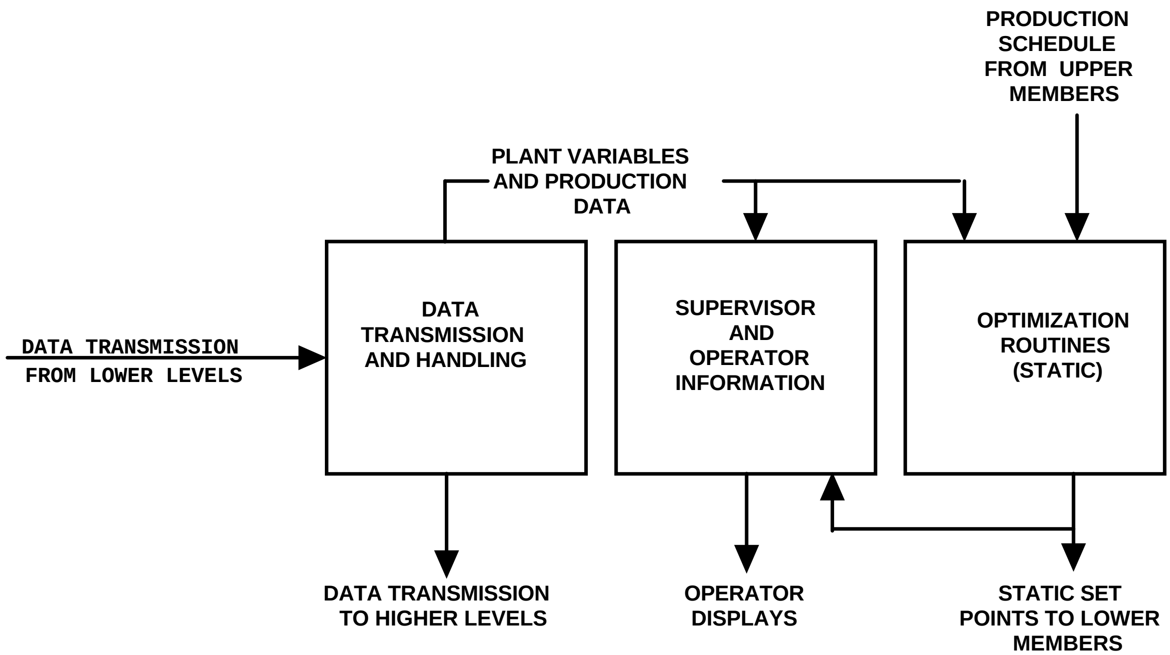


FIGURE AI-22 A BLOCK DIAGRAM OF THE SUPERVISORY CONTROL LEVEL (LEVEL 2) OF AN OVERALL PROCESS CONTROL SYSTEM

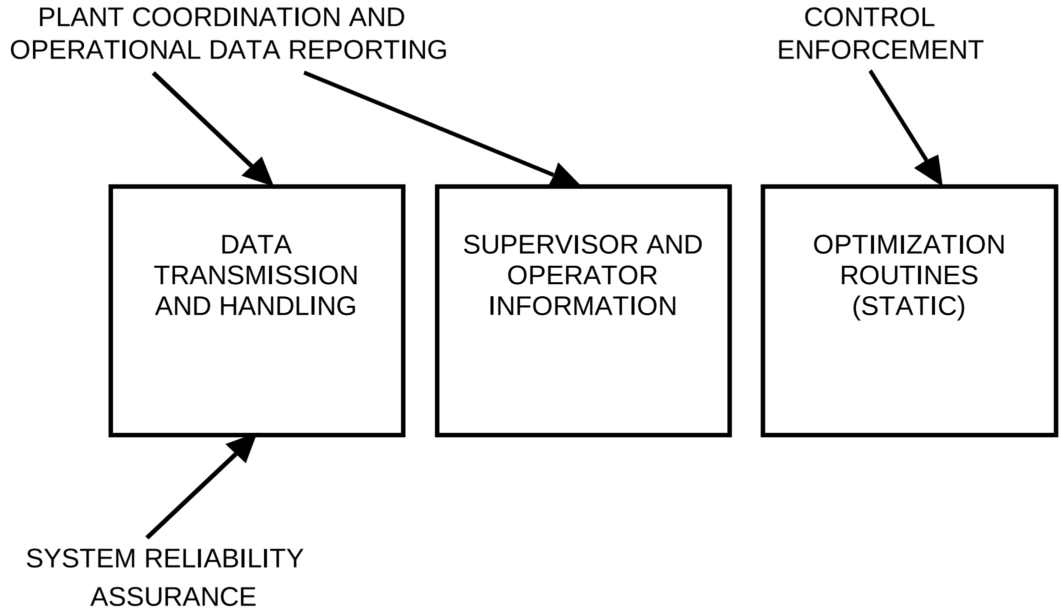


FIGURE AI-23 EXPLANATION OF THE TASKS OF HIERARCHICAL LEVEL TWO VERSUS MATERIAL OF TABLES AI-IV AI-VI - AI-X AND

FIGURE AI-19

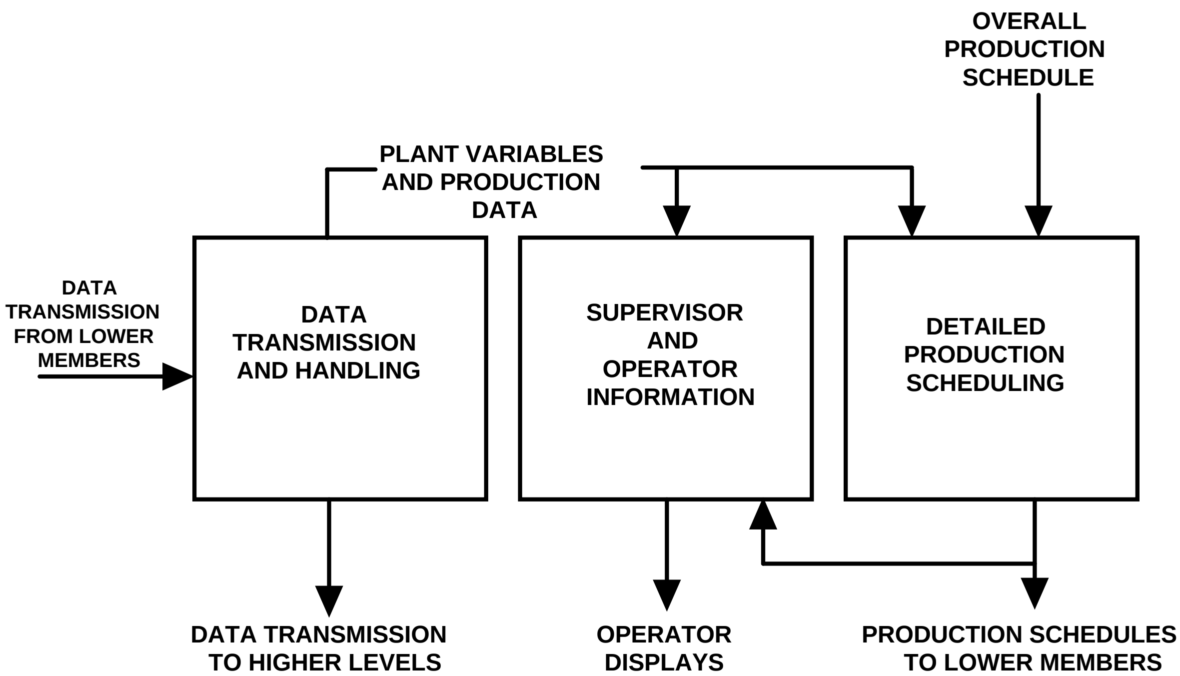


FIGURE AI-24 A BLOCK DIAGRAM OF THE INTERMEDIATE PRODUCTION SCHEDULING LEVEL (LEVEL 3) OF AN OVERALL PROCESS CONTROL SYSTEM

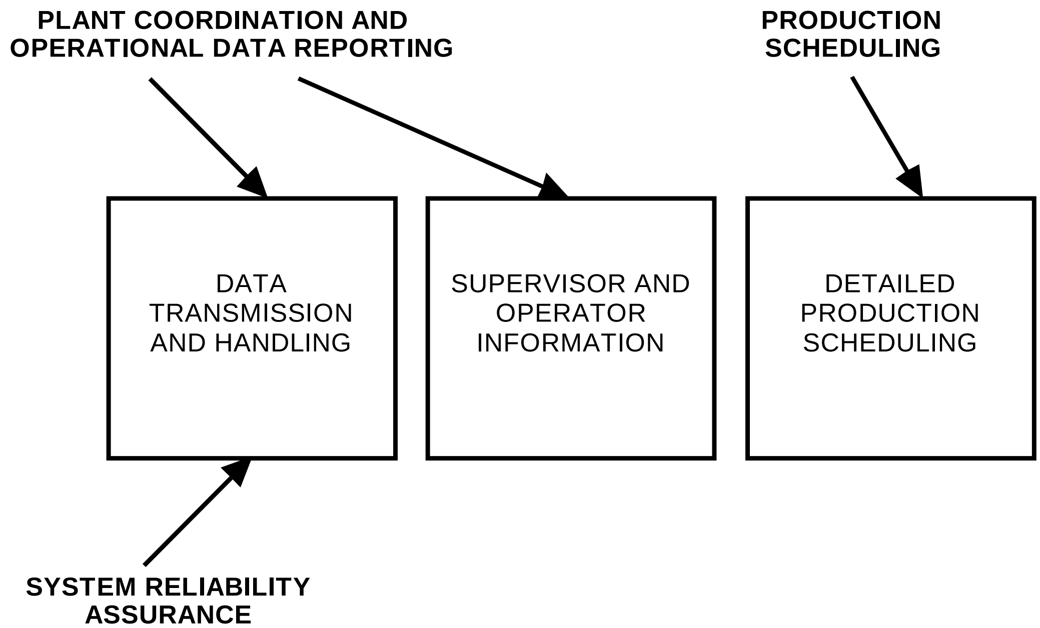


FIGURE AI-25 EXPLANATION OF THE TASKS OF HIERARCHICAL LEVELS THREE AND FOUR VERSUS MATERIAL OF TABLES AI-IV, AI-VI - AI-X AND FIGURE AI-19

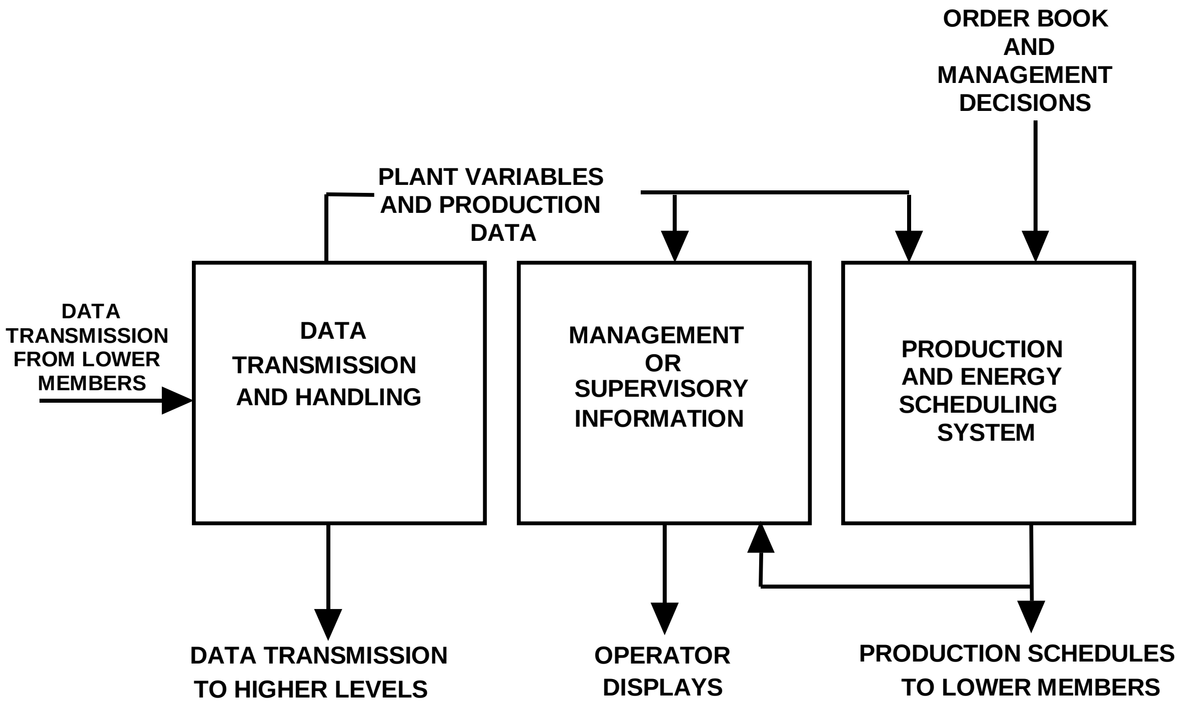


FIGURE AI-26 A BLOCK DIAGRAM OF THE PRODUCTION SCHEDULING LEVEL (LEVEL 4A) OF AN OVERALL PROCESS CONTROL SYSTEM

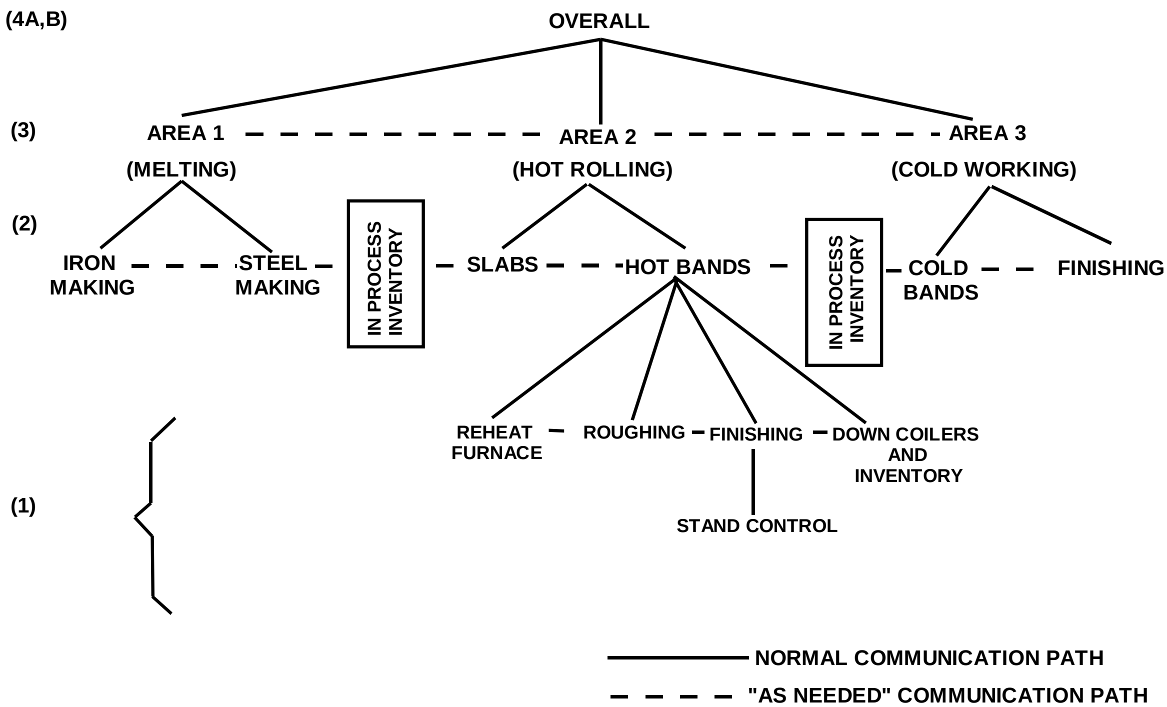


FIGURE AI-27 HIERARCHY ARRANGEMENT OF THE STEEL PLANT CONTROL TO SHOW RELATIONSHIP OF HIERARCHY TO PLANT STRUCTURE

APPENDIX I – Generic Macro-Functions – Data Flows

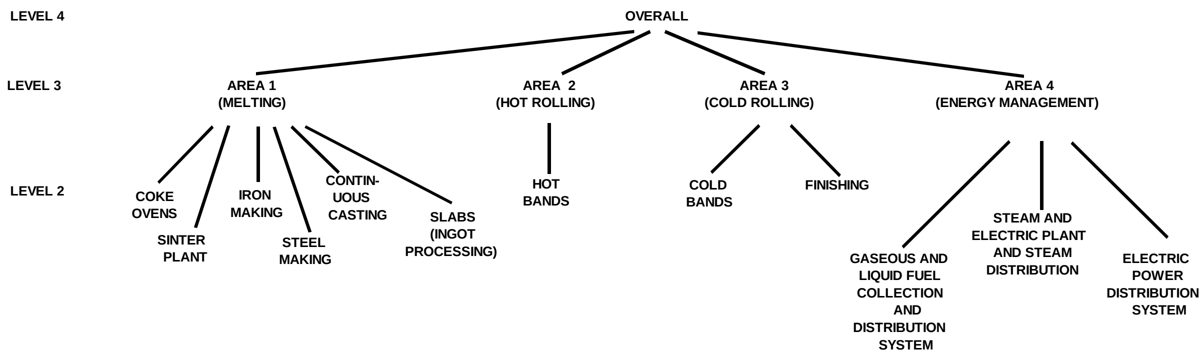


FIGURE AI-28 HIERARCHY ARRANGEMENT OF THE STEEL PLANT CONTROL SYSTEM AS STUDIED FOR ENERGY OPTIMIZATION

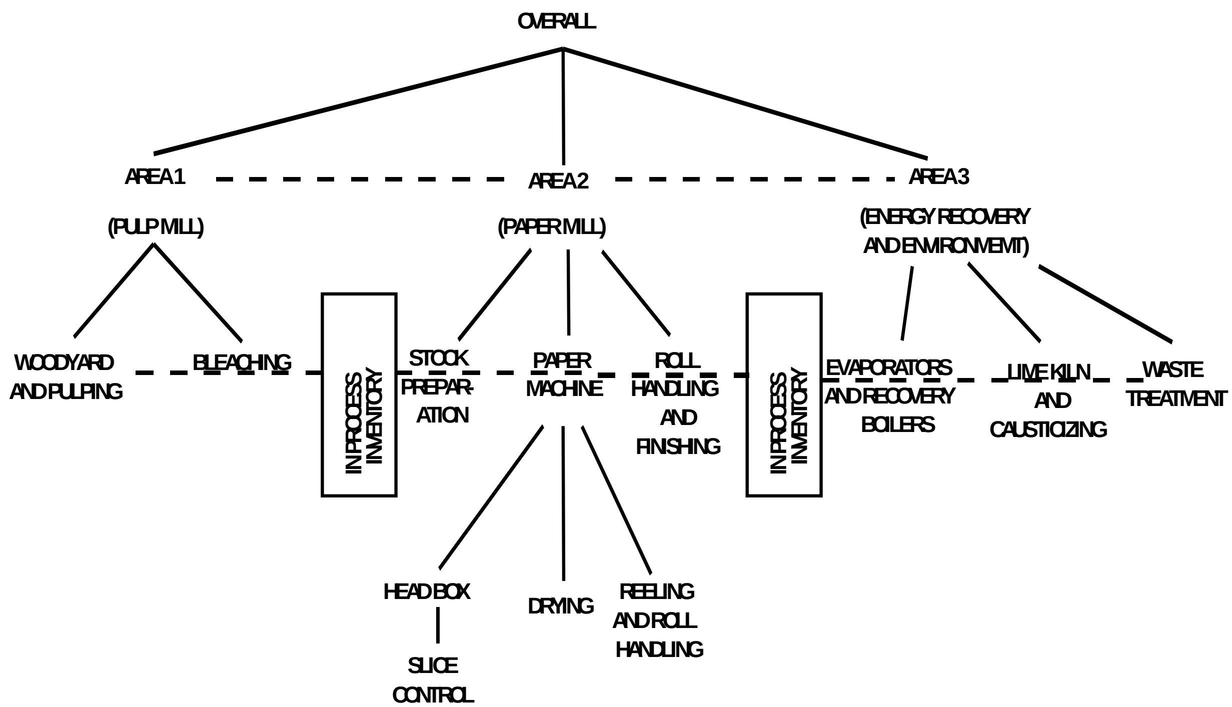


FIGURE AI-29 HIERARCHY ARRANGEMENT OF THE PAPER MILL CONTROL TO SHOW RELATIONSHIP OF HIERARCHY TO PLANT STRUCTURE

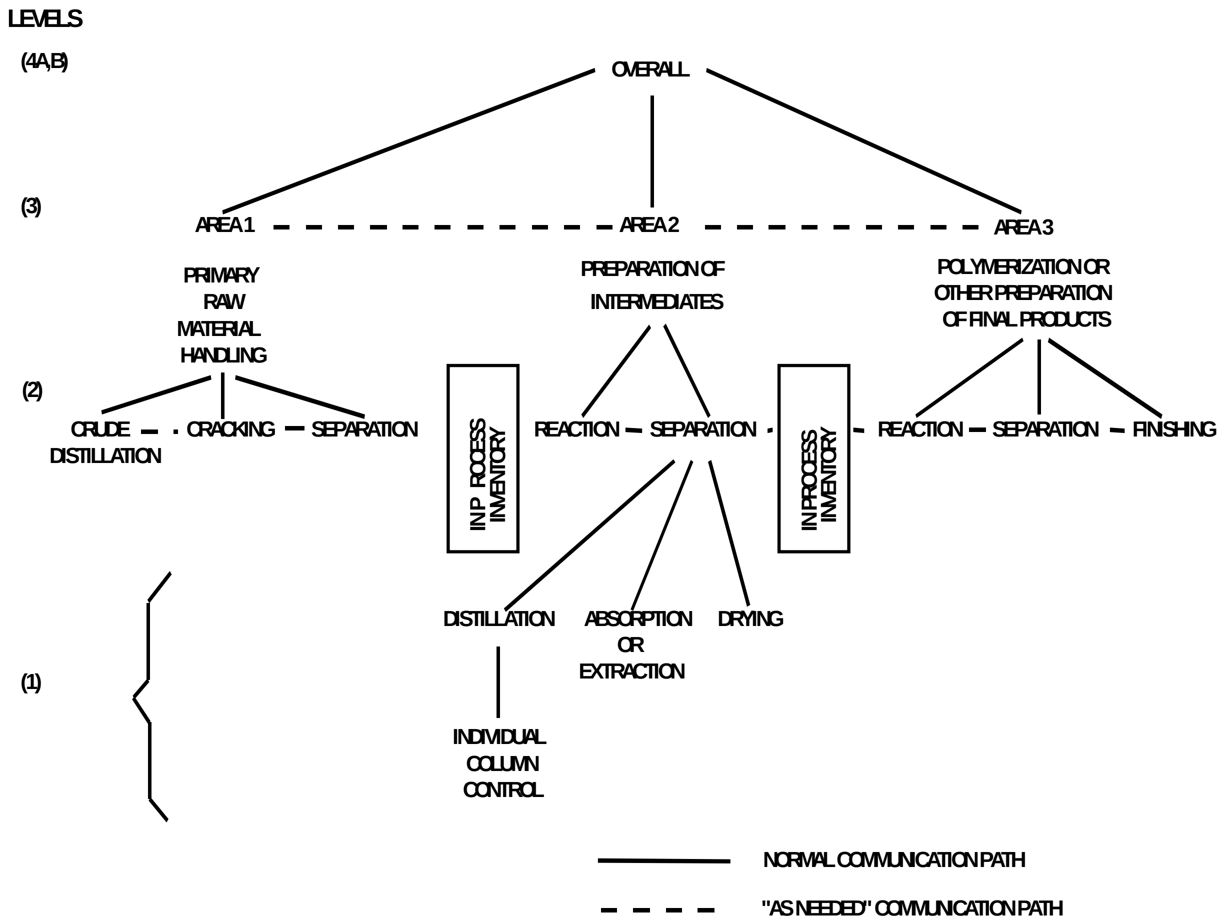


FIGURE AI-30 THE HIERARCHY CONTROL SCHEME AS APPLIED TO A PETROCHEMICAL PLANT

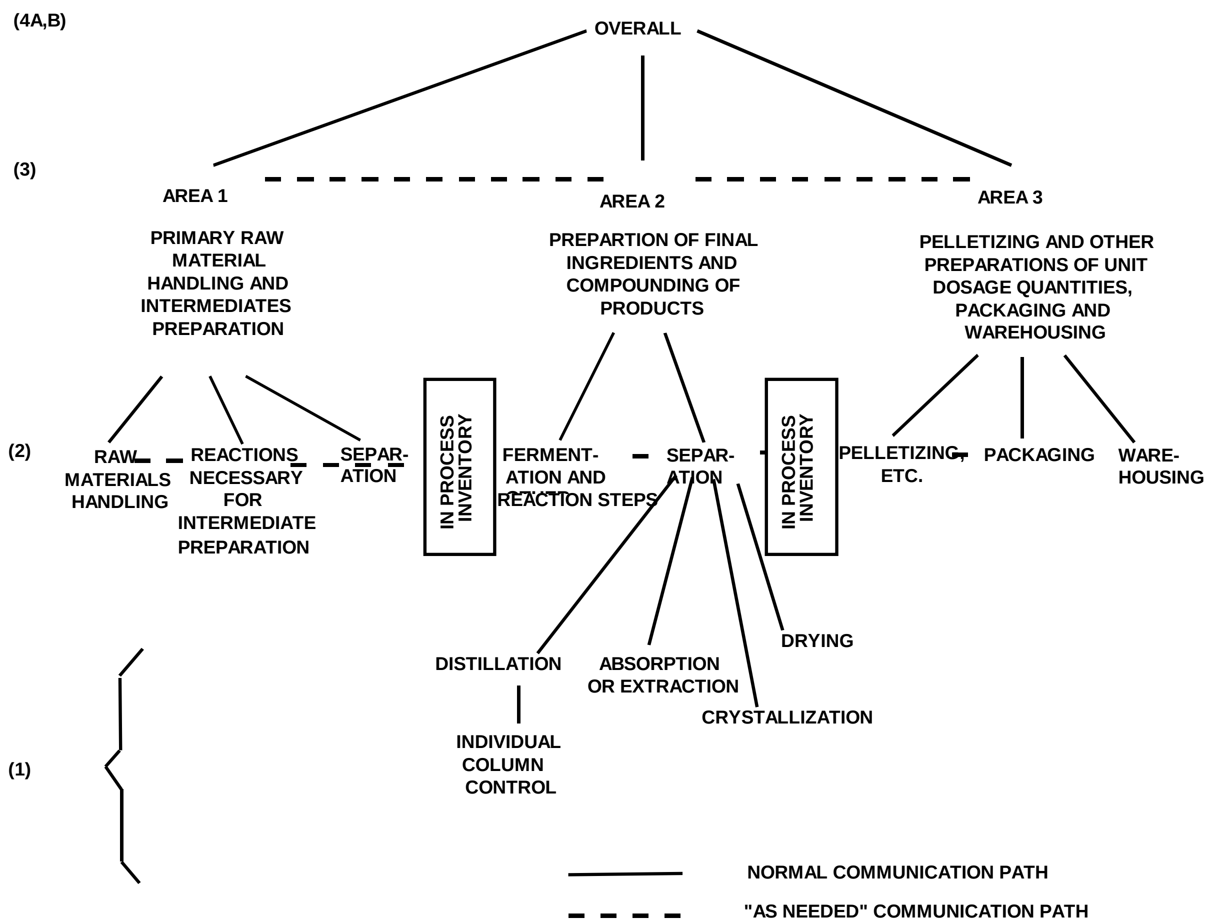


FIGURE AI-31 THE HIERARCHY CONTROL SCHEME AS APPLIED TO A PHARMACEUTICALS PLANT

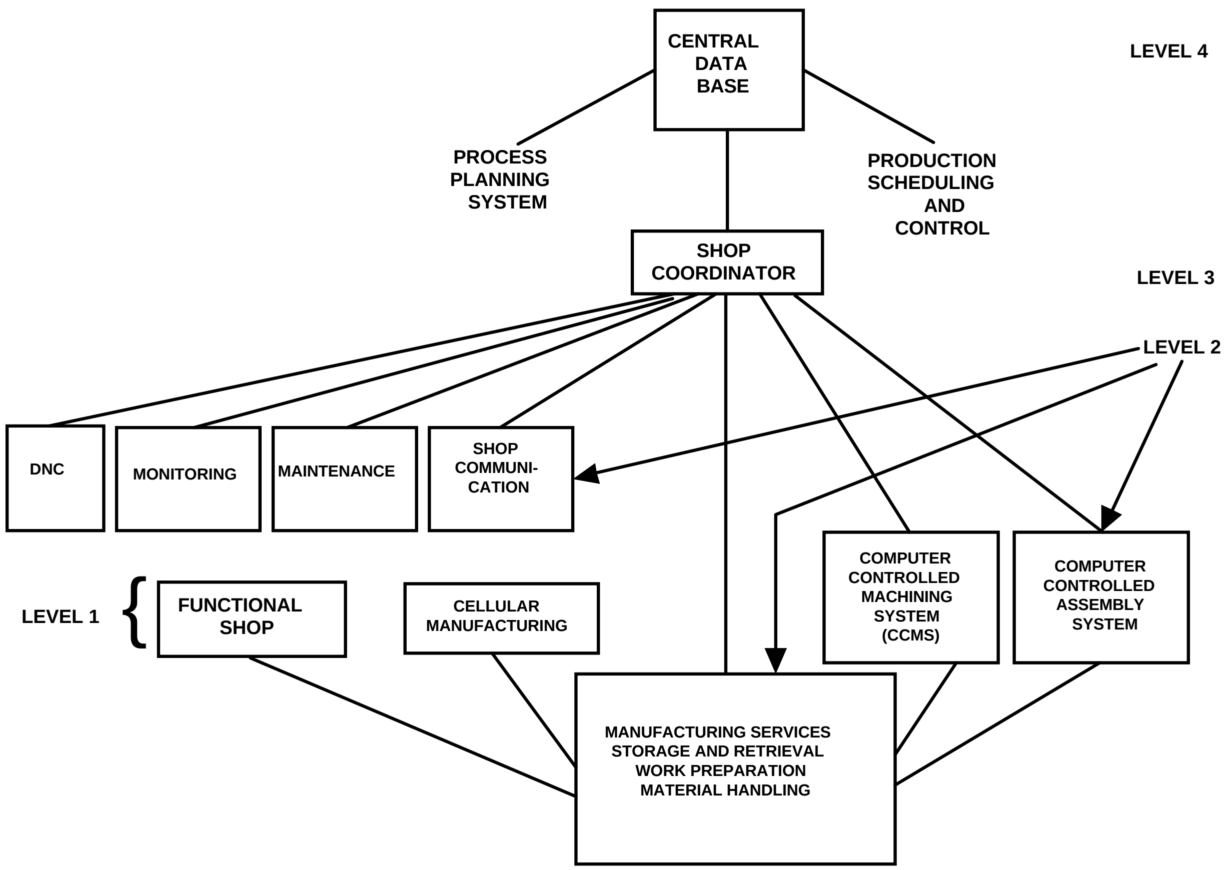


FIGURE AI-32 COMPUTER INTEGRATED MANUFACTURING SYSTEM (CIMS) (CINCINNATI-MILICRON PROPOSAL)

APPENDIX I – Generic Macro-Functions – Data Flows

The Data Flow Graph – A Functional Network View of the CIM Reference Model

There is need in the Reference Architecture to have a mechanism to show the interconnection and precedence of the several tasks assigned to the overall mill-wide control system which is not shown by the Scheduling and Control Hierarchy view. An excellent method for showing this is the so-called Data-Flow Graph or Information-Flow Graph using a technique known as Structured Analysis [28], also known as the Yourdon-DeMarco technique.

This section will develop such a representation as derived from the CIM Reference Model. The basis for this work will be a Data-Flow Model entitled, Information Flow Model of Generic Production Facility, contributed to the Purdue Reference Model for CIM project by The Foxboro Company in August 1986 [9]. The original document has been considerably modified by the Workshop CIM Committee to match the nomenclature, etc., of other parts of the model's documentation.

As noted above this method diagrams the interconnection of the several tasks carried out by the control system and allows the potential for an ever greater detailing of these tasks in the form of sub-tasks and the resulting interconnections of these sub-tasks with each other and the main tasks. These diagrams are restricted to the model as defined in the Purdue Reference Model for CIM (i.e., the definable scheduling and control system for the manufacturing facility and including only interfaces to the external influences), i.e., the Integrated Information Management and Control System of Figure AI-33 and the Information Systems Architecture of this text.

The set of diagrams begins with the interconnection of the influencing external entities on the factory itself (Figure AI-34). In the present model one very important external influence on the factory is the company management itself. As noted in Figure AI-35 management interfaces through the staff departments who provide services to the factory itself or express management's policies in sets of requirements to be fulfilled by the factory.

It will be immediately noticed by the reader that the two lists of tasks and functions we are developing here look entirely different even though each is a complete listing within itself. This is because these two different models of the Information Architecture show different views of the task and function relationships. The Scheduling and Control Hierarchy shows subordination, precedence, time horizon and span of control, while the Data Flow Diagram shows connectivity and precedence. Since there is no layering in the Data Flow diagram (subordination) and no connectivity in the Scheduling and Control hierarchy, their views of the tasks and functions are quite different. This results in a different definition of each task in many cases particularly because of a difference in span of concern. Therefore the description and labels may be (and are) different between the two models.

Table AI-XI presents the functions and tasks listed on the diagrams of Figures AI-38 to AI-50. Table AI-XII makes a comparison of the tasks listed in Tables AI-VI to AI-X versus those on Figures AI-38 to AI-50 as discussed just above.

The readers attention is called at this point to Appendix V, A Glossary of Enterprise Integration Terms

APPENDIX I – Generic Macro-Functions – Data Flows

Some Inadequacies of the Data-Flow-Graph Model

Foundation functional entities (the common supporting functions generic to all applications) cannot be shown on the data flow diagram. That is, the data flow diagram mainly shows the interconnection of manufacturing-specific functional entities (those parts of the integrated information and control system which distinguish this plant from its fellows).

The data-flow graph will accommodate all functional entities which exhibit the principle of locality (i.e., their location in the plant is important in carrying out their function). Those which are diffuse (that can be located anywhere or everywhere) cannot be accommodated because of the number of lines involved. The principle of locality may be a virtual location for the functional entity (i.e., real or virtual consolidation of operations for the sake of the diagram).

Most foundation functional entities are diffuse, e.g., database, communications, management, etc. See the Purdue Reference Model for CIM [81] for a further discussion of this.

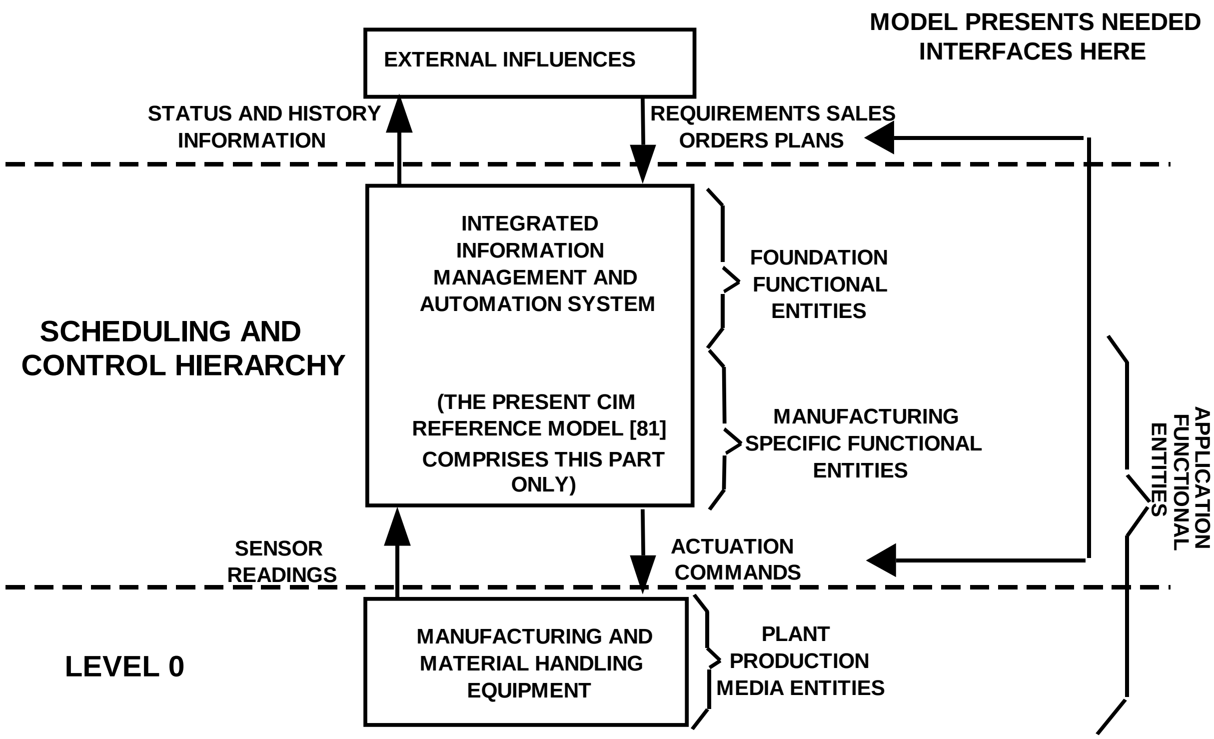


FIGURE AI-33 RELATIONSHIP OF THE SEVERAL CLASSES OF FUNCTIONAL ENTITIES WHICH COMPRISE THE CIM REFERENCE MODEL AND COMPUTER INTEGRATED MANUFACTURING ITSELF

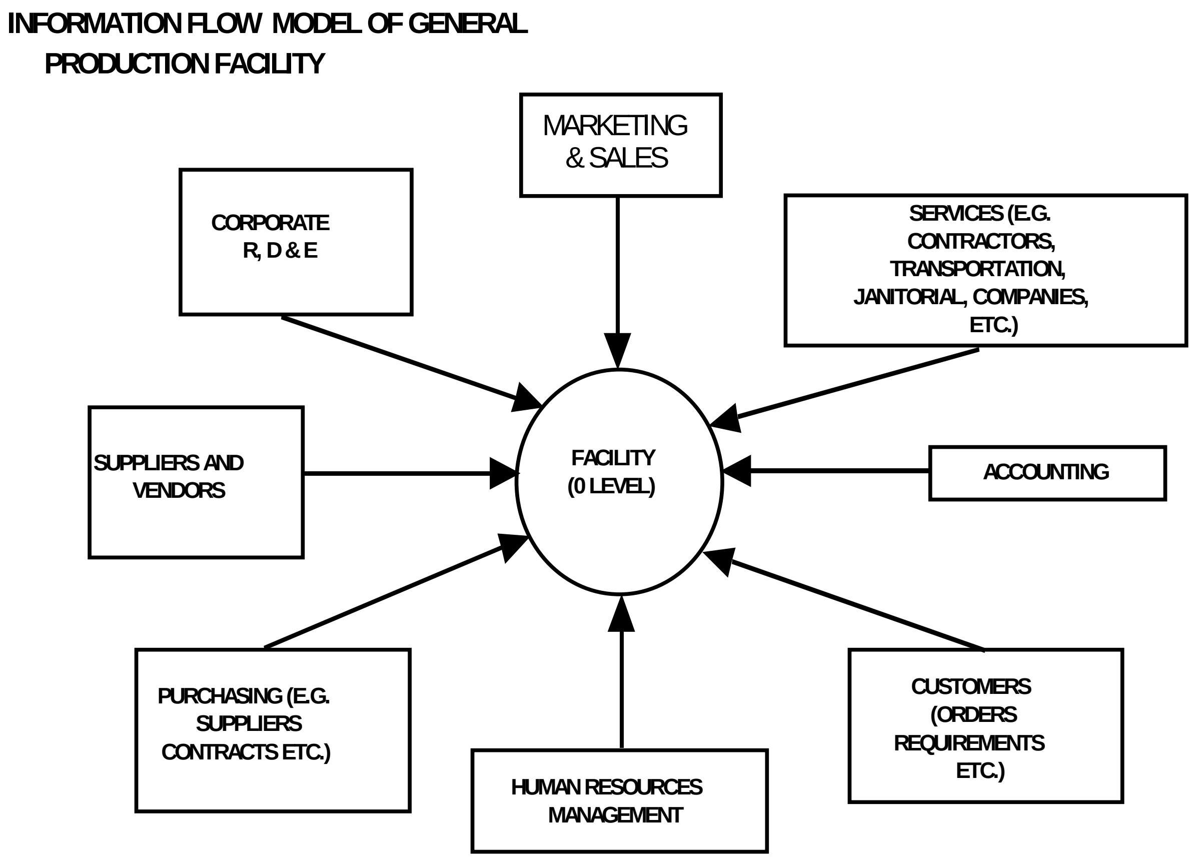


FIGURE AI-34 MAJOR EXTERNAL INFLUENCES AS USED IN THE DATA-FLOW MODEL

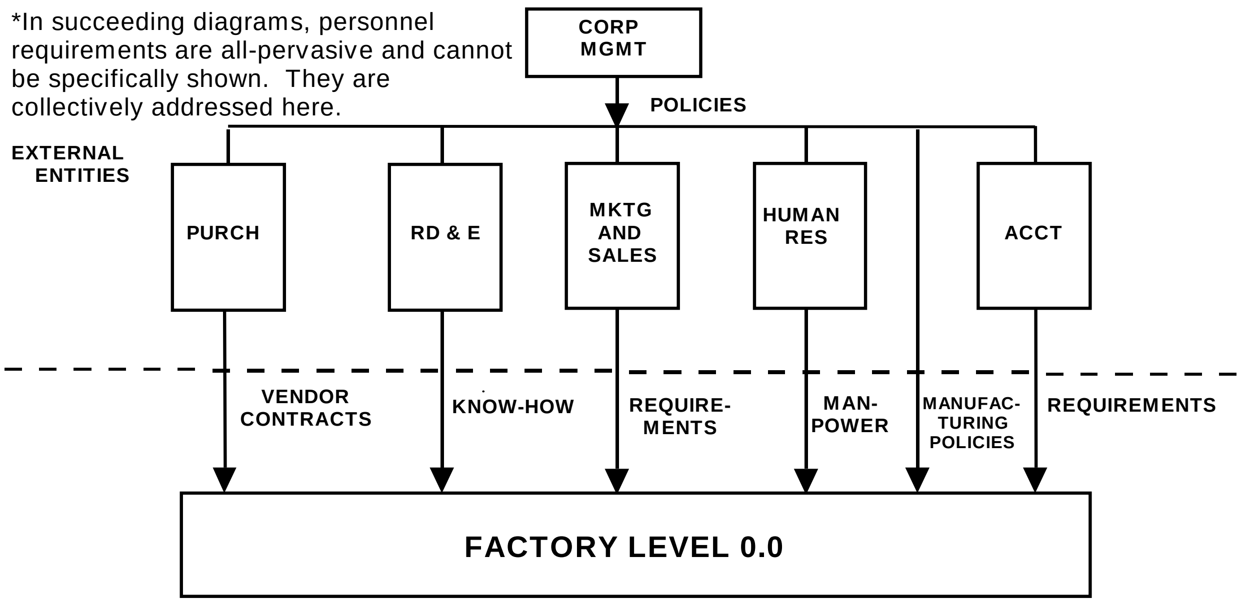


FIGURE AI-35 REQUIREMENTS INTERFACING OF CORPORATE MANAGEMENT AND STAFF FUNCTIONAL ENTITIES TO THE FACTORY

APPENDIX I – Generic Macro-Functions – Data Flows

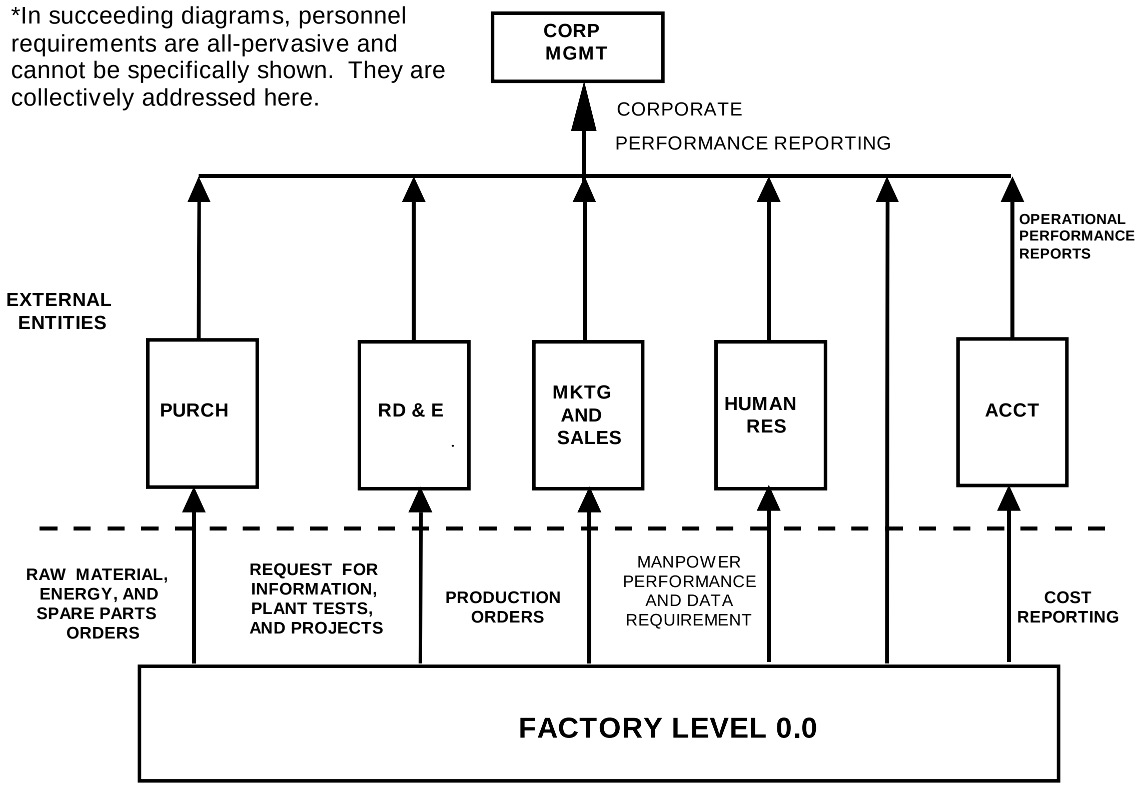


FIGURE AI-36 REPORT INTERFACING TO CORPORATE MANAGEMENT AND STAFF FUNCTIONAL ENTITIES FROM THE FACTORY

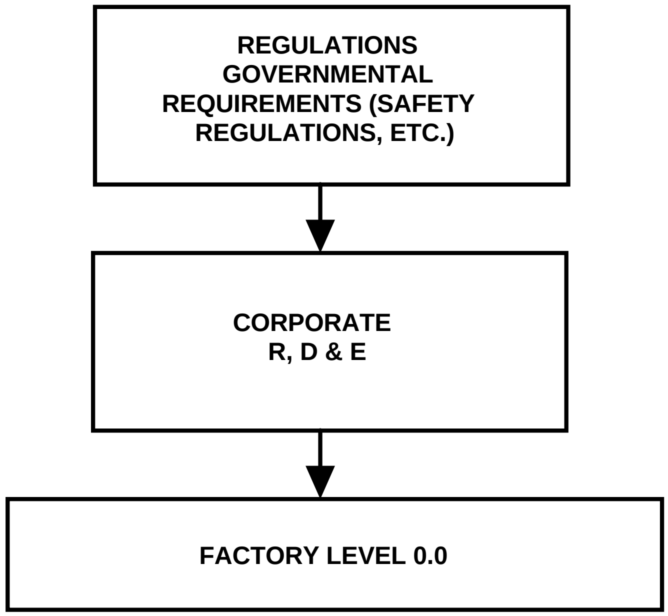


FIGURE AI-37 INTERFACE OF GOVERNMENT REGULATIONS, ETC., TO THE FACTORY

APPENDIX I – Generic Macro-Functions – Data Flows

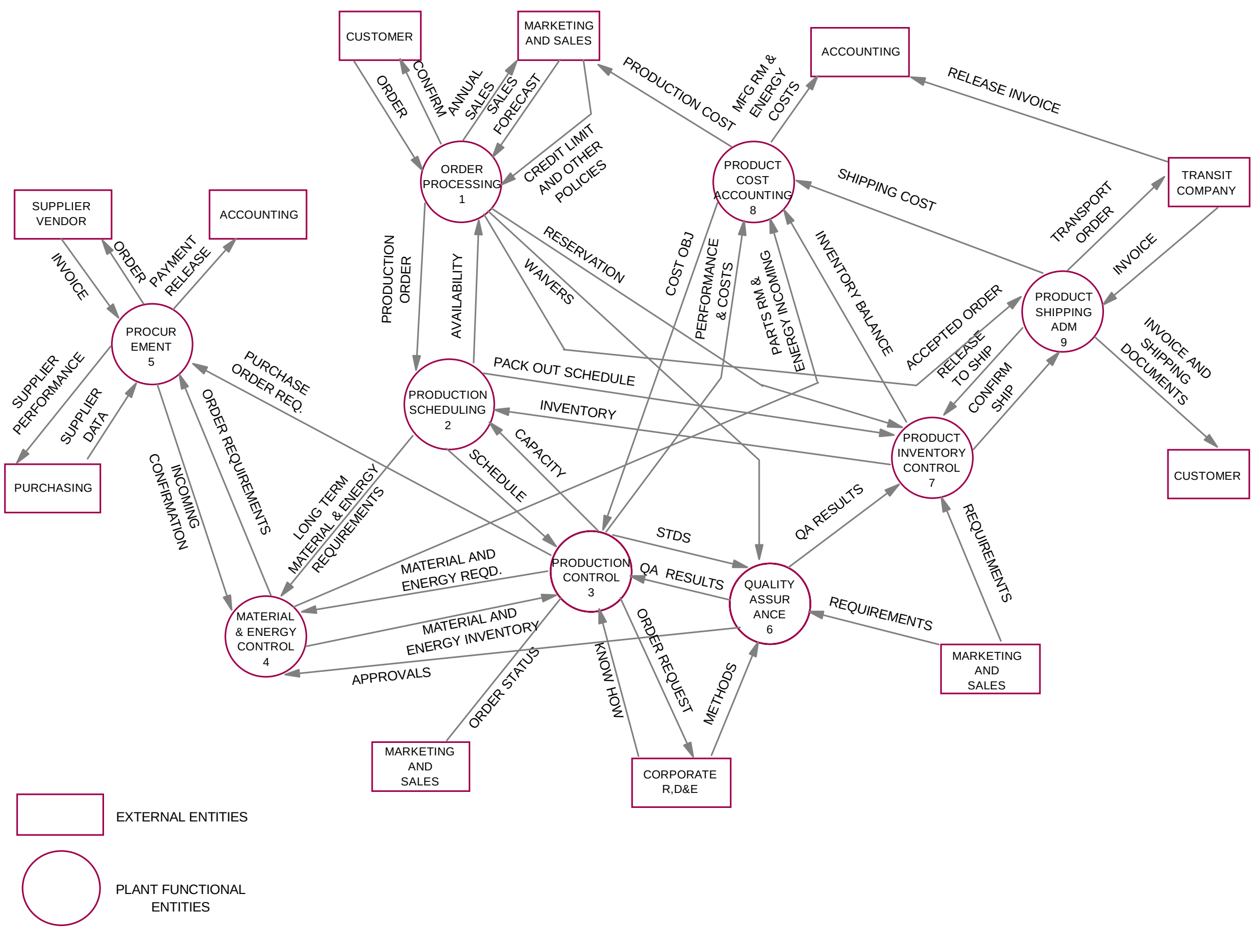


FIGURE AI-38 0.0 FACILITY MODEL

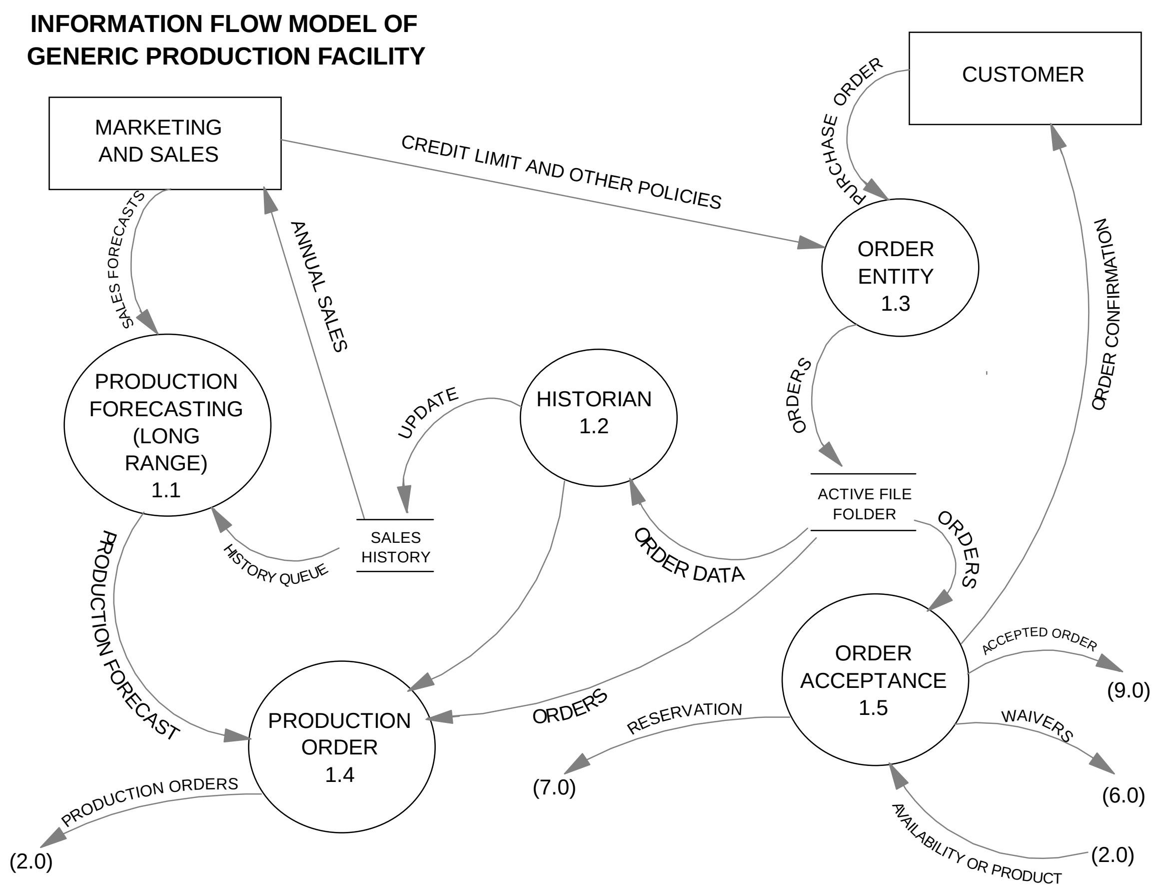


FIGURE AI-39 1.0 ORDER PROCESSING

APPENDIX I – Generic Macro-Functions – Data Flows

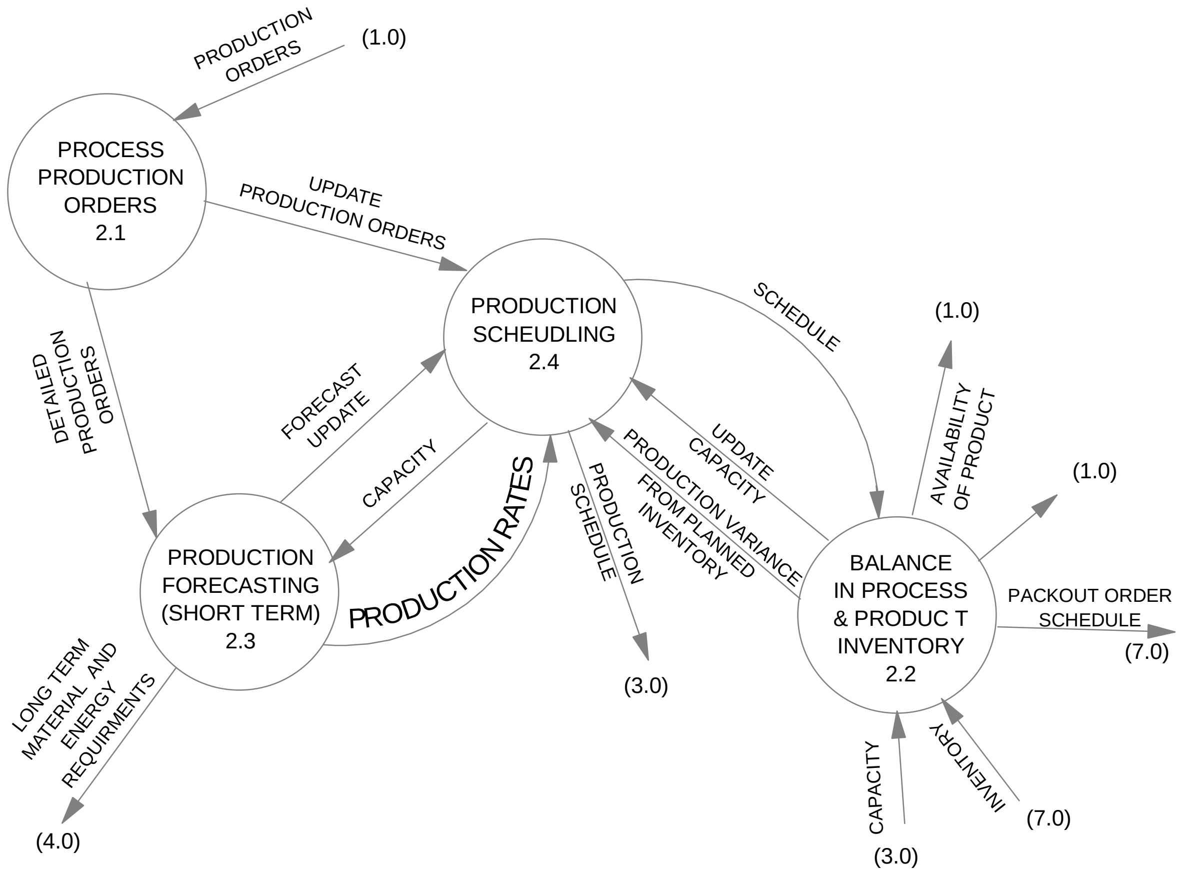


FIGURE AI-40 2.0 PRODUCTION SCHEDULING

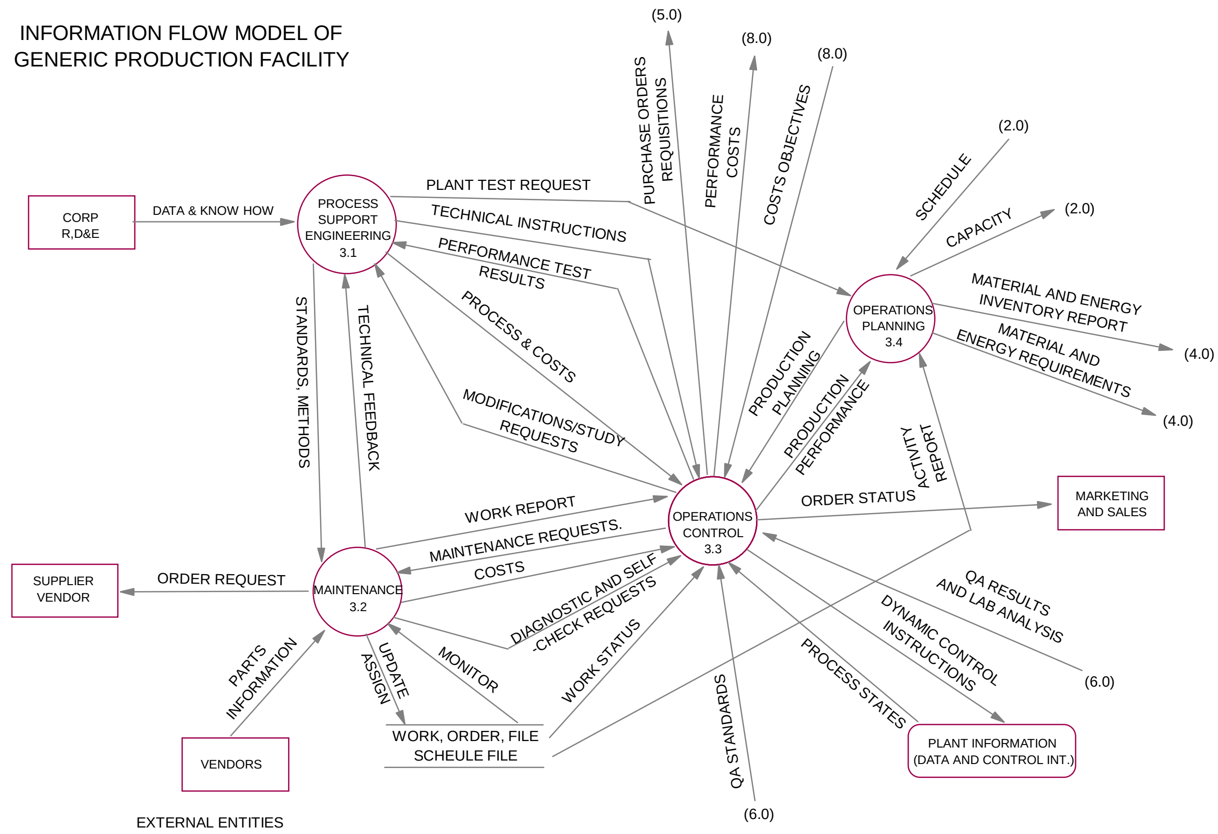


FIGURE AI-41 3.0 PRODUCTION CONTROL

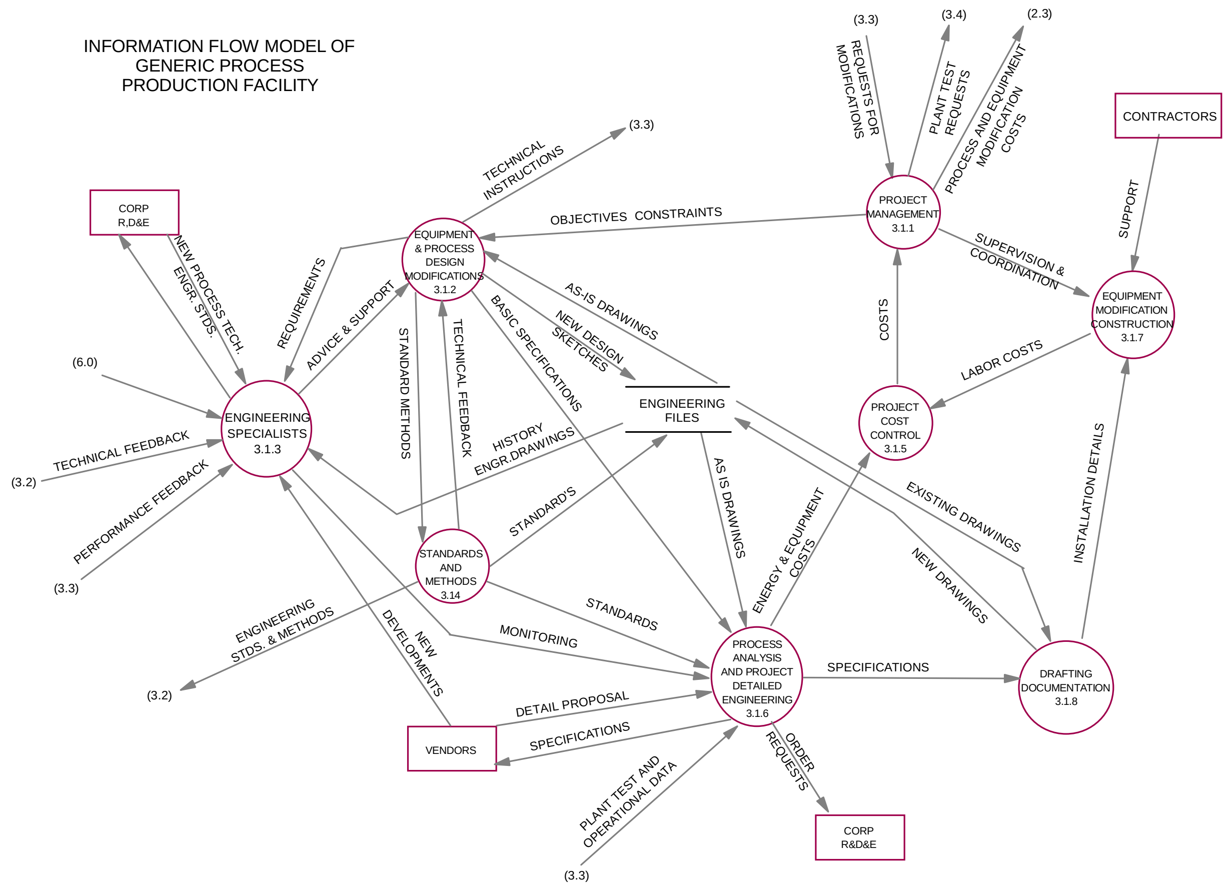


FIGURE AI-42 3.1 PROCESS SUPPORT ENGINEERING

APPENDIX I – Generic Macro-Functions – Data Flows

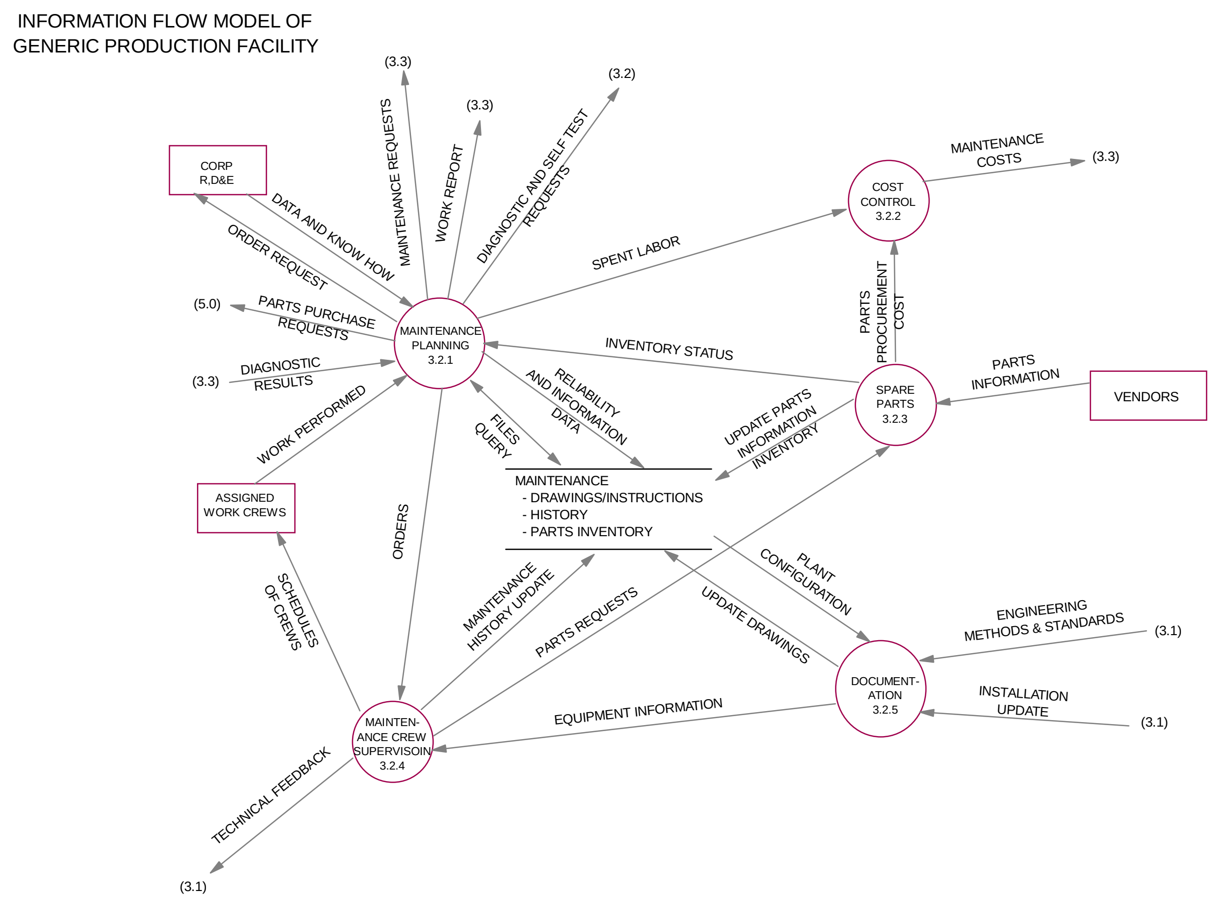


FIGURE AI-43 3.2 MAINTENANCE

APPENDIX I – Generic Macro-Functions – Data Flows

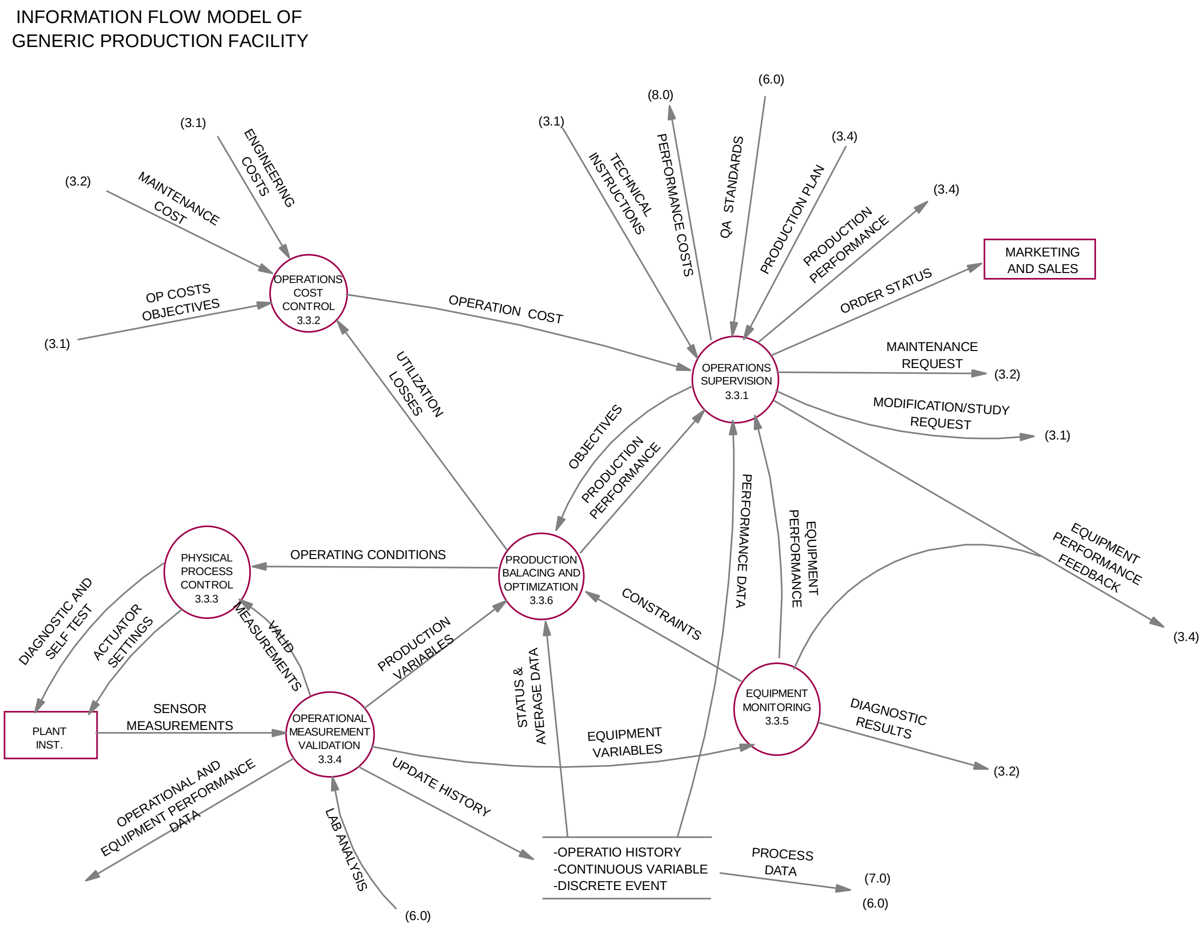


FIGURE AI-44 3.3 OPERATIONS CONTROL

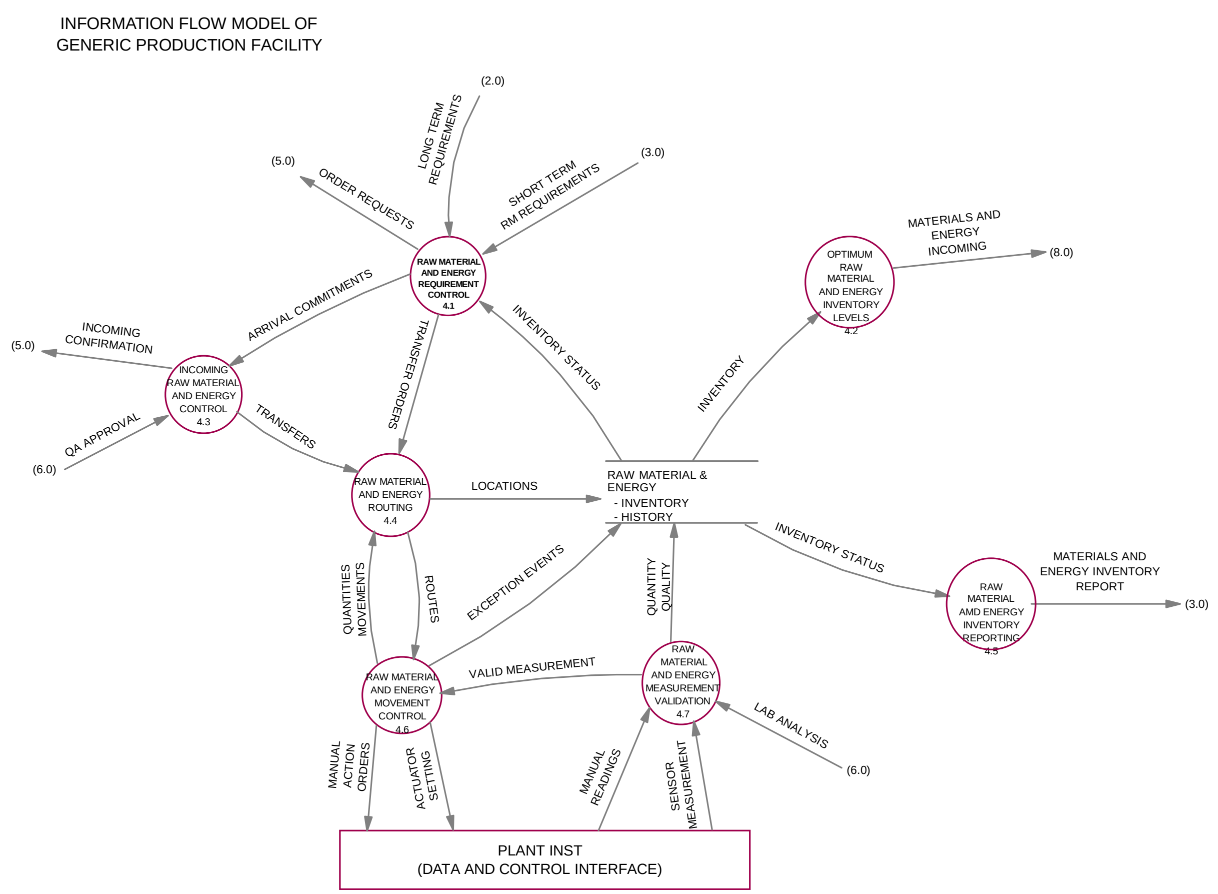


FIGURE AI-45 4.0 MATERIALS AND ENERGY CONTROL

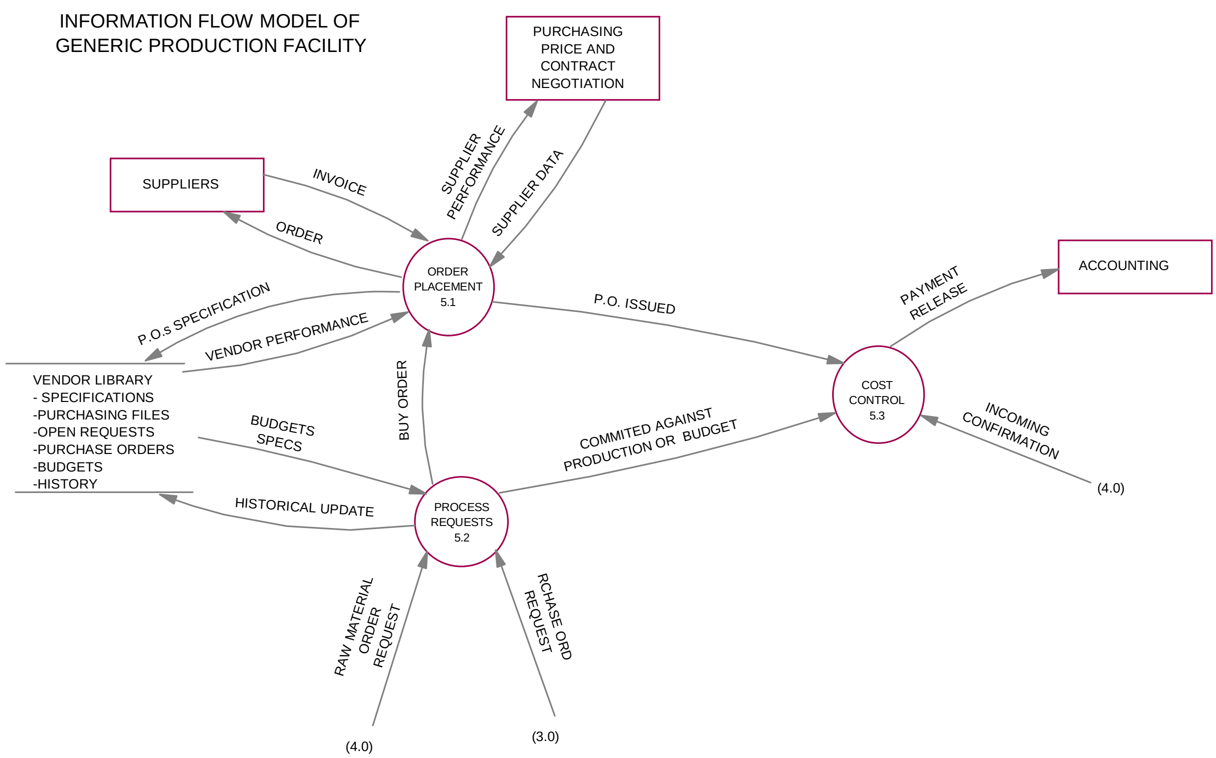


FIGURE AI-46 5.0 PROCUREMENT

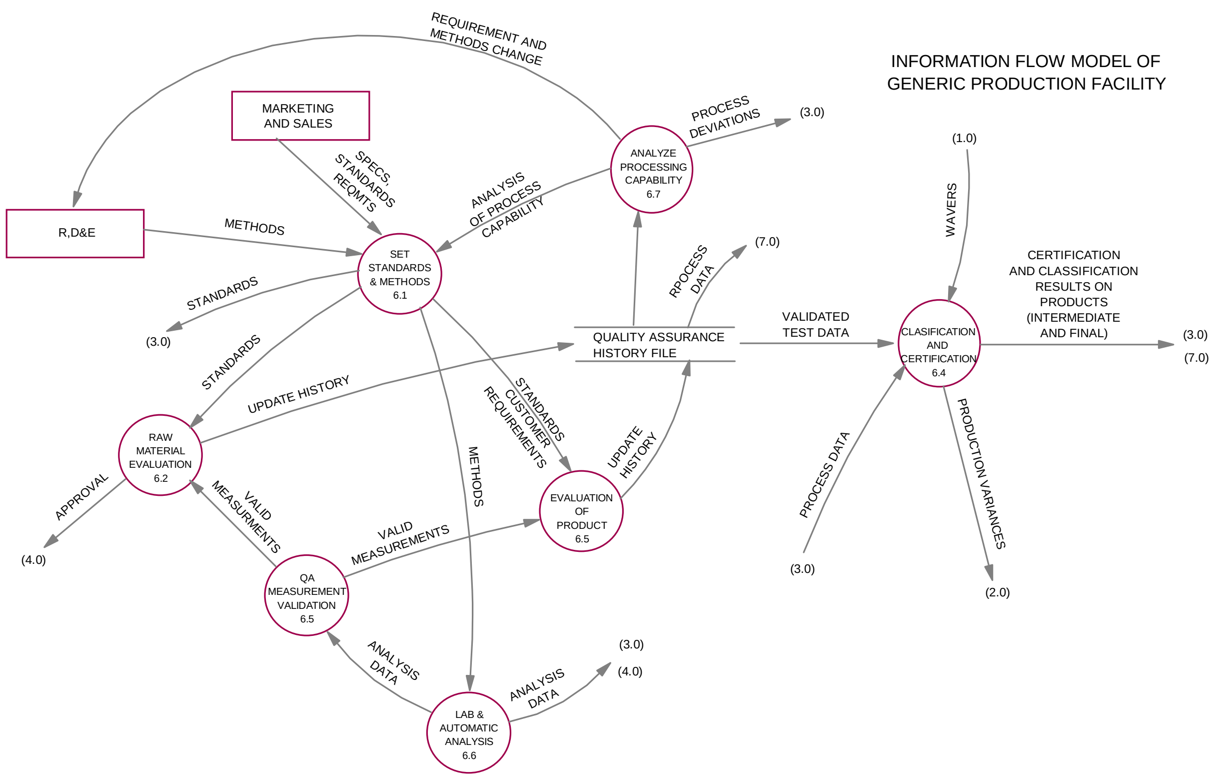


FIGURE AI-47 6.0 QUALITY ASSURANCE

APPENDIX I – Generic Macro-Functions – Data Flows

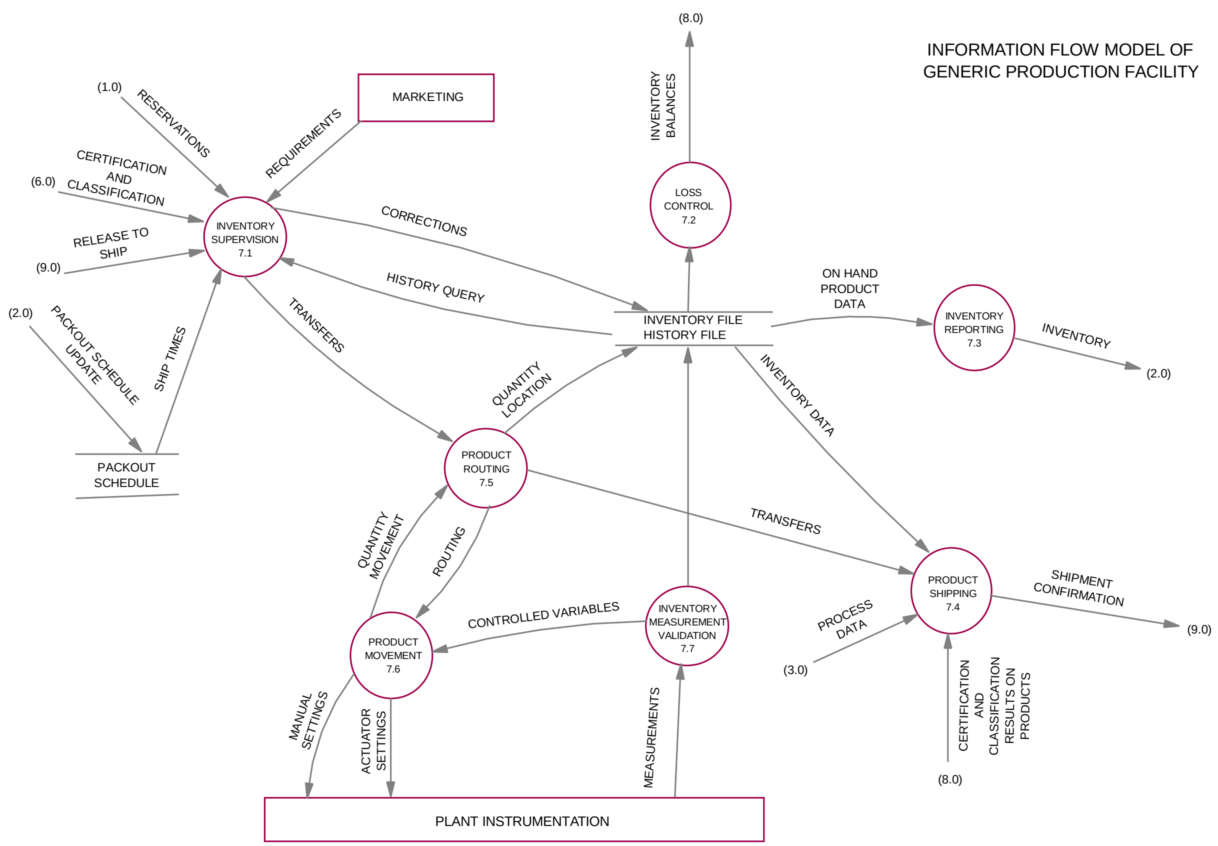


FIGURE AI-48   7.0 PRODUCT INVENTORY

APPENDIX I – Generic Macro-Functions – Data Flows

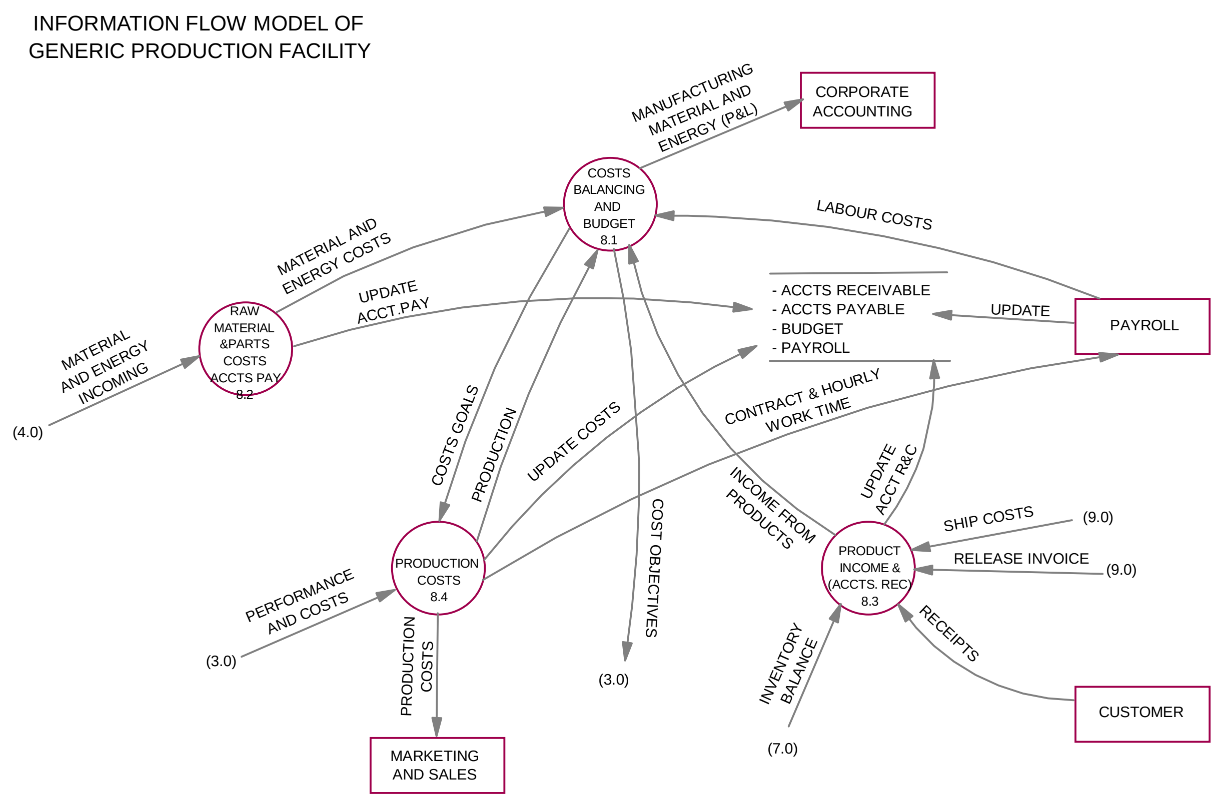


FIGURE AI-49 8.0 COST ACCOUNTING

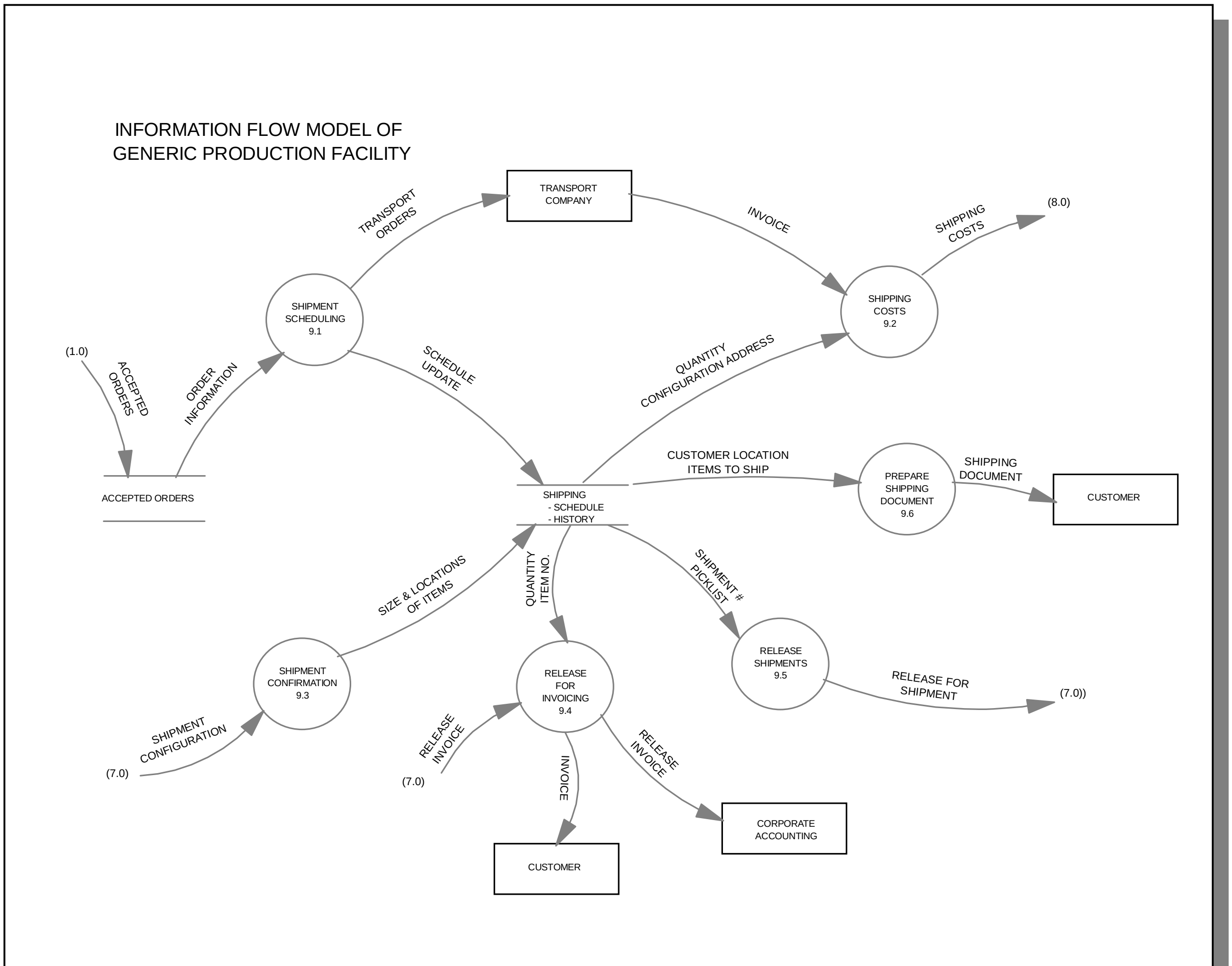


FIGURE AI-50 9.0 PRODUCT SHIPPING ADMINISTRATION

TABLE AI-XI

INFORMATION FLOW MODEL OF GENERIC PRODUCTION FACILITY MINI-SPECS (DEFINITION OF FUNCTIONS)

FIRST ORDER ENTITY DIVISIONS

APPENDIX I – Generic Macro-Functions – Data Flows

0.0 FACILITY MODEL CONTEXT - Figure AI-38

External Entities
Marketing and Sales
Corporate R. D. & E.
Supplier
Vendor
Customer
Transport Company
Accounting
Purchasing

0.1 ORDER PROCESSING - Bubble 1 of Figure AI-38 and Figure AI-39

Customer order handling, acceptance and confirmation
Sales forecasting
Waiver and reservation handling
Gross margin reporting
Determine production orders

0.2 PRODUCTION SCHEDULING - Bubble 2 and Figure AI-40

Determine production schedule
Identify long term raw material requirements
Determine packout schedule for end products
Determine available product for sales

0.3 PRODUCTION CONTROL - Bubble 3 and Figure AI-41

Control of transformation of raw materials into end product in accordance with production schedule and production standards
Maintenance of processing equipment
Plant engineering and updating of process plans, etc.
Issue requirements for raw materials
Produce reports of performance and costs
Evaluate constraints to capacity and quality
Self test and diagnostics of production and control equipment

0.4 MATERIALS AND ENERGY CONTROL - Bubble 4 and Figure AI-45

Keep stock of raw materials
Reorder raw materials according to production Requirements
Accept delivery of raw materials, request QA tests and release for utilization after approval
Reporting on RM and energy utilization
Reporting on RM inventory to production

TABLE AI-XI (continued).

0.5 PROCUREMENT - Bubble 5 and Figure AI-46
Place orders with suppliers for RM supplies, spares, tools, equipment & other mat'ls
Monitor progress of purchases and report to requisitioners
Release incoming invoices for payment after arrival and approval of goods

0.6 QUALITY ASSURANCE - Bubble 6 and Figure AI-47
Testing and classification of incoming material and end products
Set standard for production QA in accordance with market and technology requirements
Assist production with exceptional and effective QA tests

0.7 PRODUCT INVENTORY - Bubble 7 and Figure AI-48
Keep stock of produced end products
Make reservation for specific product on list in accordance with product selling directives
Pack-out end product in accordance with schedule
Report on inventory to production scheduling
Report on balance and losses to product cost accounting
Arrange physical loading/shipment of goods in coordination with product shipping administration

0.8 COST ACCOUNTING - Bubble 8 and Figure AI-49
Calculate and report on total product cost
Report cost results to production for adjustment
Set cost objectives for production

0.9 PRODUCT SHIPPING ADMINISTRATION - Bubble 9 and Figure AI-50
Organize transport for product shipment in accordance with accepted orders reqmnts
Negotiate and place orders with transport companies
Accept freight items on site and release material for shipment
Prepare accompanying documents for shipment (BOL, customs clearance)
Confirm shipment and release for invoicing to general accounting
Report on shipping costs to product cost accounting

SECOND-ORDER ENTITY SUBDIVISIONS

1.1 PRODUCTION FORECASTING (LONG RANGE) - Bubble 1.1, Figure AI-39
The orders expected within the next period of time are predicted
The prediction is based on the sales history and function of the market expectation
Forecasting makes use of the traditional statistical techniques (smoothing, seasonal indices, etc.)
The forecasting period is set by the confidence of market expectations
Market expectations are influenced by outside factors, e.g., economical or political situation, or by inside factors, e.g., long term contracts, production problems

1.2 HISTORIAN - Bubble 1.2 , Figure AI-39
Create and update a sales history file with clarification of product, customer, shipping method

TABLE AI-XI (continued).

1.3 ORDER ENTRY - Bubble 1.3, Figure AI-39
Main interface with customer for inquiries and orders
Supply product price and availability
Handle order entry and amendments
Give confirmation and progress of entered orders

1.4 PRODUCTION ORDER - Bubble 1.4, Figure AI-39
Based on active and forecasted orders determine the required production

1.5 ORDER ACCEPTANCE - Bubble 1.5, Figure AI-39
Handle the acceptance for delivery of entered orders
Acceptance is based on ability to manufacture and availability of product customer credibility is checked
In specific cases the product specifications can be waived in accordance with marketing policies to ratify a particular customer or market need

2.1 PROCESS PRODUCTION ORDERS - Bubble 2.1, Figure AI-40
Produce detailed production requirements from sales production orders
Highlight specification requirements for non-standard requests
Produce production order entry in scheduling file and append shipment requirements

2.2 BALANCE IN PROCESS & PRODUCTION INVENTORY - Bubble 2.2, Figure AI-40
Identify ordered quantities against produced products and initiate packout of specific shipments
Identify availability of on-hand product
Highlight variance in production schedule
Maintain capacity estimates for production facility in terms of products

2.3 PRODUCTION FORECASTING (SHORT TERM) - Bubble 2.3, Figure AI-40
From existing production orders and known capacity, produce specific schedule entries for production rates and specifications
Set long term raw material order rates to meet production schedule
Produce a long term forecast report

2.4 PRODUCTION SCHEDULING - Bubble 2.4, Figure AI-40
Produce formal production schedule
Modify production schedule to account for production variances and interruptions
Modify production schedule to account for inventory and shipments

3.1 PROCESS SUPPORT ENGINEERING - Bubble 3.1, Figure AI-41; Figure AI-42
Issue request for modification or maintenance
Coordinate maintenance and engineering activities
Provide technical standards and methods to maintenance function
Follow-up on equipment and process performance
Provide technical support to operators
Follow-up on technological developments
Provide specifications for purchase order requests

TABLE AI-XI (continued).

3.2 MAINTENANCE - Bubble 3.2, Figure AI-41; Figure AI-43
- Provide maintenance for existing installations
- Provide preventative maintenance program
- Provide equipment monitoring program to anticipate Failure including self-check and diagnostic programs
- Place purchase order request for materials and spare parts
- Develop maintenance cost reports
- Coordinate outside contract work effort

3.3 OPERATIONS CONTROL - Bubble 3.3, Figure AI-41; Figure AI-44
- Supervise the operations of production process
- Keep track and report on production costs and performance
- Interpret the production plan in terms of the set points to individual units
- Diagnostics and self-check of production and control equipment

3.4 OPERATIONS PLANNING - Bubble 3.4, Figure AI-41
- Set up a daily production plan as function of the production schedule
- Check schedule against raw material availability and product storage capacity
- Determine percent of capacity status
- Modify production plan hourly to account for equipment outage, manpower and raw materials availability

4.1 MATERIAL AND ENERGY REQUIREMENT CONTROL - Bubble 4.1, Figure AI-45
- Determine supplier of new materials based on short and/or long term requirements from planning or manufacturing taking existing inventory into account
- Set up transfers of materials and energy to manufacturing
- Issue purchase request for new material and energy supplies
- Notify incoming material and energy control on expected incoming orders

4.2 OPTIMUM MATERIAL AND ENERGY INVENTORY LEVELS - Bubble 4.2, Figure AI-45
- Continuously calculate and report inventory balance and losses of RM and energy utilization

4.3 INCOMING RAW MATERIAL AND ENERGY CONTROL - Bubble 4.3, Figure AI-45
- Receive incoming material and energy supplies and request QA tests
- Transfer material and energy to storage and/or classify for use after QA approval
- Notify purchasing of accepted material and energy supplies to release payment

4.4 RAW MATERIAL AND ENERGY ROUTING - Bubble 4.4, Figure AI-45
- Set up and monitor the movement of material and energy in storage
- Update inventory of all movements and changes

TABLE AI-XI (continued).

4.5 RAW MATERIAL AND ENERGY INVENTORY REPORTING - Bubble 4.5, Figure AI-45

Reporting of inventory to production

4.6 RAW MATERIAL AND ENERGY MOVEMENT CONTROL - Bubble 4.6, Figure AI-45

Control and monitor transfer of materials

4.7 DRAW MATERIALS AND ENERGY MEASUREMENT VALIDATION - Bubble 4.7, Figure AI-45

See 3.3.4

5.1 ORDER PLACEMENT - Bubble 5.1, Figure AI- 46

Order preparation for raw materials, spare parts, etc., for presentation to the vendors based on procurement contracts negotiated by company purchasing

Updating of vendor library and purchasing files of vendors performance on orders

5.2 PROCESS REQUESTS - Bubble 5.2, Figure AI-46

Collection and processing of unit requests for raw materials, spare parts, etc., for order placement to vendors

Checking of requests for those materials versus historical files and budgets to assure correctness of requests

5.3 COST CONTROL - Bubble 5.3, Figure AI-46

Certification of invoices on raw materials and spare parts based on satisfactory receipt of requested materials or parts

6.1 SET STANDARDS AND METHODS - Bubble 6.1, Figure AI-47

Issue standards to manufacturing and testing laboratories in accordance with requirements from technology, marketing and customer services

6.2 RAW MATERIALS EVALUATION - Bubble 6.2, Figure AI-47

Testing of incoming raw materials and approval for use if in accordance with set standards

Collect and maintain quality control file for data for quality control analysis

6.3 EVALUATION OF PRODUCT - Bubble 6.3, Figure AI-47

Test of final product and report results to classification

Collect and maintain quality control file for data for quality control analysis

6.4 CLASSIFICATION AND CERTIFICATION - Bubble 6.4, Figure AI-47

Classify quality and properties of end product in accordance with set marketing standards

Waiver classification on exceptional basis as per request from product selling

Report QA results and classification to finished product inventory control

Certify that product was produced according to standard process conditions

Report process data and certification to finished product inventory control

TABLE AI-XI (continued).

6.5 QA MEASUREMENT VALIDATION - Bubble 6.5, Figure AI-47
Checking of product data versus customer's requirements and statistical quality control routines to assure adequate quality before shipment
Maintenance of quality statistics on each item checked for continuing quality control studies.

6.6 LABORATORY AND AUTOMATIC ANALYSIS - Bubble 6.6, Figure AI-47
Conduct of metric, chemical and physical tests on sample product items to obtain data for on-going quality control tests
Transmission of this data to analysis facilities and quality control systems to assure future quality of product

6.7 ANALYZE PROCESS CAPABILITY - Bubble 6.7, Figure AI-47
Use SQC methodology to examine product data to determine process capability of meeting product specifications
Relay process deviations to process engineering for reevaluation to upgrade process
Relay methods deviation to standards and methods group for corrective action

7.1 INVENTORY SUPERVISION - Bubble 7.1, Figure AI-48
Coordinate all activities in product inventory control
Set up transfers of material to packing unit in accordance to packout schedule
Request replenishment of packing materials
Handle reservations and update inventory accordingly

7.2 LOSS CONTROL - Bubble 7.2, Figure AI-48
Continuously calculate and report on inventory balance and losses

7.3 INVENTORY REPORTING - Bubble 7.3, Figure AI-48
Generate daily, weekly ... reports on actual amounts of materials in storage

7.4 PRODUCT SHIPPING - Bubble 7.4, Figure AI-48
Set-up and monitor transfers of products to customer in accordance with requirements from shipping administration
Report confirmation of shipment for release of invoicing

7.5 PRODUCT ROUTING - Bubble 7.5, Figure AI-48
Set-up and monitor the routes of product transfer and update inventory on changes

7.6 PHYSICAL PRODUCT MOVEMENT CONTROL - Bubble 7.6, Figure AI-48
See 4.6

7.7 INVENTORY MEASUREMENT VALIDATION - Bubble 7.7, Figure AI-48
See 3.3.4

8.1 COSTS BALANCING AND BUDGET - Bubble 8.1, Figure AI-49
Establishment of criteria and tests to assure that operational budget is being followed
Collection of raw material, labor, energy and other costs for transmission to accounting

TABLE AI-XI (continued).

8.2 RAW MATERIAL AND PARTS COSTS (ACCOUNTS PAYABLE) - Bubble 8.2, Figure AI-49
Collection of cost data on all raw materials and spare parts in inventory or procured for the plant

8.3 PRODUCT INCOME (ACCOUNTS RECEIVED) - Bubble 8.3, Figure AI-49
Collection of data of product shipped or in inventory
Release invoice data to cost accounting at standard cost

8.4 PRODUCTION COSTS - Bubble 8.4, Figure AI-49
Collection of data on costs of production in the plant - labor, energy, raw material usage, spare parts usage, etc.

9.1 SHIPMENT SCHEDULING - Bubble 9.1, Figure AI-50
Classify accepted order and produce shipping schedule

9.2 SHIPPING COSTS - Bubble 9.2, Figure AI-50
Calculate and report cost of shipping

9.3 SHIPMENT CONFIRMATION - Bubble 9.3, Figure AI-50
Update shipping schedule to indicate that shipping has been done and configuration of shipments

9.4 RELEASE FOR INVOICING - Bubble 9.4, Figure AI-50
Notify accounting of shipment in order to release invoice

9.5 RELEASE SHIPMENT - Bubble 9.5, Figure AI-50
Send information for shipment to product shipping

9.6 PREPARE SHIPPING DOCUMENTS - Bubble 9.6, Figure AI-50
Issue bill of lading, customer clearance, documents that are required with shipment

THIRD-ORDER ENTITY SUBDIVISIONS

3.1.1 PROJECT MANAGEMENT - Bubble 3.1.1, Figure AI-42
Management of engineering function
Coordination of equipment and process modification
Cost and progress reporting
Project planning
Design follow-up with corrective action

3.1.2 EQUIPMENT AND PROCESS DESIGN MODIFICATION - Bubble 3.1.2, Figure AI-42
Establish design basis of new project
Supply necessary information to allow cost estimating
Report and Coordinate Specialists' Assistance
Provide Technical Information to Operators

TABLE AI-XI (continued).

3.1.3 ENGINEERING SPECIALISTS - Bubble 3.1.3, Figure AI-42
Provide support and advice in special area
Follow-up on state of the art in technology
Assess plant process and equipment performance
Adjust standards and methods to needs and progress
Monitor the interpretation of design basis during detailed engineering

3.1.4 STANDARDS AND METHODS - Bubble 3.1.4, Figure AI-42
Establish standards for process equipment, design techniques and process operational methods (practice files)
Promulgate such standards within the process support engineering functions and within the operational groups of the factory

3.1.5 PROJECT COST CONTROL - Bubble 3.1.5, Figure AI-42
Provide cost estimates of planned projects
Follow-up and report on costs of projects in execution

3.1.6 PROCESS ANALYSIS AND PROJECT DETAILED ENGINEERING - Bubble 3.1.6, Figure AI-42
Conduct plant performance studies
Provide details for the construction of equipment or process modification project in accordance to design basis
Issue report for ordering of new equipment
Issue specifications to vendor
Report on engineering and committed equipment costs

3.1.7 EQUIPMENT MODIFICATION CONSTRUCTION - Bubble 3.1.7, Figure AI-42
Provide for construction of project
Report on cost and labor

3.1.8 DRAFTING DOCUMENTATION - Bubble 3.1.8, Figure AI-42
Maintain master copies of all plant drawings for units under its cognizance
Responsible for updating drawings and associated documentation as units are modified
Supply copies as needed

3.2.1 MAINTENANCE PLANNING - Bubble 3.2.1, Figure AI-43
Organization and supervision of requested maintenance
Reporting on performed maintenance
Coordinate planned work with operators and plant supervision
Monitor and update maintenance history file

3.2.2 MAINTENANCE COST CONTROL - Bubble 3.2.2, Figure AI-43
Follow-up on used spare parts, report maintenance labor and report on maintenance costs

TABLE AI-XI (continued).

3.2.3 SPARE PARTS - Bubble 3.2.3, Figure AI-43
- Supervise spare parts warehouse
- Supply necessary parts to maintenance crews
- Report on inventory to planning for reordering
- Report to cost control on used parts
- Accept and control new delivered parts from vendors

3.2.4 MAINTENANCE CREW SUPERVISION - Bubble 3.2.4, Figure AI-43
- Perform requested maintenance work
- Supervise and coordinate with outside contractors
- Report on technical activities to files
- Report on installation and equipment performance to engineering

3.2.5 DOCUMENTATION - Bubble 3.2.5, Figure AI-43
- See Item 3.1.8

3.3.1 OPERATIONS SUPERVISION - Bubble 3.3.1, Figure AI-44
- Set objectives for process operation
- Supervise people in operation of the process and equipment
- Deal directly in the resolution of exception conditions
- Issue modification or maintenance requests
- Set and report production capacity limits
- Monitor and report on production cost and performance

3.3.2 OPERATIONS COST CONTROL - Bubble 3.3.2, Figure AI-44
- Calculate total operating costs
- Maintain short term economic balances of energy and materials
- Capture maintenance and engineering costs chargeable to operations

3.3.3 PHYSICAL PROCESS CONTROL - Bubble 3.3.3, Figure AI-44
- Stabilize process variables to defined operating set points
- Alarming of operating variables for exceptional conditions
- Maintain operation against constraints or at specifications
- Response to operators and process engineers requests
- Response to emergencies

3.3.4 OPERATIONAL MEASUREMENT VALIDATION - Bubble 3.3.4, Figure AI-44
- Assess the validity of the measurements for further use within their limits of confidence
- Tag measurement data with quality and time

3.3.5 EQUIPMENT MONITORING - Bubble 3.3.5, Figure AI-44
- Assess the operating performance and limits of process equipment
- Alarming of equipment status variables against constraints
- Indicate performance against expected equipment life cycles

TABLE AI-XI (continued).

3.3.6 PRODUCTION BALANCING AND OPTIMIZATION - Bubble 3.3.6, Figure AI-44
Optimization of production process to set objectives within equipment constraints
Maintain material and energy balance to indicate exceptional conditions
Perform performance tests where necessary to determine capacity
Monitor product quality against specifications and standards

TABLE AI-XII CORRELATION OF INFORMATION FLOW TASKS WITH THE TASKS OF THE SCHEDULING AND CONTROL HIERARCHY			
Data Flow Diagram Listing		**Scheduling and Control Hierarchy Listing**	
Figure No & Location	**Title**	**Table No. and Entry**	**Title**
Figure AI-38 Task 1.0	Order Processing	Table AI-VII Item I(2)	Production Scheduling
Figure AI-38 Task 2.0	Production Scheduling	Table AI-VIII Item I(1-3,5) Table AI-VIII Item I(1,3)	Production Scheduling Same
Figure AI-38 Task 3.0	Production Control	Table AI-VIII Item I(2) Table AI-IX Item II Table AI-X Item II	Area Optimization Control Enforcement Same
Figure AI-38 Task 4.0	Raw Material Control	Table AI-VII Item I(4) Item III (6,7)	Optimum Inventory Levels Procurement Order Entry
Figure AI-38 Task 5.0	Procurement	Table AI-VII Item III (6,7)	Procurement Order Entry
Figure AI-38 Task 6.0	Quality Assurance	Table AI-VIII Item III(9) Table AI-VIII Item III(8)	Quality Control File Statistical Quality Analysis and Control Functions
Figure AI-38 Task 7.0	Product Inventory Control	Table AI-VII Item I(4) Item III(8)	Optimum Inventory Levels Goods in Process Inventory
Figure AI-38 Task 8.0	Product Cost Accounting	Table AI-VII Item III(6-8) Table AI-VIII Item III(4,6) Table AI-X Item III(3) Table AI-X Item III(3)	Production & Raw Mat'l, Energy Source & Spare Parts Use, Plus Inv. Data Same Same Same
Figure AI-38 Task 9.0	Product Shipping Adm.	Table AI-VI Item III(1B,2B) Table AI-VIII Item III(8)	Product Inventory and Production Status and Data Same

TABLE AI-XII (continued)			
Figure AI-39 Task 1.1	Production Forecasting	Table AI-VIII Item I (1)	Basic Production Scheduling
Figure AI-39 Task 1.2	Historian	Table AI-VIII Item I (1)	Basic Production Scheduling
Figure AI-39 Task 1.3	Order Entry	Table AI-VIII Item I (1)	Basic Production Scheduling
Figure AI-39 Task 1.4	Production Order	Table AI-VIII Item I (1)	Basic Production Scheduling
Figure AI-39 Task 1.5	Order Acceptance	Table AI-VIII Item I (1)	Sales Coordination
Figure AI-40 Task 2.1	Balance In-Process and Product Inventory	Table AI-VIII Item I (1,2)	Production Scheduling
Figure AI-40 Task 2.2	Forecasting	Table AI-VIII Item I (1,2)	Inventory Management
Figure AI-40 Task 2.3	Production Scheduling	Table AI-VIII Item I (4)	Basic Production Scheduling
Figure AI-40 Task 2.4	Process Production Orders	Table AI-VII Item I (1-3,5) Table AI-VIII Item I (1,3)	Production Scheduling Same
Figure AI-41 Task 3.1	Process Support Engineering	Table AI-VIII Item III (8)	Engineering Functions
Figure AI-41 Task 3.2	Maintenance	Table AI-VIII Item I (3) Item III (10) Table A7-VIII Item I(1)	Maintenance Scheduling Maintenance Data Immediate Production Schedule

TABLE AI-XII (continued)			
Figure AI-41 Task 3.3	Operations Control	Table AI-VIII Item I (2) Table AI-IX Item II Table AI-X Item II	Area Optimization Control Enforcement Same
Figure AI-41 Task 3.4	Operation Planning	Table AI-VIII Item I (1,3)	Production Scheduling
Figure AI-42 Task 3.1.1	Project Management	Table AI-VIII Item III (8)	Engineering Functions
Figure AI-42 Task 3.1.2	Equipment and Process Design Modification		
Figure AI-42 Task 3.1.3	Engineering Specialists		
Figure AI-42 Task 3.1.4	Standards and Methods		
Figure AI-42 Task 3.1.5	Project Cost Control		
Figure AI-42 Task 3.1.6	Project Detailed Engineering		
Figure AI-42 Task 3.1.7	Equipment Modification Construction		
Figure AI-42 Task 3.1.8	Drafting Documentation		
Figure AI-43 Task 3.2.1	Maintenance Planning	Table AI-VIII Item I (3) Item III (10) Table AI-VIII Item I (1)	Maintenance Scheduling Maintenance Data Immediate Production Schedule

TABLE AI-XII (continued)

Figure AI-43 Task 3.2.2	Cost Control	Table AI-VII Item III (10,11) Table AI-VIII Item III (6,10)	Cost Reporting Same
Figure AI-43 Task 3.2.3	Spare Parts	Table AI-VII Item I (4) Item III (6)	Procurement Same
Figure AI-43 Task 3.2.4	Maintenance Crew Scheduling	Table AI-VIII Item III (10)	Personnel Functions
Figure AI-43 Task 3.2.5	Documentation	Table AI-VII Item III (10) Table AI-VIII Item III (6)	Maintenance Data Same
Figure AI-44 Task 3.3.1	Operations Supervision	Table AI-VII Item I, III Table AI-VIII Item I, III	Maintenance Data Same
Figure AI-44 Task 3.3.2	Operations Cost Control	Table AI-VII Item III Table AI-VIII Item III (4, 6-10)	Maintenance Data Same
Figure AI-44 Task 3.3.3	Physical Process Control	Table AI-IX Item II Table AI-X Item II	Maintenance Data Same
Figure AI-44 Task 3.3.4	Operational Measurement Validations	Table AI-IX Item II Table AI-X Item II	Maintenance Data Same

TABLE AI-XII (continued)			
Figure AI-44 Task 3.3.5	Equipment Monitoring	Table AI-VII Item III (10) Table AI-VIII Item III (1) Table AI-IX Item II (1) Table AI-X Item II (2) Item IV	Maintenance Data Immediate Production Schedule Emergency Response Reliability Assurance Emergency Response Reliability Assurance
Figure AI-44 Task 3.3.5	Production Balancing Optimization	Table AI-VII Item I Table AI-VIII Item I (2) Table AI-IX Item II (2)	Production Optimization
Figure AI-45 Task 4.1	Raw Material Requirement Control	Table AI-VII Item I (4) Item III (6) Table AI-VIII Item III (6) Table AI-IX Item III (3) Table AI-X Item III (3)	Raw Material Procurement Raw Material Use Data Same Same Same
Figure AI-45 Task 4.2	Inventory Balancing		
Figure AI-45 Task 4.3	Incoming Raw Material Routing		
Figure AI-45 Task 4.4	Material Routing		

TABLE AI-XII (continued)			
Figure AI-45 Task 4.5	Inventory Reporting		
Figure AI-45 Task 4.6	Material Movement Control		
Figure AI-45 Task 4.7	Raw Material Measurement Validation		
Figure AI-46 Task 5.1	Order Replacement	Table AI-VII Item I (4)	Procurement
Figure AI-46 Task 5.2	Process Requests		
Figure AI-46 Task 5.3	Cost Control		
Figure AI-47 Task 6.1	Set Standards and Methods	Table AI-VII Item III (9) Table AI-VIII Item III (8)	Quality Control Analysis Quality Control Analysis
Figure AI-47 Task 6.2	Raw Material Evaluation		
Figure AI-47 Task 6.3	Evaluation of Product		
Figure AI-47 Task 6.4	Classification		
Figure AI-47 Task 6.5	Q/A Measurement Validation		
Figure AI-47 Task 6.6	Lab and Automatic Analysis		
Figure AI-47 Task 6.7	Analyze Processing Capability		

TABLE AI-XII (continued)			
Figure AI-47 Task 7.1	Inventory Supervision	Table AI-VII Item I (4) Item III (8) Table AI-VIII Item III (6) Table AI-IX Item III (3) Table AI-X Item III (3)	Product Inventory Same Same Same
Figure AI-48 Task 7.2	Loss Control		
Figure AI-48 Task 7.3	Inventory Reporting		
Figure AI-48 Task 7.4	Product Shipping		
Figure AI-48 Task 7.5	Product Routing		
Figure AI-48 Task 7.6	Product Movement		
Figure AI-48 Task 7.7	Inventory Measurement Validation		
Figure AI-49 Task 8.1	Cost Balancing and Budget	Table AI-VI Item III (2C) Table AI-VII Item I (4) Table AI-VII Item III Table AI-VIII Item III (4, 6-10) Table AI-IX Item III Table AI-X Item III	Cost Reporting Same Same Same Same Same

APPENDIX I – Generic Macro-Functions – Data Flows

Table AI-XII (continued)			
Figure AI-49 Task 8.2	Raw Materials and Parts (Costs and Accounts Payable)		
Figure AI-49 Task 8.3	Product Income (Accounts Receivable)		
Figure AI-49 Task 8.4	Production Costs		
Figure AI-50 Task 9.1	Shipping Scheduling	Table AI-VI Item III (1B, 2B) Table AI-VII Item I Table AI-VII Item III (8) Table AI-VIII Item III (6) Table AI-IX Item III (6) Table AI-X Item III (3)	Product Inventory and Availability Production Scheduling Product Inventory and Availability Same Same Same
Figure AI-50 Task 9.2	Shipping Costs		
Figure AI-50 Task 9.3	Shipment Configuration		
Figure AI-50 Task 9.4	Invoicing		
Figure AI-50 Task 9.5	Release Shipments		
Figure AI-50 Task 9.6	Prepare Shipping Documents		

Some Further Examples

Figures AI-51 to AI-55 present a series of sketches by the author and others, mostly using hierarchical representations like the Scheduling and Control Hierarchy in the early part of this Appendix, to show the relationship of the implementation of the tasks and functions of the CIM system or other enterprise endeavor. Please note that these generally support the distribution of functions presented in this Appendix and the analysis and discussion of the Architecture as presented to this point.

The topic of configuration as a substitute for direct programming or reprogramming of the software implementation of the tasks and functions of the Information Systems Architecture has been mentioned often in this text and is diagrammed in Figure AI-51. Configuration is the presentation of a very large menu or selection of preprogrammed modules representing several alternate methods of implementing specific control and information systems tasks and functions. These are selectable at build time of the operational programs of the computers of the system. Selection may either be made by personnel through CRT presentation of the possible choices or automatically by computer based on system operating conditions. At present configuration capabilities are readily available commercially for Levels 1 and 2 of the Purdue Hierarchy. They are technically possible at the higher levels but much more extensive and capable preprogrammed modules are necessary before they are commercially practicable.

Figures AI-52, 53 and 54 relate the control and data flow directions in the hierarchy and summarize the types of control commands and of data or information involved at each level. Figure AI-55 is a graphical summary of the task assignments of Tables AI-VI through AI-X and the associated Figures AI-20 through AI-26 showing the data flow connecting them.

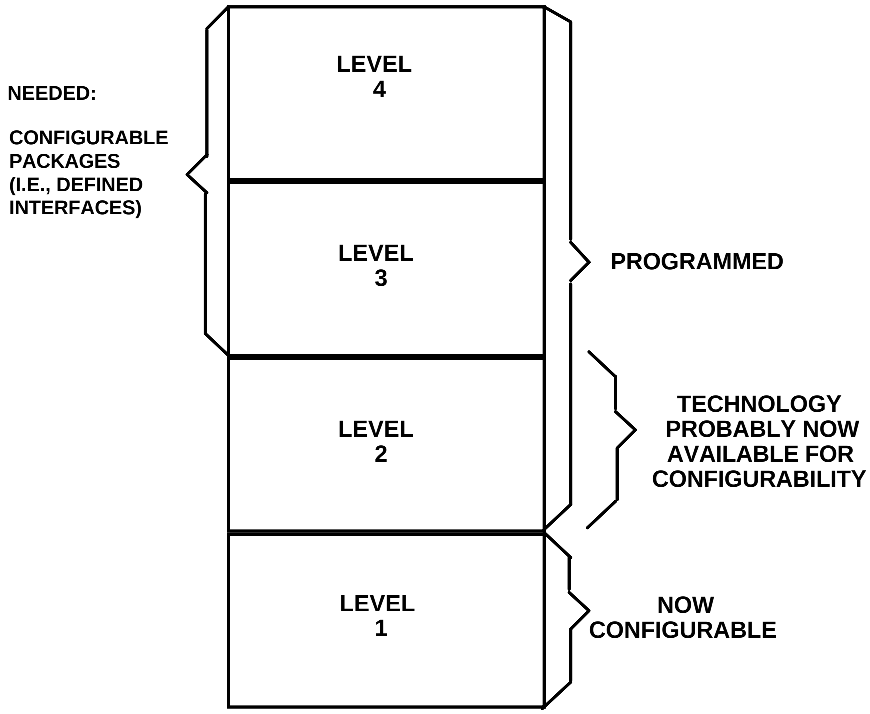


FIGURE AI-51 PRESENT EXTENT OF CONFIGURABILITY IN COMPUTER CONTROL SYSTEMS

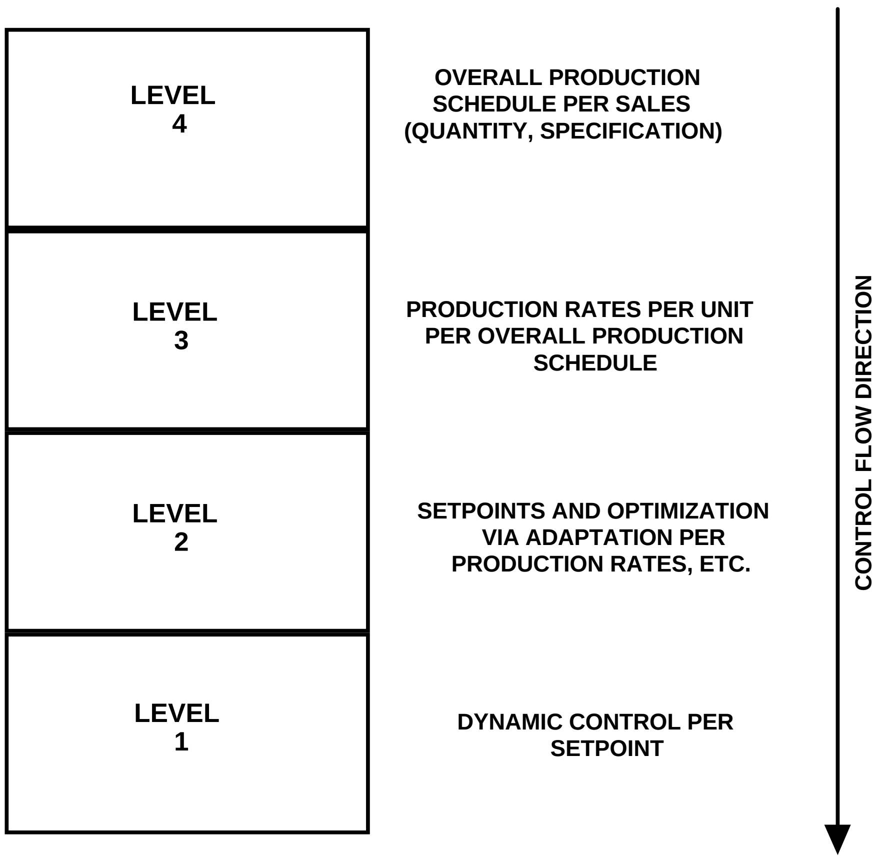


FIGURE AI-52 PROVISION OF CONTROL FUNCTIONS

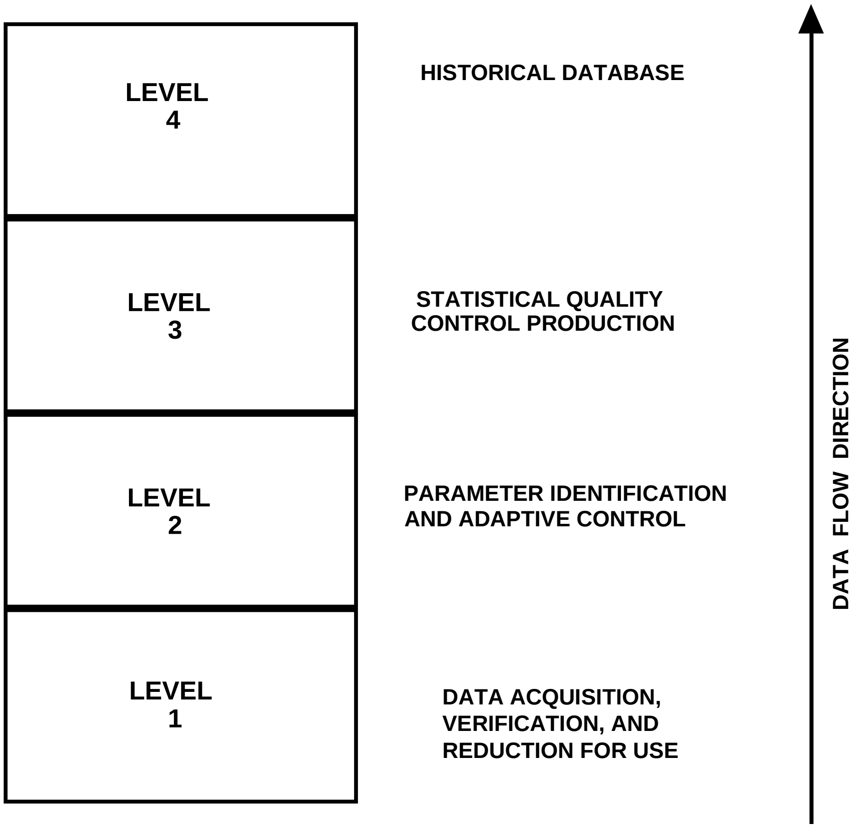


FIGURE AI-53 PROVISION FOR DATA AND ITS USE

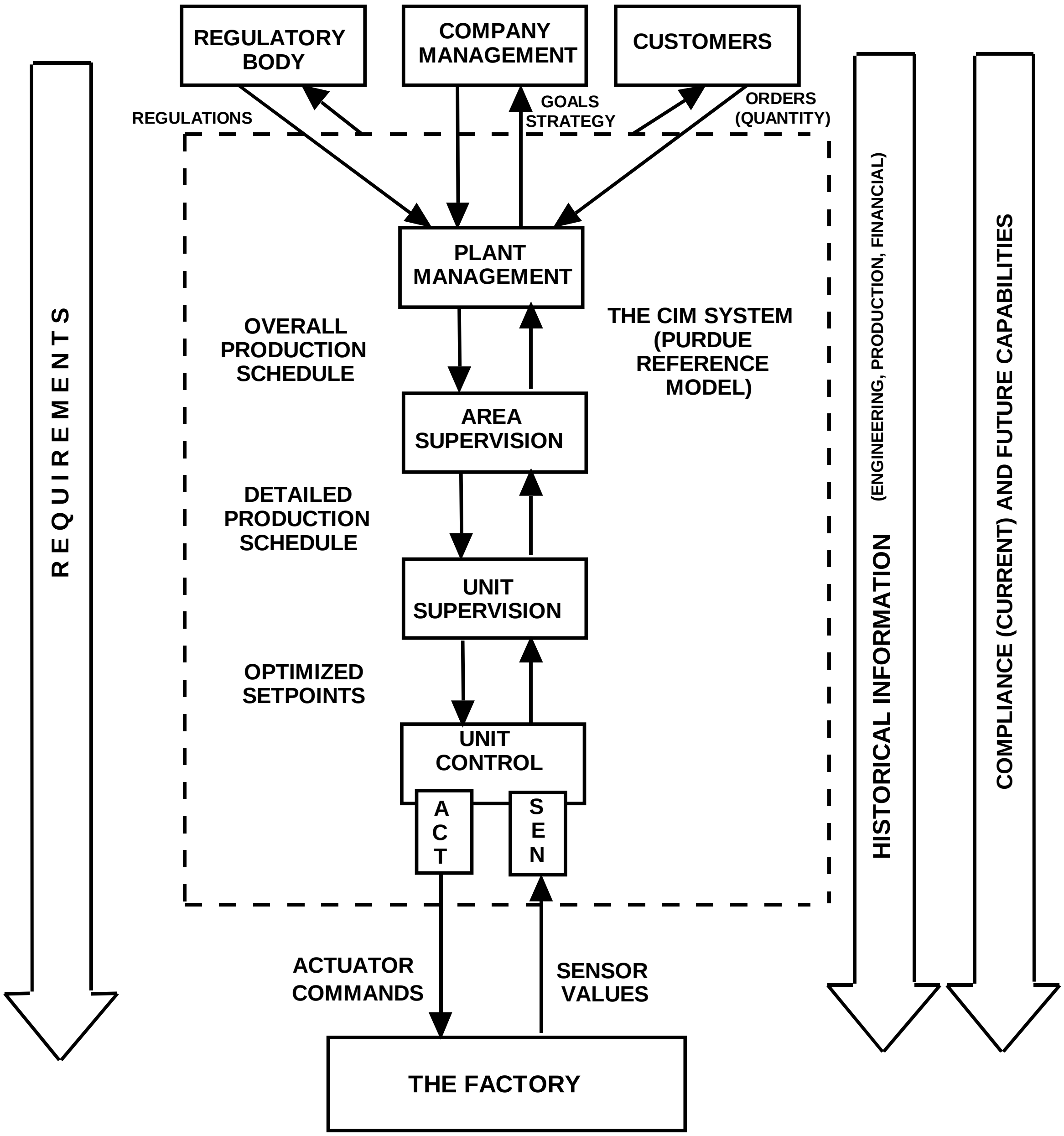


FIGURE AI-54 DATA FLOW IN THE PURDUE REFERENCE MODEL [47]

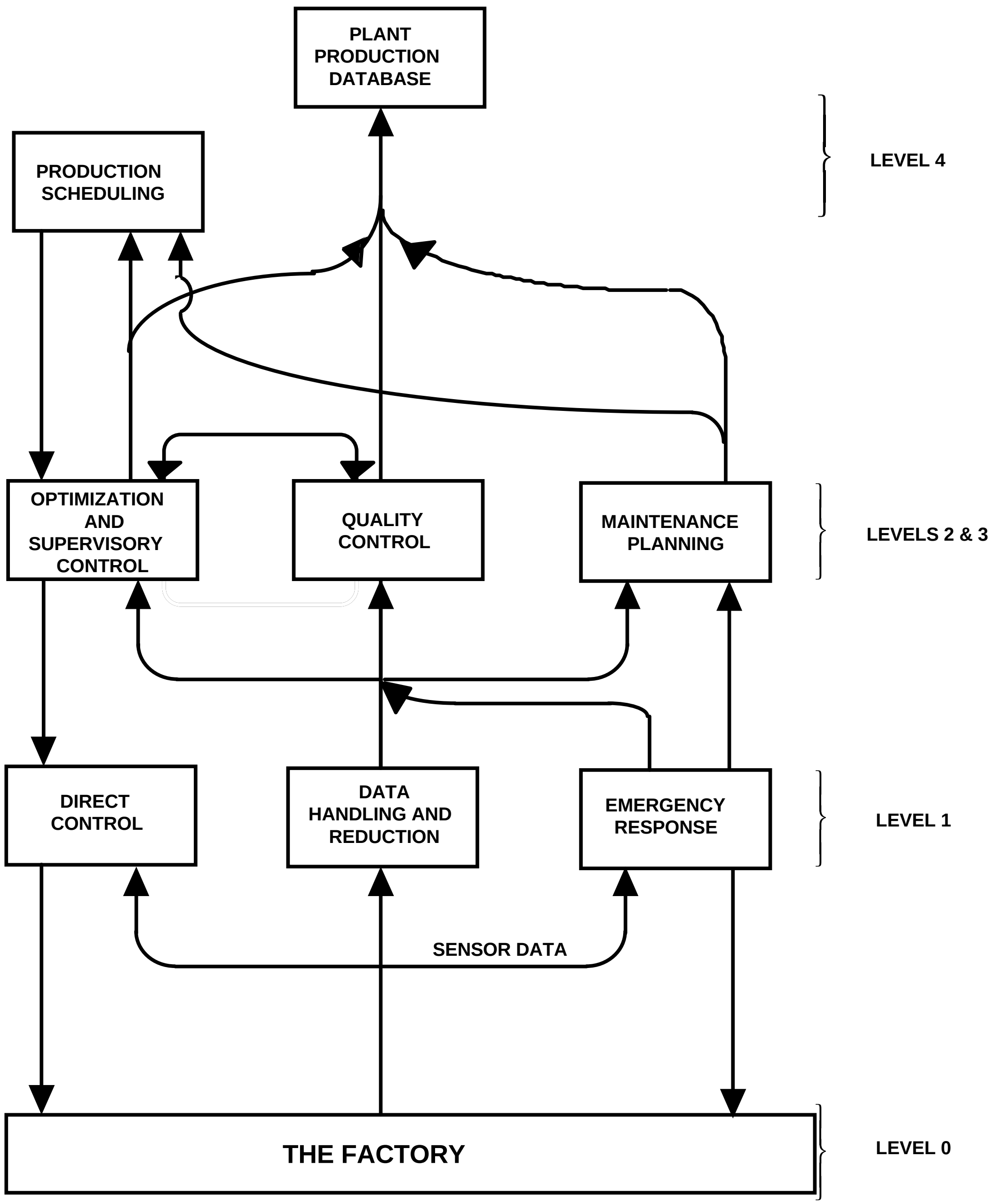


FIGURE AI-55 SOME TASK RELATIONSHIPS WITH RELATED DATA & INFORMATION FLOW [47]

Appendix II – Examples of the Potential Benefits of Enterprise Integration

Some quantitative examples of enterprise integration benefits as presented by various authors are given in Tables AII-I [41], AII-II [4], AII-III, and AII-IV [5]. Other publications present equally high pay-out values [3,33,36,38,40,57,80]. In addition to the indirect benefits listed above (Table AII-III and the text), Tables AII-V and VI present others as noted by Kallos and Sawyer [52]. Table AII-VII shows how the enterprise integration system can supply the data needs of a wide variety of plant personnel. Some further benefits listed by the authors [52] are given in Table AII-VIII.

The benefits listed above are taken directly from the references noted as listed in the References section at the end of this Handbook. No effort has been made to resolve any discrepancy between them or to remove any existing overlap. This was done in order to preserve the integrity of the works of the authors quoted.

The material in the next part discusses how the enterprise integration program justification part of this preliminary investment study might be made.

Investment Justification

Despite the call for consideration of non-quantifiable cost benefits in the earlier parts of this manual it is well recognized that tangible, quantifiable benefits are always important in the final justification of any project, including enterprise integration. This is especially important when one considers, as shown in Figure AII-2, that these projects may have a substantial period before tangible gains are shown. Thus every means should be used to obtain viable cost and benefit figures as part of the justification process.

New technologies have dramatically changed manufacturing cost behavior patterns - as a percentage of product costs in that the direct costs are decreasing while the indirect costs are increasing. The costs of quality and of the reduction of product to market lead times are not considered in traditional cost and justification practices yet are quantifiable. In the context of enterprise integration, the capital investment justification process must be revised to reflect these changes. Antique capital investment justification processes that emphasize only direct savings are no longer appropriate.

Investment justification (cost-benefits analysis) for advanced manufacturing technology projects may be carried out using the steps found in the guidelines proposed by Muir [62].

Justification approaches can generally be categorized as [73]:

1. **Economic:** appropriate for systems with strictly economic benefits.
2. **Analytic:** appropriate for systems with both economic and non-economic benefits.
3. **Strategic:** appropriate for systems with strategic advantages.

In the context of enterprise integration, two or all of the approaches may have to be used together. A strategic justification accompanying an economic one, for example, may help to avoid the pitfall of failing to "economically justify" a project that might well determine whether the company will become a competitive force in the market or disappear from it. It may be that a project that by itself yields very little or no return, is justified from a strategic viewpoint because it is a prerequisite for other profitable follow-on projects. On the other hand, when a strategic justification is used, the other two also should be used to reveal the full impact of the investment decision on capacity, productivity, and quality, etc. The strategic justification alone is rarely enough to authorize investment. Figure II-3 shows an enterprise integration projects justification framework and the various evaluation techniques which may be used.

This process can also be used to provide the basis for the final choice of the business entity to be involved in the proposed Enterprise Integration program. In addition, it should greatly aid the recruitment of the members of the Enterprise Integration Steering Committee and to assure each of them of their stakeholder position in the program. As noted such is necessary to secure their wholehearted and continuing support of the program as it develops and to insure the necessary resources (personnel and capital) required for its pursuit.

TABLE AII-I

ENTERPRISE INTEGRATION POTENTIAL BENEFITS

REDUCTIONS	
Product design lead times	20-50%
Manufacturing lead time	50-70%
Space	25-40%
Inventory:	
Raw material	30-60%
Work In Progress	60-80%
Finished goods	40-50%
Labor:	
Direct	20-35%
Indirect	30-50%
Exempt	0-30%
Cost of quality	25-40%
Additional capacity	10-15%
IMPROVEMENTS	
Yield improvements	40-50%
Delivery performance	40-80%

TABLE AII-II

INTEGRATION BENEFITS [4]

In 1984, NASA asked the National Research Council (NRC) to study the impact of integration efforts at McDonnell Aircraft Co., Deere and Co., Westinghouse Defense Electronics Center, General Motors, and Ingersoll Milling Machine Co. The NRC's committee on the CAD/CAM interface checked the results carefully before printing them. The committee found that these companies had already received significant benefits, even though they were only partially into their 10 to 20-year integration efforts. The table below summarizes these benefits.

Reduction in engineering design cost	15-30%
Reduction in overall lead time	30-60%
Increased productivity of production operations (complete assemblies)	40-70%
Reduction of work in process	30-60%
Increased product quality as measured by yield of acceptable product	2-5 Times
Increased capability of engineers as measured by extent and depth of analysis in same or less time	3-35 Times
Increased productivity (operating time) of capital equipment	2-3 Times

TABLE AII-III

BENEFITS OF MANUFACTURING PLANNING AND CONTROL SYSTEMS (SOURCE: ARTHUR D. LITTLE, INC.[5])

QUANTITATIVE	QUALITATIVE
Reduces inventory levels by up to 33%. Increases customer service. Reduces purchased parts cost by up to 6%. Reduces overtime by up to 50%. Increases labor productivity by up to 10%.	Improves customer relations due to ability to react quickly to changing market conditions. Provides a company game plan with no "hidden numbers". Increases teamwork between company functions. Increases workforce and management morale. Allows foremen to be managers, not expediters. Allows buyers to become purchasing managers, not expediters. Reduces scrap and rework. Allows better planning.

TABLE AII-IV

BENEFITS OF ENTERPRISE INTEGRATION
(SOURCE: ARTHUR D.LITTLE, INC[5])

NUMERICALLY CONTROLLED MACHINE TOOLS	FLEXIBLE MANUFACTURING SYSTEMS
Enables 3 to 1productivity gains.	Improves productivity due to unmanned operation capability.
Increases product quality.	Increases product quality.
Reduces scrap and rework.	Reduces scrap and rework.
Reduces operator skill requirements.	Increases production flexibility.
Reduces overall setup time.	Increases machinery utilization.
Allows higher machine utilization through off-line programming.	Reduces production floor space requirements.

TABLE AII-V

OTHER EXAMPLES OF CORPORATE GOALS AND OBJECTIVES SATISFIABLE THROUGH AN ENTERPRISE INTEGRATION SYSTEM

1. Optimum allocation of orders amongst manufacturing plants, depending upon production capacity, availability, logistics and other considerations.
2. Cost cutting through company-wide standardization of grades, operating practices, and overall reduction of duplicated overhead-type activities.
3. Labor reductions.
4. Evaluation and ranking of corporate investment opportunities.
5. New market developments.
6. New products.
7. Plant consolidation.

TABLE AII-VI

PLANT OR FACTORY REQUIREMENTS OF AN ENTERPRISE INTEGRATION SYSTEM

1. Meeting production and quality targets on an order-by-order basis.
2. Increased operating flexibility.
3. Effective monitoring of work in progress/inventory reductions.
4. Quality improvements.
5. Raw material savings and overall production cost reductions.
6. Improved labor efficiencies.
7. Control center consolidation.
8. By-product disposition.
9. Maintenance.
10. Safety.

TABLE AII-VII

DIFFERING REQUIREMENTS FOR PLANT INFORMATION VERSUS PLANT ORGANIZATIONAL LEVEL AS OPPORTUNITIES SATISFIED BY AN ENTERPRISE INTEGRATION SYSTEM [52]

I. MILL MANAGER
   A. Cost to produce versus price by shipment
   B. Shift-to-shift profitability
   C. Backlog
   D. Inventories
   E. Maintenance costs/downtime
   F. Labor availability
   G. Profitability on a grade-by-grade basis
   H. Historical switch-over cost: by grade and by crew
   I. Etc.

II. PRODUCTION SUPERINTENDENT
   A. Actual cost versus standard for grade being run
   B. Production unit (e.g. paper machine #2) efficiencies for grade being run, start to date, shift by shift, and compared to standard
   C. Availability of required raw materials
   D. Processing equipment, remaining reservoir capacities, projections of vital resource outages
   E. Total production by shift, grade, and deviation from standard
   F. Labor requirements versus actual; total overtime worked by key personnel; work out a schedule to minimize overtime
   G. Shipments to be made versus projected availabilities plus stock on hand
   H. Quality being run
   I. Defect/off-spec analysis—What is the root of the problem?
   J. Equipment breakdown analysis
      1. Mean-time-to-repair
      2. Uptime percentage by shift
      3. By cause
      4. By grade being run
      5. Downtime totals year to date
      6. Repair crew involved
   K. Equipment replacement analysis
   L. Personnel information
      1. Absenteeism rate
      2. Lost time accidents
   M. Order scheduling
      1. Query incoming orders in terms of lead-time, production disruption costs, warehousing space, customer history, flexibility of schedule, etc.

Table AII-VII (Continued)

III. MAINTENANCE SUPERINTENDENT
- A. Repair crew availability
- B. Equipment breakdown analysis (cause of failure)
- C. Spare parts inventory
- D. Run-time logs of major equipment with repair due notices
- E. Costs to repair per equipment on a comparative basis, historical data, etc.

IV. OPERATOR INFORMATION REQUIREMENTS
- A. Point-by-point readings
- B. Normal operating limits for each point
- C. Trending
- D. Scheduling, including displays of future production runs
- E. Open loop optimization, including graphic display of "How To Get There"

Figure AII-1 is an example of the information matrix in terms of who needs what data and to what degree of detail.

TABLE AII-VIII

SOME ADDITIONAL BENEFITS OF ENTERPRISE INTEGRATION SYSTEMS

1. Maintains current technology
2. Allows information ownership
3. Ensures data security
4. Distributes processing loads
5. Off loads communications networks
6. Separates plant operating functions
7. Provides maximum security from inadvertent or unauthorized data access
8. Supports a stepwise bottom-up implementation approach
   - a) Starts at the measurements
   - b) Assures data integrity
   - c) Emphasizes unit optimization
   - d) Based on economic planning model
9. Current and proven technology is assured; new technologies can be incorporated as they are accepted
10. Flexibility of change during the multi-year life span of the project
11. Stresses a top-down design

Appendix II – Potential Benefits

	INDIVIDUAL			
	PLANT MANAGER	PROD'N MANAGER	MAINT SUPVR	OPER
Quality				
Lot Tracking	No	Yes	Yes	Yes
Returns	Yes	Yes	Yes	Yes
Rework	Yes	Yes	Yes	Yes
Profitability				
By Product	Yes	Yes	Yes	Yes
By Shift	No	Yes	Yes	Yes
By operator	No	Yes	No	Yes
On time	Yes	Yes	Yes	Yes
Downtime				
By Machine Group	Yes	Yes	Yes	Yes
By workcenter	Yes	Yes	Yes	Yes
By shift	No	Yes	Yes	Yes
By product	Yes	Yes	Yes	Yes
By [time period]	No	Yes	Yes	Yes
By [time period] Y-T-D	Yes	Yes	Yes	Yes
Backlog				
By product	Yes	Yes	Yes	No
By workcenter	Yes	Yes	Yes	No
Inventories				
By customers	Yes	Yes	Yes	No
By product	Yes	Yes	Yes	No
Shipments Scheduled	Yes	Yes	Yes	Yes
Manpower Scheduled	Yes	Yes	Yes	Yes
Effiencies				
By workcenter	Yes	Yes	Yes	Yes
By machine	Yes	Yes	Yes	Yes
By product	Yes	Yes	Yes	Yes
Current Goals	Yes	Yes	Yes	Yes
Operating Summary				
By department	Yes	Yes	Yes	Yes
By workcenter	Yes	Yes	Yes	Yes
Total organization	Yes	Yes	Yes	Yes
Detail Items	No	Yes	Yes	Yes
Operating Alarms	No	Yes	Yes	Yes
Optimization	Yes	Yes	Yes	Yes
Debottle-necking	Yes	Yes	Yes	Yes

FIGURE AII-1 INFORMATION MATRIX SUMMARY AS A SET OF OPPORTUNITIES FOR ENTERPRISE INTEGRATION[1,2]

[1] It must be kept in mind that this figure is only a set of examples and no claims are made for completeness and accuracy.

[2] Note that the concept of timeliness of data will change some of the answers given above.

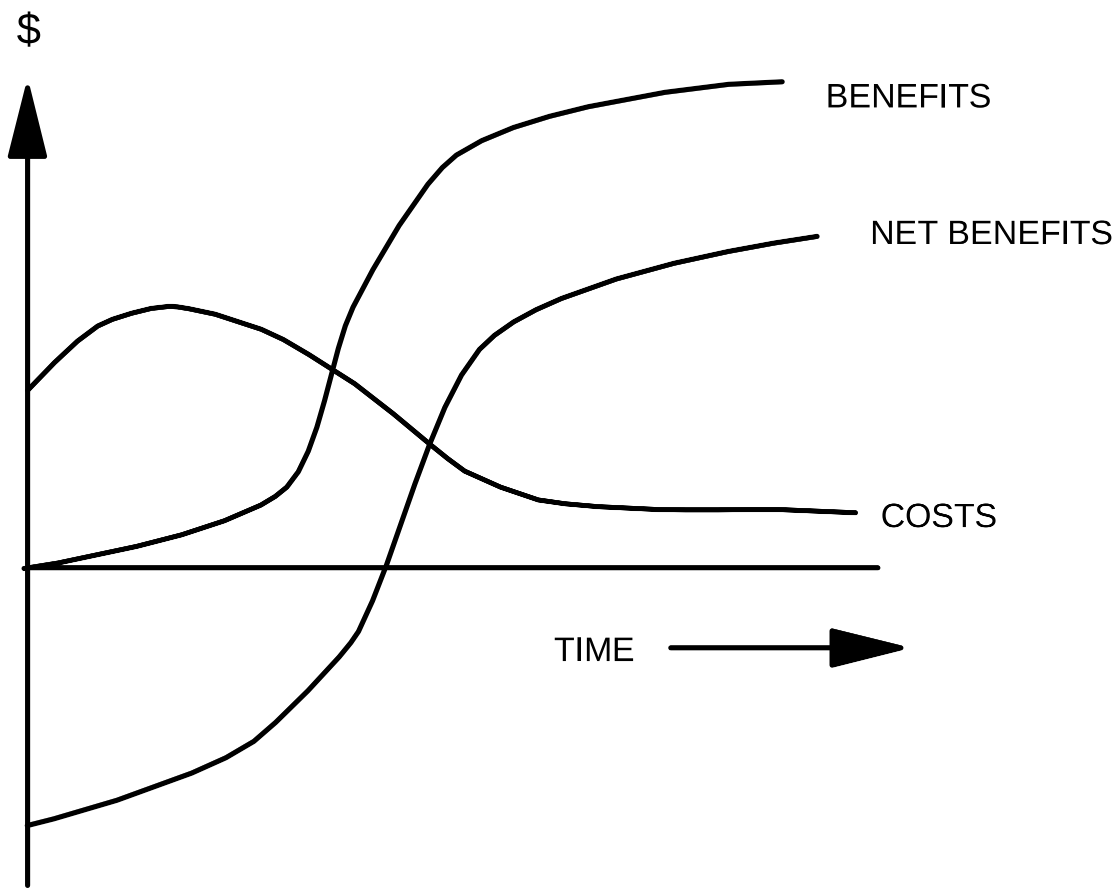
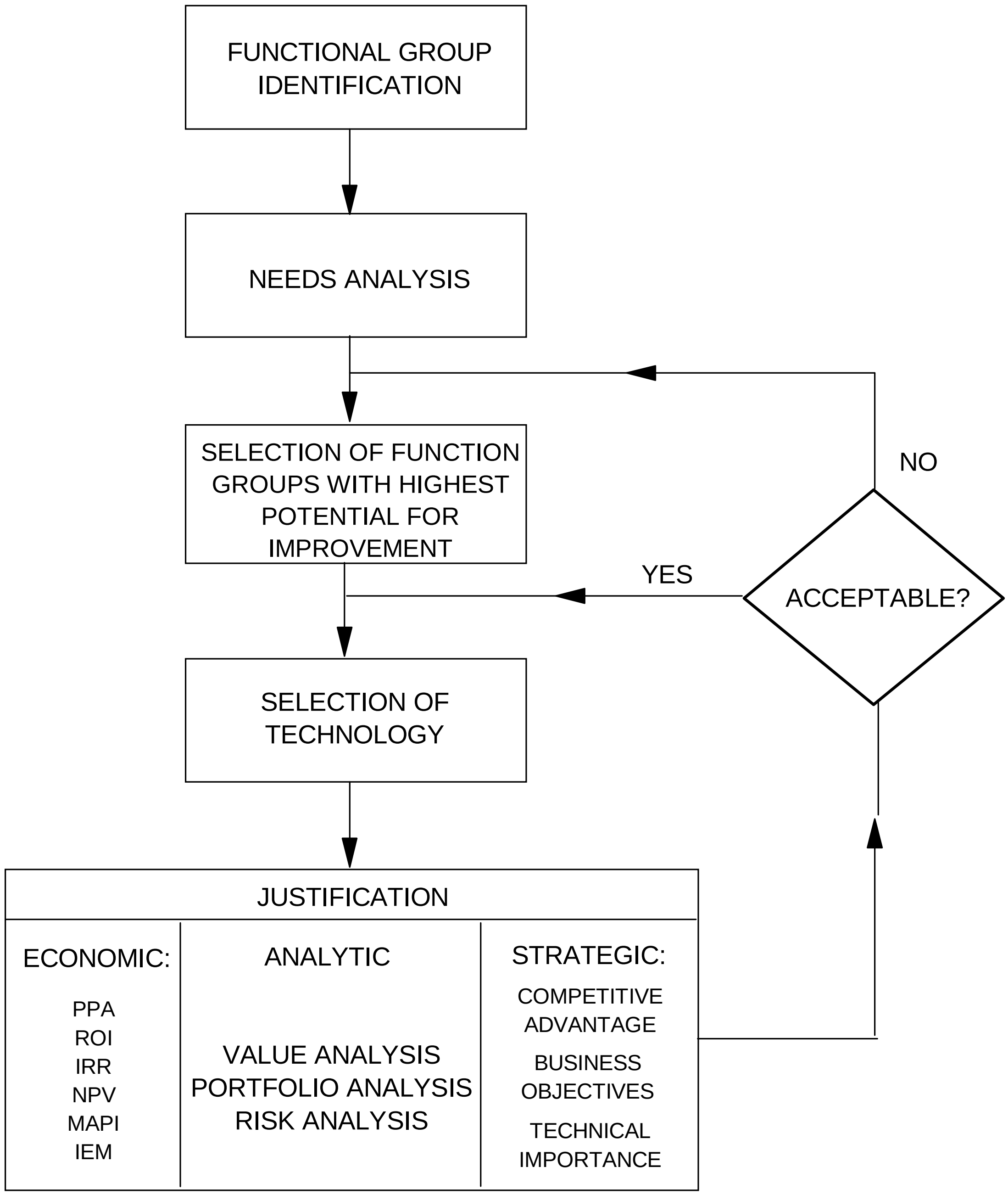


FIGURE AII-2 ENTERPRISE INTEGRATION PAYOFF OFTEN TAKES SEVERAL YEARS



PPA = Payback Period Analysis
ROI = Return on Investment
IRR = Interest Rate on Return
NPV = Net Present Value
MAPI = Machinery and Allied Products Institute Formulas
IEM = Investment Evaluation Methodology

FIGURE AII-3

Appendix II – Potential Benefits

In the context of enterprise integration, two or all of the approaches may have to be used together. A strategic justification accompanying an economic one, for example, may help to avoid the pitfall of failing to "economically justify" a project that might well determine whether the company will become a competitive force in the market or disappear from it. It may be that a project by itself yields very little or no return, it is justified from a strategic viewpoint because it is a prerequisite for other profitable follow-on projects. On the other hand, when a strategic justification is used, the other two also should be used to reveal the full impact of the investment decision on capacity, productivity, and quality, etc. The strategic justification alone is rarely enough to authorize investment. Figure AII-3 shows an enterprise integration projects justification framework and the various evaluation techniques which may be used.

This process can also be used to provide the basis for the final choice of the business entity to be involved in the proposed Enterprise Integration program. In addition, it should greatly aid the recruitment of the members is the Enterprise Integration Steering Committee and to assure each of them of their stakeholder position in the program. As noted such is necessary to secure their wholehearted and continuing support of the program as it develops and to insure the necessary resources (personnel and capital) required for its pursuit.

Appendix III – Example Mission, Vision & Values, Objectives, Strategies, Goals, & CSFs

The Company first defines the business it wants to be in terms of the nature of the products, and the market. This is defined as a Mission Statement. Vision Statements and Value Statements support the Mission Statement with a vision of the future of the company and definition of the values that will guide it.

The company then defines its desired future position in terms of growth, profitability, etc. These are the company's Objectives — general statements about the directions in which a firm intends to go, without stating specific targets to be reached at particular points in time. Note that all sub-units of the enterprise also have Objectives which reinforce those of the enterprise. In order to achieve these Objectives, both the enterprise and its sub units develop Strategies which are then used to define Goals to be achieved. These Goals define specific targets and times for their completion. Thus Strategies and Goals add detail to the relatively non-specific Objectives.

For the given Goals, Critical Success Factors define those individual conditions which must be present, or events which must occur, to assure attainment of the chosen Goals.

The above definitions are presented in more detail in Table AIII-I

Example Mission, Vision and Values

For reference, we have included some typical Mission, Vision and Values statements from well-known companies. For example, Table AIII-V presents the Mission, Vision and Value Statements of two major steel companies of the United States: ARMCO Inc., and. Bethlehem Steel Corporation. Likewise, Table AIII-III and AIII-IV presents the values of Amoco and the James River Corporation respectively.

It can readily be seen that these are very high level, brief and incomplete statements, and are often of a philosophical and "good citizen" nature. They do, however, form the basis from which the more complete Objectives, etc. are developed as shown on Figure AII-10.

Example Objectives, Strategies and Goals

As noted above, Objectives define the direction which the Enterprise is expected to take in fulfilling its Mission and in particular in improving its fulfillment of that Mission. Goals are "mile-posts" on the road to the Objectives with specific accomplishments and times specified.

Tables AIII-VI and AIII-VII present an example list of Objectives and Goals with an associated list of Critical Success Factors. The latter is annotated with the corresponding number of the related Objectives to show the connectivity between them. Goals would prescribe specific accomplishments and desired times of occurrence for each of them.

As an aid in understanding the analysis of Chapter 2, Table AIII-II presents a coordinated set of each of the definitions in Table AIII-I for a Regional Airline Company showing the interrelationship of each of the terms for each example [69]. Figure III-1 shows that each sub-unit (sub-sub-unit, etc.) of the Enterprise has its own Objectives, Goals and Critical Success Factors, although these are necessarily coordinated.

In order to better understand the significance of these terms and their relationship to each other a series of further examples will be helpful [43,69]. Table AIII-VIII presents one such example comparison.

Example Business Strategies

The definition of a Business Strategy involves the establishment of the pattern of Missions, Objectives, Policies, and significant resource utilization plans of the company, stated in such a way as to define what business the company is in (or is to be in) and the kind of company it is (or is to be). A complete statement of Strategy will define the product line, the markets and segments for which products are to be designed, the channels through which these markets will be reached, the means by which the operation is to be financed, the profit objectives, the size of the organization, and the "image" which it will project to employees, suppliers and customers.

The relationship and levels of strategies are depicted in Figure AIII-3. Note on the figure that Business Unit Strategy contains and requires definition and subtitles in areas of marketing, manufacturing, finance and R&D. Each one of these should have a Strategy that is supportive of the Business Unit Strategy.

To achieve the Objectives and accomplish the Mission, the company must set three Strategies: the market, the product, and the manufacturing strategy. The manufacturing strategy must be connected to the market and product strategies — it must be derived from the latter and at the same time it must support and influence them as expressed in Figure AIII-4. The latter must themselves be closely coupled and their choice must be the result of a careful analysis of the external environment, the company's objectives, and the strengths and weaknesses of the company itself.

By establishing the implications of the market and product strategies on the manufacturing function, manufacturing objectives are set and prioritized. They are set in terms of productivity, flexibility, quality, and adaptability which are critical success factors (i.e. factors which contribute to the company's overall success) of companies operating in today's competitive market economy.

The manufacturing objectives are then translated into a manufacturing strategy, which defines in broad terms what changes must take place within the manufacturing structure and infrastructure to achieve the manufacturing objectives. In the context of Enterprise Integration, the necessary structural changes may include changes in capacity, facilities and processes, adoption of new technologies, and a move towards integration: forward and backward as well as vertical and horizontal integration, involving both people and technology. The necessary infra-structural changes to support the structural changes may include changes in attitude and knowledge of people, in rules, in policies, in procedures that manage the resources, in functional organization, in management styles, and in operating values of the company, etc.

Again a set of business strategies compatible with the expected applications and results expected from the proposed Enterprise Integration program must be in place and operative in order to assure the success of this program. The same will also be true of each of the additional factors to be named below.

Example Business Plan

The Business Plan shows the specific targets to be sought at specific points in time (goals) and an array of programs/projects through which the goals are pursued and the strategies implemented.

The Business Plan may consist of items for each functional area such as marketing, manufacturing, product development, etc. The strategies are elaborated upon in the Business Plan and show the specific targets to be sought at specified points in time.

An example of brief Business Plan statements can be found in Table AIII-II.

Example Critical Success Factors

Critical Success Factors are defined as specific measurable indications of how enterprise Goals and Objectives are being achieved. There has to be some specific performance measures which can be related to the critical success factors. The relationship between business metrics and critical success factors will assist in identifying positions of strength.

The key is to identify only those few key specific areas where "things must go right" for the business unit. In today's competitive market terms such as productivity, flexibility, quality, and adaptability are all seen as critical success factors. Many times they do sound generic but most are specific to particular industries and markets.

Critical Success Factors are becoming very popular ways of expressing objectives in a way that catches the attention of company employees — almost as slogans. For the work outlined by this chapter such critical success factors must be collected and verified, confirmed as to language and meaning and then evaluated against similar lists of aims in the same or other companies.

Some characteristics of critical success factors as a whole are presented in Table AIII-IX. Their sources and their hierarchical nature are illustrated by Table AIII-X and Figure AIII-5. Figure AIII-6 shows some of the factors which affect their development and use.

These can also vary considerably between different companies in the same industry and even between different managerial positions within the same company as shown by Figures AIII-7 and AIII-8 for the automotive industry and Chrysler Motors as a member of it. Note that for the individual companies the critical success factors are the same as for the industry as a whole although rearranged in priority to fit the specific needs of the individual companies. However, because of their much more limited horizon and specific assignments, the critical success factors for the individual managers are quite different from each other. Note also the presence of individual position success factors (labeled ROLE) and temporarily critical ones (labeled TEMPORAL) for the managerial areas.

The work of the Enterprise Integration Planning Team members is to determine exactly what are the Company, Enterprise Business Unit, and subsidiary unit Critical Success Factors and how they will affect and be affected by the proposed enterprise integration system.

Hopefully the enterprise integration system will be the key to satisfying at least some of these critical success factors and thus assuring instant political and economic success if technical success is attained.

Appendix III – Example Mission, Objectives, CSFs

Note that critical success factors are best developed from a top-down analysis. Those of the Business Entity are the most important. Those for subsidiary units will be selected to assure the attainment of those for the higher level units while at the same time satisfying the needs of the lower level units.

TABLE AIII-I
BUSINESS PRINCIPLES DEFINITIONS AND RELATED TERMS

1. MISSION:
   This is a statement that defines the business the company wants to be in, in terms of the nature of the products, and the market.

2. VISION:
   Is defined as statements or scenarios that describe a future desired state or capability to support long-range strategic objectives.

3. VALUES:
   Are defined as fundamental beliefs and philosophies that guide the implementation of strategies and tactics of the business enterprise. They reflect a consensus of management decisions on/for the business.

4. OBJECTIVES:
   Are general statements about the directions in which a firm intends to go, without stating specific targets to be reached at particular points in time.

5. STRATEGY:
   Is the pattern of missions, objectives, policies, and significant resource utilization plans stated in such a way as to define what business the company is in (or is to be in) and the kind of company it is or is to be. A complete statement of strategy will define the product line, the markets and market segments for which products are designed, the channels through which these markets will be reached, the means by which the operation is to be financed, the profit objectives, the size of the organization, and the "image" which it will project to employees, suppliers and customers.

6. GOALS:
   Are specific targets which are intended to be reached at a given point in time. A goal is thus an operational transformation of one or more objectives.

7. PLANS (BUSINESS):
   The methodology by which the specific targets to be sought at specific points in time (goals) are to be reached. They detail the array of programs/projects through which the goals are pursued and the strategies implemented.

8. CRITICAL SUCCESS FACTORS (CSFs)
   Are the limited number of areas in which satisfactory results will ensure successful competitive performance for the individual, department or organization. CSFs are the few key areas where "things must go right" for the business to flourish and for the manager's goals to be attained.

9. POLICY:
   A definite course or method selected from among alternatives and in light of given conditions to guide and determine present and future decisions.

TABLE AIII-II
COMPARISON OF BASIC TERMS IN AIRLINE COMPANY CONTEXT

Term	Brief Definition	Brief Examples
Objectives	Markets and general directions of effort	Develop profitable route structure
Strategy	How we are going to meet objectives	Regional airline transportation Improve routes profitability Decrease operational cost
Goals	Specific targets for a period of time	Eliminate all routes with less than “N”% average seat usage By year-end replace all “X” planes with “Y” planes Provide stockholders with 10% ROI
Business Plans	Programs/Projects to achieve Target Goals	Increase advertising plan to achieve Target Goals in key routes by “Z%”in 1992 Special promotion campaign for airline in 1993 Implement cost reduction to obtain 10% savings in 1992
Critical success factors	Key areas where things must go right in order to successfully achieve objectives and goals	Obtain certification for higher-density routes Develop bank financing for new equipment
Measures	Calibrations of performance capacity used	Average % seat % of cash requirements under written equipment loan agreements with banks
Problems	Tasks resulting performance or the environment	Increasing price of fuel Future competition from video conferencing

TABLE AIII-III

THE MISSION, VISION AND VALUES OF THE AMOCO CORPORATION AS AN EXAMPLE OF SUCH PRINCIPLES

OUR MISSION:
Amoco is a worldwide integrated petroleum and chemical company. We find and develop petroleum resources and provide quality products and services for our customers. We conduct our business responsibly to achieve a superior financial return, balanced with our long-term growth, benefiting shareholders, and fulfilling our commitment to the community and the environment.

OUR VISION:
Amoco will be a global business enterprise, recognized throughout the world as preeminent by employees, customers, competitors, investors, and the public. We will be the standard by which other businesses measure their performance. Our hallmarks will be the innovation, initiative, and teamwork of our people and our ability to anticipate and effectively respond to change, and to create opportunity.

OUR VALUES:

Integrity:	We insist on honest, fair, and trustworthy behavior in all our activities.
People:	We respect the individual rights and dignity of all people. Our individual and collective actions and talents create our competitive advantage.
Technology:	We believe that technology is a key to the future success of our organization.
Environment, Health, Safety:	We pledge to protect the environment and the health and safety of our employees, the users of our products, and the communities in which we operate.
Business Relationships:	We are committed to customer satisfaction and mutually beneficial business relationships.
Progress:	We challenge ourselves to continually improve.

TABLE AIII-IV

THE VALUES* AS EXPRESSED BY THE JAMES RIVER CORPORATION AS A SECOND EXAMPLE OF SUCH PRINCIPLES

Since our inception eighteen years ago, James River has been committed to a set of fundamental values and beliefs which continue to guide the Company today. Employees share in the corporate belief that success is a product of emphasizing strict ethical standards, superior value and service to customers, involvement in job-related decision making, ownership and profit sharing in the Company, safe and productive jobs, and corporate independence consistent with shareholders' interest. In addition to these is a dedication to "Finding a Better Way" of solving traditional business problems. Sustaining this system of values, beliefs and principles demands a company-wide commitment to and acknowledgment of:

1. Exploring uniquely cost effective approaches to problems and opportunities.
2. A willingness to experiment and take calculated risks.
3. Developing and implementing winning strategies.
4. Excellence in individual performance.

* As expressed in their annual report for 1990 [18]

TABLE AIII-V
EXAMPLE MISSION, VISION AND VALUES
AMERICAN STEEL COMPANIES

I. ARMCO, Inc. (As derived from their 1990 Annual Report [16].)

GROWTH, ARMCO's challenge and commitment for the nineties

Growth opportunities through research.
"Armco will grow as a technology-driven company through a commitment to maintaining the best research organization possible."

Growth opportunities through capital improvements.
"We must have the latest technology and modern facilities to produce materials that meet today's customer demands."

Growth opportunities through customer partnerships.
"Even the most promising new product won't survive unless it meets the customer's requirements."

Growth opportunities through joint ventures.
"The use of joint ventures has created access to new technology, spread business risk and generated fresh capital for modernization."

Growth opportunities through acquisitions and investments.
"We have to maintain flexibility and anticipate the changes needed to improve the company. We will continue an active, ongoing evaluation process."

Committing to our people and their communities.
"While we work hard to improve shareholders' equity and provide a fair return, our focus is also on improving the world in which we live."

TABLE AIII-V (Continued)

EXAMPLE MISSION, VISION AND VALUES
AMERICAN STEEL COMPANIES

II. <u>Bethlehem Steel Corporation</u> (As derived from their 1991 Annual Report [17])

GETTING READY FOR A NEW CENTURY
 Developing 21st Century Steel Products

REBUILDING OUR NATION'S INFRASTRUCTURE
 Millions of Tons of Steel Will Be Required
 Plates and Structurals for Infrastructure Projects

STRENGTHENING OUR MARKET POSITION
 Investing $564 Million in Equipment and Facilities
 Awards to Burns Harbor for Quality Products

IMPROVING OUR PRODUCTION FACILITIES
 Modernizing Hot-Strip Mill On-Line
 Employees Meet Challenge of New Mill

RECYCLING MORE STEEL
 Turning Old Cans Into New Steel Products

TABLE AIII-VI

EXAMPLE SET OF MANUFACTURING ENTERPRISE OBJECTIVES

1. Improve current delivery performance to each customer.
2. Monitor and conform to the requirements of product, process, and environmental regulations.
3. Continually improve product quality and consistency.
4. Increase operational flexibility of the plant and reduce change-over time for new products.
5. Improve safety and health aspects of the work place for employees
6. Improve the enterprise's return on assets in terms of:
    a. Profitability
    b. Reduction of necessary assets
7. Maintain good relationships with vendors and suppliers in the Enterprise's supply chain.
8. Reduce required lead time on new product developments.
9. Develop new products and new markets for both present and future products.
10. Aim at complete customer satisfaction

The enterprise integration project program should directly affect Items 1 to 5 and through them influence Item 6. Items 7 to 9 are usually outside the purview of an enterprise integration manufacturing system.

TABLE AIII-VII
EXAMPLE CRITICAL SUCCESS FACTORS TO MATCH OBJECTIVES*

Time to market	(1,4,8)
Low cost productions	(6)
Customer service	(1)
Flexible manufacturing	(4)
Regulatory compliance	(2)
Quality	(3)
Asset utilization	(6)
Market penetration	(9)
More secure raw material supply	(7)
Customer satisfaction	(10)

* Numbers in parenthesis refer to similarly numbered objectives in Table AIII-VI.

TABLE AIII-VIII RELATIONSHIP OF ORGANIZATIONAL OBJECTIVES AND CRITICAL SUCCESS FACTORS (CSFs)		
TYPE OF INDUSTRY	**OBJECTIVE**	**CFS**
AUTOMOTIVE COMPANY		
1. For Profit Concern	a. Increase earnings per share b. Increase return on investment c. Increase market share d. Assure new product success	a. Better styling b. Quality dealer system c. Cost control d. Meeting industry standards (Not necessarily one for one)
REGIONAL HOSPITAL		
2. Non-profit concern	a. Excellence of health care environment b. Meeting needs of future health environment	a. Integration of health care with hospitals in region b. Efficient use of scarce medical facilities c. Better cost accounting

TABLE AIII-IX

SOME CHARACTERISTICS OF CRITICAL SUCCESS FACTORS

1. A critical success factor is something you must get right in order to succeed.
2. It is neither a goal nor a summary of goals.
3. It lists an area of importance, or one or more mechanisms.
4. Its importance may be the reason for the development of one or more strategies, objectives or goals.
5. Critical success factors are hierarchical.
6. Each manager has his or her own set of them.
7. Not all critical success factors generate goals.
8. There is no standard set of measures for their attainment.
9. They are not limited to factors reported solely by historical, aggregated, or accounting information.

TABLE AIII-X

FIVE PRIME SOURCES OF CRITICAL SUCCESS FACTORS

1. The industry
2. Competitive strategy and industry position
3. Environmental factors
4. Temporal factors
5. Manager's position

THEY ARE HIERARCHICAL IN NATURE

1. Industry wide
2. Corporate wide
3. For each sub-organization
4. For each individual separately

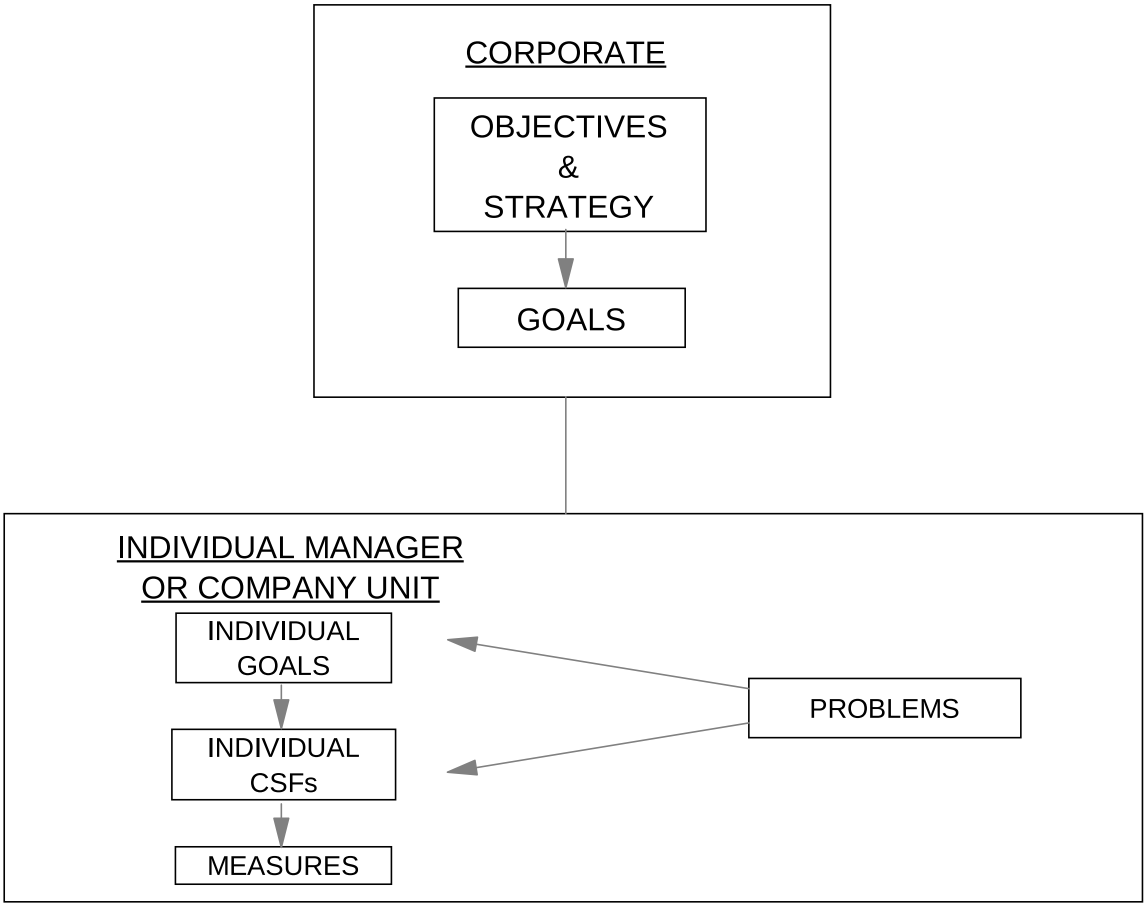


FIGURE AIII-1 HIERARCHY OF MANAGEMENT CONCEPTS AND TERMS

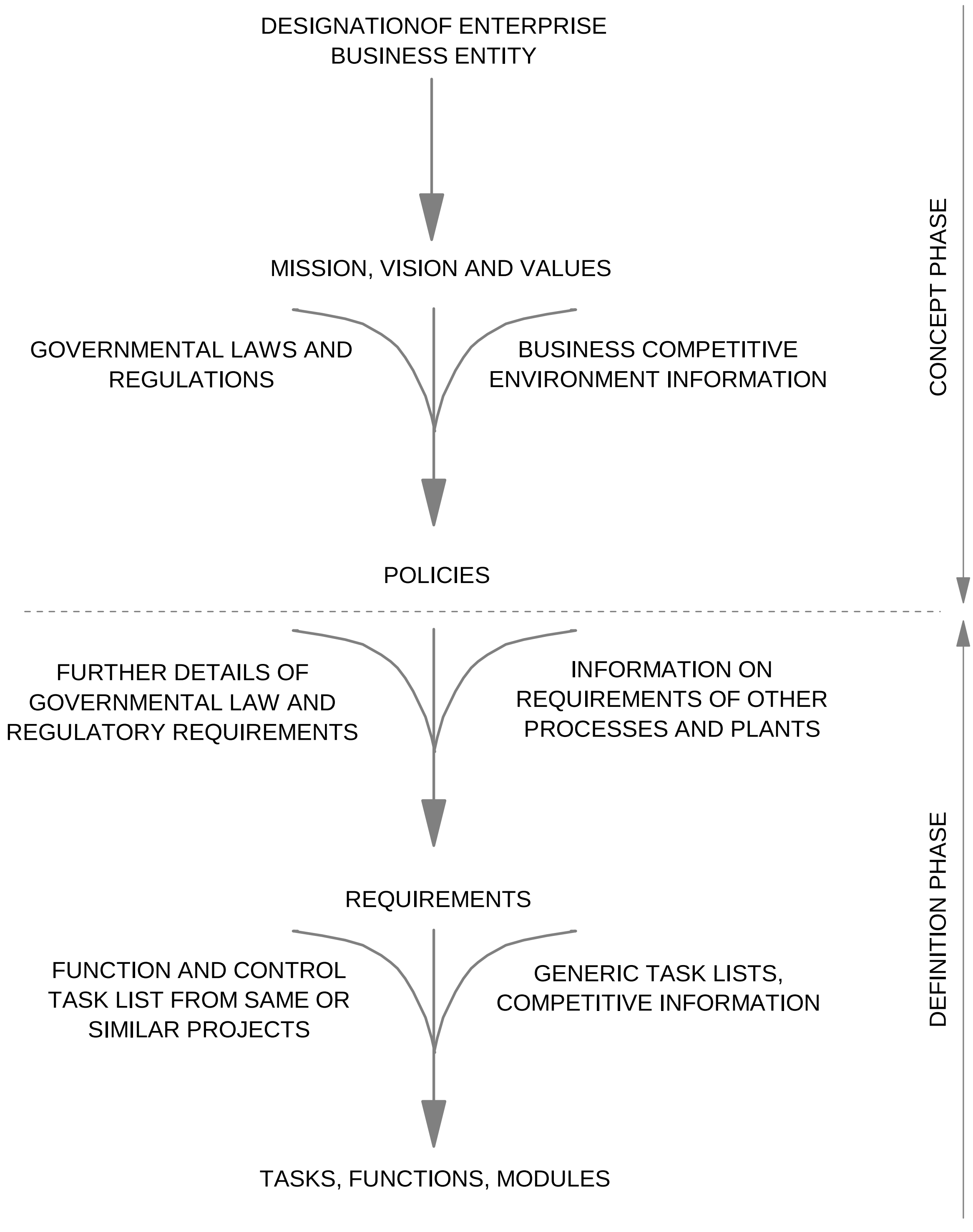


FIGURE AIII-2 DEVELOPMENT OF ENTERPRISE REQUIREMENTS

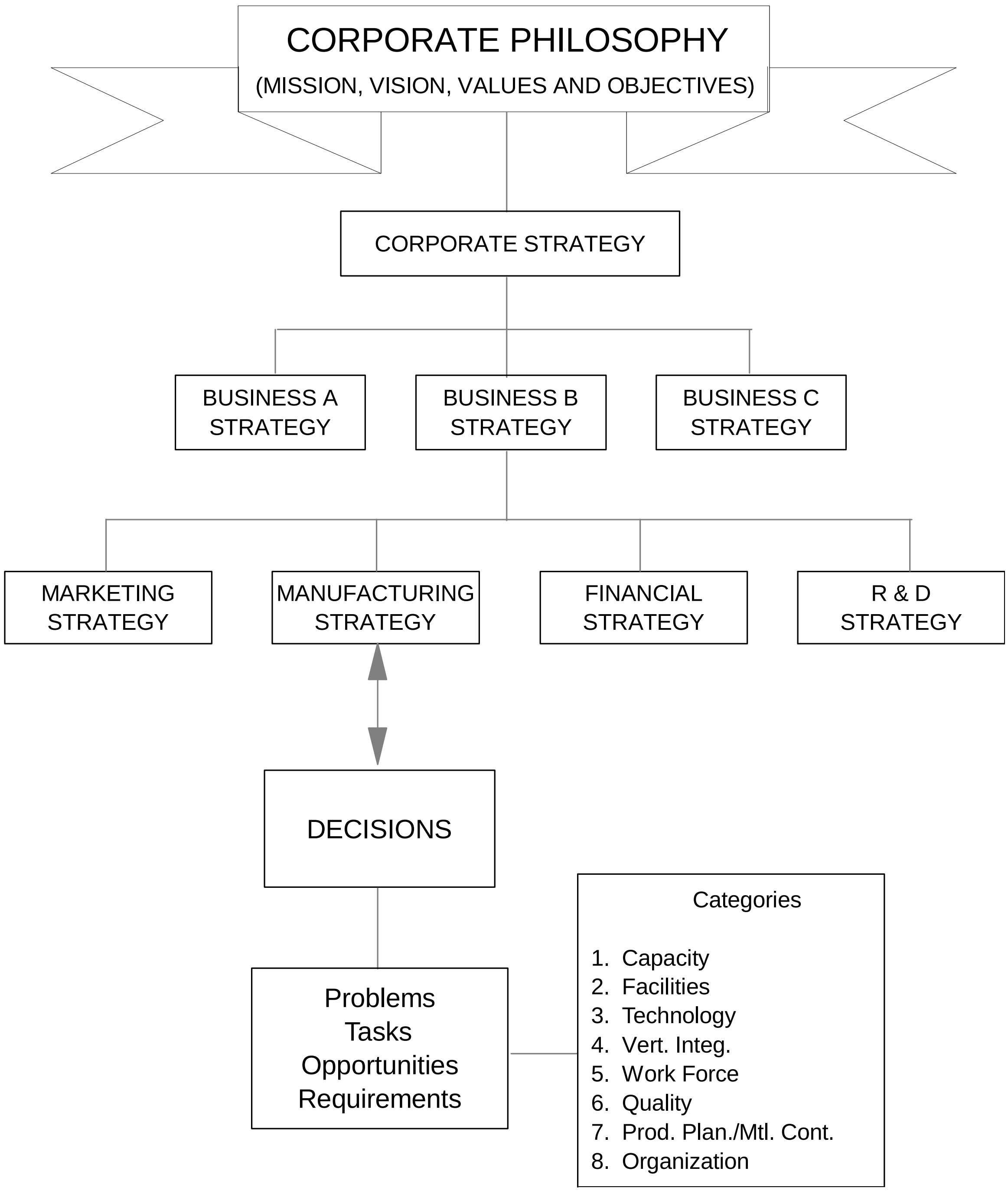


FIGURE AIII-1 HIERARCHY OF MANAGEMENT CONCEPTS AND TERMS

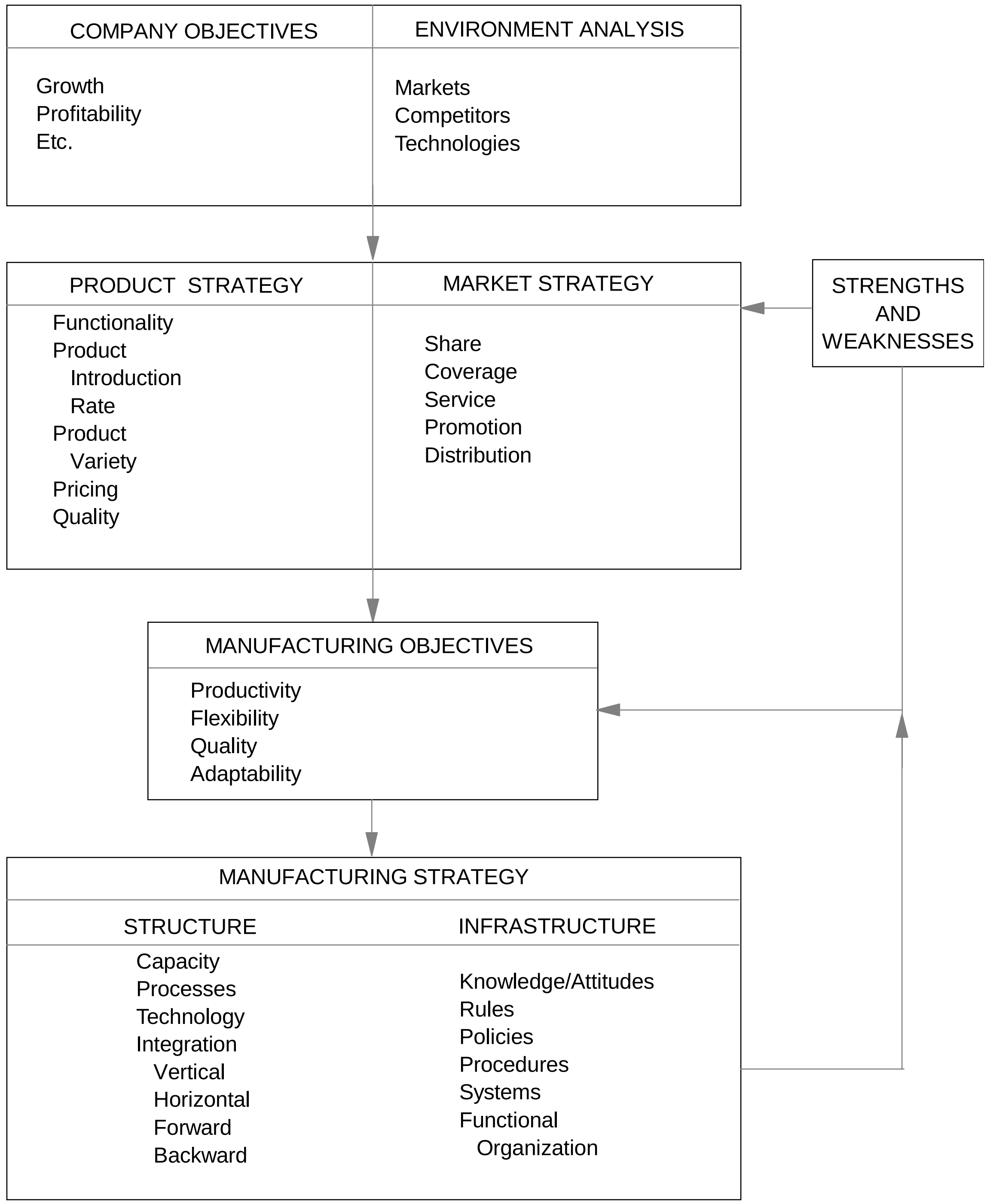


FIGURE AIII-4 SETTING THE STRATEGIES [1]

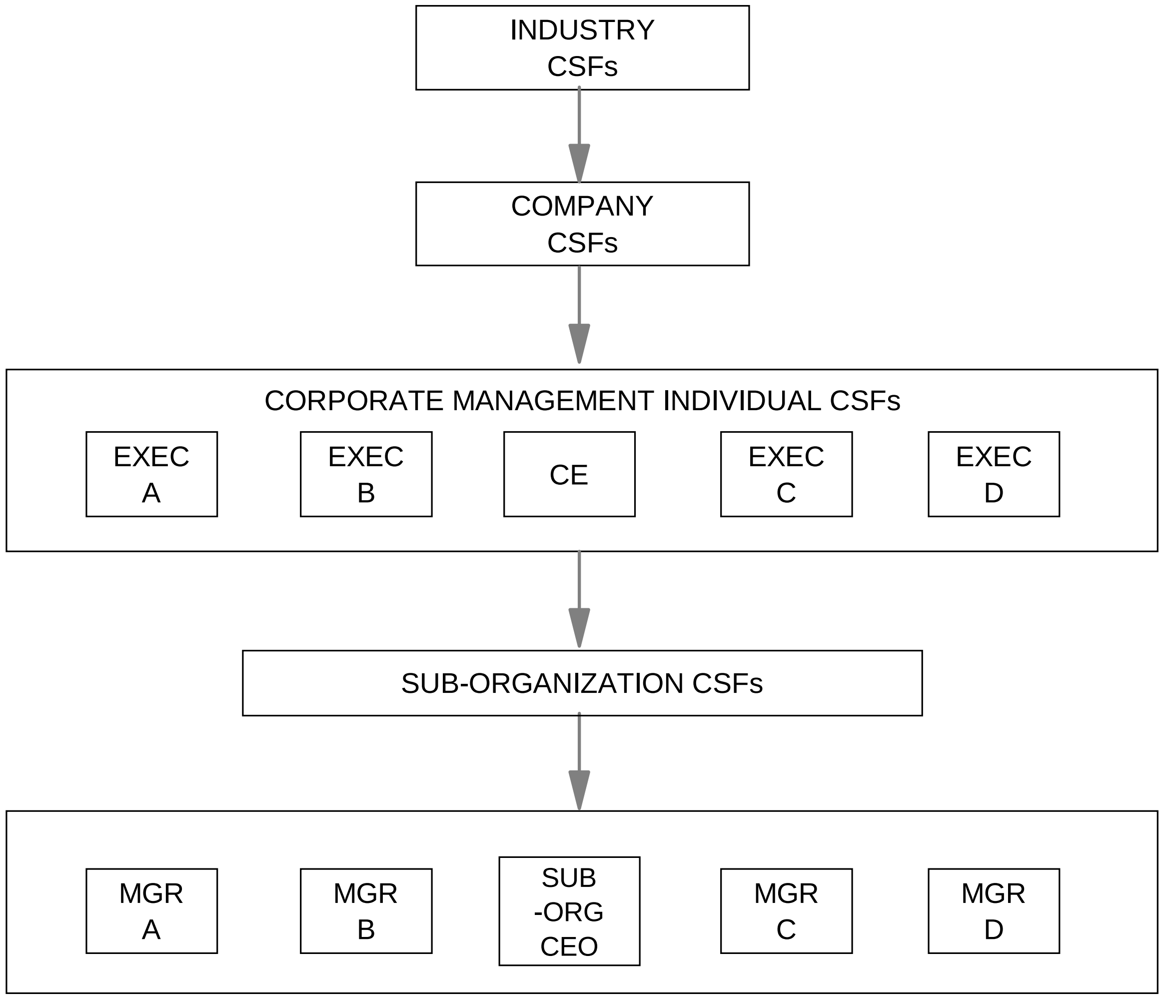


FIGURE AIII-5 AN ILLUSTRATION OF THE HIERARCHY OF CRITICAL SUCCESS FACTORS

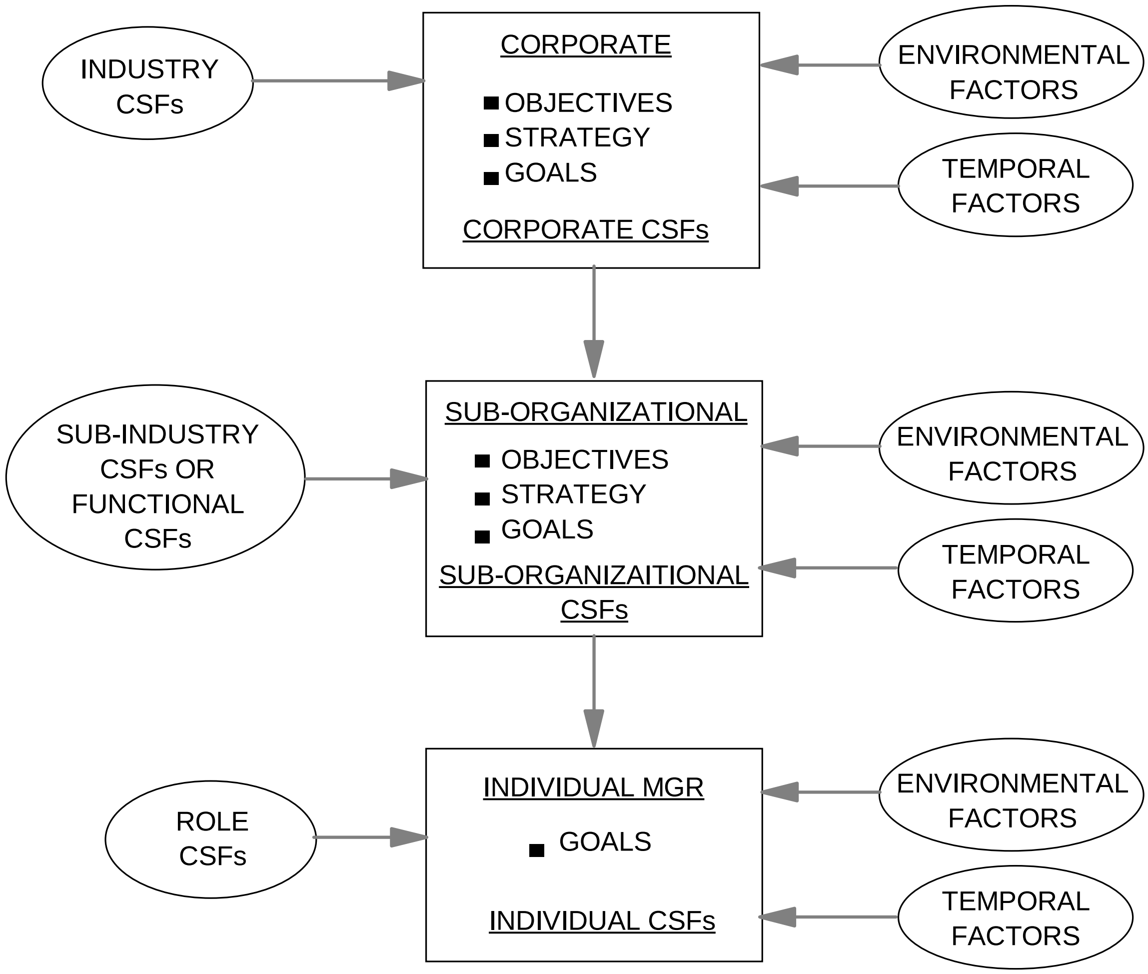


FIGURE AIII-6 FACTORS WHICH INFLUENCE THE DEVELOPMENT OF CRITICAL SUCCESS FACTORS

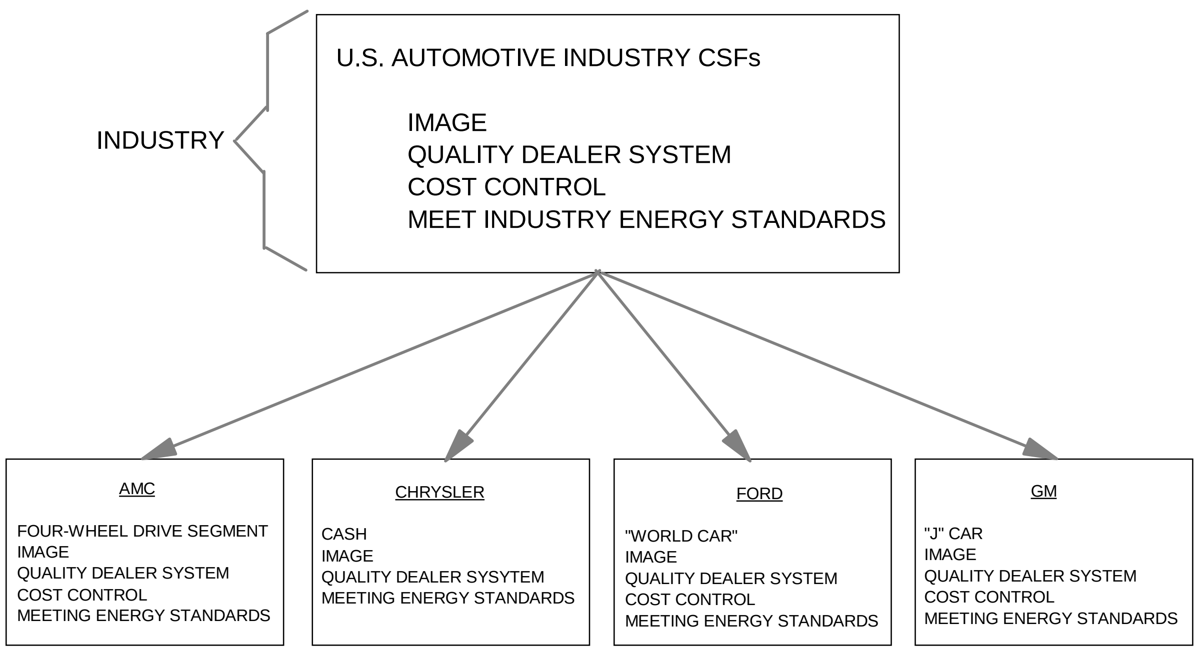


FIGURE AIII-7 DIFFERENCES BETWEEN INDUSTRY AND INDIVIDUAL COMPANY CRITICAL SUCCESS FACTORS

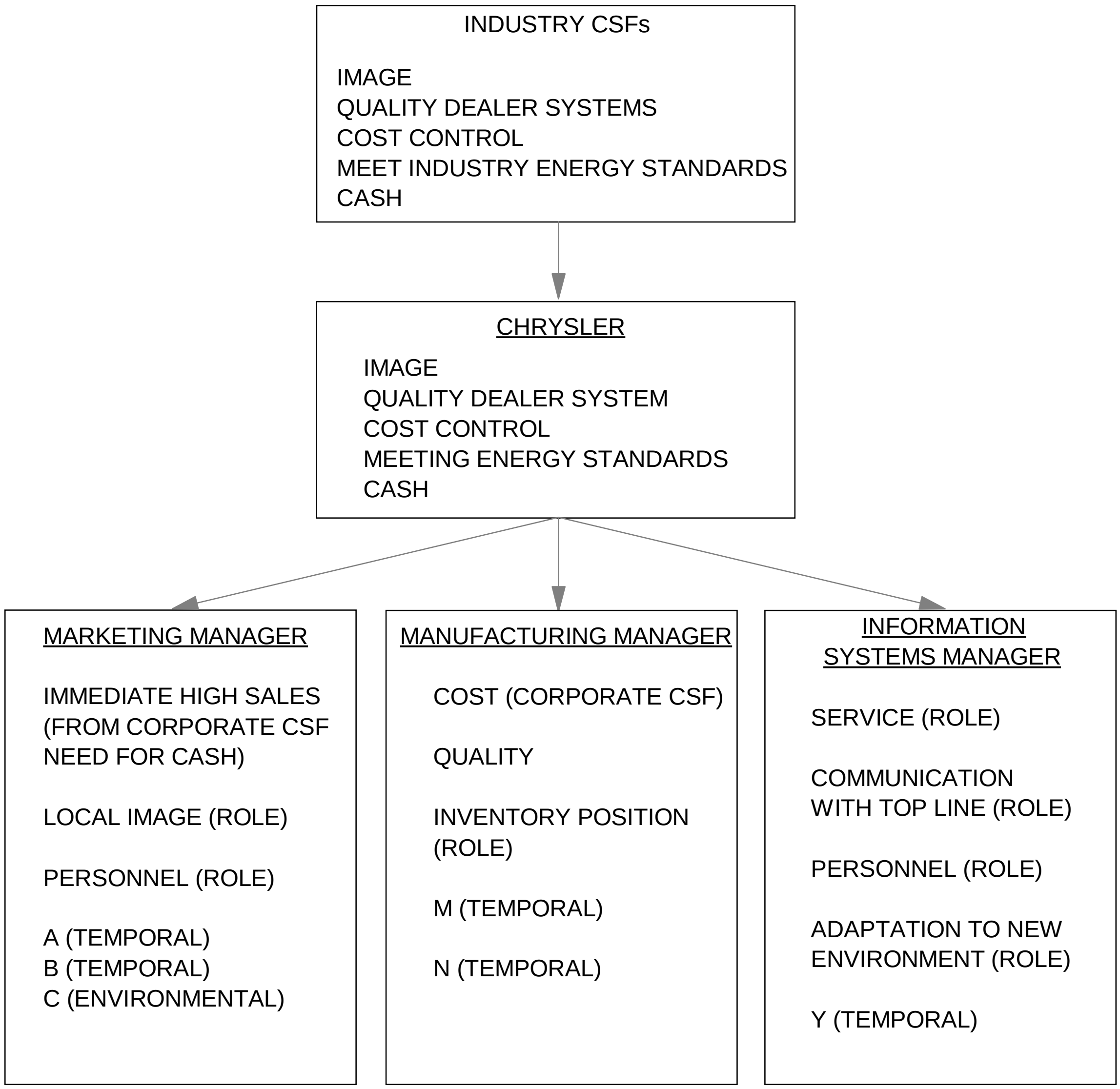


FIGURE AIII-8 THE DIFFERING RELATIONSHIPS OF INDUCTRY, COMPANY, AND INDIVIDUAL MANAGER'S CRITICAL SUCCESS FACTORS

Appendix IV - Enterprise Integration Planning Team

Introduction

The Initiating Sponsor's and the Champion's decision that a viable enterprise integration program is possible along with the Enterprise Integration Steering Committee's support of the planned program initiates the next step of recruiting an Enterprise Integration Planning Team. This chapter will detail the considerations important for staffing the Enterprise Integration Planning Team. The company unit and educational backgrounds needed by the members, the organization of the Team, its working methods, the tools and resources required, and the tasks to be performed will be discussed. To aid this discussion Figure AIV-1 outlines these activities.

Establishing the Enterprise Integration Planning Team Basis

Sponsorship of the Master Plan development work will come from the Initiating Sponsor and the Steering Committee. Leadership for this activity will come from these same people, plus the Champion and the Enterprise Integration Program manager who will be the leader of the Planning Team.

These individuals will be responsible for providing the resources required by the team, including committed and qualified people, financial, secretarial, and other resources as required. Limitations on time and resources must be considered and reconciled with the estimate of the total effort required to accomplish the planning tasks involved.

The membership of the Enterprise Integration Planning Team must include knowledgeable experienced operations personnel representing production, accounting, engineering, maintenance, planning, information services, human resources, and any other departments inside or closely associated with the business entity. The Enterprise Integration Champion also should be a member of the Team. Union participation may also be helpful.

Personnel Required for the Team

An Enterprise Integration Program Manager must be chosen who has project management skills and experience. This will be a long term position for directing the development of the Master Plan, on-going reviews, and possibly the subsequent implementation projects. The Program Manager leads the Enterprise Integration Planning Team and provides the discipline and continuity required as Team membership changes, as it inevitably will.

The Enterprise Integration Program Manager will report to the Steering Committee and will be responsible for keeping the Steering Committee appraised of program status. A way to assure this would be to make the Program manager a member of the Steering Committee. This person should have knowledge of enterprise integration, and skills in the areas of strategic planning, work group management, project management, and general leadership and communication (oral, presentation, and written).

The Enterprise Integration Planning Team (the team) members should be full-time members of the master planning effort if at all possible. To repeat an earlier description of the team, the members should be from the chosen business entity, knowledgeable of the current operations, respected by their peers, influential and able to represent their area of expertise on the team. It is extremely desirable that these members have strategic thinking capability and some ideas about process and/or operation improvements. The team members must be able to represent the areas of production, engineering and maintenance, planning, accounting, information services and human resources. A member could represent more than one area if so qualified in order to reduce the size of the overall team. Members should have a thorough understanding of the business in at least their own operating areas. They should be influential, supportive of the enterprise integration initiative, and see themselves as beneficiaries of the enterprise integration effort. As a group they must have a basic knowledge of all the relevant areas, and the team should have all the skills to be self-sustaining. As a minimum the team should include at least one individual experienced in enterprise integration planning or who has had recent education in this area.

Another important point is that members of the operational staff organization of the business entity itself must be a highly visible part of the Enterprise Integration Planning Team. Only this way will personnel of the business entity feel that the enterprise integration program is "theirs" and thus assure an automatic "buy-in" of the program by them.

Table AIV-I to AIV-III summarize desirable skills and attributes of various individuals and groups of persons involved in the planning effort and their relationships to each other. Please note these items are not in priority order.

The team should include a representative from every organization that is perceived to have an expertise even if only as a short-time consultant to the Enterprise Integration Planning Team.

People like consensus and abhor divisiveness: management is no exception. Both corporate and plant managers want to have the highest degree of confidence in the proposed system, particularly when their own skill level is minimal. This means that the widest possible range of expertise needs to be sought and included in the planning process. In this situation, a majority vote is not sufficient; consensus developing techniques must be used whenever possible to assure total Planning Team support of the project as it develops. Otherwise the credibility of the project is reduced until any existing differences can be resolved.

Attachment AIV-I presents a summary of considerations important for the formation of the Enterprise Integration Planning Team.

Appendix IV – Enterprise Integration Planning Team

TABLE AIV-I
TEAM CRITICAL SUCCESS FACTORS FOR PROJECT TEAMS (81)
(NOT IN PRIORITY ORDER)

The three critical success factors for project teams are:

1. A Mission Statement defining the project scope and objectives, project budget and schedule, and a task list with the required resources specified.
2. Team Members who together have all the general skills required to perform the tasks.
3. An Organizational Energy which is defined as a combination of authority, power, budget and influence required to carry out the project.

TABLE AIV-II
DESIRABLE TEAM SKILLS

Five general skill areas are specified for team members (not listed in priority order):

1. Team Skills - Ability to work collaboratively
2. Production Skills - Ability to get things done
3. Administration Skills - Ability to organize people and tasks
4. Entrepreneurial Skills - Creativity, new ideas
5. Integration Skills - Ability to synthesize diverse views

TABLE AIV-III
TEAM MEMBER ATTRIBUTES
(NOT IN PRIORITY ORDER)

Enterprise Integration Planning Team members should have the following characteristics:

1. Credibility of function represented
2. Visionary, not bound by current systems
3. Business/customer oriented
4. Desire to participate on team
5. Business knowledge
6. Perseverance
7. Communication skills

Program Methodologies

Table AIV-IV summarizes the material of this Appendix. This presents an outline of the Enterprise Integration Planning Team and its task of preparing the Master Plan as included in this Guide.

It is noted that projects of this type always have a sense of urgency about them because of the preparation time already noted in the earlier chapters and management's desire to have the results of the study as soon as practicable in order to "get on with the task" they have already (at least preliminarily) decided to carry out. Thus it is important that the Enterprise Integration Planning Team employs the best project management methods and techniques to assure an early, complete and accurate fulfillment of their mandate to produce the Master Plan.

TABLE AIV-IV

THE ENTERPRISE INTEGRATION PLANNING TEAM AND ITS TASK

Project Team Members
Ideal team requirements:
1. A limited number of full-time members (4 or 5)
2. A basic knowledge of all relevant areas of the project scope must be available in the team.
3. At least one information systems specialist must take part
4. The team composition may be different for the different phases of the project

Project Reference Group (Consultants (Internal and External) and Part-Time Members)
Used to discuss selected deliverables in depth:
1. Increases the quality of the deliverables
2. Broadens the commitment of the organization
3. Limits the project team to a manageable size

Other Resources
1. Secretarial support
2. Documentation and analysis facilities

Tools and Techniques
1. Project management tools
2. Business model analysis tools
3. Function/entity matrix
4. Function/benefits matrix
5. Structural analysis tool
6. Data flow diagrams
7. Entity relationship diagrams
8. Data gathering and organizing tools
9. Data base technology
10. Cost/benefit/risk analysis tools
11. Human resources/organization tools
12. Display technology
13. Network technology
14. Industry standards
15. Documentation tools
16. Presentation tools

Phase I - Strategic - Chapters 1 to 3 of the Handbook
1. Define the business unit and identify its internal structure and external linkages
2. Define the manufacturing policy for the business unit and identify the critical success factors

Table AIV-4 (Continued)

Phase II - Definition (TO-BE) – Chapters 4 to 7 Tasks
1. List and define all tasks to be carried out by the desired system
2. List all input information by the system and all output information produced by the system and specify sources and destinations
3. Outline the basic data flows, entity relationships, and functional hierarchy required to accomplish the manufacturing policy
4. Compile a Data Dictionary

Phase III - Definition (AS-IS) - Chapters 8 to 10 Tasks
1. Where required outline the basic data flows, entity relationships, and functional hierarchy as they currently exist
2. Supervise the gathering of the required plant data

Phase IV - Transition Planning - Chapters ll to 15 Tasks
1. Define applications program areas and identify standards
2. Define computer systems requirements and identify standards
3. Compare the AS-IS with the desired, determine the necessary changes required and develop a basic transition plan
4. Get approval for the conceptual plan and approval to proceed with the development of a detailed plan
5. Outline the changes and additions required in plant organization, processes, controls, business systems, and computers to migrate fully to the new architecture.
6. Develop a program of project steps to accomplish the migration including considerations of priority, costs, timing, and benefits

Phase V - Finalize Master Plan - Chapters 16 and 17 Tasks
1. Prepare the Master Plan and Enterprise Integration Program Proposal documentation.

Since these necessary techniques and methods have been well documented elsewhere and since a prime components of the Enterprise Integration Program manager's major qualification criteria was to have project management skills and experience, these will not be further discussed here.

However, there are several additional major considerations regarding the Master Plan development project which should be called to the attention of the Team. These are:

1. Education and training of the Enterprise Integration Planning Team
2. Relationship and dependencies of the AS-IS to the overall planning process
3. The detail necessary in the Master Plan
4. Education and Training of the Planning Team

Since many companies, universities and other organizations have been working in the field of enterprise integration for many years there is much information that is already in the open literature or otherwise available. It is recommended that any person or group attempting to do enterprise integration planning spend the required time reviewing the available material to avoid redoing work that may already have been accomplished and reported by others.

Suggested sources include:

1. Visits to plants of other companies that have indicated some success with enterprise integration.
2. Participation in seminars, and computer and control trade shows on the subject.
3. Selective reading of trade journals like Enterprise Integration Review, Control, Control Engineering, Datamation, Manufacturing Systems and Modern Manufacturing.
4. Computer and control systems suppliers.
5. Consultants.
6. Education in the use of the Computer Aided Software Engineering tools.
7. Education in the Purdue Enterprise Integration Reference Model and the Purdue Enterprise Reference Architecture.
8. The APICS Certification Program
9. The Primer on Enterprise Integration developed by the Honeywell Corporation.
10. Publications as developed by the Gartner Group.
11. Datapro.

APICS is an international organization of more than 70,000 members offering education and materials on the latest resource management techniques and practices. APICS offers a program providing Certification in Integrated Resource Management (CIRM). The CIRM program offers a results oriented, continuous improvement curriculum developed by industry experts. The CIRM effort has produced many new publications supporting manufacturing education from the total business perspective. The APICS educational materials are an important source of information which can help with the integration of all the functional areas of the business.

The CIRM curriculum is designed to provide people with an understanding of the interdependency of business functions, team interaction, and how decision making affects other disciplines within manufacturing companies. The following major subject areas are addressed: customers and products, logistics, manufacturing processes, and business support functions. Key topics covered include the following:

1. Marketing, sales and field service
2. Product design and development
3. Process design and development
4. Production and inventory control
5. Procurement and distribution
6. Industrial facilities management
7. Total quality management
8. Human relations
9. Information systems
10. Accounting and finance

Subject outlines and study guides are available at nominal cost from APICS website at www.apics.org or at APICS Publication Sales at 1-800-444-2742.

It is important to remember that every care must be taken that the group not redo a piece of work that has already been done by others or that has been done incorrectly even though the correct methods were already available. Thus adequate training and knowledge of the state-of-the-art is indispensable.

Therefore, invest heavily in training. Broadly defined, training may absorb up to 25 percent of the payroll budget on a project - particularly for a highly technical subject such as enterprise integration. This time can also be even more productive if Team Building is done concurrently.

Relationship and Dependencies of the AS-IS to the Planning Process

Although earlier discussion implies a time line of activity, the process is actually iterative. In the development of the Master Plan, the way in which problems are identified, and the order in which the AS-IS, TO-BE and Transition Planning activities are carried out is important. Figure II-21 is offered as a guide to understanding these relationships and managing these activities. Experience has shown that getting off on the wrong path can result in the spending of excess amounts of time and money and often killing or significantly delaying management's interest in completing an Enterprise Integration Master Plan.

Although it may seem illogical, defining the TO-BE state first (before defining the AS-IS) is less expensive, takes less time and provides a more innovative vision of the future state. Using this procedure is less costly because only the necessary AS-IS functions are fully documented, i.e. to support the transition from the AS-IS to the TO-BE state. The trap in which many find themselves in doing the AS-IS first is that people often go off in the direction of documenting and bringing up-to-date, ALL plant drawings, manuals, work methods and procedures independent of the actual needs of the enterprise integration project. If done independently of the TO-BE needs, this leads to unnecessary work, added expense and delays. The tendency to have the existing state documented perfectly before proceeding should be avoided.

Another potential problem of looking at the AS-IS first is that the future vision is often constrained by past thinking. This usually leads to incremental change or simply the automation of existing practices; a result the Enterprise Integration Master Planning process is trying to avoid.

Within the Purdue Reference Architecture, a methodology is provided to give an integrated view of the business and its relationship to manufacturing activities. Using this enterprise integration methodology usually leads to significant and often discontinuous changes as opposed to incremental changes in business and manufacturing strategies. Some of the driving forces behind this more dramatic change is the shift from physical labor to cognitive labor and the changes from a narrowly defined work scope to a broader defined work scope. In general, a paradigm shift occurs in an Enterprise Integration organization. See Table AIV-VI.

The use of inefficient methodologies should be resisted by the Sponsor and the Enterprise Integration Planning Team.

Figure AIV-2 shows a procedural flow to guide the Planning Team. In understanding these activities, it is important to note that there are both concurrent and iterative processes going on within this procedure. A simple sequential approach is not as effective. Therefore, this model should be viewed as more dynamic and iterative than shown.

Appendix IV – Enterprise Integration Planning Team

Two critical procedural issues shown in Figure II-21 are:

1. The TO-BE activity drives the AS-IS documentation requirements, and
2. The iterative loops for the TO-BE and AS-IS activities are driven by the requirements of the transition activity.

The steps taken in this procedure are as listed below:

STEP 1: PROVIDE TO-BE BUSINESS REQUIREMENTS AND VISION, AS COLLECTED IN CHAPTERS 1, 2 AND 3

The first requirement is to have a clearly defined and documented vision of the Enterprise Business Entity Critical Success Factors from Chapter 2. Without this input the purpose of the Enterprise Integration plan is not clear. A second requirement is a clear commitment from management.

STEP 2: DEFINE SIGNIFICANT OPPORTUNITIES, DESCRIBED IN CHAPTER 4

This activity takes existing known problems from the knowledge of the AS-IS architectures (human and organization, manufacturing, and informational) and combines them with the TO-BE business critical success factors to define significant opportunities for Enterprise Integration solutions. The known problem list is represented as an output from the AS-IS activity block. The list deals with strengths, weaknesses, threats to the business and limitations and restrictions of the existing facility or Business Entity.

STEP 3: DEFINE TO-BE, DESCRIBED IN CHAPTERS 5, 6 AND 7

Once the significant opportunities are verified, the TO-BE vision can be developed based on the Enterprise Business Entity goals and objectives and the significant opportunities. The focus of the TO-BE activity is on defining the future functional manufacturing, human organizations and information architectures required to meet the enterprise integration business critical success factors. This activity develops an unconstrained view of the future.

STEP 4: TRANSITION PLANNING, CHAPTER 12

After the first pass TO-BE vision is defined, the result is passed to the Transition Planning activity. It develops a list of AS-IS functions that need to be documented before the final Transition Plan can be determined. AS-IS documentation is only required for TO-BE functions that exist in the AS-IS state. No AS-IS documentation is required for functions that do not change or do not exist in the current AS-IS state.

STEP 5: DEFINE AS-IS, CHAPTERS 8, 9 AND 10

The Transition Planning drives this activity as shown in Figure AIV-2. The results of the AS-IS activity is fed back to the Transition Plan.

STEP 6: TRANSITION PLANNING, CHAPTER 12

> After one iteration of the AS-IS activity, the transition activity determines if additional feedback cycles are required to completely define the Transition Plan. Several cycles may be required to complete the Transition Plan.

Necessary Detail of the Master Plan

The task of developing the Master Plan can be an open-ended undertaking unless preliminary judgement is made concerning the required detail needed to describe the Enterprise Business Entity.

This is especially important when it is likely that the proposed enterprise integration system for the Enterprise Business Entity will not be implemented all at once due to resource or available capital limitations. A lesser amount of detail would be necessary for those functions or units to be implemented later. A set of criteria is thus necessary to judge the amount of detail required in each case. This section will propose such a set of criteria.

Several requirements must therefore be satisfied without fail in the Master Plan. These are:

1. All requirements, principles, guidelines and standards for the overall conceptual functional architecture of the proposed total enterprise integration system for the Enterprise Business Entity must be established in the Master Plan. This is to assure the ultimate compatibility of all installed systems regardless of when they may be implemented. Ultimate compatibility requires the relative ease of functional, communications and programming interfacing between the newly installed components and those already in place.

2. The proposed overall physical architecture of the total enterprise integration system should be sketched in enough detail to again help insure that any later implemented components of the enterprise integration system will be compatible with those installed earlier.

3. The differences between the overall AS-IS and TO-BE enterprise integration systems must be developed to a degree which allows an order-of-magnitude (± 50%) costing of the overall system and for each of the possible subsystems which receive early consideration. This latter would be the basis of the preliminary selection and prioritization of the Enterprise Integration Program Proposal of the company.

The above described level of detail for all units under the umbrella of the Enterprise Business Entity can be termed as the First Pass of the Master Plan development. Note that consideration of the material described under each chapter of Section 3 of this Manual will be necessary to accomplish the above.

Those units of the Enterprise Business Entity selected for further consideration in the Enterprise Integration Program proposal of the company will next require a sharpening of the detail of the description of the differences between the AS-IS and TO-BE enterprise integration systems in order to be able to develop the costs for the proposed work for immediate consideration to an accuracy of ±25%. This will require a reworking of Item 3 just above. Such work is termed as Pass Two of the Master Plan development.

Appendix IV – Enterprise Integration Planning Team

Those projects of the resulting Enterprise Integration Program Proposal which survive the Second Pass selection procedure must then have further development of their description to permit the development of implementation project proposals. This is the Third Pass of the Master Plan development and is generally accurate to $\pm$ 10%.

Figure AIV-3 presents the above concepts in graphical form. The horizontal axis of this figure represents the units of the Enterprise Business Entity in approximately the direction of material flow through the plant. The vertical direction represents the amount of detail required concerning each unit of the Enterprise Business Entity in terms of the passes described above.

All of the plant units must be developed to the detail of Pass I as noted. Complete areas in some cases, or only individual units are selected for further consideration in Passes II and III as indicated. Finally the Summary Level indicates the treatment to be accorded to each Unit in the Master Plan as finally presented.

Project Management Reviews

As noted above, management, particularly the Steering Committee, must be regularly appraised of the status of the planning effort carried out by the Enterprise Integration Planning Team. Particularly important among the items to share with them are the following:

1. Meetings with the Steering Committee should be held on a regular planned basis to discuss the status of the accomplishment of the Team's operational schedule and the state of preparation of each item on the list of deliverables previously agreed upon.
2. Ongoing and additional resources, both manpower and material, needed to perform the agreed upon planning activity. Make corrections in needed resources early. Do not "spring surprises" on the Steering Committee and other management.
3. Quality checkpoints for insuring the proper level of detail and content will need to be defined and reviewed to assure that the manufacturing equipment architecture requirements are appropriately documented.
4. Resolution of all issues which may arise as soon as possible is very important as the results of this activity are needed by other planning activities early in the planning process.

Required Skills and Knowledge

The team will require a broad range of knowledge about the existing systems and of the Enterprise Business Entity in which they are operating. It will also be important to be able to determine the useful purpose being performed by these existing systems and their relative value in supporting the business objectives. Some of the required skills which they should possess are as follows:

1. Ability to use interviewing techniques to obtain information missing from existing documentation from current operating and supervisory personnel.
2. An understanding of information systems and procedures in general.
3. A complete understanding of the requirements of the TO-BE and Transition Path endeavors and of the corresponding sections of the developing Master Plan.

Appendix IV – Enterprise Integration Planning Team

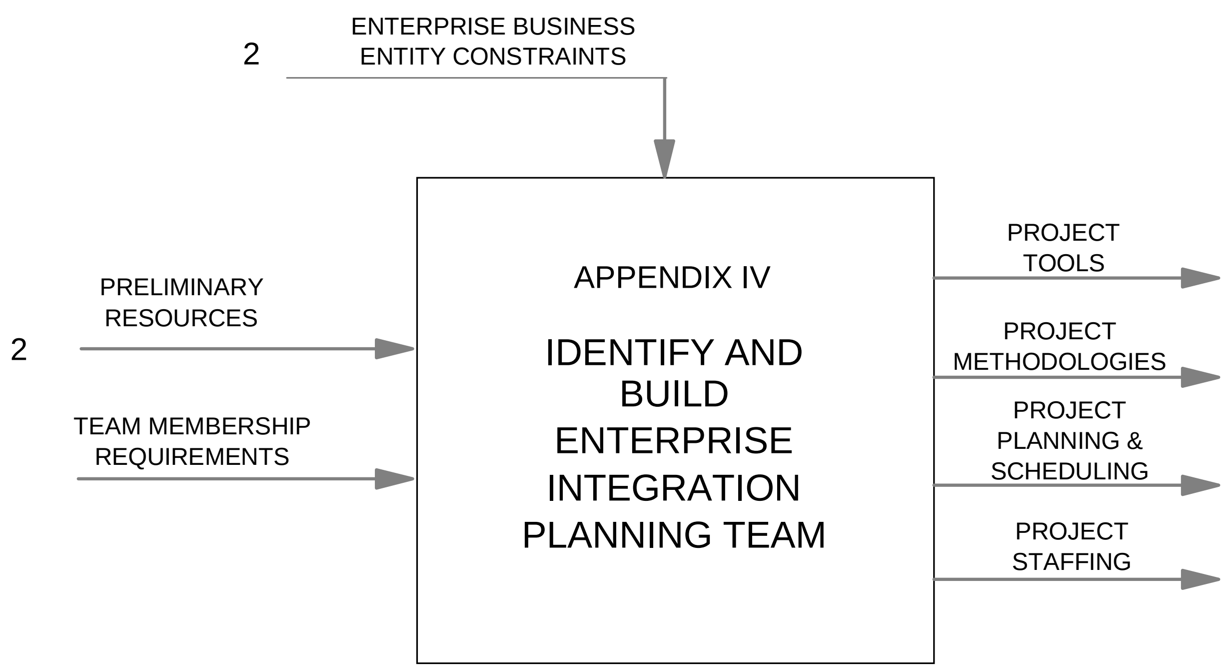


FIGURE AIV-1
THE TRANSFORMATION TASK OF APPENDIX AIV—IDENTIFY AND BUILD THE
ENTERPRISE INTEGRATION PLANNING TEAM

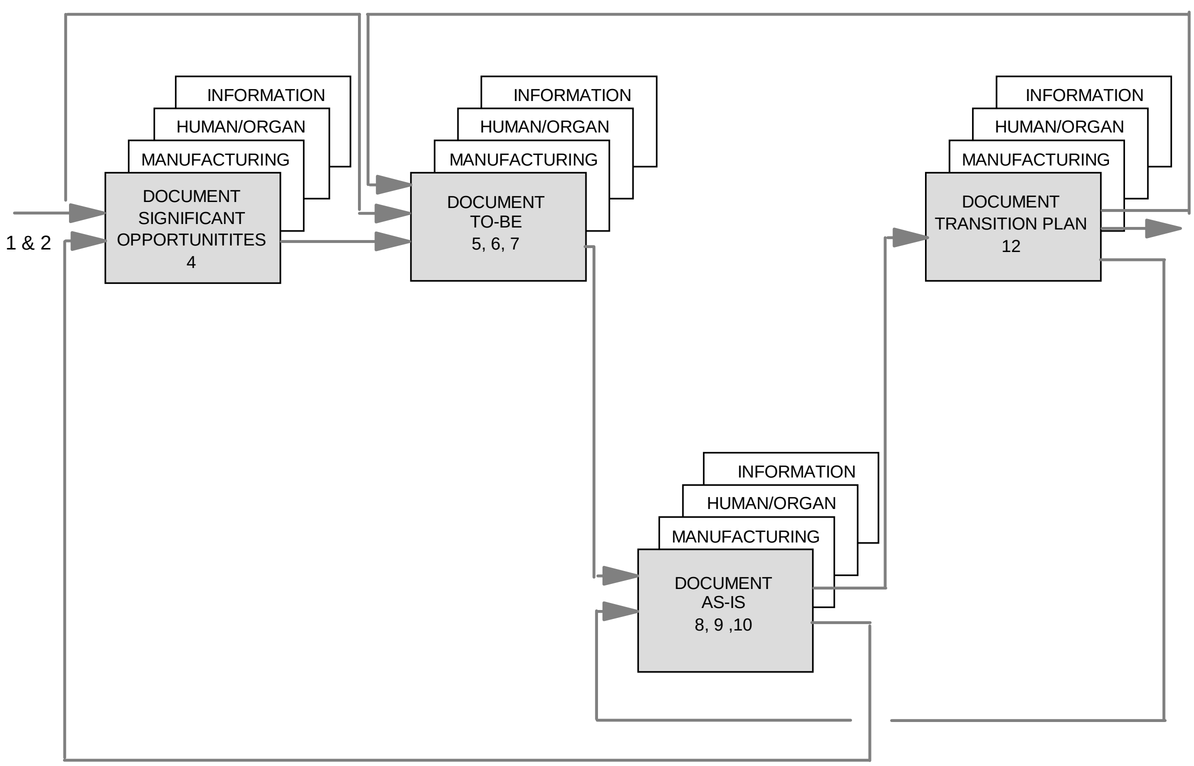


FIGURE AIV-2 RELATIONSHIP AND DEPENDENCIES OF THE AS-IS TO THE OVERALL PLANNING PROCESS

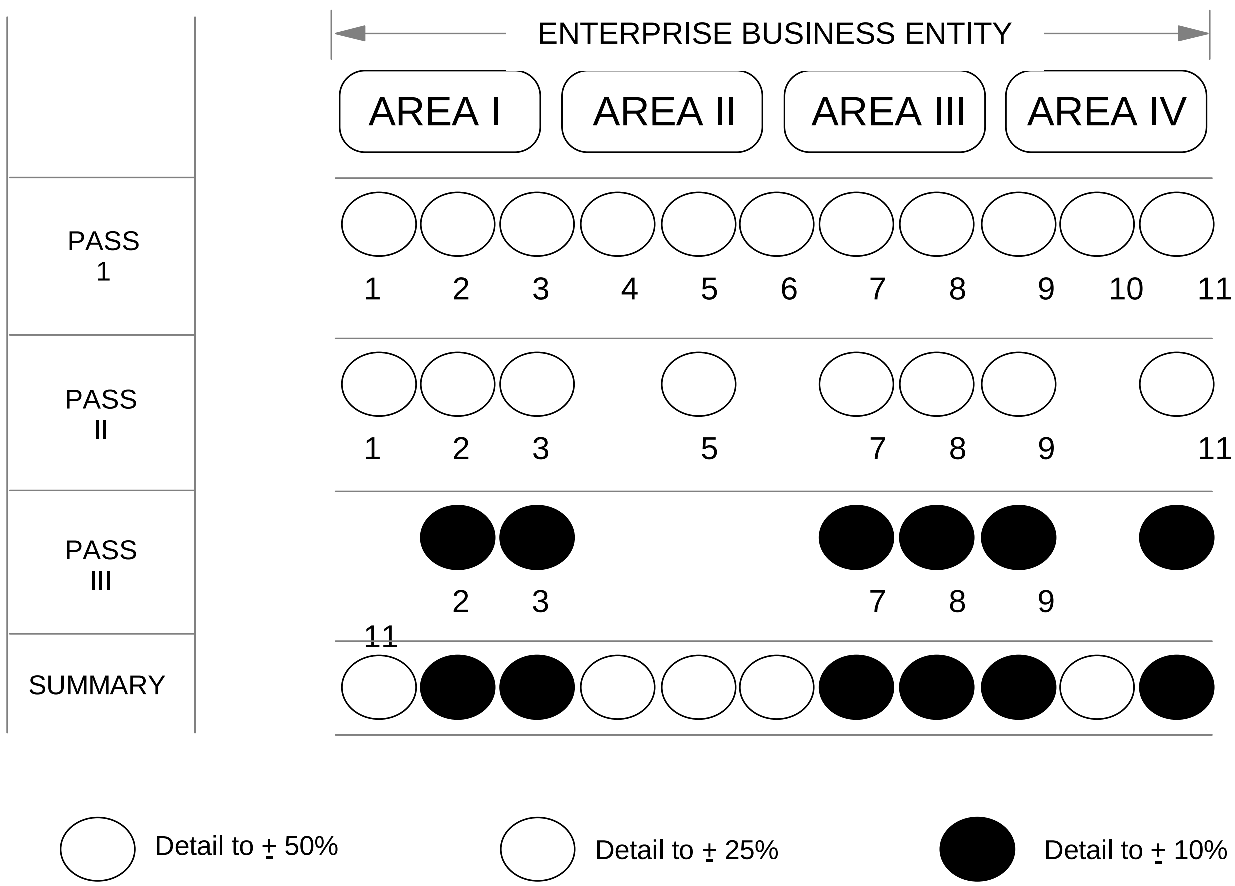


FIGURE AIV-3 PHASING OF THE MASTER PLAN DEVELOPMENT PROCESS AS FUNCTION OF THE DETAIL REQUIRED IN THE PLAN CONCERNING INDIVIDUAL ENTERPRISE BUSINESS ENTITY UNITS.

Appendix IV – Enterprise Integration Planning Team

Summary

This chapter has outlined the requirements for the staffing of the position of the Enterprise Integration Program Manager as the leader of the Enterprise Integration Planning Team and of the members of the team. Their task of conducting the study for and of developing the Enterprise Integration Master Plan has been outlined. The necessity for their use of the latest program conduct and management tools and techniques has been emphasized. No attempt has been made here to detail these tools and techniques because of their ready availability and the volume of material involved.

ATTACHMENT AIV-I

PROJECT TEAM STAFFING CHECKLIST

I. Who Is On the Team?

1. What Team? Is There a Single Team or More than One Team?
2. What is the Process for Selecting Team Members?
3. What are the Criteria?
4. What are the Different Role(s) for People on the Team(s)?
5. How is Leadership Carried Out?
6. What is the Charter of the Team? What are Their Guidelines? How are These communicated to the Team?
7. When Does the Team Go Out of Business?
8. Is Team Building Necessary? If So, What Kind and How Much?

II. How Does the Organization Support the Team(s)?

1. To Whom Does the Team Report?
2. To Whom Do Team Members Report? What is the Nature of Their Support?
3. How Long Do People Serve on the Team? How is This Commitment Made? How good Is It?
4. What Level of Funding is There to Support the Team? (NOTE: Are There any Pilot Projects, Proof-of-Concept, Prototyping, etc.?)
5. How Much Time do They Have to do Their Work?
6. Wheat Are the Criteria Used to Make These Last Two Decisions? (NOTE: Is This Viewed as a Strategic, "Bet the Company" Effort; or, is it "Just Another Project?")
7. What Authority Does the Team Have? How Difficult is it to Add (or Remove) Members?

Appendix V - GLOSSARY

Acceptance	The process by which the customer's representative formally agrees to ownership of completed equipment [SAMA]. Updating of active order to indicate acceptance of order
Acceptance Criteria	An acceptance data package describe the form, fit, manufacturing requirements, characteristics, and performance history of a piece of equipment. The package includes specifications, drawings, plans, manufacturing orders, inspection data, test procedures, test data and other data required by the customer. [SAMA].
Accounting Information	Information that accounting has gathered and accumulated, such as the cost of labor, material, equipment, tools, and facilities and transformed into the cost of the product, overhead, operating costs, inventory, etc. Synonym: Ledger.
Activity-based Costing	Alternative accounting method that costs products by the production activities performed during actual manufacture.
Actual Cost	An acceptable approximation of the true cost of producing a part, product, or group of parts or products, including all labor and material costs and a reasonable allocation of overhead charges. Actual costs are those labor and material costs that are charged against a job as moves through the production process [APIC].
Actual Cost System	A cost system which collects direct costs as they are incurred during production, and allocates indirect costs based upon their specific costs and achieved volume.
Adaptive Control	A control strategy that automatically changes the type or influence of control parameters to improve overall control systems performance.
AIX	Advanced Interactive Executive. The UNIX operating system delivered by IBM for its mainframe, workstation and PC hardware.
Alarm	An audible or visible signal indicating abnormal or out-of-limit conditions in a plant or a control system [CMSG]. Synonym- Bell, Light, Siren.
Algorithm	A prescribed set of well defined rules or processes for the solution of a problem in a finite number of steps, e.g., a full statement of an arithmetic procedure for evaluating sin x to a stated precision. An explicit, finite set of instructions that is guaranteed to find a solution to a particular problem, although not necessarily by the best or fastest route (contrast with heuristic).
AMT	Advanced Manufacturing Technology

Appendix V – Glossary

Analogue, Analog — Noun. Something that is analogous, acts similar to another.

ANSI — American National Standards Institute (see Standards Organizations).

API (Application Programming Interface) — An interface that enables programs written by users or third parties to communicate with certain IBM program products. The facility enables users and third parties to add functions to IBM-supplied software.

APICS — American Production and Inventory Control Society.

Application — A user or machine oriented function supported by automation technology. Software packages which execute the functions defined in the model of the enterprise. [CIM-OSA].

Application Process — An element within a system that performs the information/data processing for a particular application.

Architectural Resources — The integrating elements used to build a CIM (Computer Integrated Manufacturing) system. Resources can be categorized as interfaces, protocols or handlers, management tools, etc.

Architecture — The set of principles, rules and standards and other supporting data, classified and presented in an orderly form to illustrate the basic arrangement and connectivity of parts of a system. (2) The formation or construction of an object, device or system whether this is the result of the conscious act of, or the gross or random, disposition of the constituent parts. (3) The structure or arrangement of the several steps involved in planning, designing and carrying out the development and implementation of a system.

ART — Automated Reasoning Tool, is an expert system software development environment from Inference-Corporation. ART provides knowledge engineers with a comprehensive set of knowledge representation and storage techniques and graphics capabilities for building expert systems. [DEC].

Artificial Intelligence — A growing set of computer problem- solving techniques being developed to imitate human thought or decision making processes, or to produce the same results as those processes. [DEC].

ASC — Accredited Standard Committee. A standards committee accredited to ANSI.

As-Is Plant — A description of the subject entity of a CIM study at the current time or prior to CIM implementation.

ASN.1 — Abstract Syntax Notation One. An ISO standard (DIS 8824 and DIS 8825) that specifies a canonical method of data encoding. This standard is an extension of CCITT Standard X.409.

Appendix V – Glossary

Assembly Specification The assembly specification establishes detailed assembly procedures for any combination of parts, subassemblies, etc., that perform a specific function [SAMA].

Attribute A data fact about an entity or relationship.

AUTOFACT A yearly trade show sponsored by the Society of Manufacturing Engineers which specializes in CAD/CAM technology.

Available To Promise The uncommitted portion of a company's inventory or planned production. This figure is frequently calculated from the Master Production Schedule and is maintained as a tool for order promising.

Available Product Defined as Inventory + planned production - accepted orders.

Average Inventory In an inventory system, this is the sum of one-half the lot sizes plus the reserve stock in formula calculations.

Backbone The trunk media of a multimedia LAN separated into sections by bridges, routers, or gateways.

Backtracking An element of a search process that involves returning the database or conditions in a system to a previous state in order to try all alternative solution paths.

Backward Chaining A type of expert systems activity that attempts to solve a problem by stating a goal and looking into the database for the conditions that would cause that goal to come about, then reiterating this process, using those conditions as the goals while searching for their preconditions. [DEC].

Bandwidth The number of user data bytes (i.e. exclusive of communications overhead) that can be sent across the network per second.

Bar Code (1) Array of rectangular marks and spaces in a predetermined pattern depicting object identification, machine performance or other required data; can be numeric, alphanumeric or combinations thereof. (2) Also used to identify finished or semi-finished products.

Baseband A signaling technique in which a single channel digital signal is encoded and impressed on the physical medium.

Batch Process An industrial manufacturing method in which several separate serial and, or parallel operations are carried out to produce a product, in contrast to Continuous Process (q.v.).

Baud Unit of signaling speed. Baud is the same as bits per second only when every signal event represents exactly one data bit and there is no communications overhead.

Benchmark Noun: A standard by which something can be judged.

Appendix V – Glossary

Bill of Lading	A contract or receipt for goods that a carrier agrees to transport from one place to another and to deliver to a designated person or that it assigns for compensation upon the conditions stated therein [APICs].
Bill of Material	A listing of all the subassemblies, parts and raw materials that go into the parent assembly. It shows the quantity of each raw material required to make the assembly. There are a variety of display formats for BOMS, including single level, indented, modular/ planning, transient, matrix and costed BOMs [APICs, CMSG].
Bit	(1) An abbreviation of Binary Digit. (2) A single character in a binary number. (3) A single pulse in a group of pulses. (4) A smallest code element which may possess information in either of two states. (5) An acronym for Binary Digit; the smallest unit of information in the binary numbering system. Represented by the digits 0 and 1.
Blackboard	A structured workspace on which a system can post information about the internal states of objects or system registers, for consultation and appropriate action in the system by operators. [DEC].
Blending	The process of physically mixing two or more lots of material to produce a homogeneous lot. Blends normally receive new identification and require re-testing.
BOM Costed	A form of the Bill Of Material that extends the quantity of every component by the cost of the components [APICs].
Bond-room Location	A controlled storeroom for configuration items such as material and parts [SAMA].
Bottleneck	A facility, function, department, etc., that impedes production.
Bridge	A network device that interconnects two local area networks that use the same LLC (Logical Link Control) but may use different MACs (Media Access Control). A bridge requires only OSI (Open System Interconnect) Level 1 and 2 protocols (Also see Gateway and Router).
Broadband	A medium based on CATV (Community Antenna Television) technology where multiple simultaneous signals may be frequency division multiplexed.
Broadcast	A message addressed to all stations (e.g. all stations connected to a LAN).
Bus	A broadcast topology where all data stations are connected in parallel to the medium (see Topology).
Business Plan	A statement of income projections, costs and profits usually accompanied by the budgets and a projected balance sheet as well as a cash flow statement (source and application of funds). The business plan

	and the production plan, although frequently stated in different terms, should be in agreement with each other. (of. manufacturing resource planning). Components: Profit Objectives, Production Strategy, Inventory Level, Employment Level, Budgets) [APIC].
Business Unit	The lowest level of the company which contains the set of functions that carry a product through its life span from concept through manufacture, distribution, sales and service.
Business Unit Scope	A description of the boundaries and content of a Business Unit.
Buy-in	Noun: The process of acceptance of and active cooperation in the development, promulgation and use of a project, technology or new equipment by those individuals concerned.
By-product	Noun: Something produced in the making of something else, a side effect.
Byte	A small unit of data bits that are treated as a single unit or “character”. The number of bits is most commonly eight (see Octet).
Calibration Schedule	The objective of a calibration schedule is to detect the deterioration of performance of equipment and tools before the thresholds of performance are exceeded. Calibration schedules are established by classes of equipment and are varied to reflect precision, nature and extent of use. Schedules can be based on elapsed calendar time, actual amount of usage or actual operating hours. [JURA].
Calibration Status	The status of the calibration, such as adherence or deviation from a calibration schedule, etc.
CAM	Computer Aided Manufacturing, that part of Computer Integrated Manufacturing restricted to the operation and control of manufacturing functions.
Capacity Plan	The capacity requirements plan determines how much labor and equipment are needed to accomplish the tasks of production. The capacity requirements plan translates the production orders into hours of work at a work center by time period. [APICs].
Capacity Plan Rough	The process of converting the master schedule into capacity needs for critical resources: manpower, equipment, warehouse space, vendor capabilities and money. Often the Bill of Resources is used to accomplish this. The purpose of the Capacity Plan is to evaluate the master schedule prior to implementing it. [APICs] Synonym: Capacity Resource Plan.
Carrier Band	A single channel signaling technique in which the digital signal is modulated on a carrier and transmitted (also see Baseband).

Appendix V – Glossary

Carrying Cost	The cost of carrying inventory is usually defined as a percent of the dollar values of inventory per unit of time. Carrying Cost depends on cost of capital invested as well as the costs of maintaining inventory, such as taxes and insurance, obsolescence, spoilage and storage. Costs vary from 10 to 35 percent annually. Carrying Cost is an opportunity cost due to alternative uses found for funds tied up in inventory [APIC].
CASA/SME	The Computer and Automated Systems Association of the Society of Manufacturing Engineers. CASA/SME is a professional engineering association dedicated to the advancement of engineering technology. CASA/SME sponsors both the MAP and TOP (Technical and Office Protocol) Users Groups.
CASE	Computer Aided Software Engineering: computer based tools to aid programming tasks.
CATV	Community Antenna Television (see Broadband).
CBEMA	Computer and Business Equipment Manufacturers Association (see Standards Organization).
CCITT	International Consulting Committee on Telephone and Telegraph (see Standards Organizations). French abbreviation.
Cell Model	A graphic representation of a human- or machine-directed function, which has elements of input, activity and output.
CI List	A tabulation of engineering drawings, specifications and other reference documents needed to fabricate and assemble a Configuration Item. [SAMA].
CIM	Computer Integrated Manufacturing. The computer integrated enterprise of manufacturing including the management of required resources; people, organization, material, energy, data, computer technology and automation equipment.
CIM Architecture	A graphical representation of organization and connectivity of elements that participate in a CIM system.
CIM Program Proposal	A logical series of projects to achieve key business requirements.
CIM System	Refers to an implementation of the CIM architecture to integrate an enterprise. Proper selection of CIM products and standards as part of the system will require characteristics of the particular enterprise and attributes of its data requirements to be defined.
CI Parts List	This list may be either an indentured or an alphanumeric listing of all parts making up a configuration item, (CI). The list illustrates the indentured relationship, application, quantities and engineering revision status for all parts and assemblies within the CI [SAMA].

Appendix V – Glossary

CI Specification — The Configuration Item (CI) Specification establishes the functional, performance and design criteria for the design, development, testing and production of any combination of parts, subassemblies, units or groups that perform a specific function and is essential to the completeness of a system or subsystem [SAMA].

Closed Loop System — Refers to a feedback control system involving one or more feedback control loops, which combine functions of controlled signals and of commands, in order to keep relationships between the two stable.

CMSG — Cost Management Systems Guide.

Code ID — A unique number assigned to each company that builds or develops items for the government [SAMA].

Cohesion — Requires that each module is designed to perform a single-well-defined function, and the function is completely contained in the module.

Common LISP — An implementation of the LISP programming language that incorporates features that are common to several implementations of LISP. [DEC]

Communication — The transfer of information and understanding from one point or person to another person. The basic elements in the process of communication are an information source, encoding, transmission, reception, and decoding.

Compatibility — Ability to use an instruction, program, or component on more than one computer with the same result. [DEC].

<u>Component</u> **<u>CEN</u>**

Computer Aided Software Engineering — Computer based tools to aid programming tasks, CASE tools.

Computer Graphics — A human-oriented system which uses the capabilities of a computer to create, transform, and display pictorial and symbolic data.

Computer Integrated Manufacturing — The computer integrated enterprise of manufacturing including the management of required resources; people, organization, material, energy, data, computer technology and automation equipment. There is no universally agreed definition but some common descriptions include:

(1) Computer Integrated Manufacturing (CIM) is manufacturing supported by information and automation intended to create an overall system,
   a. Which is responsive to the human and economic environment interpreted on all levels and,
   b. Which improves the management of the industrial facility.

(2) Computer Integrated Manufacturing involves the use of computers to streamline the flow of materials and information within a manufacturing organization. The goal of CIM is to increase productivity, product quality and manufacturing flexibility while decreasing cost and time-to-market. It is important to keep in mind that CIM itself is not the goal, but instead a strategy to ensure the long-term survivability of the manufacturing organization.

(3) CIM is a strategy by which manufacturers organize the various hardware and software components, such as robotics, machine vision, CAD (Computer-Aided Design), CAM (Computer-Aided Manufacturing) and Manufacturing Resource Planning (MRP-II), into a unified system working toward the same goals.

(4) CIM involves the development and implementation of a computer-based information management and automation system for the enterprise that allows the establishment of a business process to:

a. Automate the information flow of the plant.
b. Deploy appropriate automation and information technologies wherever they are needed in the plant.
c. Make optimal use of the capabilities of plant personnel.
d. Maximize information access at all levels of the system.
e. Provide timely, accurate and complete information on plant operations wherever and whenever needed with the object of obtaining a competitive advantage for the company.

Computer Integrated Manufacturing (CIM) Architecture A graphical representation of organization and connectivity of elements that participate in a CIM system.

Computer Integrated Manufacturing (CIM) System Refers to an implementation of the CIM architecture to integrate an enterprise. Proper selection of CIM products and standards as part of the system will require characteristics of the particular enterprise and attributes of its data requirements to be defined.

Conceptual Design The result of the conceptual phase in defining the product. It begins with the broad product objectives and decomposes these objectives into concept formulation, general design approaches, feasibility evaluations, block diagrams and high-level layouts of the product design [SAMA]. In Manufacturing environments some times also called Functional Baseline.

Conceptual Model An abstract representation of an object or phenomenon that provides a common understanding.

Conceptual Schema Comprising the central description of the various information contents that may be in a database.

Appendix V – Glossary

Configuration The complete technical description required to build, test, accept, operate, maintain and logistically support a piece of equipment. It includes the physical and functional characteristics of the equipment. [SAMA].

Configuration As-Designed When a drawing list on the As-Planned list is formally released, the drawing constitutes the As-Designed Configuration requirement. The purpose of this list is to provide a reference point for comparing the As-Built Configuration of the product to the As-Designed Configuration. [SAMA].

Configuration As-Modified The list which identifies the changes made to a product in the field or at a test site. This report is an updated record of the product as it proceeds through a series of field modifications and changes. It includes the Cl and serial numbers, modification drawing number, ECP numbers, date of incorporation, product location, persons making the modification and the results of the modification. [SAMA].

Configuration As-Planned Lists which are used to enable advanced planning by various departments to record interface definitions and systems requirements. These lists are based on the specification tree and design requirements defined in the product specification. The drawings are initially identified in an indentured assembly drawing list, and detail drawings are added to the list as the task progresses. The list is released by engineering. [SAMA].

Configuration Change Request Used to request a change to the approved product configuration. [SAMA].

Configuration Control Documents Documents to control changes in configuration. Configuration Control establishes procedures to process these changes from initiation of the document through analysis and finally to the approval or disapproval and affectivity of the document. [SAMA].

Configuration Identifier An alphanumeric designator used to identify configuration elements. [SAMA].

Configuration Log A logbook kept with each end item after final assembly. The logbook is used for recording data on all periods of operation, for example, operation history, tests, failures, repair and replacements, diagnosis and rework. [SAMA].

Constraints CEN

Constraint Rule A type of rule that applies limits to a search by specifying that its associated pattern is never allowed to occur in a valid solution. These rules help reduce the number of unproductive searches. [DEC].

Contacts Inquiries, orders, information, confirmation.

Continuous Process Processes which run at some relatively constant rate for long periods of time. Contrasts with Batch Process (q.v.).

Contractor Planning	Schedules of requests for outside contractor assistance.
Contractual Obligations	Conditions/agreements/contracts with customers, and/or suppliers. By definition these are written and must be honored. Examples are blanket orders, terms and conditions for purchase orders or service requests, etc.
Control	Measurement of performance or action and comparison with established standards in order to maintain performance and action within permissible limits of variance from the standard. May involve taking corrective action to bring performance into line with the plan or standard.
Control Action	Is the institution of the necessary activity to cause a process, device or system to carry out the tasks assigned to that particular process, device or system.
Controlled Variables	Validated measurements for direct control of pressure, temperature, flow, etc.
Controls IDEF	Inputs to the top surface of the IDEF0 block representing those items which exercise controls or constraints over the transformation represented by the block.
Coordination Needs	Extent to which operators must work with others to obtain the information necessary to perform their jobs.
COS	Corporation for Open Systems. An organization of vendors formed in 1985 to coordinate member company efforts in the selection of standards and protocols, conformance testing, and the establishment of certification. The purpose was to improve and eventually insure interoperability of different vendors products.
Coupling	Refers to the informational and control linkages between two modules. It is desirable to minimize these linkages and make them explicit.
Criterion	Noun: A standard on which a judgment can be based; Pl: Criteria; Usage note: Criteria is a plural form and should not be substituted for the singular criterion.
Critical Success Factors	The few key areas of activity in which favorable results are absolutely necessary for a particular business entity to reach its goals. "Things that must go right."
CSF	See Critical Success Factor
CSMA/CD	Carrier Sense Multiple Access with Collision Detection, a method of assigning mastership in a communications network. The basic access method used by Ethernet.
Customer	Anyone who makes a demand on the manufacturing entity that is external to the entity that requires a quality response, whether they be

research and development, corporation management, government authority or product customers.

Customer Details Customer information (name, address, shipping address, credibility, special needs).

Customer Products and Services Output items or activities of an enterprise which are its reason of being, ie, those for which it receives remuneration, etc.

Customer Profile Information relating to a customer used to facilitate manufacturing activities. This includes such information as customer contact, specific product, product information requirements, shipping requirements and special instructions and anything else related to customer relations.

Customer Responses Replies to customer in response to requests for order status, purchase order acknowledgement, technical information, shipping dates, quality information, etc.

Customer Returns, Requests and Feedback Any contact with a customer of the manufacturing entity. It may be requests for information, requests for manufacturing capacity, feedback on manufacturing performance or product performance, or information on any output sent to a customer that was returned for failure to meet expectations. They are converted into any further output that is sent to the customer in response.

Data Flows Like pipelines that carry data between processes, data stores or external agents.

Data and Information If we use the term data, we mean data to which relevance and semantics could be associated. The term information refers to data, to which the relevance and the semantics are already associated.

INFORMATION
RELEVANCE
SEMANTICS (MEANING)
DATA

The values stored in a database are referred to as data. They become information only when associated with some definition of their meaning, purpose and relationship with other values. Normally, it is the user who synthesizes data to derive information that is meaningful. This synthesis can also be performed through the use of artificial intelligence.

Data Stores Serve as repositories of data produced by processes. These data are then made available to other specified processes.

DBMS **DATABASE MANAGEMENT SYSTEM.** A software package that enables end users or application programmers to share data. DBMSs are generally also responsible for data integrity, data access control and automated rollback/restart/recovery.

DCS	Distributed Control System. Usually consists of regulatory control devices connected via a data highway to HMI (Human-Machine Interface) computers.
Decentralization	The extent to which the organizational structure allows lower-level workers to make decisions about their jobs, work flow, and work activities.
Decision-Making	The response to a need or stimulus by means of acquiring and organizing information, processing this information to yield alternative courses of action, and selecting one course of action from among the alternatives.
Demand Management	The function of recognizing the managing all of the demands for products to ensure that the master scheduler is aware of them. It encompasses the activities of forecasting, order entry, order promising, branch warehouse requirements, interplant orders, and service parts requirements.
Department	Noun: A distinct usually specialized division of an organization, government, or business.
Dependent Demand	Demand is considered dependent when it is directly related to or derived from the demand for other items or end products. Such demands are, therefore, calculated and need not, and should not, be forecast. A given inventory item may have both dependent and independent demand at any given time.
Design Basis	Document that contains the basis of a design to allow further detailed engineering.
Design Practices	Engineering methods, standards, practices.
Digitizer	A graphical input device (e.g., a CAD digitizer) with a surface on which a location or a point is selected and then automatically converted into a digital x y coordinate suitable for transmission to a computer. A device for converting a signal of any type into a digital representation for storage in a computer or other related component or system.
Direct Digital Control (DDC)	The use of a digital computer to read dependant variables, and establish commands to the final control elements of multiple regulatory loops.
Directory Service	The network management function that provides all addressing information required to access an application process.
DIS	Draft International Standard. The second stage of an ISO Standard (see IS).
Discipline	Noun: Training intended to produce a specified character or pattern of behavior, controlled behavior resulting from such training, a state of order based on submission to rules and authority, punishment intended to

correct or train, a set of rules or methods, a branch of knowledge or teaching.

Dispatching The selecting and sequencing of available jobs to be run at individual workstations and the assignment of these jobs to workers.

Distributed Computing Computing performed within a network of distributed computing facilities. The processors for this type of system usually function with control distributed in time and space throughout the network. Associated with the distributed process are distributed storage facilities.

Distributed Control System A series of computer-based devices that operate in conjunction with each other on a variety of applications. These are usually (widely) separated throughout the system being controlled.

Distributed Processing A data processing organizational concept under which computer resources of a company are installed at more than one location with appropriate communication links. Processing is performed at the user's location generally on a minicomputer, and under the user's control and scheduling, as opposed to processing for all users which is done on a large, centralized computer system.

Distribution Constraints Information which influences the choice of distribution channels including distribution channel priorities, alternates, availabilities, customer requests, procedures, and lead times.

Domain CEN

Domain Expert In the Expert System domain, one who has knowledge that a knowledge engineer uses to structure the knowledge and formulate the rule base. [DEC]. One who is well versed on all aspects of a domain of knowledge.

Domain Knowledge Representation The knowledge representation that is specific to the application. These may be compound knowledge representations. The advantage of domain specific representations is that they represent knowledge in the most natural form for the knowledge engineer and domain expert.

DP Draft Proposal. The first stage of an ISO Standard (see DIS).

ECSA Exchange Carriers Standard Association (see Standards Organizations).

EDI Electronic Data Interchange. Technology that permits the standardized transfer of electronic information between different parts of an organization or different organizations. EDI uses a variety of protocols and standards depending upon the application and the industry.

EIA Electrical Industries Association (see Standards Organizations).

Electronic Data Processing	(1) Data processing largely performed by electronic devices. (2) Pertaining to data processing equipment that is predominantly electronic, such as an electronic digital computer.
Engineering Change	A revision to a parts list, Bill of Materials drawings, authorized by the engineering department. Changes are usually identified by a control number and are made for "safety," "cost reduction," or "functionality" reasons. To effectively implement engineering changes, all affected functions, such as materials, quality assurance and assembly engineering, etc. should review and agree to the changes.
Enterprise	CEN
Entity	(1) Is a thing (e.g., a person or a device), a concept, an organization, or an event of interest about which the business cares enough to keep data. Usually expressed as nouns in English. (2) An active element within an OSI layer (e.g. Token Bus MAC is an entity in OSI Layer 2).
Entity/Relationship (E/R) Model	Conceptual model of business subject matter consisting of a diagram (showing the structural organization of entities, relationships, and attributes) and formal policy-based definitions of each, usually stored in a dictionary.
ERP	**Enterprise Resource Planning.** A concept developed by Gartner Group describing the next-generation of manufacturing business systems. The next-generation of MRPII technology that will facilitate the running of business applications in a much more distributed fashion under the client/server model.
Established Manufacturing Policy	The set of rules for operating a manufacturing plant to achieve the goals of management. It can be articulated and delegated in a general way (e.g., a set of algorithms rather than required human innovation, etc.). The term policy is understood to extend to individual measurements and tolerances prescribed to implement production.
Ethernet	A baseband LAN developed by Xerox Corporation and supported by Intel, DEC, Hewlett-Packard and others. It uses a bus topology and CSMA/CD access control. See also IEEE 802.3.
Exception Policies	Rules and guidelines from marketing to handle waiver and special requirements when accepting an order.
Expert System	A computer system that embodies the specialized knowledge of one or more human experts and uses that knowledge to solve problems. [DEC].
Explanation Facility	A feature of many Expert Systems that tells what steps were involved in the process by which the system arrived at a solution. These facilities can be simple traces of steps, or they can be more complex, supplying

encoded reasons why the solution uses one alternative rather than another. [DEC].

External Agents — Components outside the model boundaries that send data to and receive data from the functional entities (process).

External Influence — A functional entity (external entity) that is separate from the production plant and does not take part in its internal on-going operations but whose actions can have an effect upon the future operation of the plant. They may be part of the company in question or may be units of a separate company working with the functional entities of the production plant.

Failure Report — A report describing the failure of a piece of equipment or item, its cause, and the corrective action taken to prevent the recurrence of the failure. [SAMA].

Feedback — The determination of the degree or manner of accomplishment of the control action and the use of the information to assure that the control action is accomplished. Degree and type of feedback needed by the equipment about a variety of different factors, such as tolerance, temperature, density , and so on.

Feedback Control — A type of system control obtained when a portion of the output signal is operated upon and fed back to the input in order to obtain a desired effect.

Feed-forward Control — A control strategy that converts any control systems upset or disturbance into corrective action so that deviations to the control variable can be predicted and minimized.

Fiber Optics — A medium that uses light conducted through glass or plastic fibers for data transmission.

Field Bus — A standard developed by ISA (S50) for a bus to interconnect process control sensors, actuators, and control devices.

Finish Specification — The finish specification establishes the method and requirements for protective treatments and finishes for materials, parts, etc. [SAMA].

Finite Loading — Conceptually, the term means putting no more work into a factory than the factory can be expected to execute. The specific term usually refers to a computer technique that involves automatic shop priority revision to level load operation by operation.

FIPS — Federal Information Processing Standards (see NBS).

Fixed Costs — An expenditure that does not vary with production volume, such as rent, property tax, administrative salaries, etc. [APIC].

Flow Rate	(1) Running rate: The inverse of cycle time, for example, 360 units per shift [APIC]. (2) Continuous/Liquid/Fluid/Gaseous flow in terms of Units/Second-Minute-Hour.
FMS	Flexible Manufacturing Systems.
Forecast	An estimate of the future demand. A forecast can be determined by mathematical means using historical data and it can be created from informal techniques or both. [APIC]. A forecast is an extrapolation of the past into the future. It is an objective computation involving data as opposed to an informal predication of changes and new factors influencing demand. [CMSG].
Forward Chaining	A type of system activity that applies operators to a current state in order to produce a new state until the solution is reached. In an expert system, a forward-chaining rule detects certain facts in the database and takes action because of them. [DEC].
Frame	In artificial intelligence systems, a knowledge representation technique based on the idea of a frame of reference. A frame carries with it a set of slots which can represent objects that are normally associated with the frame's subject, allowing frame-based systems to support inferences.
Framework System	A type of artificial intelligence systems-building tool designed to reduce the amount of time required to develop an expert system. A knowledge engineer customizes a framework system for a specific application by building a knowledge base for the problem domain of interest.
FTAM	File Transfer Access and Management Protocol (ISO DP 8571). FTAM is one of the application protocols specified by MAP and TOP.
Function	A group of tasks that can be classified as having a common objective within a company.
Function Analysis	The task of developing and studying each and all of the tasks to be carried out by an enterprise in performing its established mission.
Function Design	The task of making a preliminary design of the system necessary to carry out the established mission of an enterprise.
Functional Requirement	A specification constraining the way in which a given task is to be performed, the results to be obtained (speed, accuracy, etc.) as well as the elements of the functional entities involved (initiator, source, receptor, etc.).
Functional Entity	That cohesive collection of elements (humans, machines, computers, control devices, computer programs [any or all]) required to carry out one or more closely related tasks or transformations which comprise a recognized function of the manufacturing plant in fulfilling the established manufacturing policy of the company, e.g., production units or staff departments, etc.

A functional entity may contain other functional entities.

An [application functional entity] is involved in carrying out the primary mission of the manufacturing plant in question as outlined by the established manufacturing policy of the company. It is directly concerned with the handling and control of raw materials, intermediates and products of the company. The principles of autonomy and locality apply to these entities.

Application functional entities serve as sources and/or sinks of process operational data in the problem domain. They are made up of manufacturing specific functional entities and the physical means of production or plant production media.

A [foundation functional entity] is a cohesive collection of elements (possibly shared) that carry out a generic supporting function. It does not necessarily obey the principles of autonomy and locality in its operations. Examples of foundation functional entities are:

Communications	Man-Machine Interfaces
Control Library	Operating Systems
Databases	Sensor Management
Graphics Packages	Statistical Quality Control Systems
Hardware	Etc.

[Manufacturing specific functional entities] are commonly elements of larger applications functional entities but may be listed as separate entities in their own right. They form the parts of the application functional entities which are included in the plant's integrated information and automation system in contrast to the plant production media which carry out the physical production steps and material handling functions of the plant. Manufacturing specific functional entities will commonly include foundation functional entities within their make-up. Examples of manufacturing specific functional entities are:

Computer System Configurations	Product Shipping
Administration	Inventory Management
Cost Accounting	Product and Process Planning
Purchasing (Raw Material & Spares)	Quality Control
Maintenance Planning	Resource Management
Order Entry	Scheduling

[Plant production media functional entities] comprise those physical production machines, equipment and devices including material handling, which move, position, and transform raw materials into the desired products of the manufacturing enterprise.

Gateway A network device that interconnects two networks that may have different protocols (see Bridge and Router).

Generic Level — Contains those parts of an Architecture which are generic to many systems. [CIM- OSA]

GM C4 — The General Motors program that looks to set a variety of standards for all levels of manufacturing applications. The two parts of the program that are most developed include standards for communications technology, as well as CAD/CAM software and hardware.

Goals — Specific targets for a period of time.

Gross Margin — Selling price - product cost.

Gross Requirements — The total of independent and dependent demands for a part or an assembly prior to netting on-hand and scheduled receipts. [APIC].

Group Technology Classification by Process — A means of coding parts or processes based on the similarities of the parts or grouping parts into product families or grouping production equipment together to produce a family of parts [CMSG]. It provides for rapid retrieval of existing designs and anticipates a cellular-type equipment layout. [APIC]. In this context it is the code or classification for a <u>process</u>.

Group Technology Classification by Product — A means of coding parts or processes based on the similarities of the parts or grouping parts into product families or grouping production equipment together to produce a family of parts. [CMSG]. It provides for rapid retrieval of existing designs and anticipates a cellular-type equipment layout. [APIC]. In this context, it is the code or classification for a <u>product</u>.

Group Technology Data — A means of coding parts or processes based on the similarities of the parts or grouping parts into product families or grouping production equipment together to produce a family of parts. [CMSG]. It provides for rapid retrieval of existing designs and anticipates a cellular-type equipment layout. [APIC].

Grouping Departments by Process — An organizational structure where the main departments of the organization are grouped by distinctly different production processes — for example, raw materials handling, continuous processing, and finished goods packaging.

Grouping Departments by Products — An organizational structure where the main departments of the organization are grouped by major product lines — for example, consumer paints and industrial paints.

GUI (GRAPHICAL USER INTERFACE) — A generic user interface. Examples include Microsoft Windows, OSF’s Motif and Apple's Macintosh interface. A comprehensive GUI environment includes four components: a graphics library, a user interface tool kit, a user interface style guide and consistent applications. A graphics library provides a high-level graphics programming interface. The user-interface tool kit, built on top of the graphics library, provides application programs with mechanisms for creating and managing the dialogue elements of the WIMPS interface. The user interface style guide specifies how applications should employ the dialogue elements to present a consistent, easy-to-use environment (i.e., "feel") to the user. Application program conformance with a single user interface style is the primary determinant of ease of learning and use and, thus, of application effectiveness and user productivity.

Guidelines Provided to ensure a consistent application of a Reference Architecture and/or Reference Shells when creating particular models. [CIM-OSA].

Hardware Physical equipment, as opposed to the computer program or method of use; e.g., mechanical, magnetic, electrical or electronic devices. Contrast with software.

Heuristic A self learning or adaptive process that may help in the solution of a problem, but that does not guarantee the best solution, or any solution. [DEC].

Hierarchy Noun: Plural: Hierarchies. Organized or classified according to rank or authority, an arrangement of persons or things in a graded series. Adj: Hierarchical, hierarchic. Adv: Hierarchically. (1) A data structure consisting of sets and subsets such that every subset of a set is a lower rank than the data of the set. (2) Any structure consisting of units and sub-units where the sub-units are of lower rank than the units involved.

Human-Machine Redundancy Extent to which operators should be involved in tasks performed by machines as a check on machine operation.

Human and Organizational Architecture That part of the Purdue Enterprise Reference Architecture which describes and illustrates those functions , tasks, etc. involved with all human activities necessary for its subject enterprise.

Human Interface A tool able to intercept, interpret and guide the interaction of the end user with the system.

Human Factors The field of effort and body of knowledge devoted to the adaptation and design of equipment for efficient and advantageous use by people considering physiological, psychological and training factors.

Hurdle Rate The expected rate of return on capital which a proposed project must meet in order to be accepted by management.

ICON A symbol to which a computer can point an interface in order to select a function such as "move window." [DEC].

IDEF	ICAM DEFinition Language, a systems modeling technique using a specific graphical structure.
IEEE	Institute of Electrical and Electronic Engineers (see Standards Organizations).
IEEE P1118	A standards committee working on the development of a "Micro-controller Serial Control Bus". This standard is to be technology-based, not application-based and is intended to be suitable for many different application types, including (but not limited to) instrumentation, process control, and RS232-type peripherals.
IEEE 802	One of the standards committees working on LAN standards. IEEE 802 has produced standards for CSMA/CD, Token Bus, Token Ring, and Logical Link Control (LLC). Activity continues in all of the above areas and in the area of Metropolitan Area Networks. IEEE 802 is composed of the following WGs (Working Groups) and TAGs (Technical Assistance Groups): IEEE 802.0 - Executive Committee IEEE 802.1 - Higher Layer Interface IEEE 802.2 - Logical Link Control IEEE 802.3 - CSMA/CD IEEE 802.4 - Token Bus IEEE 802.5 - Token Ring IEEE 802.6 - Metropolitan Area Network IEEE 802.7 - Broadband TAG IEEE 802.8 - Fiber Optics TAG
Implode	Compression of detailed data into a summary level record or input. Combination of “exploded” parts list into subassemblies and assemblies.
Incoming Confirmation	Updating of incoming material status to release payment.
Indirect Cost	Costs that are not incurred by a particular job or operation, such as utilities, management salaries, material handling, data processing, etc. [APIC].
Industrial Computer	A personal or process control computer that is designed to withstand the rigors of the factory floor. Typically, the device is encased in a metal or EMI (Electro Magnetic Interference) proof casing. In addition, some industrial computers are configured so that maintenance and cold start up are relatively simple. Such devices are used for applications such as data collection, monitoring and programming.
Inference	In Artificial Intelligence, a conclusion based on a premise. [DEC].
Inference Engine	The part of a rule-based system that selects and executes rules. The conclusion that an inference engine will draw from a given set of facts is not known in advance. [DEC].

Appendix V – Glossary

Information View	Describes the information required by each function. Three kinds of schemata are used to model the information, namely; conceptual, internal and external.
In-Process Inventory	Product in various stages of completion throughout the factory, including raw material that has been released for initial processing and completely processed material awaiting final inspection and acceptance as finished product for shipment to a customer.
Inspection Procedure	A tailor-made plan for a specific component or product type. It lists the characteristics to be checked, the method of check (visual, gage, etc.) and the instruments to be used. In addition, it may include the seriousness classification of characteristics: tolerances and other criteria, a list of applicable standards, sequence of inspection operations, sample plans and other lot criteria. [JURA].
Installation Details	Documentation, drawing information and instructions for construction.
Integrated System	A system in which separate programs perform separate functions with communication and data-passing between functional programs performing standardized I/O routines and a common data-base. Such systems allow flexibility in addition/revision/deletion of various processing functions without disrupting the entire system.
Integration	The extent to which components of the production process are inextricably linked. A software design concept that allows users to move easily between applications. [DEC].
Interface	A shared boundary; e.g., a hardware component to link two devices, a portion of storage or registers accessed by two or more programs.
InterLISP	A general purpose environment for building and using artificial intelligence applications based on the LISP programming language. [DEC].
Internal Schema	Describing how information present in the conceptual schema is structured and stored inside the system. [CIM-OSA].
Inventory	Parts and material on hand. Inventory is Items that are in a stocking location or work in process and that serve to de-couple successive operations in the process of manufacturing a product and distributing it to the consumer. Inventories may consist of finished goods ready for sale; they may be parts or intermediate items; they may be work in progress; or they may be raw materials. [APIC]. Actual quantities, specifications, location of materials in storage.
Inventory Management	Management of the inventories, with the primary objectives of determining: (1) Items that should be ordered, and in what quantity. (2) The timing of order release and order due dates. (3) Changes in the quantity called for and the rescheduling of orders already planned. Its

two broad areas are inventory accounting, which is the administrative aspect, and inventory planning and control, which consists of planning procedures and techniques that lead to inventory order action.

Inventory Valuation — The value of the inventory at either its cost or its market value. Because inventory value can change with time, some recognition is taken of the age distribution of the inventory. Therefore, the cost value of inventory is usually computed on a first-in, first-out, or last-in, last-out basis or a standard cost basis to establish the cost of goods sold. [APIC].

IS — International Standard. The third (and highest) stage of an ISO Standard. Prospective ISO standards are balloted three times. The first stage is as a Draft Proposal (DP). After a Draft Proposal has been in use a period of time (typically 6 months to a year) the standard, frequently with corrections and changes, is re-balloted as a Draft International Standard. After the Draft International Standard (DIS) has been in use for a period of time (typically 1 to 2 years) it is re-balloted as an International Standard (IS).

ISA — Instrumentation, Systems, and Automation Society (see Standards Organizations).

ISA SP50 — A standards committee working on a standard of a communications bus for interconnecting control device to sensors and actuators (Field Bus).

ISA SP72 — A standards committee working on a standards for use in process control. These standards include PROWAY, Process Control Architecture, and Process Messaging.

ISDN — Integrated Systems Digital Network. ISDN is a suite of protocols being defined by CCITT to provide voice and data services over wide area networks (WANs).

ISO — International Standards Organization (see Standards Organizations).

ITI — Industrial Technology Institute. A nonprofit organization founded by the University of Michigan and sponsored by the State of Michigan dedicated to computer integrated manufacturing.

Just-In-Time — A method of controlling and reducing direct and work-in-process inventory by having suppliers deliver material "just-in-time" to manufacturing.

Kit — Components of an assembly that have been pulled from stock and readied for movement to the assembly area. [APIC]. A kit is a collection of carefully identified and controlled items used to build a module, subassembly or assembly. Kit items are usually kept in a box or bag and labeled. [SAMA].

Kit List A tabulation of all parts and materials that go into a kit. The list includes part and serial numbers, lot numbers or date codes for each item listed. [SAMA].

Kitting The process of removing components of an assembly from the stock room and sending them to the assembly floor as a kit of parts. This action may take place automatically whenever a full set of parts is available and/or it may be done only upon authorization by a designated person.

Knowledge Acquisition The process of extracting knowledge. It can be derived from many sources: an expert, documents, books, manuals, forms, etc.

Knowledge Base The part of an artificial intelligence system that contains structured, codified knowledge and hueristics used to solve problems. [DEC].

Knowledge Craft A complete expert development system which provides an integrated set of programming tools. [DEC].

Knowledge Engineer A person who implements an expert system. A knowledge engineer interviews experts to utilize the raw knowledge from which to structure the knowledge base and formulate the rule base. [DEC].

Knowledge Representation A structure in which knowledge can be stored in a way that allows the system to understand the relationships among pieces of knowledge and to manipulate those relationships. [DEC].

Labor Costs Dollar amounts of added value due to labor performed during manufacturing. [APIC].
Cost and labor reporting on construction activities.

Labor Grade A classification of labor into separate groupings of those whose capability makes them unique in terms of their particular skill level or craft. [APIC].

LAN Local Area Network. Local area networks are a communications mechanism by which computers and peripherals in a limited geographical area can be connected. They provide a physical channel of moderate to high data rate (1-20 Mbit) which has a consistently low error rate (typically 10-^{9}).

Layer A subdivision of the OSI architecture (See OSI Reference Model).

Lead Time A span of time required to perform an activity. In a logistics context, it is the time between recognition of the need for an order and the receipt of goods. Individual components of lead time can include order preparation time, queue time, move or transportation time, and receiving and inspection time. [APIC].

Line Driver A circuit specifically designed to transmit digital information over long lines, that is, extended distances.

LISP	A programming language (LIST Processing) designed specifically to manipulate symbols rather than numeric data. A LISP data element is a list of symbols that may represent any object, including its own list processing functions. [DEC].
LISP Interpreter	A part of any LISP-based software tools that allows specific list-processing operations such as match, join, and substitute, to execute on a general purpose computer rather than a special purpose LISP machine. [DEC].
LISP Machine	A single-user workstation with a dedicated LISP programming architecture. [DEC].
List	In a list processing software language, a list is an ordered sequence of elements. [DEC].
LLC	Logical Link Control. The upper sub-layer of the data link layer (Layer 2) used by all types of IEEE 802 LANs. LLC provides a common set of services and interfaces to higher layer protocols. Three types of services are specified: Type 1: Connectionless. A set of services that permit peer entities to transmit data to each other without the establishment of connections. Type 1 service is used by both MAP and TOP. Type 2: Connection oriented. A set of services that permit peer entities to establish, use, and terminate connections with each other in order to transmit data. Type 3: Acknowledged connectionless. A set of services that permit a peer entity to send messages requiring immediate response to another peer entity. This class of services can also be used for polled (master-slave) operation.
Logical Cells	Consists of a set of Specified Components and support a set of Enterprise Activities. [CIM-OSA].
Logistics Documents	Documents to support field operations, such as instruction manuals, training information, spares, modification and maintenance information. [SAMA].
Lot	A quantity of items produced together and sharing the same production costs and resultant specifications. [APIC].
Lot ID	A unique identification number or code assigned to a homogeneous quantity of material (e.g., a batch number or mix number). [APIC].
Lot Traceability	The ability to identify the lot or batch numbers of consumption and/or composition for manufactured, purchased and shipped items. This is a federal requirement in certain regulated industries. [APIC].
LPC	Local Procedure Call.
LSAP	Link Service Access Point (see SAP).

MAC	Media Access Control. The lower sub-layer of the Data Link Layer (Layer 2) unique to each type of IEEE 802 Local Area Networks. MAC provides a mechanism by which users access (share) the network. The MACs defined by IEEE 802 are IEEE 802.3 CSMA/CD, IEEE 802.4 Token Bus, IEEE 802.5 Token Ring, and IEEE 802.6 Metropolitan Area Network (still under study).
Macro Function	A LISP function which serves as a template for translating a LISP form (language structure). [DEC].
Make-to-Order Product	The end item is finished after receipt of a customer order. Frequently, long lead time components are planned prior to the order arriving to reduce the delivery time to the customer. Where options or other subassemblies are stocked prior to customer orders arriving, the term "assemble to order" is frequently used.
Make-to-Stock Product	The end item is shipped from finished goods "off the shelf," and therefore, is finished prior to a customer order arriving.
Manifestation	The conversion of the subject enterprise product, etc, from a detailed design state to existence as a physical system or object.
Management Decision - Making Style	Extent to which management prefers that decisions in the organization be made using a consultative, consensus, delegative, or authoritarian style.
Management Human Resources Priorities	Top management's attitudes about the importance of such human resource (HR) issues as training and group process skills for workers.
Manufacturing	Production of items from raw materials to finished products ready for subsequent distribution to customers. Generally confined to discussion of metallic raw materials and discrete products.
Manufacturing Engineering	Analysis, design, operation and management of equipment for the production of products for customers. Generally used in terms of discrete products produced from metallic raw materials.
Manufacturing Lead-Time	The total time required to manufacture an item. Included here are order preparation time, queue time, setup time, run time, move time, inspection time and put-away time. [APIC].
Manufacturing Method	The method used to manufacture an item. There may be a choice between different manufacturing methods, such as machining a part versus bending it out of sheet metal.
Manufacturing Planning	The function of setting the limits or levels of manufacturing operations in the future, consideration being given to sales forecasts and the requirements and availability of personnel, machines, materials and finances. The manufacturing plan is usually in fairly broad terms and

does not specify in detail each of the individual products to be made but usually specifies the amount of capacity that will be required.

Manufacturing Policy The set of methods and procedures for operating the manufacturing plant to achieve the goals of management. The term policy is understood to extend to individual measurements and tolerances prescribed to implement production.

Manufacturing - Requirements/Policies/ Plans These are quality, product, and/or environmental requirements and/or policies. These can be internal(to the company) or governmentally generated. Also included here are manufacturing budgets and plans.

Manufacturing Resource Planning A method for the effective planning of all the resources of a manufacturing company. Ideally, it addresses operational planning in units, financial planning in dollars, and has a simulation capability to answer "what if" questions. It is made up of a variety of functions, each linked together: Business Planning, Production Planning, Master Production Scheduling, Material Requirements Planning, Capacity Requirements Planning and the execution systems for capacity and priority. Outputs from these systems would be integrated with financial reports such as the business plan, purchase commitment report, shipping budget, inventory projections in dollars, etc. Manufacturing resource planning is a direct outgrowth and extension of MRP. Often referred to as MRP II. (cf. closed-loop MRP).

-MAPICS (Manufacturing, Accounting and Production Information and Control System) An IBM MRP system that runs on the AS/400 minicomputer and includes 18 modules of applications.

Market Demand The total need for a product or line of product. Conditions and events in the marketplace which define the potential product volume and product mix. This includes perceived customer need for product features and product volumes, and marketplace changes due to political, social, and technology changes.

Market Plan A high-level plan of tasks and schedules to meet marketing and sales objectives.

Market Research Study of market conditions and future behavior based on market trends, marketing data and customer preferences. [CAMI].

Master Plan A document examining current enterprise capabilities and practices (AS-IS); and the desired future state of the enterprise under the proposed CIM system (TO-BE); and a proposal to manage the transition between them.

Master Schedule For selected items, a statement of what the company expects to manufacture. It is the anticipated build schedule for those selected items assigned to the master scheduler. The master scheduler maintains this

	schedule which, in turn, drives MRP. It is what the company plans to produce expressed in specific configurations, quantities and dates. [APIC].
Master Slave	A mode of operation where one data station (the master) control the network access of one or more data stations (the slaves).
Material	Any commodity used directly or indirectly in producing a product, e.g., raw materials, component parts, subassemblies, and supplies. Materials are purchased items or raw materials that are converted via the manufacturing process into components and/or products. [APIC]. This can also be consumable material used to support production operations.
Material Control	The function of maintaining a constantly available supply of raw materials, purchased parts and supplies that are required for the production of products.
Material Flow	The progressive movement of material, parts or products toward the completion of a production process between work stations, storage areas, machines, departments and the like.
Material Requisition	An authorization that identifies the type and quantity of materials to be withdrawn from inventory. [CMSG].
Material Specification	The establishment of the properties and the detailed requirements for raw or fabricated material. [SAMA].
Materials Management	A term to describe the grouping of management functions related to the complete cycle of material flow, from the purchase and internal control of production materials to the planning and control of work-in-process to the warehousing, shipping and distribution of the finished product. Differs from materials control in that the latter term, traditionally, is limited to the internal control of production materials.
Materials Planning	The planning of requirements for components based upon requirements for higher level assemblies. The production schedule is exploded or extended through the use of the bills of materials and the results are netted against inventory.
Mathematical Model	A mathematical representation of a process, device, or concept.
MBPS	Million Bits Per Second.
Media	The physical interconnection between devices attached to the LAN. Typical LAN media are Twisted Pair, Baseband Coax, Broadband Coax, and Fiber Optics.
Message	A collection of one or more sentences and/or command statements to be used as an information exchange between applications or users.
Methodology	CEN

MIPS	(Million Instructions Per Second) An approximate measure of a computer's raw processing power. It is often misleading, since it does not necessarily provide a good throughput figure of merit.
Mission Support	Output items or activities of an enterprise which are necessary for its own well-being or continuation, those which are for services to the enterprise itself in carrying out its established purpose..
MMFS	Manufacturing Messaging Format Standard. The application protocol specified by older versions of MAP to do manufacturing messaging. This protocol has been replaced by MMS.
MMS	Manufacturing Messaging Specification. MMS is one of the application protocols specified by MAP.
Modem	Modulator **-** Demodulator. A device that provides both combining (modulation) and separation (demodulation) of data and carrier, and a physical medium interface. Typically used to connect a node to a broadband network.
Modular Bill (of Material)	A type of planning bill which is arranged in product modules or options. Often used in companies where the product has many optional features, e.g., automobiles. (cf. Planning Bill, Common Parts Bill, Super Bill, Option).
Modular System	A system design methodology that recognizes that different levels of experience exist in organizations and, thereby, develops the system in such a way so as to provide for segments or modules to be installed at a rate compatible with the users' ability to implement the system.
Move Order	The authorization to move a particular item from one location to another. [APIC].
Move Ticket	A document used in dispatching to authorize and/or record the movement of a job from one work center to another. It may also be used to report other information, such as the active quantity or the material storage location. [APIC].
MRP	Materials Resource Planning.
MRPII	(Manufacturing Resource Planning) A Method for effective planning of all the resources of a manufacturing company. Ideally, it addresses operational planning in units, financial planning in dollars and has a simulation capability to answer "what if" questions. It is made up of a variety of functions, each linked together: Business Planning, Production Planning, Master Production Scheduling, Material Requirements Planning (MRP), Capacity Requirements Planning and the execution systems for capacity and priority. Outputs from these systems would be integrated with financial reports such as the business plan, purchase

commitment report, shipping budget, inventory projections in dollars, MRPII is a direct outgrowth and extension of MRP.

Multiplexing — The time-shared scanning of a number of data lines into a single channel. Only one data line is enabled at any instant.

MVS (Multiple Virtual Storage) — IBM's flagship operating system. Essentially all device support, software functions, time-sharing aids and reliability improvements ever produced by IBM are available with MVS/XA.

Natural Language — A person's native tongue. Natural language systems attempt to make computers capable of processing language the way people normally speak. [DEC].

NBS/NIST — National Bureau of Standards, now NIST (National Institute for Standards and Technology) (see Standards Organizations).

NCMRP — NET CHANGE MRP. An approach via which the material requirements plan is continually retained in the computer. Whenever there is change in requirements, open order to inventory status or engineering usage, a partial explosion is made only for those parts affected by the change. NC systems may be continually and totally transaction-oriented, or done in a periodic (often daily) batch.

Net Requirements — In MRP, the net requirements for a part or an assembly are derived by netting the gross requirements against inventory on hand and the scheduled receipts (released orders). Net requirements, lot sized and offset for lead time, become planned orders. [APIC].

Network Management — The facility by which network communication and devices are monitored and controlled.

Networking — Consists of software/hardware in combination systematically linking a number of devices (computers, workstations, printers) into a network (system) for the purpose of sharing resources.

Nonconformance Report — An inspection report on an item that describes the item's failure to meet its specification, drawing or quality requirements. [SAMA].

Object — See below.

Object-Oriented Programming — Programming that focuses on individual program units (objects) consisting of instruction and data rather than on procedures.

OCR (Optical Character Recognition) — A method of collecting data involving the optical scanning of hand printed or special character fonts. If handwritten, the information must adhere to pre-defined rules of size, format and location on the form.

Appendix V – Glossary

ODA (Office Document Architecture) An international standard for the interchange of documents that may contain text, graphics, image and data material.

ODBMS **Object Oriented DBMS**. A Database Management System that takes the concepts of object-oriented programming and applies them to the management of persistent objects on behalf of multiple users, with capabilities for security, integrity, recovery and contention management, while also providing acceptable performance.

ODIF **Office Document Interchange Format.** The format of the data stream used to interchange documents in accordance with ODA.

OOP **Object-Oriented Programming.** A style of programming characterized by the identification of classes of objects closely linked with the methods (functions) with which they are associated, thus leading to information hiding. It also includes ideas of inheritance of attributes and methods.

Open Loop System A control system which has no automatic means of comparing the output with the input; i.e., there is no feedback.

Open System A system that obeys public standards in its communication with other systems and/or between layers.

Operating Costs Total operating costs = maintenance + engineering + operation + RM + energy + waste disposal.

Operating System (1) Software which controls the execution of computer programs and which may provide scheduling, debugging, input/output control, accounting compilation, storage assignment, data management and related services. (2) The master control program of a computer which controls all hardware activity.

Operator (1) In the description of a process, that which indicates the action to be performed on operands. (2) A person who operates a machine.

Opportunity Cost The return on capital that could have resulted had the capital been used for some purpose other than its present use. Sometimes refers to the best alternative use of the capital; at other times to the average return from a feasible alternative.

Order Information Information on accepted order (confirmation, due date, changes...).

Order Inquiries Request for information on product or formal purchase order.

Order Traceability A production order that travels with the job and may include a route, blueprint, material requisition, move tickets, time tickets, etc. [APIC]. This is also used to collect data.

Organization

(1) The classification or groupings of the activities of an enterprise for the purpose of administrating them. Division of work to be done into defined tasks along with the assignment of these tasks to individuals or groups of individuals qualified for their efficient accomplishment. (2) Determining the necessary activities and positions within an enterprise, department or group, arranging them into the best functional relationships, clearly defining the authority, responsibilities and duties of each and assigning them to individuals so that the available effort can be effectively and systematically applied and coordinated.

OSI

Open System Interconnect. A logical structure for network operations using seven layers as defined by the ISO. It defines network protocol standards to enable any OSI, compatible computer or device to communicate with any other OSI compliant computer or device for information exchange.

OSI Reference Model

A seven layered model of communications networks defined by ISO. The seven layers are:

Layer 7 - Application:	Provides the interface for the application to access the OSI environment.
Layer 6 - Presentation:	Provides for data conversion to preserve the meaning of the data.
Layer 5 - Session:	Provides user-to-user connections.
Layer 4 - Transport:	Provides end-to-end reliability.
Layer 3 - Network:	Provides routing of data through the network.
Layer 2 - Data Link:	Provides link access control and reliability.
Layer 1 - Physical:	Provides an interface to the physical medium.

Overhead Costs

Costs incurred in the operation of a business which cannot be directly related to individual products or services. These costs, such as light, heat, supervision and maintenance, are grouped in several pools (department overhead, factory overhead, general overhead) and are distributed to units of product or service by some standard method, such as direct labor hours, direct labor dollars, direct materials dollars. [APIC].

Costs of non-productive services (accounting, administration, management ...).

Packaging Specification

A specification establishing the method and detailed requirements for packaging, handling, preservation, storage, or shipment of a part, material, product or system. [SAMA].

Parameter

(1) A variable that is given a constant value for a specified application. (2) A variable that controls the effect and usage of a command. (3) Alterable values that control the effect and usage of a graphics command. (4) A constant whose values determine the operation or characteristics of a system.

In $y= ax^2 - bx + c$; a, b, and c are the parameters of a family of parabolas. (5) A variable, t, such that each variable of a related system of variables may be expressed as a function of t.

Part — A material item that has been purchased or fabricated from raw material and is normally not handled as part of an assembly. [CMSG].

Part Supplies — Delivery of parts to maintenance crews.

Parts for Rework — Nonconforming material that is dispositioned to be reworked.

Parts Order Request — Purchase order request for spare parts replenishment.

Parts Replenishment — Supply of reordered parts to replenish inventory.

Parts Request — Request to spare parts warehouse for parts by work order.

Parts Specification — A specification which establishes the design and detailed requirements for components that are joined together and cannot be taken apart without destroying the function of the resulting assembly.

Pattern Matching — In Expert Systems, a process performed by an expert system during a search through its knowledge base or rule base. [DEC].

PCA — Process Communications Architecture. An architecture for a three layer (Physical, Data Link, and Application) open communications system being developed by ISA SP72. It can provide communications functions that are needed in control and automation applications. PCA uses OSI protocols and provides a transparent application interface to 7-layer MAP networks.

PDU — Protocol Data Unit. Each of the seven OSI layers accepts data SDUs (SubData Unit) from the layer above, adds its own header PCI (Protocol Control Information) and passes the data to the layer below as a PDU. Conversely, each of the layers also accepts data from the layer below, strips off its header, and passes it up to the layer above.

Performance and Reporting Data — Plant operating and production data as developed to satisfy historical records, customer requests, plant test operations, costing needs, plant performance results, etc.

Performance Specification — A specification that describes what is to be accomplished by the equipment, but does not describe how the system is to be designed. It specifies the development goal. [SAMA].

PHIGS — **Programming Hierarchical Graphics System.** An ANSI (American National Standards Institute) standard for graphic representations and data.

Pick List	A document that lists the material to be picked for manufacturing or shipping orders. [APIC] - Picking is the process of withdrawing from stock the components to make products or the finished goods to be shipped to the customer. [APIC].
PID	**Proportional-Integral-Derivative control** A popular control strategy that produces output control action proportional to the sum of the input, plus the integral of the input, plus the rate of change of the input.
PIEEE 1003	**POSIX Institute of Electrical and Electronics Engineers** The PIEEE 1003 activity represents different committees that are crafting sets of specifications for Posix. The IEEE 1003.4 group is focusing on real-time issues that all facilitate the use of Posix-compliant hardware on the factory floor.
Planned Order	A suggested order quantity and due date created by MRP processing when it encounters net requirements. Planned orders only exist within the computer and can be changed or deleted before they are released. Planned orders at one level are exploded into gross requirements for the next level. [APIC].
Planning Horizon	In an MRP system, the planning horizon is the span of time from the current to some future date for which material plans are generated. This must cover at least the cumulative purchasing and manufacturing lead time, and usually is quite a bit longer.
Plant Agreements With Suppliers	Written agreements that specify quality and delivery time of materials provided by suppliers.
PMS	Process Messaging Service (see ISA SP72).
Policy	A definite course or method of action selected from among alternatives and in light of given conditions to guide and determine present and future decisions.
Policy Implementors	Entities which execute the established manufacturing policy. They may be humans, computer systems or other devices depending upon the capabilities needed. Policy implementors comprise the information management and automation system configuration. Policy implementors comprise those agents whose decisions are effectively computable.
Policy Makers	Are external influences that formulate the established manufacturing policy. Because of the innovation necessary, they will be human beings for the foreseeable future.
POMS	**Process Operations Management System.** An IBM and customer-sponsored software initiative to link MRPII applications running on AS/400 minicomputers and shop-floor data collection systems running on PS/2 computers. It is not an IBM product, though IBM funded its development.

POSIX	**Portable Operating System for Computer Environments.** UNIX-based standard under development by the IEEE. In 1988, the committee officially released the first installment of the standard (1003.1), which presents a core set of system cells. POSIX has been adopted as a Federation Information Processing Standard and is included in OSFs basic specifications.
Predictive/Preventive Maintenance	Maintenance specifically intended to prevent faults from occurring during subsequent operation.
Priority	In a general sense, priority refers to the relative importance of jobs or tasks and determines in which sequence the competing jobs for one resource will be performed. [APIC].
Procedure Policy	These are definitions of approved methods of how to accomplish tasks. [APIC].
Procedure Rules	Represent the Enterprise operations as they dynamically control sets of Enterprise activities.
Process	Functions conducted by the enterprise to accomplish its purpose. Processes satisfy the principle of locality and the principle of autonomy (Purdue model). A process can be decomposed into infinite levels of sub-processes.
Process Analysis	Analytical examination of a process for the purpose of documenting and understanding the phenomena which occur in/within the process.
Process Control	The regulation of variables that influence and/or control the conduct of a process so that a specified quality and quantity of product is obtained. Pertaining to systems whose purpose is to provide automation of continuous operations. This is contrasted with numerical control, which provides automation of discrete operations.
Process Data Requirements	A specification of the data that must be collected to support the information needed for other functions, such as process planning.
Process Plan	A detailed plan for the production of a piece part or assembly. It includes a sequence of steps to be executed according to the instruction in each step and consistent with the controls indicated in the instructions. [CAMI].
Process Specification	A specification which establishes material properties and detailed process control requirements for materials or items that require specific process operations. [SAMA].
Process Status	Information concerning the current well being of the process; in control, alarms (out of control process), etc.

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Producibility Requirements An evaluation of the product's design with respect to how the design can be changed to improve the producibility of the product.

Product Allocation List Identifies the planned systems and/or the geographical location of each configuration item and the quantity requirements at each location or in each system. [SAMA].

Product Cost Total manufacturing cost of product excluding sales, marketing and company overhead.

Product Family A group of products having a common classification criteria. Design engineering may classify items by function, size, shape or material in order to retrieve all items having common characteristics when required for a specific design purpose. This avoids duplication of design, routings, items, stock accounting, etc. The sales department may classify items by product groups according to potential users, function, size, etc. [CMSG].

Product Information Product related sales information (price, availability, documentation...).

Product Specification A specification describing the requirements that a product must meet.

Product Strategy A strategy on how to produce or market a product. It includes product mix, etc.

Product Structure The definition of the way components go into a product during its manufacture. A typical product structure would show the relation of one component to another; i.e., the relationship of the raw material being converted into fabricated components, components being put together into subassemblies, subassemblies going into assemblies, etc. [APIC].

Product Structure Lead-Time A product structure that describes the lead time needed for raw material, time to manufacture parts, assemble parts, etc.

Product Structure Make-Buy A product structure that specifies which components will be made and which will be bought.

Product Structure Material A product structure describing the raw material needed to produce a part, and the material needed to support the production operation.

Product Structure Resource A product structure describing the resources needed to produce each component.

Production Baseline The resulting state of a product after preliminary design, detail design, and qualification and prototype testing are complete.

Production Capacity The highest, sustainable output rate which can be achieved with the current product specifications, product mix, worker effort, plant, and equipment.

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Production Order — A document or group of documents conveying authority for the manufacture or assembly of specified products or components in specified quantities. [APIC].

Production Plan — A plan for setting the overall level of manufacturing output. Its prime purpose is to establish production rates that will achieve management's goals of lowering/raising inventories or backlogs while keeping the production force relatively stable. It is usually stated in broad terms such as product families or end products. [APIC].

Production Planning — (1) The systematic scheduling of workers, materials, and machines by using lead times, time standards, delivery dates, work loads, and similar data for the purpose of producing products efficiently and economically and meeting desired deliver dates. (2) Routing and scheduling.

Production Schedule — A plan which authorizes the factory to manufacture a certain quantity of a specific item. Usually initiated by the production planning department.

Productivity Shell — A combination of underlying knowledge representations and user interfaces that is highly domain-specific. It includes objects, decision making processes and interface representations that are user, rather than artificial intelligence dependent.

Products and Waste Materials and Utilities — This output includes finished product, intermediate products including subassemblies and modules, as well as process generated utilities (i.e., steam, electric). It further includes all waste materials produced by the process including consumables, scrap material, heated water, toxic waste and solvents.

Programmable Logic Controller — A specialized industrial computer used to program automatically control production and process operations by interfacing software control strategies to input/output devices.

Protocol — A formal definition (semantic or syntax) that describes how data is to be formatted for communication between a data source and a data sink.

PROWAY — A standard for a process control highway based on IEEE 802.4 token bus immediate acknowledged MAC (Media Access Control), a physical layer utilizing a phase-contiguous signaling technique. Developed by ISA SP72.

Purchased Energy, Material and Supplies — Are the tangible items that are brought into the manufacturing entity to facilitate the manufacturing process. They are converted to materials leaving the entity in the form of produced or waste material.

Purchasing Lead Time — The total time required to obtain a purchased item. Included here are order preparation, release time, vendor lead time, transportation time, receiving, Inspection and put away time. [APIC].

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Quality	Measure of the degree to which items fulfill their specifications. Generaly used in terms of acceptability of a system or product by a customer.
QA	Quality assurance.
QA Approvals	Classification of QA results after testing.
QA Results	Classification and test results for finished product.
QA Standards	Limits, specifications and standards for in-process quality control.
Qualification Results	Results and conclusions of tests, examinations, documents and processes showing that an item meets or exceeds the expected environmental stresses without failure or malfunction. [SAMA].
Quality Audit	An independent review conducted to compare some aspect of quality performance against a standard for that performance. Audits span the entire spectrum of the quality function. Quality audits are used mainly by the company to evaluate its own quality activities or the quality activities of vendors, licensees, etc. Audits can also be required by regulatory agencies to judge different organizations. [JURA].
Quality Control	The procedure of establishing acceptable limits of variation in size, weight, finish, and so forth for products or services and of maintaining the resulting goods or services within these limits.
Quality Plan	Planning performed to meet quality objectives. The quality plan is a detailed breakdown and assignment of responsibilities of activities and deeds that must be performed through each phase of the product life cycle (cradle to grave). [JURA].
Quantities Locations	Updates to inventory of locations, quantity, specification of RM.
Quantities Movements	Actual quantities and status of transfer.
Queue Time	The amount of time a job waits at a work center before setup or work is performed on the job. Queue time is one element of total manufacturing lead time. Increases in queue time result in direct increases to manufacturing lead time.
Real Time	(1) Pertaining to the actual time during which a physical process transpires. (2) Pertaining to computations performed while the related physical process is taking place so that results of the computation can be used in guiding the physical process.
Real Time System	Always provides responses (both periodic, time initiated responses and input or interrupt driven responses) within a specified window of time. The time is determined by the time constant of the dynamic process. Example time constants for external processes are milliseconds for machining or electric power systems, seconds for flow processes,

minutes for thermo-chemical compositions and weeks for social/economic processes.

Receipt - Finished Goods Physical acceptance of an item into a stocking or storage location. This also refers to the transaction reporting of this activity. [APIC]- In this context, this is a receipt for accepting finished goods from WIP (Work in Process).

Receipt - Stockroom The physical acceptance of an item into a stocking or storage location. This also refers to the transaction reporting of this activity. [APIC].

Receipt - WIP This is the physical acceptance of an item into a stocking or storage location. This also refers to the transaction reporting of this activity. [APIC].

Reference Architecture Non-industry specific reference base from which to construct models of a particular enterprise. Contains both Building Blocks and Guidelines. [CIM-OSA].

Reference Model A standard definitive document or conceptual representation of a system or process.

Relationship (1) An interaction between entities. Usually expressed as verbs in English. (2) A named business association between occurrences of one or more entity types which provides some relevant information value.

Relationship Type Is a classification of relationships based on certain criteria. The numerical relationship between two entities is called the cardinality.

Relay Ladder Logic A control language for programming Programmable Logic Controllers.

Released Order Within MRP, open production orders and open supply orders are considered as released, are assumed to be available on their due dates, and will be treated as part of the available inventory during the netting process for the time period in question. [APIC].

Reliability The actual degree of dependability with which the equipment performs (note: actual, versus hoped-for).

Repeater A device that amplifies or regenerates data signals in order to extend the distance between data stations.

Resource Build Schedule A schedule of the activities needed to make, install or procure production resources, such as equipment, facilities and tools (excluding material), which are needed to support production.

Resource Definition The layout, requirements, configuration, design and capacity of resources needed to perform a particular function or operation.

Resource Plan Long-range resource planning is based on the production plan, the plan for the long-term capacity needs out to the time period necessary to acquire gross capacity additions, such as a major factory expansion. [APIC].

Resource Requirements Planning
The process of converting the production plan and/or the master production schedule into the impact on key resources, such as man hours, machine hours, storage, standard cost dollars, shipping dollars and inventory levels. Product load profiles or bills of resources could be used to accomplish this. The purpose of this is to evaluate the plan prior to attempting to implement. It is sometimes referred to as a rough-cut check on capacity. Capacity requirements planning is a detailed review of capacity requirements.

Resource View
Describes an enterprise's resources and their relations to the functional structure, control structure and organizational (responsibilities) structure. [CIM-OSA].

Response Time
The total time necessary to send a message and receive a response back at the sender exclusive of application processing time.

Return-to-Vendor
Material that has been rejected by the buyer's inspection department and is awaiting shipment back to the Supplier for repair or replacement. [APIC].

Rework
(1) The process of correcting a defect or deficiency in a product or part. (2) Units of product requiring correction.

RISC (Reduced Instruction Set Computer)
A computer architecture using a small set of instructions at the hardware level. RISC enables a complex processor to be built from very high-speed, simple components. IBM invented the RISC concept.

RM Energy Utilization
Total of raw materials, parts, tools and incoming energy, consumed or transferred on hourly, daily, monthly basis.

RM Order Request
Request to order raw materials, quality, type specifications, special requirements.

Route Sheet
A document that specifies the operations on a part and the sequence of these operations, with alternate operations and routings where feasible. It also can include material requirements (kind and quantity), machining tolerances (tool, jig and fixture requirements) and the time allowances for each operation. [APIC].

Router
A network device that interconnects two computer networks that have the same network architecture. A router requires OSI Level 1, 2 and 3 protocols (see Bridge and Gateway).

Routing
A document describing the manufacture of a particular item and specifying the sequence of operations, transportation, storage and inspections to be used. It usually includes the standard times applicable,

the machines, equipment, tools, operations, labor requirements and materials that are required for each operation.

RPC (Remote Procedure Call) A mechanism that extends the notion of local procedure call to a fully distributed computing environment.

RS511 A messaging standard, also known as MMS, under development in EIA for communication between factory floor devices. It uses ASN.1 for data encoding (see ASN.1 and MMS).

SAA (Systems Application Architecture) IBM announced SAA as a collection of selected software interfaces, conventions and protocols that were published in 1987. SAA is a framework for development of consistent applications across future offerings of the major IBM computing environments: MVS, VM, OS/400 and OS/2.

Safety Stock (1) In general, this is a quantity of stock planned to be in inventory to protect against fluctuations in demand and/or supply. (2) In the context of master scheduling, safety stock can refer to additional inventory and/or capacity planned as protection against over planning or as a market hedge. [APIC].

Sales History Sales performance of the product over the past.

SAMA Scientific Apparatus Manufacturer Association. An organization of companies which produce control equipment sensors, etc.

Sample Plan Sampling inspection conducted to learn about the quality of a product lot by inspecting a small number of units of the product (the sample) drawn from that lot. The prime purpose is to classify lots as acceptable or unacceptable. A sampling plan is a set of instructions on how to conduct the sampling inspection. [JURA].

SAP Service Access Point. The connection point between a protocol in one OSI layer and a protocol in the layer above. SAPs provide a mechanism by which a message can be routed through the appropriate protocol as it is passed up through the OSI layers.

SAP AG is a major supplier of integrated enterprise software.

SCADA (Supervisory Control and Data Acquisition) A software package that obtains data from production environment activities and uses it for a variety of applications. These applications include simple control, monitoring, trending and data collation for upstream use.

Scheduled Audit Audits of quality plans are usually conducted on a scheduled basis. The schedule provisions for new products or projects (during the original planning or after launching the product), for stable product lines (audits

	are performed on a regular cycle), and for particular quality problems, such as product, performance, customer feedback and audit reports. [JURA].
Schedule of Operations	The actual assignment of starting and/or completion dates to operations or groups of operations to show when these must be done if the manufacturing order is to be completed on time. These dates are used in the dispatching operation. [APIC].
Scheduled Maintenance	Maintenance scheduled at a factory-wide level, for example, if power is going to be shut down for the entire factory or the plant will be shut down for two weeks, etc.
SCN	Specification Change Notice. A document that describes changes to an approved specification. The SCN is incorporated as part of the specification after customer approval. [SAMA].
Sensor	A device that monitors a process variable (temperature, pressure, flow, position) and transmits a voltage or current proportional to that measured variable to a control system.
Serial Identification	A serial number or block number used with a part number to denote each unit (a lot has a quantity of several units) in a family of similar items. It provides for affectivity identification of design changes. [SAMA].
Service Level	A measure of delivery performance in the form of a percentage of the number of items or dollars on actual customer orders that were shipped on schedule for a specific time period compared to the total that were planned to be shipped for that time period. [APIC]. This can also include back orders, items shipped, orders past due and age by week. In manufacturing, the service level can be measured by shortages, missed promise dates and excess.
Shipping Documents	Bill of lading, customs clearance,
Shrinkage Factor	A percent factor that compensates for expected loss during the manufacturing cycle by either increasing the gross requirements or by reducing the expected completion quantity of planned and open orders. The shrinkage factor affects all uses of the part and its components, and the scrap factor. Relates only to one usage. [APIC].
Simulation	The representation of certain features of the behavior of a physical or abstract system by the behavior of another system.
SME	Society of Manufacturing Engineers (see CASA/SME).
SNA (Systems Network Architecture)	A layered network architecture developed by IBM. The layers isolate applications from system networks, services, enabling users to write applications independent of the lower networking software layer.

SNAP (Sub-Network Access Protocol)	Provides a mechanism to uniquely identify private protocols above LLC.
Source Address	The physical (hardware) address of the node that transmitted the frame.
Source of Primary Training	Use of either vendors, corporate training departments, consultants, local educational institutions, or in-house training programs as the primary source of worker training.
Spares	Parts used for the repair/maintenance of an assembled product. Typically, they are ordered and shipped at a date later than the shipment of the product itself. [APIC].
SPC/SQC	(Statistical Quality Control/Statistical Process Control)A set of techniques based on statistical principles and methods used to regulate the quality of products and processes.
Specification	A document that describes the major technical requirements for an item. May also include the procedure for determining that the requirements have been met. [SAMA].
Specification List	Lists which are used to maintain the current status of specifications for the product. They list all released specifications in consecutive or numerical order, the current status of each specification (change status/completion, etc.) and the title. [SAMA].
Specification Tree	A drawing showing the indentured relationships among specifications independent of the assembly or installation relationships of the items specified. The tree shows the dependency of specifications on other specifications. [SAMA].
SQL (Structured Query Language)	A relational data language that provides a consistent, English keyword-oriented set of facilities for query, data definition, data manipulation and data control. It is a programmed interface to relational DBMSs. IBM Research introduced SQL as the main external interface to its experimental relational DBMS, System R, which it developed in the 1970s.
Standard Costs	The normal expected (target) costs of an operation, process or product, including labor, material and overhead charges, computed on the basis of Past performance costs, estimates or work measurement. [APIC].
Standard Time	The length of time that should be required to (a) set up a given machine or operation, and (b) run one part/assembly/batch/end product through that operation. This time is used in determining machine requirements and labor requirements. Also, it is frequently used as a basis for incentive payrolls or cost accounting. [APIC].

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Standards Organizations

Many different national and international organizations are involved in developing LAN and WAN standards. Some of the key organizations are:

ANSI - American National Standards Institute. ANSI X3T9.5 is working on high speed (50 to 100 Mbit/second) LAN standards.

CBEMA - Computer and Business Equipment Manufacturers Association. CBEMA committee X3T9.5 is working on high speed (50-100 Mbit) LAN standards.

CCITT - International Consulting Committee on Telephone and Telegraph. CCITT standards include the X.25 family of standards that are used in wide area networks (WANs) and X.409 which provided the basis of ASN.1.

ECMA - European Computer Manufacturers Association. ECMA is also working on LAN standards in cooperation with IEEE 802.

ESCA - Exchange Carriers Standard Association.

EIA - Electrical Industries Association. Work is currently in progress in EIA on RS511, a messaging standard for use between factory floor applications.

IEC - International Electrical Technical Commission. An IEC standards committee (IEC TC97/WG6) has defined a LAN for use in process control environments (PROWAY) in cooperation with IEEE 802.4 and is working on a Field Bus standard. Also known as EIC.

IEEE - Institute of Electrical and Electronic Engineers. An IEEE standards committee (IEEE 802) is chartered to work on LAN standards for data rates of 1 Mbit/second to 1 Gigabit/second. These standards have also been approved by ISO (DIS 8802/3 and DIS 8802/4).

ISA – Instrumentation, Systems, and Automation Society. The ISA is responsible for the S50 Field Bus standard. ISA is the American cognizant organization for EIC-developed standards.

ISO - International Organization for Standardization. ISO takes standards submitted by its member national standards bodies, ballots the standards internationally, and approves international standards. The major ISO standards used by MAP are ISO FTAM (DP 8571), ISO Session (IS 8327), ISO Transport (IS 8073) and ISO Internet (DIS 8473).

NBS - National Bureau of Standards (now NIST, National Institute for Standards and Technology). An organization of the United States government that is responsible for the standards used by other government agencies (e.g. FIPS, Federal Information Processing Standards). NBS also provides compliance testing services, and hosts standard development workshops.

SME - Society of Manufacturing Engineers (see CASA/SME).

Station Management The portion of Network Management that applies to the lowest two OSI layers.

Statistical Quality Control A means of controlling the quality of a product or process by the application of the laws of probability and statistical techniques to the observed characteristics of such product or process.

Stop Order An order used to notify manufacturing or testing to stop work on an item for the C1 List because an engineering change is in process. It is used to avoid waste of labor or material on an item that will have to be scrapped or reworked due to the change. [SAMA].

Sub-layer A subdivision of an OSI layer (e.g. the IEEE 802 Standard divides the link layer into the LLC and MAC sub-layers).

Subsystem A collection of logically connected functions that implement a particular function in the system.

Subsystem Specification A specification which establishes the functional, performance and design criteria for the design, development, testing and production of equipment that performs a major function and is essential to the completeness of a system. [SAMA].

Supply Order A time-phased replenishment order from MRP for purchasing material or parts.

Supply Order Planned A suggested order quantity and due date created by MRP processing, when it encounters net requirements. Planned orders only exist within the computer and can be changed or deleted before they are released. Planned orders at one level are exploded into gross requirements for the next level. [APIC].

Supply Order Status The status of the supply order includes whether it is on schedule or if it will be overdue.

Symbolic Processing A type of processing that primarily uses symbols rather than numeric representations of data. In expert systems, symbols are not restricted to a numeric context, but may represent objects, concepts, and processes. [DEC].

System An organized collection of personnel, machines, and methods required to accomplish a set of specific functions.

System Development The process of selecting and functionally integrating distinct devices, mechanism, and subsystems necessary for optimum performance of the operation of the joined system.

System Engineering A formal, phased approach to producing a significant new system or major changes to an existing system. It stresses teamwork among users and technical personnel, a series of major milestones, and thorough documentation to assure compliance with performance and schedule goals.

System Parts List A tabulation of applications, cumulative quantities and affectivity of all parts, components and assemblies within a system. [SAMA].

System Requirements Definition Phase The portion of system development whose purpose is to investigate a company, or part of a company, in sufficient depth to produce a firm business proposition involving a changed method of operation. It results in a statement of the functional requirements of new systems.

System Specification The specification which establishes the functional, performance and design criteria for the design, development, testing and production of a complete system. This specification allocates the system into functional entities identified as configuration items. [SAMA].

TAGS Technical Assistance Groups. (See IEEE 802).

Task A recognized action or set of actions comprising a specific part of the operations of a functional entity in fulfilling the established manufacturing policy of the company. It is the lowest level of functional decomposition of an enterprise that corresponds to the function of a single person or machine at a point in time. A task corresponds to an information transformation in the usual definition of a CIM system.

TC Technical Committee.

Time-Phased Decomposition Involves reducing the complexity of a system by decomposing the solution into a number of hierarchically arranged modules. Each level of the hierarchy represents: A. A shift in the time domain (lower-level layers are closer to real-time). B. A corresponding narrowing of the "scope-of-control" in lower levels. C. Each level provides planning (control) input to lower layers and accepts process status from lower layers.

Token Bus An access procedure where the right to transmit is passed from device to device via a logical ring on a physical bus. (See IEEE 802.4)

Token Passing A LAN-access technique in which participating stations circulate a special bit pattern (the token) that grants network access to each station in sequence; it is often used in ring topology networks, which have a single cable or dual cables strung from station to station in the shape of a ring. Bus topologies utilize a single strand of cable to which stations are attached. Tokens are special bit patterns or packets that circulate from node to node when there is no network traffic. Possession of the token gives a node exclusive outgoing access to the network, thus avoiding conflict with other nodes that wish to transmit.

TOP	Technical and Office Protocol. An obsolete development of Boeing Computer Services for office and laboratory automation use. This was combined with MAP and further development will be under the auspices of the MAP/TOP Users Group.
Topology	The surface structure or arrangement of parts of any object as in “Network Topology”.
TQC (Total Quality Control)	A theory of quality whereby the maker of the part has the responsibility for the quality of that part.
Traceability Identification	An identifier used with a part number to denote each unit (a lot has a quantity of several units) in a family of similar items. It provides for affectivity identification of design changes. [SAMA].
Unit Cost	The total labor, material and overhead cost for one unit of production. [APIC].
UNIX	A family of operating systems licensed by AT&T that are known for their relative hardware independence and portable applications interface. UNIX is used widely in technical and scientific computing applications.
Usage	The number of units or dollars of an inventory item consumed over a period of time. [APIC].
Usage Variance	The deviation of the actual consumption of materials as compared to a standard. Standard Costs - Actual costs becomes usage variance. [APIC].
Use As Is	Material that has been dispositioned as unacceptable per the specifications but can be used as is. [APIC].
Utilization Losses	Utilization and imbalances of raw materials and energy.
UTP	Unsheilded Twisted Pair. A network medium that uses existing telephone wiring. UTP standards exist for IEEE 802.3 (Ethernet) and IEEE 802.5 (Token Ring).
Variable Costs	An operating cost that varies directly with the production volume including direct material, direct labor and variable overhead costs (fixed factory overhead is not included in variable costs). For inventory order quantity purposes, unit costs must include both variable and fixed costs to determine the unit costs. [APIC].
Vendor Lead Time	The time that normally elapses between the time an order is received by a supplier and shipment of the material requested.
Vendor Performance Rating	The result of measuring a vendor's performance-to-contract. Performance ratings usually cover on-time delivery, quality and price (vendor measurement). [APIC].

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Virtual Memory	A programming method that allows the operating system to provide essentially unlimited program address space by “swapping” memory sections to disk storage. [DEC].
VMS	DEC's VAX operating system (now obsolete but once used widely in engineering and real-time industrial environments).
Waiver	A written authorization report to accept material that during production or after inspection has been found to depart from the specified requirements, but the material is considered to be suitable for use 'as is' or after repair by an approved method. This allows production to proceed. A deviation permits a change before it occurs and a waiver permits a change after it has occurred. [SAMA].
Waiver Description	May include the reason for the waiver or deviation, the impact on production if approved, the impact on production or the schedule if not approved, and corrective action information.
WIMPS	User interfaces including Windows, Icons, Mice, Pointers, Scroll Bars.
Window	An application software "design concept" that allows several programs to be run and displayed on the screen simultaneously and which supports integration of data between applications programs. [DEC].
Wiring Closet	The room or location where the telecommunication wiring for a building, or section of building, comes together to be interconnected.
Work Authorization	Documents or information conveying authority to a function to perform specified work per a specified priority or schedule. This can include maintenance of equipment and manufacture of specified parts or products in specific quantities. [APIC].
Work In Process	Work in process is the set of products in various stages of completion throughout the plant, including raw material that has been released for initial processing, up to the completed processed material awaiting final inspection and acceptance as a finished product. [APIC].
Work Order	Transmittal to maintenance of order to perform work (work description, symptoms, special precautions, clearance procedures...).
Work Report	Reporting on performed maintenance time, diagnosis, and parts used.
Work Request	A request for work to be performed that has not been scheduled, such as requesting tools and material to be moved to a workstation. This could include a work cell that is idle and needs more work, or it could be a request for unscheduled maintenance to be performed on a piece of equipment.
Workflow Unpredictability	Degree to which the anticipated inputs, processes, and outputs to the human-machine system are unpredictable.

Workstation	The assigned location where workers perform their job. Human-machine interface devices that are composed of coordinated input/output devices which include video displays, keyboards, functional menus and may or may not include off-line storage capabilities. Used for graphics, text, data and retrieval functions.
Yield	The ratio of usable output from a process to the material of value put into the process. Yield is usually expressed as a percentage and may be expressed in terms of total input of a specific raw material.

Appendix V – Glossary

This Glossary was derived by a Subcommittee of the Industry-Purdue University Consortium in An Implementation Procedures Manual for Developing Master Plans for Computer Integrated Manufacturing (CIM), [Reference 49] under the Chairmanship of Mr. Jim Brosvic of Honeywell, Inc. The Glossary was derived mainly from the following sources plus considerable input from the Consortium:

1. The Honeywell Computer Automated Manufacturing (HCAM) Glossary, developed from Honeywell's participation in the Consortium for Advanced Manufacturing International (CAMI). This Glossary was thoroughly revised by the Purdue Consortium Committee and the Implementation Procedures Manual Committee.

2.