A HANDBOOK ON MASTER PLANNING AND IMPLEMENTATION

FOR ENTERPRISE INTEGRATION PROGRAMS

Based On The
Purdue Enterprise Reference Architecture
and the
Purdue Methodology

Purdue Laboratory for Applied Industrial Control

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FOREWARD

The development and use of enterprise integration to improve the operation of industrial plants has recently become much more feasible. Three major factors have come together to open the way for a new era of manufacturing computing. These are:

1. Computer hardware price/performance trends
2. New tools and approaches to software delivery
3. The tasks, techniques and processes of enterprise integration have been defined

This document provides overall guidance for the development of Master Plans and Implementation Programs for the application of enterprise integration. Such Master Plans provide the company the necessary preliminary planning and operational guidance to be able to take full advantage of the above hardware and software developments. The Implementation Programs give advice on the actual instantiation of the required systems. The methodology described has been deliberately maintained at a level of "abstraction" that may be one level above what the users will require for their particular environment. It may therefore, be necessary to implement a specific methodology that is more adapted to their tools, terminology, and development practices.

Preparation of such Master Plans is thus an absolutely necessary early step in any contemplated enterprise integration program. In order to contribute to this important area of endeavor for all Industries, Purdue University, through its Purdue Laboratory for Applied Industrial Control, has cooperated with industry to prepare this Handbook on Master Planning and Implementation for Enterprise Integration Programs.

The University became involved in this work initially because of the development and publication of the Purdue Reference Model for CIM [81]. This model was developed by the CIM Reference Model Committee of the International Purdue Workshop on Industrial Computer Systems, a major activity of the Purdue Laboratory for Applied Industrial Control. The model was published in book form by the Instrument Society of America in October 1989 and reprinted in 1991.

The potential value of the Purdue Reference Model was immediately recognized by several companies to be used as the basis for industrial enterprise integration programs because of its enumeration and discussion of all of the functions and requirements for a computer integrated manufacturing system. In addition, its totally generic nature makes it applicable to any industry. However, it was also recognized by these companies that the Purdue Reference Model alone was not sufficient for this purpose. It was therefore proposed to Purdue University that an intermediate document, the Implementation Procedures Manual [49], be developed via the medium of an industry-university cooperative consortium.

The Implementation Procedures Manual was prepared under the aegis of the Industry-Purdue University Consortium for CIM, a group of ten industrial companies who banded together with the Purdue Laboratory for Applied Industrial Control to carry out the work during the period of June 1989 to June 1992.

The Implementation Procedures Manual and its related explanatory material was to provide the detailed instructions, an example format, and a discussion and check list system to prompt the Steering Committee and the Enterprise Integration Planning Team of the company throughout their preparation of the Master Plan. The Manual was initially intended to outline the overall guidance that was possible from the Purdue CIM Reference Model.

At the time of the preparation of the Purdue CIM Reference Model there were no satisfactory ways available to the Reference Model Committee for modeling the place of the human in the manufacturing system. In particular there were no means for modeling the human innovative activities involved in management, research, marketing, etc. These depend for their success upon new innovative ideas espoused and developed by the individuals filling these positions in the company. The CIM Reference Model Committee of the International Purdue Workshop "solved" this major problem by designating all human innovative functions as "external entities" and assuring that the individuals involved had complete communications access in both directions with all manufacturing activities and thus access to all pertinent information and data available. This proved satisfactory for the definition of all manufacturing functions and the Purdue CIM Reference Model as published has been quite successful.

However, when the Consortium members began to develop the Implementation Procedures Manual they soon realized that the approach taken by the CIM Reference Model Committee was not entirely satisfactory. Management, the Plant Floor, the Operator, Marketing, Engineering, Process Technologies - indeed all aspects of the Company's activities - must be incorporated into the enterprise integration system, not just the manufacturing activities. As a result, the provision of direct communications access to all plant data and operations was not, of itself, sufficient. All human activities had to be integrated with the manufacturing activities into the Total Enterprise and the Enterprise Integration System Master Plan must mirror this development.

Accordingly a parallel activity to the Implementation Procedures Manual was initiated, the Purdue Enterprise Reference Architecture [83]. Its purpose was to solve, if possible, the problems of the enterprise relationships, manufacturing technology and human innovation involvement bypassed by the Purdue Reference Model.

This activity has succeeded far beyond the Consortium members' initial hopes and expectations and indeed made possible the Implementation Procedures Manual as it finally evolved. In fact, the final Manual and its message would have been impossible without the input provided by the Enterprise Reference Architecture. The Architecture, besides solving the Enterprise and Human Involvement problems, has also shown itself to be a major elaboration and extension of the work of the Reference Model. It has also incorporated all of the significant concepts of that publication and indeed all of those developed by the Purdue Laboratory for Applied Industrial Control in its work leading up to this. Accordingly, the findings of the Reference Architecture were made an integral part of the philosophy and execution of the preparation of the Implementation Procedures Manual.

The Implementation Procedures Manual was thus formulated to permit any company or an associated consultant firm to follow a straight-forward, detailed procedure for laying out requirements for the enterprise integration system for any factory, and highlight all necessary decisions to be made during its preparation. The development of the Manual was carried out by both industry and university personnel in order to assure that the work would benefit from the wide experience of the industry personnel.

Through provisions of the contract between Purdue University and the Consortium member companies, the Implementation Procedures Manual in its total original form was restricted to these companies alone, for a period of five years beginning June 8, 1992, unless said material was already in the public domain. These restrictions could also be negated if a major and significant revision of the Manual were made during this five year period. This provision was approved by the Consortium Members and included in the Minutes of their October 1992 Meeting at Houston, Texas.

This document in its text and its diagrams reflects the specific cross section of industries involved in the Industry-Purdue University Consortium. Any particular industry that intends to use this document has to adapt it to its own specific situation.

A review of the original manual shows that our concern for ready user utility had resulting in the inclusion of many examples from earlier Purdue University work. The developers also made major reuse of multiply referenced figures, etc., rather than have the reader look up the previous experience. Finally there was major inclusion of tool descriptions in the appendices that were readily available in the literature. More importantly there was not sufficient use of the Purdue Enterprise Reference Architecture as a reference and teaching tool in explaining the Methodology presented. It was therefore recommended that a new version correcting the above editorial practices and making much more use of the architecture be produced. That is the purpose of the current Handbook on Master Planning and Implementation for Enterprise Integration Programs. The changes involved in this revision have been of such a magnitude that the use restrictions involved with the contract for the original Implementation Procedures Manual no longer apply and it can be released for use by the Industry-Purdue University Architecture Users Group, the IFAC/IFIP Task Force on Architectures for Enterprise Integration, and others as well.

Respectfully submitted

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EXECUTIVE SUMMARY

The needs of industry today require modification of manufacturing operations to assure:

1. Better and faster response to customer requirements;
2. Ever higher quality products;
3. Increased flexibility,
4. Faster introduction of new products, and
5. Faster response to marketplace changes.

At this same time, industry faces a further requirement to increase overall company earnings while:

1. Decreasing the environmental impact of their factory's operations
2. Increasing environmental and personnel safety of plant operations;
3. Improving personnel working conditions and job satisfaction.

Enterprise integration has been seen by many as the means by which much of the above could be accomplished. It is unfortunate that enterprise integration has taken a strong technology view only. For this reason efforts in this direction have only been partially successful, if at all, in achieving management goals as expressed above. Often, these efforts have been too small and too narrowly focused and have resulted in isolated "islands of automation" rather than the integrated whole originally conceived and desired.

At the same time this narrow focus was not related to the business critical success factors of the firm and has not made their proper impact on the potential benefits. Likewise the necessary human and organizational changes and the process technology issues have not been fully integrated into the enterprise integration process.

There have been several major causes for this. Primarily this has been due to the fact that those planning these projects have not realized the breadth and magnitude of the overall effort necessary and the resulting capital and other resources required. They have not developed a total plan prior to commencing implementation, and thus, neglected to outline the total effort needed.

What is needed therefore, for each company contemplating a major enterprise integration effort, is for the company to develop a Master Plan covering all of the anticipated effort required to integrate the whole of the company or factory operation.

After this, smaller projects within the monetary and personnel resources capability of the company can be initiated with the knowledge that the sum of this and all succeeding projects will result in the final total integration of the company's activities. This will be possible provided that the requirements of the initial planning effort or Master Plan be followed in each and every one of the resulting projects.

But the detail and effort required for even the Master Planning activity is itself large and if done improperly will only lead to difficulties later. Thus there is a need for a methodology to assure that the Master Plan as developed by a company's Enterprise Integration Planning Team is complete, accurate, properly oriented to future business developments and carried out with the minimum of resources (personnel and capital) necessary.

EXECUTIVE SUMMARY

The Industry-Purdue University Consortium on An Implementation Procedures Manual for Developing Master Plans for Computer Integrated Manufacturing (CIM) developed such a methodology and incorporated it into a document of the same title [49]. That manual presented a detailed description of the tasks involved in developing the Master Plan including its continual renewal. It gave the detail necessary both as to specifics and to quantity and quality of information and data needed. It specified the interrelationship of the informational, the human organizational and the physical manufacturing aspects of the integration considered; the management considerations and concerns; and the economic, cultural and technological factors involved.

To the knowledge of the Consortium members as a whole, this was the only methodology, available at the moment, that adequately treated all of these topics so vitally necessary for the accomplishment of the overall enterprise integration program.

The Implementation Procedures Manual incorporated the overall detailing of enterprise integration planning analysis and requirements available from the Purdue CIM Reference Model [81] and the more recent Purdue Enterprise Reference Architecture [83]. It is these latter documents that have supplied the framework and detailed overall understanding of the enterprise integration problem that have made the Implementation Procedures Manual possible and assured its successful use in industry.

However, a review of the resulting manual has shown that it could be considerably improved over the original version by incorporating much more guidance and explanatory material from the Purdue Enterprise Reference Architecture and by a thorough editing of the material to clarify the explanations and remove considerable duplication. The current document is the result.

This Handbook has been developed to specifically aid in the preparation of the project Master Plan that we believe to be the necessary initial step in any CIM or indeed any systems engineering project. As such it has been formulated to match the format of one suggested form of the Master Plan. That is, once past the initial introductory material, there is a Handbook Chapter that matches each suggested Master Plan step.

INTRODUCTION AND OVERVIEW

0.1 *Background*

0.1.1 A Short History of CIM

Computer Integrated Manufacturing (CIM) was proposed in the late 1970s and early 1980s as a technique by which discrete manufacturing companies might take advantage of computer technology to reorganize the way in which information was collected, analyzed, and used to streamline their manufacturing plants' operations. The resulting benefits should include: improved product quality; a company organization more responsive to new products, new customer requests and changing competition; higher productivity; and in addition would result in reduced costs and/or higher profits. Unfortunately, a high proportion of the attempts to achieve these benefits from the CIM technology that existed at that time, have been disappointing at best.
These results were due to several factors:

1. Early practitioners did not realize the magnitude in sheer size and complexity of the overall task they were attempting. As a result, most were too small and specific to accomplish the benefits desired. This also resulted in many so-called "islands of automation," with plant areas unable to communicate with each other and thus defeating the desired information integration of the whole plant.

2. A sufficiently detailed methodology for carrying out the CIM project was never developed and applied as a general procedure. As a result each project had to originate its own methodology thus greatly increasing the manpower, resources, time and costs required and eliminating the possibility of a learning curve developing in this field.

3. Likewise early practitioners did not appreciate the extent to which the human factors involved affected the outcome of their projects. Lack of knowledge or of training combined with lack of acceptance of the new systems by plant workers spelled failure. Studies have shown that over 75 percent of failures could be attributed to human factors [1][*].

However, the need still exists. Thus CIM has been supplemented recently by many techniques designed to achieve all or part of the earlier benefits ascribed to CIM. These have included: Just-in-Time Manufacturing (JIT) [2], Concurrent Engineering [3], Business Process Reengineering [4], Agile Manufacturing [5], and many other techniques.

These proposed alternatives to CIM were often sold as "quick fixes" to reap the early easy gains possible from such a study. They, in turn, were too small and incomplete to do a full integration and upgrading of the plants involved and thus themselves often became failures.

Another method of attacking the overall factory operational improvement problem has been developing in parallel with those discussed above. This involves use of an architecture (more properly an enterprise integration architecture) to act as a framework for the overall tasks of initiation, planning, design, construction, operation, etc., involved in the establishment of a new enterprise or the renovation of an existing one. Along with the architecture, a general methodology for the implementation process is also provided.

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[*] As a separate component of this book, this introductory chapter has its own set of Chapter References at the end of the chapter. All other chapters of the book use a common References and Bibliography section, following Chapter 19.

Thus, many of the shortcomings of the earlier technology can be avoided:

1 The framework or architecture outlines the whole task involved and becomes a checklist on completeness of the overall project.
2 The necessary full extent of the needed project can be appreciated before major work is started.
3 The importance of human factors, culture, etc., can be evaluated and included in the project.
4 The associated methodology is general and applicable to a wide variety of plants and situations. Thus it can be repeatedly used with the resulting learning and improvement possibilities.

0.1.2 The Simplifying Concepts of Enterprise Integration

Several concepts emerged from the study of enterprise integration architectures [6] that can greatly simplify and extend the work of enterprise integration. Some of these are:

1 While the early work in CIM was confined to the field of discrete manufacturing, it can readily be shown that the basic principles involved apply to any enterprise, regardless of its size and mission or any of the other such attributes involved. These are generally principles that apply to all aspects of the field of systems engineering. In addition, it is a mistake to confine the integration discussions to information and control systems alone. Often there are problems within the mission system (manufacturing or other customer product and service operations) whose solution would greatly ease the overall plant system problem (i.e., it must involve both information and mission).

2 No enterprise can long exist without a business or mission, i.e., it must produce a "product(s) or service(s)" desired by a "customer(s)." It usually must also produce these product(s) or service(s) in competition with other enterprises also vying for this same business.

3 There are only two basic classes of functions involved in operating any enterprise:
   a. Those involved in operating the "process(es)"* which result in producing the "product" which fulfills the enterprise's mission, i.e., the customer product or service business in which the enterprise is engaged. In the manufacturing plant these would include all material and energy transformation type tasks and the movement and storage of the same materials, energy, goods in process and products.
   b. Those involved in the "control" of the mission in an "optimal" manner to achieve the necessary economic or other gains that assure the viability or continued successful existence of the enterprise. These comprise the collection, storage and use (i.e., transformations) of information concerning the business processes in order to control them, i.e., to develop and apply necessary changes to the business processes to achieve and maintain their required "optimal" operation. Thus it includes all management, planning, scheduling, control, data management, etc., functions.

4. Normally, information or data will undergo multiple transformations, i.e., many separate tasks (where a task defines each transformation) in fulfilling the information-handling requirements for an enterprise or CIM system. These transformations or tasks are

* The use of quotation marks on several of the terms used here indicates they are defined in the most general manner possible in order to cover the extremely wide range of aims, methods and conditions covered.

usually successive operations forming sets of sequential and parallel networks (i.e., they can be modeled as data flow diagrams.).

5. The same is true of the material and energy transformation tasks for fulfilling the physical production or plant operations requirements for the enterprise. The resulting material and energy flow diagrams may look very much like the data flow diagrams above.

6. In each case, the networks involved can be combined, if desired, to achieve one major network of each type (Informational Transformations or Material and Energy Transformations, respectively). The totality of this defines the functionality of the enterprise or other business entity being considered (i.e., the totality of the information network, plus the manufacturing networks, both of which are developed separately but used conjointly).

7. The two networks interface in those tasks that develop operating variable state or status data from the manufacturing processes (sensors) and those that deliver operational commands to the operational units (actuators and related devices). Except for these tasks and their related requirements, which do affect the other networks, each network can be developed independently of the other.

8. Initial functional analysis or general study of either or both classes of functions above can be carried out without knowledge or concern of how they will ultimately be implemented in the operating enterprise.

9. For many technological, economic, and social reasons, humans are involved in the implementation and execution of many business processes of all types in both classes above. Others, of course, may possibly be automated or mechanized. Thus there must be three classes of implemented tasks or business processes:
   a) Those of the information and control type that can be "automated" by computers or other "control" devices.
   b) Those of the mission tasks or business processes which can be automated or mechanized by the "mission fulfillment" equipment.
   c) Those functions carried out by humans, whether of the control or mission fulfillment class. There must be a simple way of showing where and how the human fits in the enterprise and how the distribution of functions between humans and machines is accomplished.

10. All enterprises, of whatever type, follow a "life cycle" from their initial concept in the mind of an entrepreneur through a series of stages or phases comprising their development, design, construction, operation and maintenance, refurbishment or obsolescence, and eventually to their final disposal.

11. Not only does this life cycle apply to the enterprise but also to the enterprise's products as well. Thus, carried further, one enterprise can be the product of another. For example, a construction enterprise could build a manufacturing plant (enterprise) as its product. The manufacturing plant would then manufacture (produce) its own product, such as an automobile. The automobile also has its own life cycle, which goes through similar steps to those discussed here.

12. Once the integration of all of the informational and customer product and service functions of an enterprise have been properly planned (the Master Plan), the actual implementation of such an integration may be broken into a series of coordinated projects. These may be carried out as the resources of the enterprise allow, as long as the requirements of the Master Plan are followed.

13. All tasks will be defined in a modular fashion, along with their required interconnections, so they may be interchanged with other tasks that carry out similar functions but in a different manner.

14. Likewise, these tasks will be implemented in a modular fashion, again permitting their later substitution by other different methods of carrying out the same function. The choice of these implementation methods can be governed by independent design and optimization techniques as long as the task specifications are honored.

15. Provided the modular implementation just noted is used, the interconnections between these modules can be considered interfaces. If these interfaces are specified and implemented using company, industry, national and/or internationally agreed upon standards, the interchange and substitution noted in Item 13 and 14 will be greatly facilitated.

16. By considering that manufacturing is a type of customer service, i.e., production of goods for purchase by the customer, and then expanding customer service to include all possible goods and services the enterprise may render to the customer, we can expand the Architecture to cover all possible types of enterprises. Thus the right-hand side of the Architecture would then represent the customer service rendered by any enterprise even if that service itself involved information.

These concepts then form the basis for developing the architecture and its associated methodology needed for carrying out enterprise integration engineering tasks.

The universal applicability of the systems engineering concept of a life cycle (Items 10 and 11 above) allows one to develop a sketch or graphical model to illustrate most of the concepts and tasks involved in enterprise integration. This gives all the individuals involved a common and easy way for describing, planning, and carrying out all aspects of this very complex task in the easiest way possible. The other concepts listed establish the overall form and content of the resulting sketch. This sketch will be called an “architecture” since it describes the form or structure of the process of carrying out the life cycle of the enterprise or entity involved.

We will discuss the Purdue Enterprise Reference Architecture next and show how it fulfills the concepts listed above.

0.2 *The Architecture*

0.2.1 Description of Purdue Enterprise Reference Architecture (PERA)

The Purdue Enterprise Reference Architecture [9] has been a major aid to the members of the Industry-Purdue University Consortium for CIM in their development of the original Implementation Procedures Manual for Developing Master Plans for Computer Integrated Manufacturing [8]. Likewise, it has been an equally important aid in describing and illustrating the procedures involved in the Master Planning process and in showing the interrelationships of the various aspects of overall enterprise integration. For these reasons, this section will be a relatively brief discussion of the architecture separate from its involvement in the master planning process. The reader is referred to the definitive description of the architecture as published by the Instrument Society of America [9] for more detail.

Before proceeding further, an aside as to the nature of enterprise reference architectures is necessary. It has been shown [6] that these architectures can be of either of two types. The first, or Type 1 Architecture, presents a pictorial description or model of the physical organization or structure of an enterprise, and thus the architecture of a physical system as used in enterprise integration such as a computer system, a communications system, the plant itself, etc. This is, by far, the most common architecture encountered in enterprise integration studies. However, there is also a second type, designated Type 2, that, in contrast to the former, describes or models the steps of the process of development of enterprise integration, and therefore, the framework or the structure of the relationship of these development steps to one another.

Either type can be called a reference architecture if its description is generic and widely applicable. It should also be noted that Type 2 architectures thus describe or model the process of analysis, design and development of the systems described by Type 1 architectures. In keeping with the more usual meaning of the word architecture (as the design of a building, for instance) both types of enterprise integration architectures are graphical rather than textual in form. It is Type 2 architectures that model the concepts of enterprise integration as given above.

The Purdue Enterprise Reference Architecture is a Type 2 architecture in that it describes graphically the steps or structure of the analysis, design and development of an enterprise integration project. This Handbook on Master Planning and Implementation, on the other hand, describes textually and pictorially the same process. The Purdue Architecture is thus a graphical model of the process described by the Handbook. The Purdue Reference Model [7], on the other hand, limits itself to a description of the computer based scheduling and control system needed for enterprise integration and is thus a Type 1 architecture.

Figures 1, 2, and 3 present simple block diagram forms of the Purdue Enterprise Reference Architecture to help in its explanation. Its complete form will be shown later in this section. As noted in Figure 3 we will use a manufacturing enterprise as our example and show later the expansion of the concepts of the architecture to cover any type of enterprise entity or system. Figure 2 is merely an elaboration of Figure 1 to show more details of the life cycle based structure of the architecture. (The numbering of the boxes and nodes of Figure 2 will be explained later in this section.) Note also that Figure 2 shows several different ways of labeling the several phases and nodes of the architecture. At each level the several terms shown are synonymous.

As noted in Concept 10, all enterprises throughout their lifetime fulfill a "life cycle." Figures 1 and 2 show the form of the architecture describing this as expressed by PERA. The life cycle proceeds from top to bottom of the figure, i.e., from initial identification of the project down through all intermediate phases to the final act of enterprise dissolution. The structure and form of the architecture will now be explained.

Starting with the Enterprise Business Entity (EBE) (top of Figure 1 and working downwards) we see that this leads first to a description of the management's mission, vision and values for the entity, plus any further philosophies of operation or mandated actions concerning it. These might include choice of processes, vendor selection, etc. From the mission, etc. we derive the operational policies for all of the units of the entity for all areas of potential concern. These form the Concept Layer.

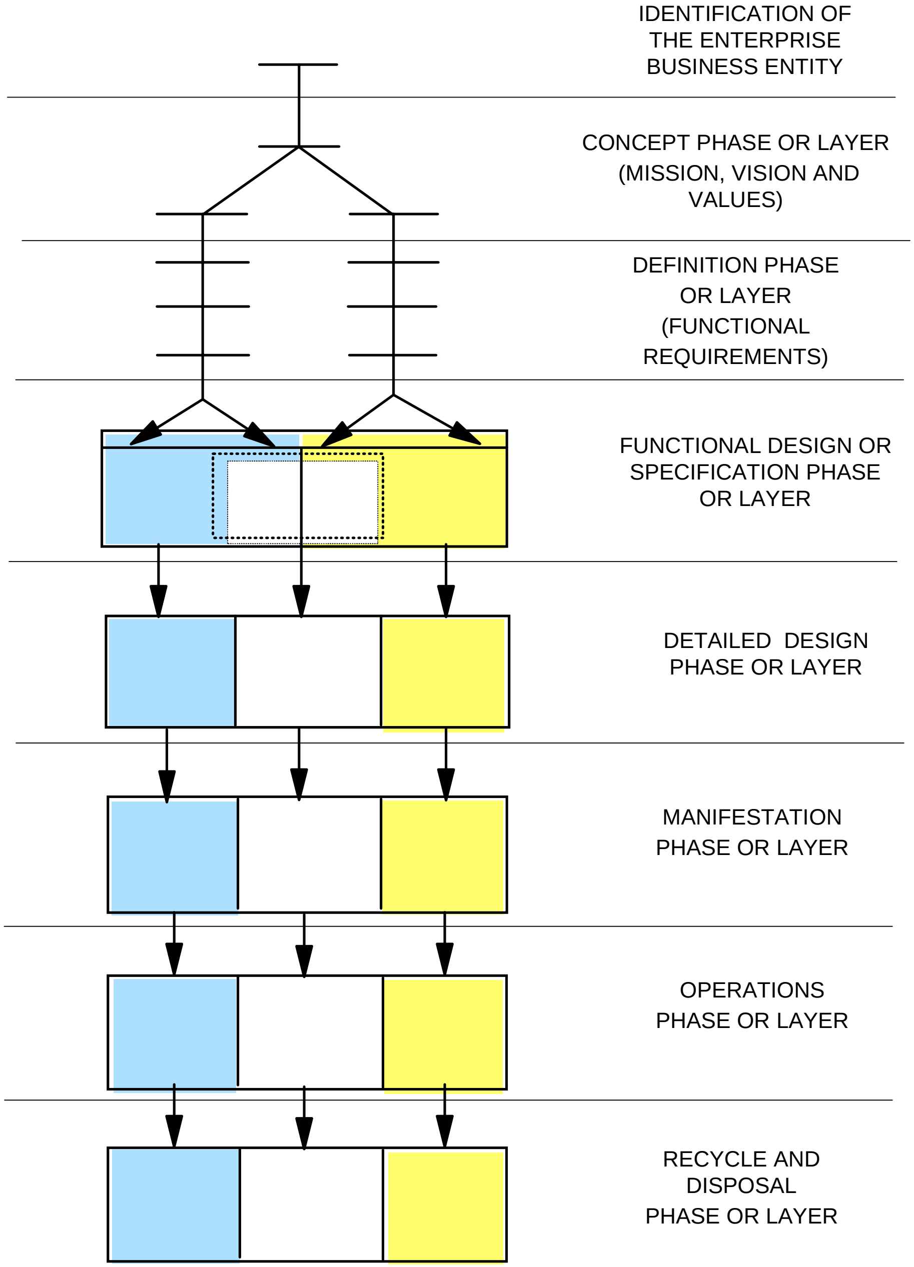
In the manufacturing plant the above prescription and selection by management of possible options leads to the establishment of operational requirements for the plant. This latter then leads to the statement of requirements for all of the tasks to be executed in carrying out the operational mission of the entity, for these plant units. These requirements and tasks are developed in the Definition Layer as illustrated in Figure 3.

Figure 3 illustrates Concept 3 concerning the existence of two and only two classifications of functional tasks in the enterprise. It is well known by these authors that most computer scientists and information specialists prefer to separate information (databases and data handling) from control or decision theory. However, since “the only use for information is to effect control now or in the future,” we hold to our premise. This axiom may be considered a little farfetched when we consider history, but even here it holds if one believes, “history is to help us avoid the mistakes of the past.”

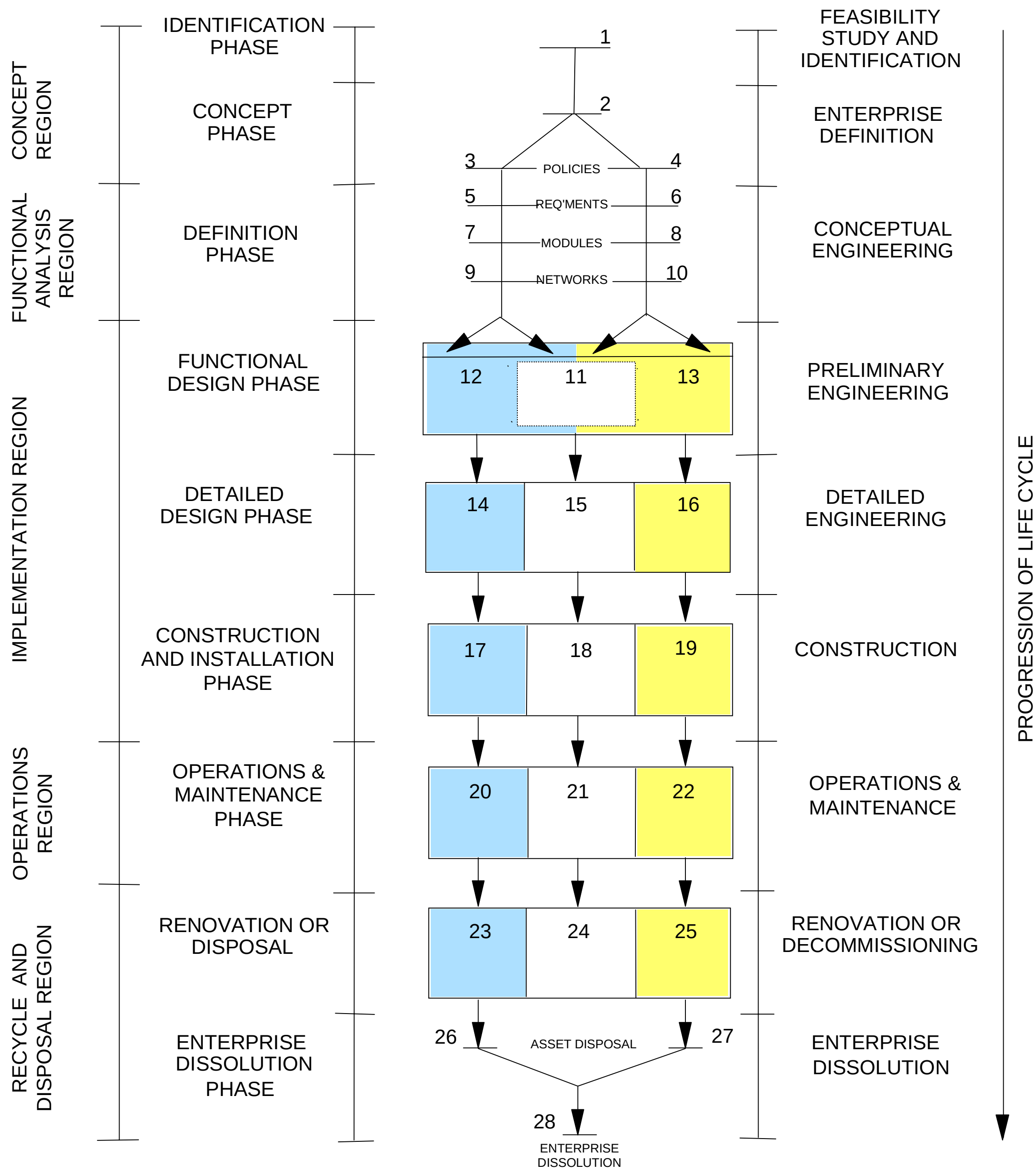
In these diagrams, material dealing with the Information System will always be on the right (as seen from the reader’s view).

Concepts 4 to 7 are illustrated by the progressing life history of Figure 3 showing requirements leading to the tasks necessary to fulfill them; and these tasks then leading to functional networks. The networks (material and energy flow diagrams and data flow diagrams) are directly analogous to each other.

Note that there are two, and only two kinds of requirements developed from the management pronouncements — those defining "information" tasks and those defining "physical manufacturing" tasks. Tasks become collected into modules or functions and these in turn can be connected into networks of information or of material and energy flow. These latter then form the Information Functional Network or the Manufacturing Functional Network respectively as shown in Figure 3.



<u>FIGURE 1</u> - A GRAPHICAL PRESENTATION OF THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE INDICATING PHASES, AND THE RELATIONSHIP OF TASKS WITHIN PHASES



<u>FIGURE 2</u> - OVERALL FORM OF THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE DIAGRAM SHOWING VARIOUS FORMS OF THE LIFE CYCLE

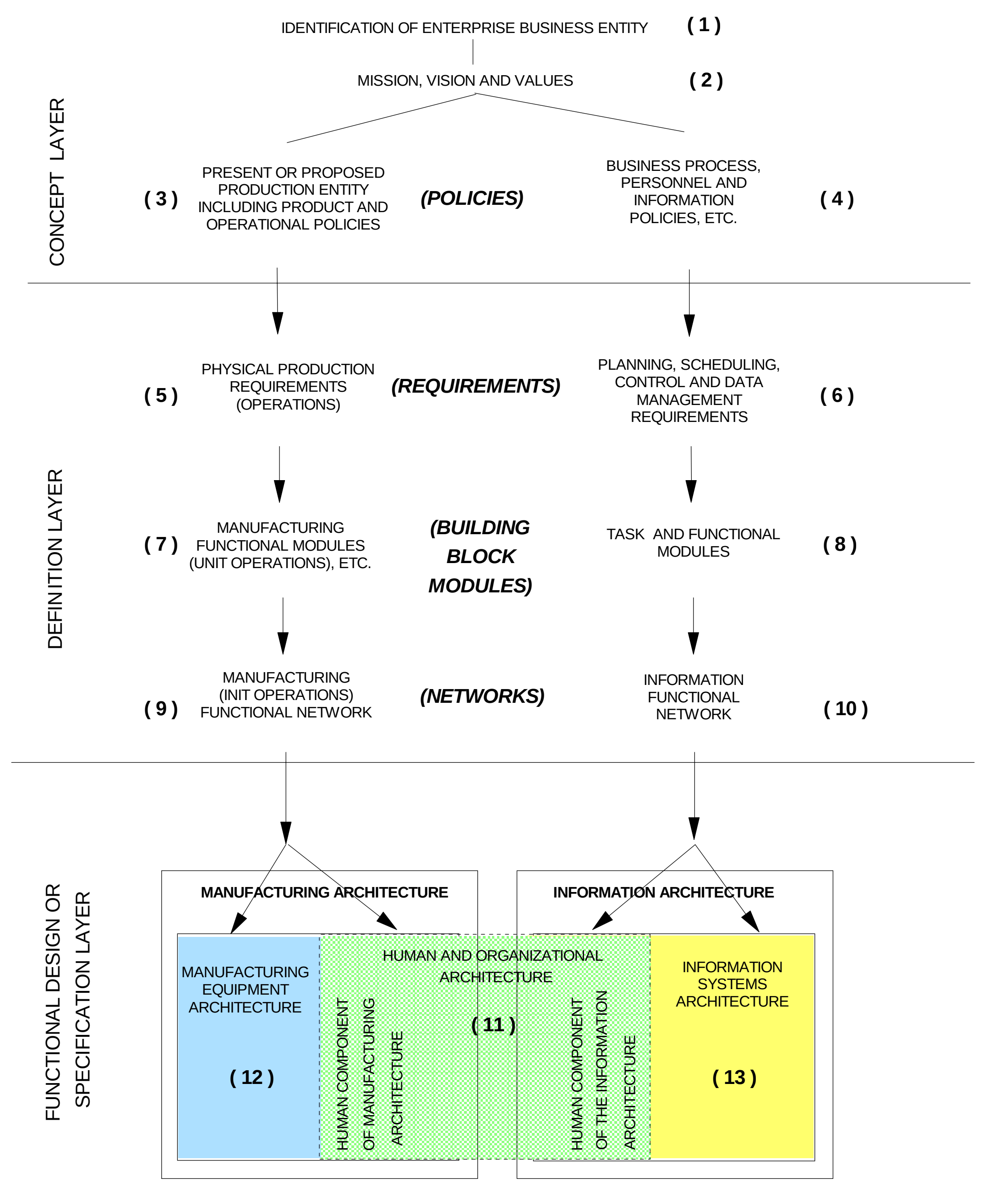


FIGURE 3 - COMPONENTS OF THE CONCEPT, DEFINITION AND FUNCTIONAL PHASES FOR THE MANUFACTURING CASE

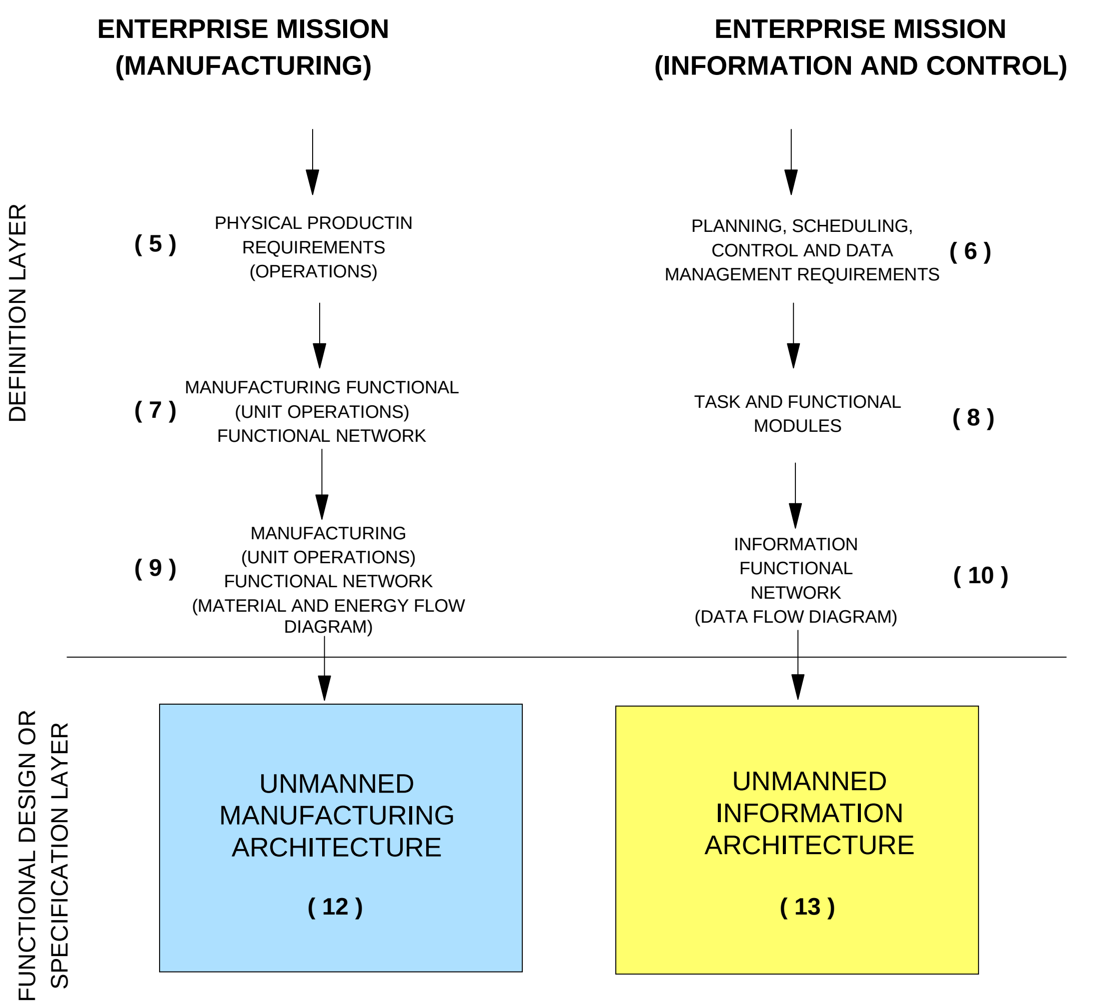


FIGURE 4 DEVELOPING THE RELATIONSHIP OF THE SEVERAL SUB-ARCHITECTURES OF PERA FOR MANUFACTURING SYSTEMS

Note also, that no consideration of implementation methods or of the place of humans in the system has yet taken place. If no humans were involved, Figure 3 would be simplified on implementation to Figure 4 and the tasks described by the Information Functional Network would be implemented as the Information Architecture while meanwhile the Manufacturing Functional Network would be implemented by the Manufacturing Architecture. These are Type 1 architectures since implementation produces the needed physical system to carry out the specified tasks of the Functional Networks. The overall architecture contains these physical architectures as parts as mentioned above and describes their further development.

Figure 3 extends Figure 4 upwards (higher level in the company) to show the initial steps of the life cycle and the origin of the Requirements Level of Figure 4. Mission, Vision and Values (Node 2) gives management's desires for economic and other gains from the contemplated project. Policies (Nodes 3-4) show how management expects to gain the desired benefits. The resultant policies lead to the requirements on the system proposal that would ultimately enable those policies and management's expected benefits.

Figure 3 also shows the split of the two classes of functional tasks into three classes of implemented tasks to account for the place of the human worker in the enterprise. How this is determined will be discussed next.

Since humans are needed in practically all implementations, we must return to Figure 3 for our further discussion. Therefore once implementation is considered, the first need is to define which tasks, on either side of the overall architecture, will be fulfilled by people. By so doing, we define the place of the human in carrying out those information and manufacturing tasks assigned to them. These human implemented tasks, from both of the functional groupings will together form a Human and Organizational Architecture. The remainder of the information tasks then define the Information System Architecture (all the computers, software, databases, etc.). The remainder of the manufacturing tasks likewise define the Manufacturing Equipment Architecture (all the tasks performed by plant equipment). We have therefore converted two functional networks into three implementation architectures (compare Figures 3 and 4). All of these architectures are sub-architectures of the Purdue Enterprise Reference Architecture itself as we have described earlier.

We can now follow the life history of the implementation through its four remaining phases -- functional design or specification; detailed design; construction and commissioning or manifestation; and finally operation to obsolescence or possible renewal.

0.2.2 Choice of Human Tasks

The lines separating the three implementation architectures in Figure 3 will now be defined.

Let us first assume that each and all of the tasks developed in the Definition Layer are collected for implementation in the boxes of the Information Architecture and the Manufacturing Architecture as shown in Figure 4. Our task now is to define which of these tasks will be implemented by humans on each side of the Purdue Architecture and which by automated or mechanized means. This will be done by separating these tasks and their subsequent implementation by the lines shown in Figure 5.

In concept there is such a line that could be called the "Automatability" line that would show the absolute extent of technology in its capability of actually automating the tasks and functions of the integration system of the Enterprise Business Entity. It would be limited by the fact that many tasks and functions require human innovation, etc., and cannot be automated with presently available technology (see Figure 5).

These latter would have to be placed in the Human and Organizational architecture blocks.

There is also another similar line that could be called the "Humanizability" line that would show the extent to which humans can be used to actually implement the tasks and functions of the integration system of the Enterprise Business Entity. It is limited by human abilities in speed of response, breadth of comprehension, range of vision, physical strength, etc. Of course, prior to the industrial revolution most information functions in manufacturing were human implemented.

Those outside the Humanizability line would have to be automated under the Information Systems Architecture or Manufacturing Equipment Architecture, respectively. Everything lying between these two lines on each side of the Architecture could be implemented by either automation or mechanized equipment. Each would be technologically feasible. The actual methodology technologically used must therefore be chosen by other methods.

There is then still a third line that can be called the "Extent of Automation" line, which defines the actual boundary between the Human and Organizational Architecture and the Information Systems Architecture on the one hand, and between the Human and Organizational Architecture and the Manufacturing Equipment Architecture on the other. These are related to each other as shown in Figure 5. The Extent of Automation line shows the Actual Degree of automation carried out or planned in the enterprise integration system of the Enterprise Business Entity.

The location of the Extent of Automation line is influenced by Economic, Social (Customs, Laws & Directives, Union Rules), as well as Technological factors.

An Automatability line showing the limits of Technology in achieving automation will always be outside of the Extent of Automation line with respect to the automation actually installed. That is, not all of the technological capability for automation is ever utilized in any installation for various reasons. Thus the Human and Organizational Architecture is larger (i.e., more tasks or functions) and the Information System and Manufacturing Equipment Architectures are smaller (less functions) than technological capability alone would allow or require. Note that for a completely automated plant, (the "lights out" plant) that both the Automatability line and the Extent of Automation line will coalesce and move to the left edge of the Information Architecture block and correspondingly to the right edge of the Manufacturing Architecture block.

Therefore the Human and Organizational Architecture would then disappear and the Information Systems Architecture and the Manufacturing Equipment Architecture would coincide with the Information Architecture and the Manufacturing Architecture respectively like Figure 4, i.e., there is no human involvement.

Another major implication of the architecture diagram is that, as long as the specifications for accomplishment of each of the tasks is honored, the three implementation architectures can be developed relatively independently.

Figures 6A and 6B expand the abbreviated sketch of the Purdue Enterprise Reference Architecture of Figure 1 as applied to a enterprise integration system to show the functions carried out at each stage or phase of the life history of the enterprise integration project. As will be noted later such a life history with minor modifications would apply to any enterprise.

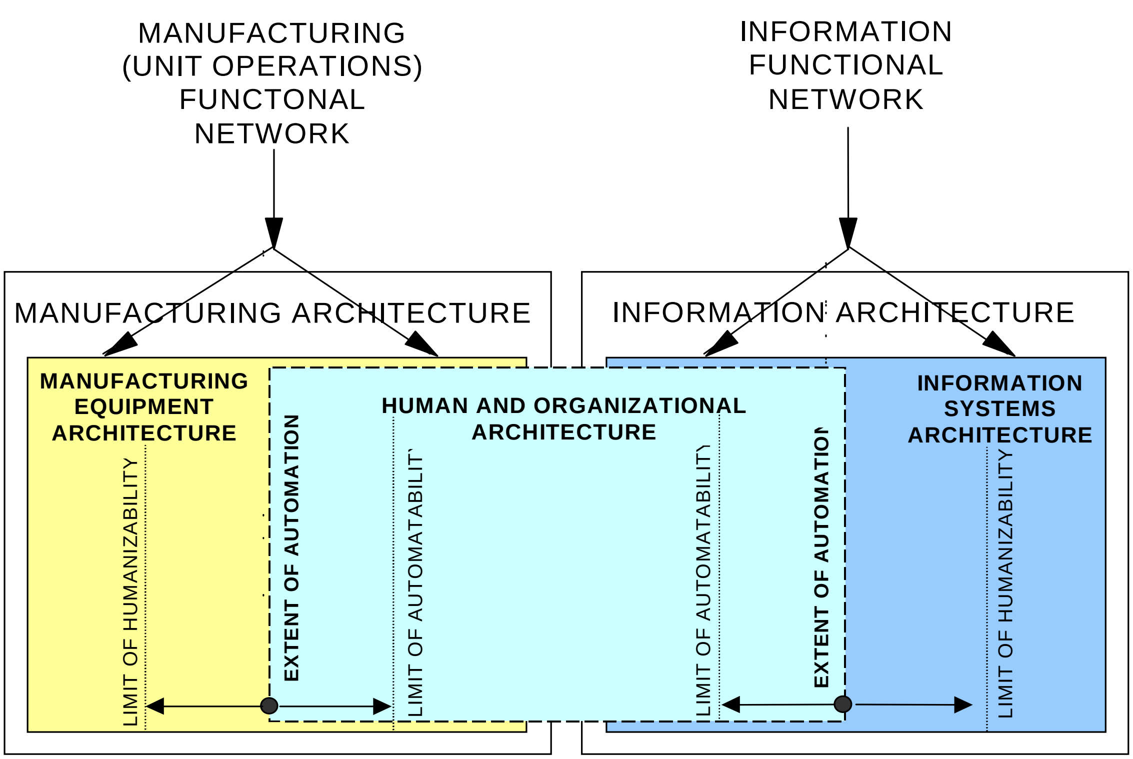


FIGURE 5 – INTRODUCTION OF THE AUTOMATABILITY, HUMANIZABILITY AND EXTENT OF AUTOMATION LINES TO DEFINE THE THREE IMPLEMENTATION ARCHITECTURES

0.2.3 Modular Task and Function Representation Method

The key to the overall applicability of the Purdue Reference Model for CIM [7] was its espousal of a set of generic tasks and functions and their assignment to certain levels in the Scheduling and Control Hierarchy of the Functional Model. This same concept is very important in the development of generic architectures.

Appendix I shows a method for the development of a set of generic tasks and functions which should be applicable to help prepare the concept of a generic functional information architecture for any enterprise integration system. The resulting set of generic tasks and functions will be the same as that presented in the Purdue Reference Model for CIM [7]. Thus Appendix I treats only the Information Systems Architecture and the information aspects of the Human and Organizational Architecture. There can be no such generality in the mission side since enterprise missions vary all across the possible spectrum.

All other concepts and statements presented in the Purdue Reference Model for CIM can be assumed to apply here except where statements here supersede those of the Reference Model such as in the Architecture's definition of the human-implemented task and function.

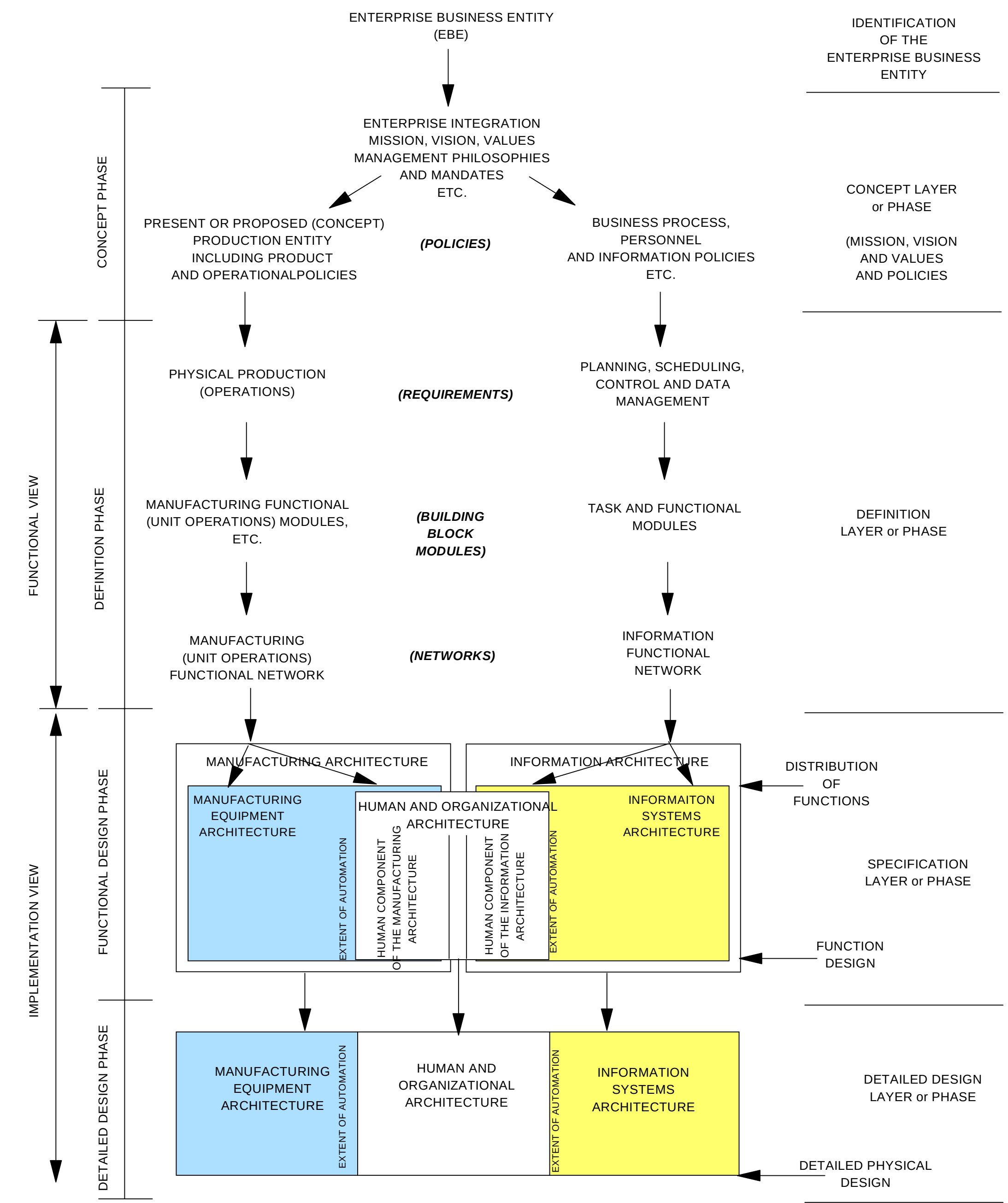


FIGURE 6A – DEVELOPMENT OF AN ENTERPRISE INTEGRATION PROGRAM AS SHOWN BY THE PURDUE ARCHITECTURE (PHASES AND LAYERS OF THE PROGRAM)

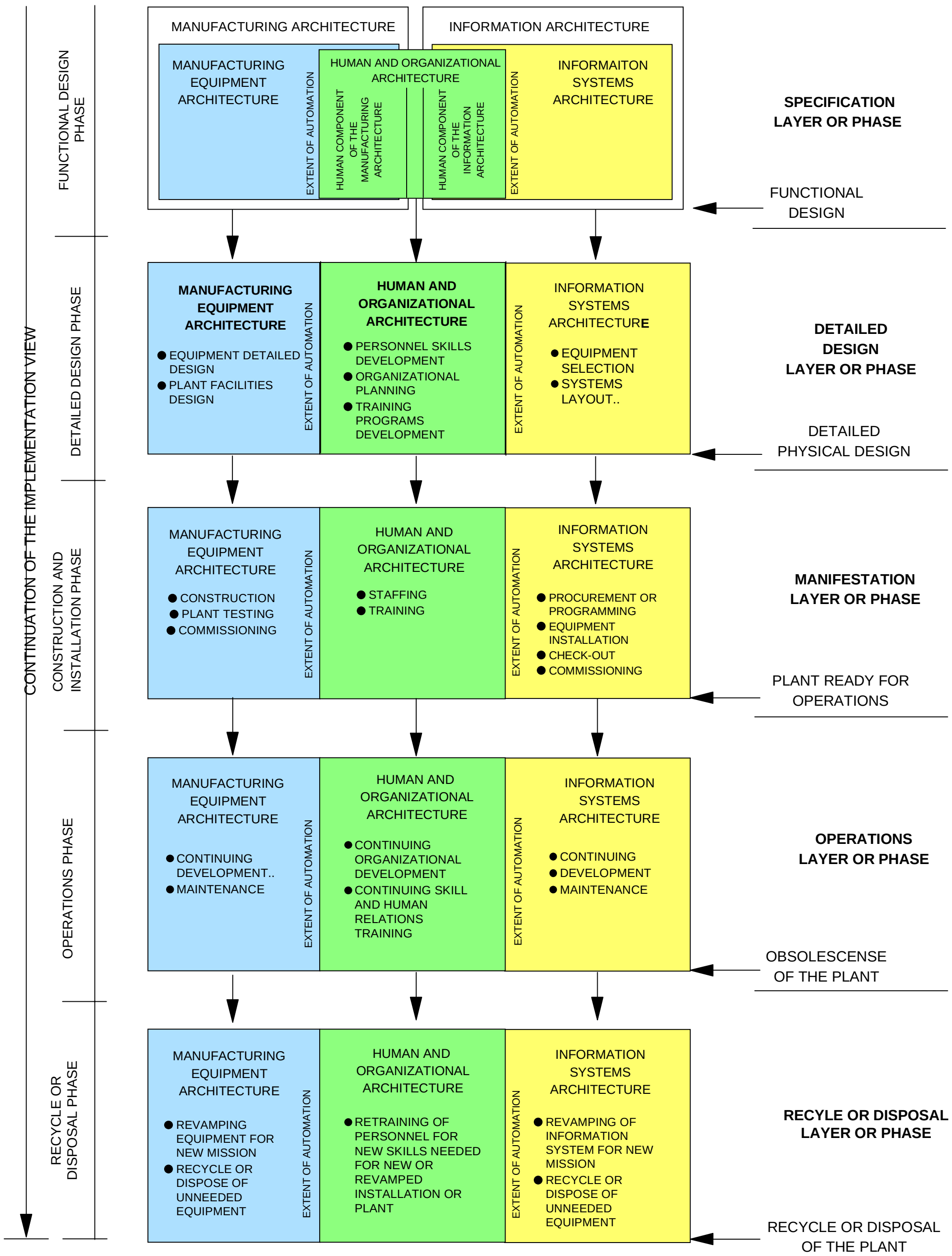


FIGURE 6B ENTERPRISE PHASES RELATED TO PURDUE ARCHITECTURE LAYERS OR PHASES

EXECUTIVE SUMMARY

This set of basic tasks and functions is that which must be carried out by any enterprise integration system effectively operating an Enterprise Business Entity or Manufacturing Facility.

As a generic list it should be completely independent of:

1. The method of implementation of the task or function ultimately chosen (whether technological or human-based).
2. Any uncertainty as to the availability, maturity, compatibility or stability of the solutions chosen.
3. The ability of the chosen solutions to meet all current and future requirements.

This development will take a bottom-up approach (i.e., detailed to general) or (task to function). The Purdue CIM Reference Model [7] and most other analyses use a top-down approach (i.e., general to detailed) or (function to task). This bottom-up approach is necessary to assure an accurate definition and description of the operation of the task or function at hand and to assure commonality of these tasks or functions when comparing them with those arising from different sources.

A bottom-up definition also assures completeness of the implementation requirements for the task or function and thus provides for the development of accurate specifications for implementation media.

Once a particular individual task, function, or macro-function has been thoroughly and correctly described by this bottom-up approach it may then be used in subsequent top-down analyses as a separate distinct, self-contained block. See Figure 7.

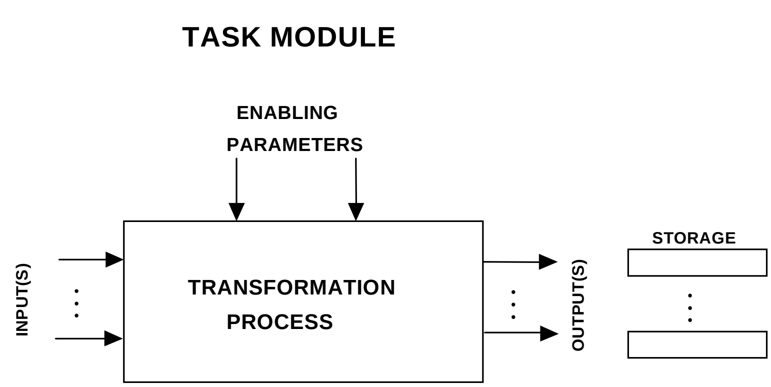


FIGURE 7 – DEFINITION OF A GENERIC TASK MODULE

0.2.4 Scheduling and Control Tasks (i.e., Information Handling)

The transformation process for a scheduling and control task involves operations on information (data) enabled by an algorithm. The transformation may be considered a computational block.

Algorithms are replaceable in the computational block along with their associated parameters. Algorithms may be represented by an algebraic, logic, expert system, fuzzy logic, neural net, differential equation, table look-up, or computer programmed procedure, or any other method of expressing the relationship involved. Note that algorithms may also be Deterministic (continuous or discrete) or Stochastic (statistical) in their expression. Note also that the word, algorithm, is used here in its broadest sense: both as a mathematical expression and as a computer programmable procedure. The key is that the operation to be carried out must be totally definable in mathematical and/or computer programmable terms.

Where no definable algorithm or computer program exists; as in a human, thought-based, innovative process; the transformation process may be described by a written scope or other text that characterizes the transformation involved. All other rules concerning modules as discussed here prevail for the scope modules. In this way management, engineering, marketing, and other human-implemented tasks and functions can be represented.

The above condition also applies for the case where an algorithm exists, but, for whatever reason, it has been chosen to use a human implemented method to carry out a particular function. These then become the non-automated or non-mechanized tasks or functions of the system.

Table I presents an overview of the breakdown of the tasks in the Information Architecture (all information tasks whether human or machine implemented) at the highest abstraction level (least detail or minimum breakdown).

0.2.5 Manufacturing-based Tasks

For manufacturing processes the basic tasks will comprise generic operations, such as the "unit operations" of chemical engineering, or similar classes of operations in each of the other fields of engineering. That is, all manufacturing modules, where applicable, follow a set of basic rules like the unit operations concepts of chemical engineering, in that each unit operation and its associated equipment would be considered a module in the context used here.

In discrete manufacturing these could probably be characterized as manufacturing functions or tasks as developed from the application of group technology principles.

Manufacturing modularity will be carried out as follows:

1. All modularity will be task or function related.
2. All physical, chemical, positional or form (size and shape) i.e., manufacturing, transformations are carried out by or in physical equipment.
3. Modularity dictates that a module at this level will comprise one or a group of such closely related transformations carried out in the same piece of equipment and will include the physical equipment required to carry it out.

EXECUTIVE SUMMARY

Manufacturing modules are generic in the chemistry and physics of their operation but are specific in terms of their parameters (dimensional and operational) and in their connectivity to form the manufacturing plant.

TABLE I

BASIC CLASSES OF TASKS OF THE INFORMATION ARCHITECTURE

1. Communications - the transmission of information between the elements (modules) of the Information Architecture (either human workers or components of the Information Systems Architecture) in the form of messages adhering to a pre-established protocol.

   Messages may be verbal (agreed upon language) visual (agreed upon non-verbal actions or symbols) or written (agreed upon language and format) if to, from or between human workers. Messages between the elements of the non-human components of the Information Systems Architecture are through electronic, light, pneumatic or other media in the agreed-upon standard protocol.

2. Information Storage - the retention of information and data for periods of time (specified or indeterminate) for use in later actions of the Information Architecture components. Storage may be in human-readable form (written - libraries, etc.) or machine-readable (electronic or magnetic or other related form in databases or related depositories).

3. Mission Fulfillment - Guidance (control) of the components of the Manufacturing (or Customer Products and Services in general) elements of the Manufacturing Architecture in carrying out their assigned tasks to assure an optimal completion of the assigned mission of the enterprise.

0.2.6 Human Tasks Representation

In developing the Purdue CIM Reference Model, in 1986-88 [7], the CIM Reference Model Committee of the International Purdue Workshop had to show an interface in the model between the humans carrying out the vital functions in the factory or in related staff and management positions and the factory equipment itself. No satisfactory way of modeling the humans, and particularly their innovative capabilities existed in the literature at the time [7]. Therefore it was decided to consider humans and their relevant functions as "external entities " and assure in the model that communications facilities existed for them to send and receive all necessary information and data from and to the plant. This served the purpose of the Purdue University CIM Reference Model well and was adopted.

However, pursuit of the Implementation Procedures Manual project in 1989-92 [8] brought the members of the then Industry-Purdue Consortium smack up against the same problem as that which had faced the CIM Reference Model Committee, that of how to treat human involvement in the enterprise integration system. In addition they wished to also represent the elements and functions of the manufacturing system of the plant as well as the control system.

0.2.7 Task Module

Both of these problems were solved by defining the general task representation shown here in Figure 7. Information System tasks (the algorithmic control tasks of the CIM Reference Model), manufacturing tasks, and human-based tasks were then defined as shown in the preceding discussion (see Figures 8 to 10).

Parameters (coefficients in algorithms or dynamic models) may be:

1. Tables of constants.
2. Operational variable value dependent selections from tables of constants (pre-computed adaptive control).
3. Results of active on-line or periodic recalculation by adaptive tuning, etc., algorithms.
4. Expert systems outputs.
5. Neural nets outputs.
6. Etc.

It should be noted that the modules represented here and their connectivity into networks comprises a type of data-flow or material and energy flow mechanism. These networks define the functional requirements of both sides of the Purdue Enterprise Reference Architecture (Figure 3).

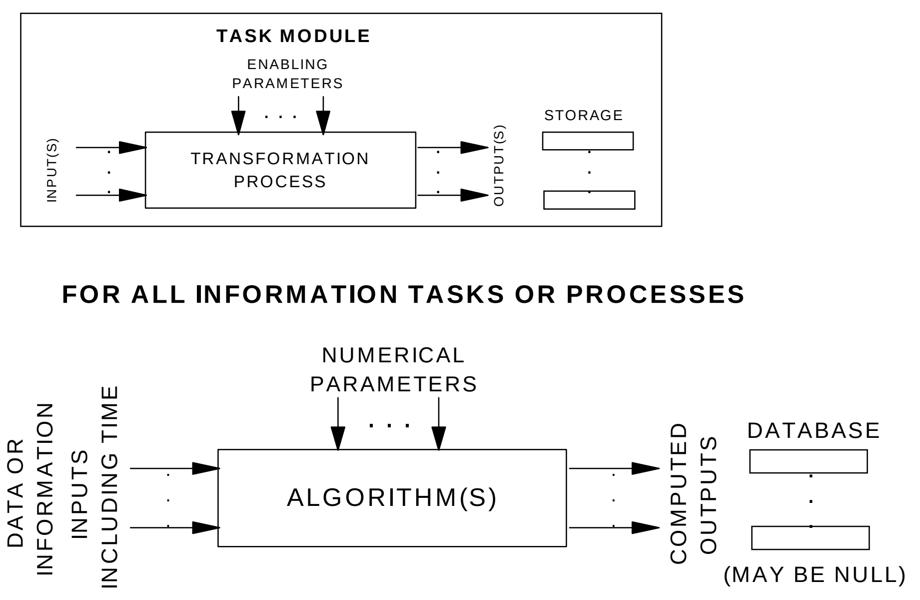


FIGURE 8 – INFORMATION FUNCTIONAL MODULE

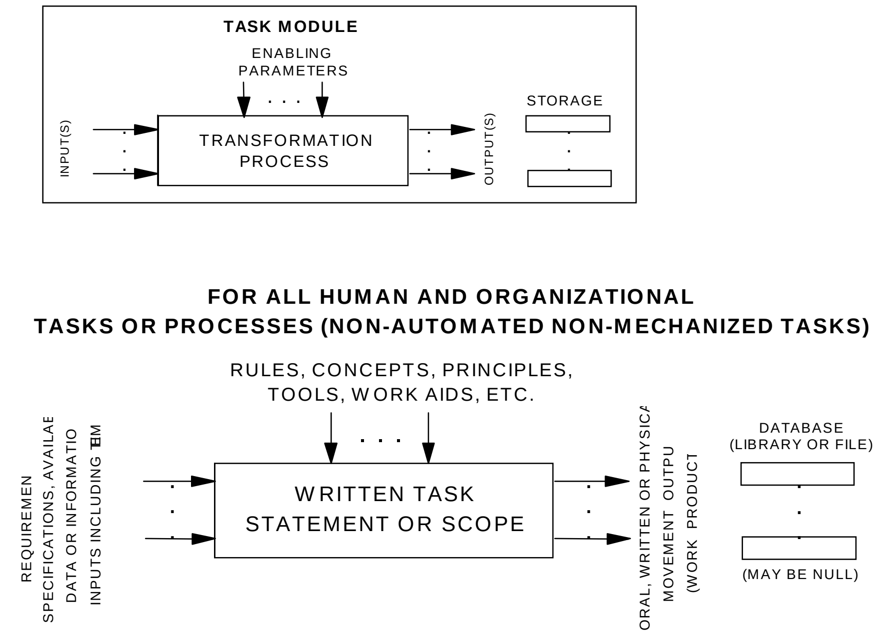


FIGURE 9 – HUMAN IMPLEMENTED TASK MODULE

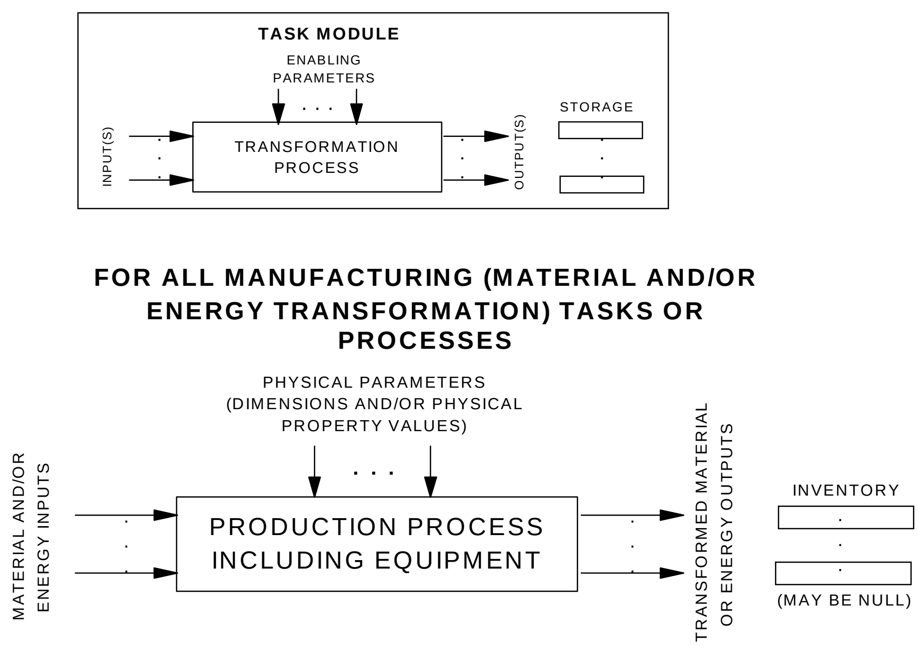


FIGURE 10 – MANUFACTURING FUNCTIONAL MODULE

0.2.8 Expansion of Reference Architecture

As noted above, the left hand side of the Business Entity life history diagram relates to functions producing customer products and services while the right hand side relates to informational services to the Enterprise itself. Thus the diagram can be expanded in its coverage to treat all enterprises - not just manufacturing or a CIM implementation program as shown by Figures 11 and 12.

Customer response or the provision to the customer of products and services may be carried out in many ways:

1. By physical things (i.e., manufactured products; [the type of Business Entity presented in all the earlier parts of this discussion]).
2. By pure physical services (transportation of goods or persons, availability of goods or service for purchase, rental [lease], etc.), or
3. Through the supply of information services (data, information) to be used by others.
4. Etc.

Figure 13 uses the information just developed to modify the labeling of the overall enterprise evolution diagram (Figure 6) to cover the corresponding generic enterprise (i.e., the production of either goods or services or both). Figure 14 shows how the definition of the tasks of the humans in each section of the Human and Organizational Architecture would change in order to be able to carry out the designated mission. For example, an information services company would employ information services type personnel to perform the desired service to the customer and thus would have these kinds of personnel in both compartments of the Human and Organizational Architecture.

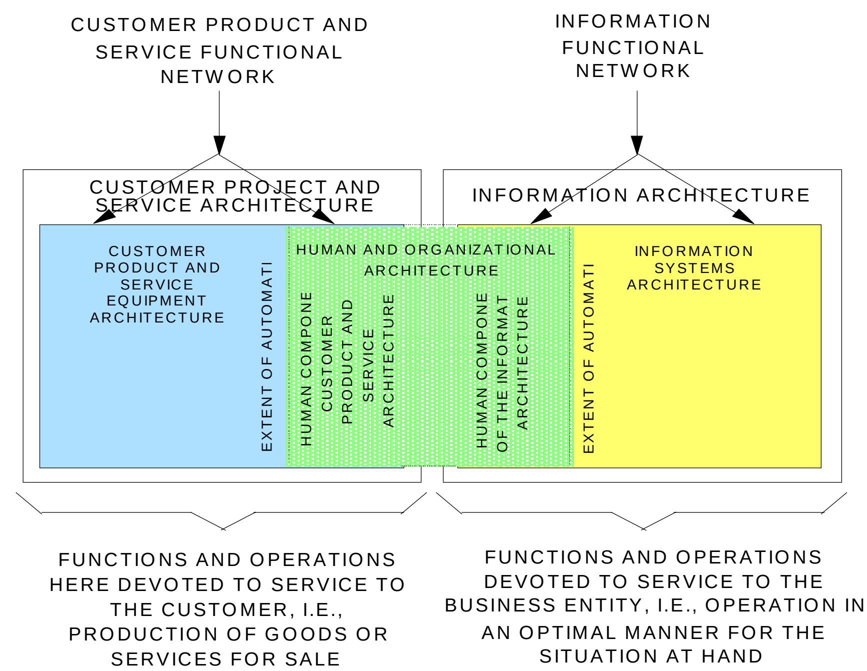


FIGURE 11 – FURTHER EXPLANATION OF THE DEFINITION OF THE GENERIC ENTERPRISE BY PERA

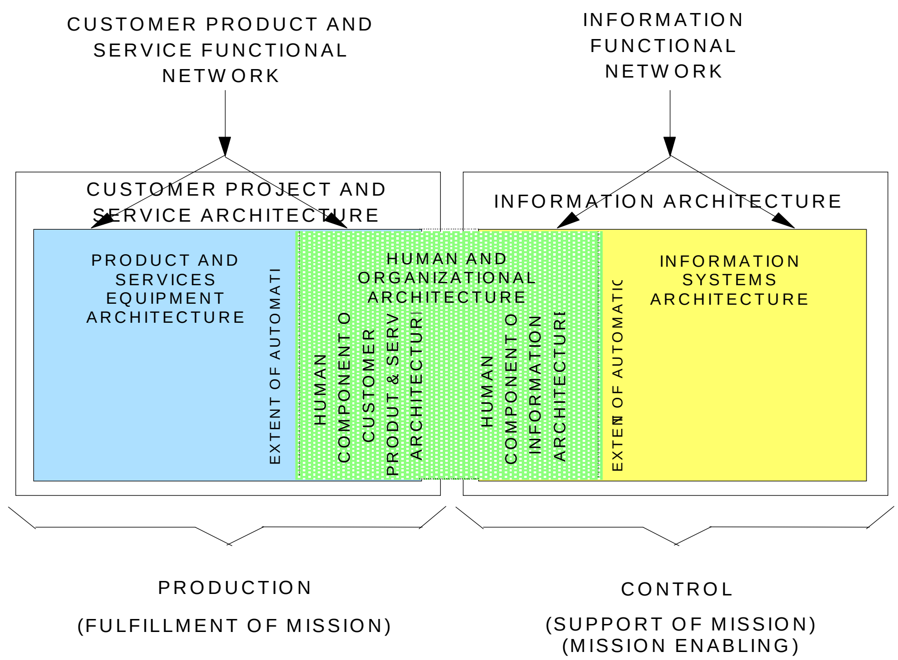


FIGURE 12 – FURTHER EXPLANATION OF THE DEFINITION OF THE GENERIC ENTERPRISE BY PERA

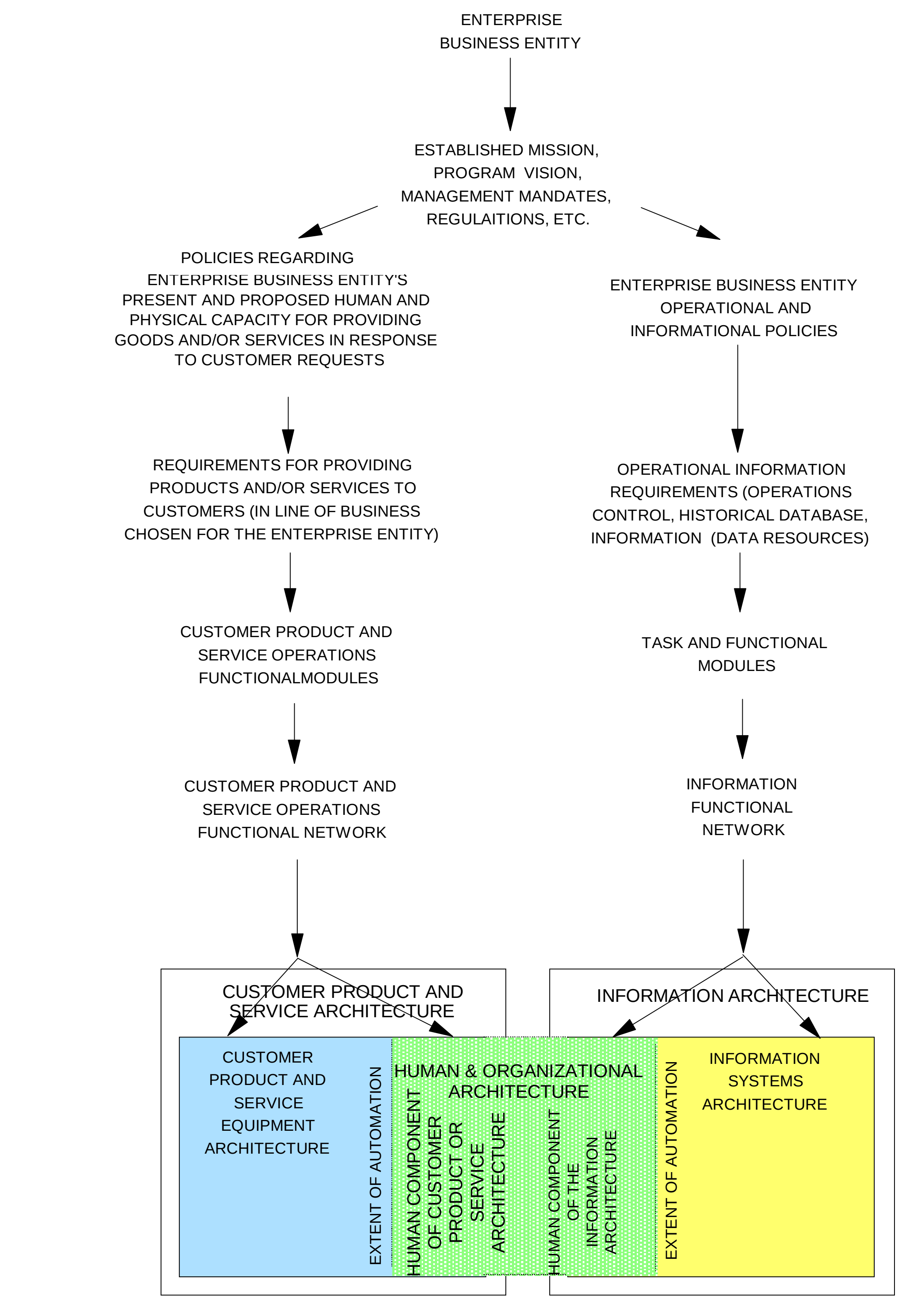


FIGURE 13 OVERALL DIAGRAM FOR THE GENERIC ENTERPRISE

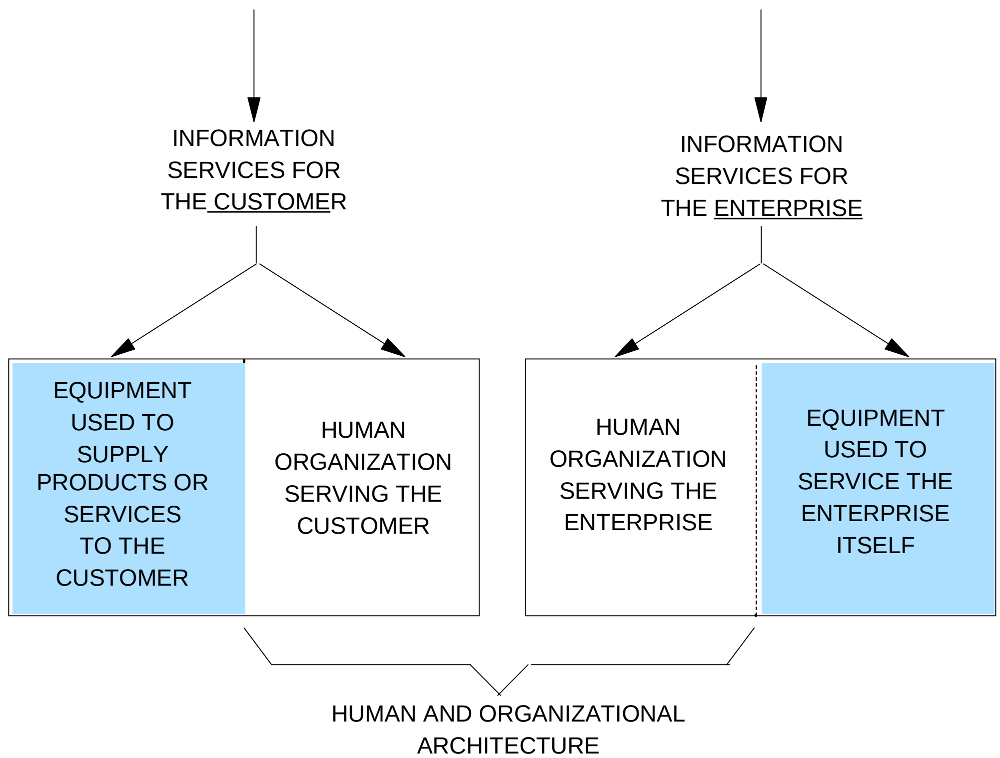


FIGURE 14 – SERVICES WHICH ARE OF AN INNOVATIVE INFORMATION TYPE WILL BE DIFFERENT FROM THE PHYSICAL SERVICE TYPE

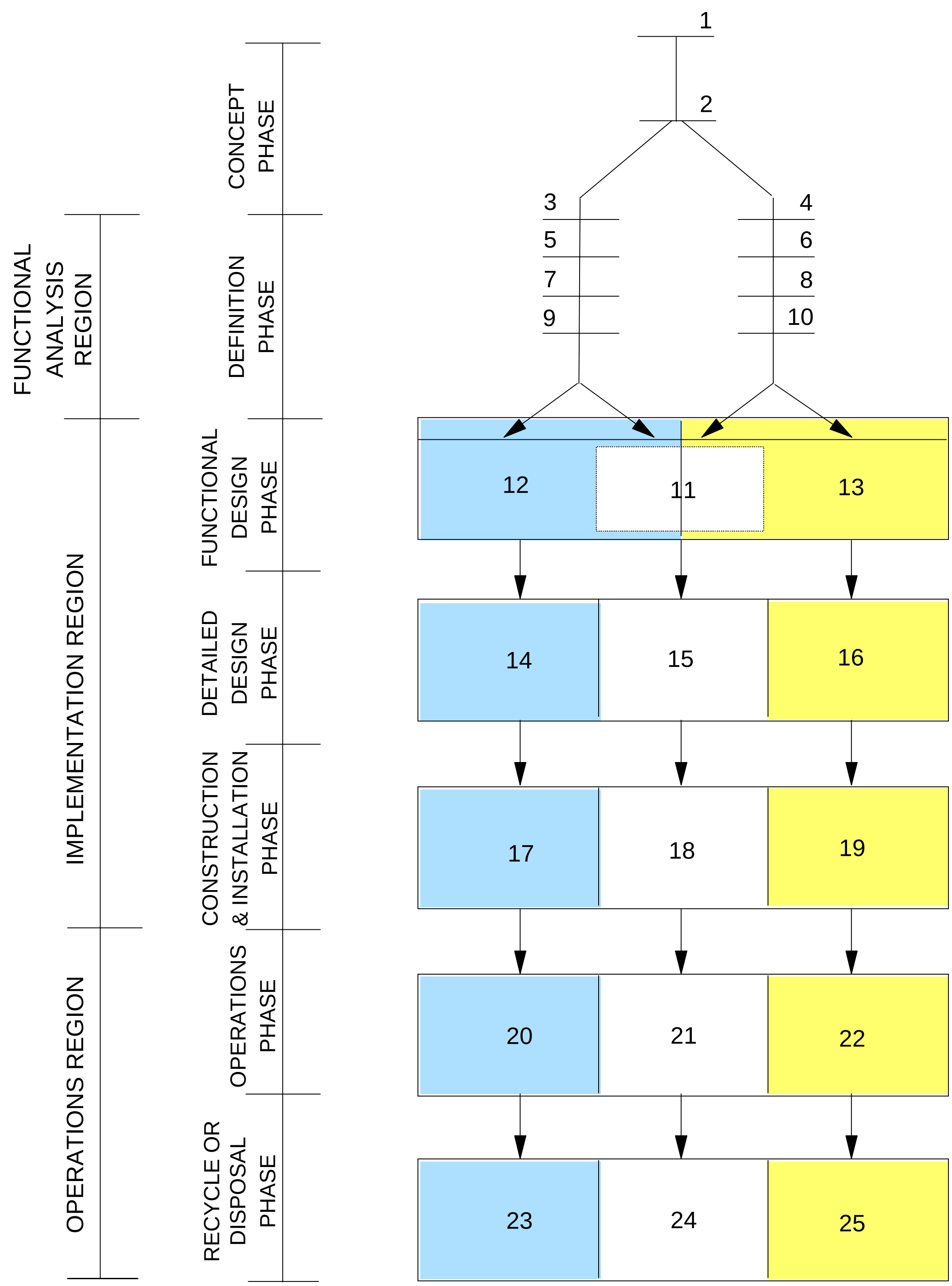


FIGURE 15 – ABBREVIATED SKETCH TO REPRESENT THE STRUCTURE OF THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

0.2.9 Tools, Etc., Available for Exploiting the Architecture

As has been pointed out, the Purdue Reference Architecture is a framework under which one can discuss one or more of the many important aspects describing an Enterprise. Each of the sub-architectures and, indeed, even the several regions within many of them thus become locales for the grouping of answers to the topic at hand as applied to that particular region or sub-architecture.

This applies to such topics as the development and assignment of policies and their resultant requirements; the formulation of tasks and functional modules; and the assignment of the tasks and functional modules for implementation. At each phase of completion, the architecture diagram can be used to help organize the collection and assignment of the wide variety of manual, graphical and computer-aided tools that are available for developing and carrying out such tasks as initial designs, detailed designs, hardware commissioning, software design and preparation, manufacturing equipment design, etc..

This discussion is in no way to be considered as a thorough review of this very wide field. It is only intended to point out to the reader another facility of the Architecture; that of providing a format for the classification and ordering of these various tools and design aids to facilitate the development, design and use of the enterprise integration system or even the whole enterprise.

Figure 15 provides an abbreviated sketch of the structure of the Architecture and provides the skeleton framework upon which to base the example collection of tools and design aids to be discussed here. Included on the diagram are numerical references to Table II which with the numerals of Figure 15 list each of the important areas on the framework diagram. Important development and implementation aids can then be listed by the areas under discussion. Table II continues by presenting an example list of some of the aids available for the development or implementation endeavor normally associated with each area of the diagram. Note that this list gives examples only and is not intended in any way to be comprehensive or complete.

TABLE II

AREAS OF INTEREST ON THE ARCHITECTURE FRAMEWORK FOR DISCUSSING DEVELOPMENT AND IMPLEMENTATION AIDS FOR ENTERPRISE INTEGRATION PROGRAMS AND OTHER ENTERPRISE STUDIES (REFER TO FIGURE 15)

Area	Subject of Concern	Types of Aids Available
1.	Identification of Enterprise Business Entity	Feasibility studies, potential gains and benefits vs. costs of proposed business entities to undergo enterprise integration programs. Identification of chosen enterprise.
2.	Mission, Vision, and Values of the Enterprise, operational philosophies, mandates, etc.	Example sets of Mission, Vision and Values expressions from company annual reports or the basic documents themselves. These are valuable to the extent that they are generic.
3.	Operational Policies and goals related to the customer Product and Service or Manufacturing goals and objectives, etc., of the Enterprise	Example scopes of the tasks for development and operation of specific processes and plants or other corresponding Customer Product or Service Operations; if for the same process or type of plant, may be directly used or otherwise will be used as an example of types of requirements needed.
4.	Operational policies related to the Information goals and objectives, etc., of the Enterprise	Generic lists of: Policies and requirements related to such topics as: control capabilities; degrees of performance of processes and equipment; adherence to classes of regulations and laws (environmental, human relations, safety, etc.); compliance in the above to a degree of good community behavior (good neighbor, citizen of the world, etc.); quality, productivity, and economic return goals; etc.
5.	Requirements to be fulfilled in carrying out the Customer Product and Service or Manufacturing related Policies of an Enterprise	Example sets of operational requirements for specific processes and process plants or other corresponding Customer Product or Service Operation; would include general safety requirements, fire rules, etc., that will influence plant design and process and equipment selection later in the program development; OSHA regulations and Fire Safety Underwriters rules.
6.	Requirements to be fulfilled in carrying out the Information Policies of the Enterprise	Generic lists of requirements necessary to carry out the policies listed in Area 4, probably in the form of scopes of the macro-functions to be listed in Area 8.
7.	Sets of Tasks, Function Modules and Macro-function Modules required to carry out the Requirements of the Manufacturing or Customer Product and Service Mission of the Enterprise	Lists of generic unit process operations of chemical engineering, or, of the manufacturing features from group technology for the discrete products industry; corresponding requirements for other types of Customer Product or Service Operations. (continued)

TABLE II (continued).

Area	Subject of Concern	Types of Aids Available
8.	Sets of Tasks, Function Modules, and Macrofunction Modules required to carry out the Requirements of the Information or Mission Support side of the Functional Analysis	Generic lists of Control and Information Tasks, Function Modules, and Macrofunctions.
9.	Process flow diagrams showing the connectivity of the Tasks, Function Modules, and Macro-functions of the Manufacturing or Customer Product and Service processes involved	Example of flow diagrams for commonly available processes showing material and energy balances and example process operating procedures are likely types of aids here; corresponding requirements for other types of Customer Product or Service Operations.
10.	Connectivity diagrams of the Tasks, Function Modules, and Macro-function Modules of the Information or Mission Support Activities probably in the form of data flow diagrams or related modeling methods	Data flow diagram techniques; the generic data flow diagram of the Purdue Reference Model.
11.	Functional Design of the Human and Organizational Architecture. Establishment of the Automatability, Humanizability and Extent of Automation Lines	Example lists of generally required personnel tasks; auditing methods for skill level determination (required vs. available); methods for cultural status assessment and correction.
12.	Functional Design of the Manufacturing or Customer Product and Service Equipment Architecture	Example specifications of process equipment required indicating process equipment and control systems necessary to accomplish the degree of automation indicated, may be obtained from the literature. Computer-based process plant layout and design optimization programs are available from a wide variety of vendors for almost any industry. There are also corresponding examples from other types of Consumer Product or Service Industries.
13.	Functional Design of the Information Systems Architecture	Example representations of typical control and information systems; functional design aids; lists of sensors, actuators, control functions for particular process equipment examples; data base design techniques; entity relationship diagrams; the Purdue Scheduling and Control Hierarchy [15]; example hardware architectures from various vendors; networked communications are also very important. (continue)

TABLE II (continued).

Area	Subject of Concern	Types of Aids Available
14.	Detailed Design of components, processes, and equipment of the Manufacturing or Customer Product and Service Equipment Architecture	Detailed design techniques for physical processes and equipment from the major handbooks of the various engineering fields; computerized versions of these design methods available from a wide variety of software vendors; corresponding examples from other types of Customer Product or Service Operations.
15.	Detailed Design of the task assignments, skills development training courses, and organizations of the Human and Organizational Architecture	Example lesson plans and syllabi for necessary training courses; example organizational charts for equivalent groups in terms of numbers of people, skill levels and tasks required; team building.
16.	Detailed Design of the equipment and software of the Information Systems Architecture	Computer control systems components selection aids from control system vendors; configuration software packages from these same vendors; software project management techniques.
17.	Construction, check-out, and commissioning of the equipment and processes of the Manufacturing Equipment Architecture	Project management techniques such as critical path method. These and related techniques are readily available as computerized project management aids from a wide variety of vendors.
18.	Implementation of organizational development training courses, and on-line skill practice for the Human and Organizational Architecture	Continuation of the work under Area 15 in terms of training and staffing of the members of the Human and Organizational Architecture
19.	Construction, check-out, and commissioning of the equipment and software of the Information Systems Architecture	Project management tools as noted under Area 17.
20.	Continued improvement of process and equipment operating conditions to increase quality and productivity and to reduce costs involved for the Manufacturing or Customer Product and Service Equipment Architecture	Continued improvement of the operation of the plant and its associated manufacturing system involving such techniques as Statistical Quality Control, Statistical Process Control, Total Quality Management, and other related techniques.
21.	Continued organizational development and skill and human relations development training of the Human and Organizational Architecture	Tasks here are continued improvement of workers' skills and training of replacement workers; same aids as for Areas 11, 15, and 18 prevail. (continue)

TABLE II (continued).

Area	Subject of Concern	Types of Aids Available
22.	Operating of the Information and Control System of the Information Systems Architecture including its continued improvement	Continued improvement of the operation of the plant and its associated control system involving such techniques and aids available as noted under Area 20 above.
23.	Review of mission for enterprise. Planning for revamping and redesign of customer product and service production equipment	Project management tools; auditing software; renovation and recycle techniques.
24.	Review of mission of enterprise. Planning for revamping and redesign of organizational architecture as mission changes; retraining of personnel as new tasks and new skills require	Same aids as for Areas 11, 15 and 18.
25.	Review of mission for enterprise. Planning for revamping and redesign of information systems; preservation and transfer of system information as needed	Project management tools; auditing software; information management tools and techniques.
26.	If decision is made to scrap Customer Product and Service Plant and Equipment, dispose of physical equipment in ways which optimize economics without major injury to environment	
27.	Dispose of Information Systems and Control equipment in ways which are benign to the environment while pursuing best related economics	
28.	Take necessary legal steps to dissolve charter of former enterprise. Complete reassignment of any remaining personnel	

Summary

Table III summarizes our discussion in this section by listing those innovations in enterprise systems modeling which can be directly attributed to the Purdue Enterprise Reference Architecture.

TABLE III

MAJOR INNOVATIONS OF THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

1. Definition of the Two Classes of Architectures
   a. Architecture of the physical system, usually the control, and/or communications systems or the connectivity of functions, again usually of the control and/or communications systems - Type 1
   b. Architecture (framework) of the development of the program life history of the Enterprise - Type 2

2. Definition of the Full Life History of the Enterprise

3. Separation of the Functional Analysis into Two and Only Two Streams
   a. Information, i.e., combining
      (1) Data management and control, or
      (2) Decision and "information"
   b. Physical manufacturing or supplying the customer with products and/or services

4. Definition of the Place of the Human in the Enterprise
   a. Distribution of both types of functional tasks
   b. Concept of automatability and humanizability lines
   c. Concept of the extent of automation line
   d. Life cycle of the human component as well as of information and manufacturing

5. Definition of the True Enterprise Reference Model or Architecture
   a. Concept of customer products and services
   b. Concept of mission fulfillment
   c. Concept of mission enablement

6. Mapping of all Type 1 Architectures onto the Life History Structure or Framework of the Type 2 Architecture

7. Place of All tools as Aids to functions Carried Out at Each Location on the Framework

8. Master Planning with Procedures Manual or Guide and Program Implementation Proposal as Vital Steps in Enterprise Integration Development, Indeed for Any Systems Engineering Endeavor in Any Enterprise

0.3 *The Methodology*

As has been emphasized, the architecture is only a model or framework showing the relationship of the several steps involved in carrying out an enterprise integration program or a systems engineering project. The second and probably more important component is the associated methodology or step-by-step method of actually carrying out the project or program itself. As also noted, each of the proffered architectures must have such an associated methodology if it is to be valuable to industrial users.

The Purdue Methodology that accompanies the PERA diagram, was developed by the Industry-Purdue University Consortium for CIM [8]. It has been updated frequently since its initial development to increase its readability and usefulness to the industrial practitioner [10].

0.3.1 The Master Plan -- Key to the Methodology

The key to the Purdue Methodology is that every program of enterprise integration or systems engineering project should start with the preparation of a master plan outlining the specifications of the proposed program or project, its schedule, its benefits, its risks, etc. The master plan should be developed as the product of carrying out steps 1-13 of the program as shown in Figure 15 and outlined in Table II, i.e., down to and including the Specification, Functional Design, or Preliminary Engineering Phase (all are synonyms for the same type of tasks).

Figure 16 shows the relationship of the Master Plan to the PERA structure as noted above. It also indicates its major uses, those of: (a) a vehicle for final evaluation and approval of the overall program by management, and (b) the means for supplying the detailed design phase personnel with the data (specifications) they need for their tasks. Figure 17 indicates the types of personnel involved at each stage or phase of the life cycle's progress. The various personnel groups will be defined below. The methodology manual goes into considerable detail concerning the identity, knowledge or training, tasks involved, etc., for these personnel [8, 10].

0.3.2 Purpose of the Handbook on Master Planning

Any systems engineering development project will be much expedited if full use can be made of the many tools and aids that are now becoming available in the literature.

One major such aid is to follow the practice of developing a Master Plan as the medium for the detailed early planning which should accompany any such project. The potential success of the development of the Master Plan can itself be enhanced by following the guidance of an enterprise integration reference architecture and its associated methodology.

An enterprise reference architecture is a graphical representation or model of the potential life history of any systems engineering development program. It points out all essential steps or phases of the programs, identifies all tasks involved and shows their interrelationship. It can also represent the corresponding tools or techniques that can help to carry out each of these tasks in turn.

The accompanying methodology is a step-by-step detailed description of the prosecution of each of the steps and their corresponding tasks in turn which will lead to the preparation of the Master Plan.

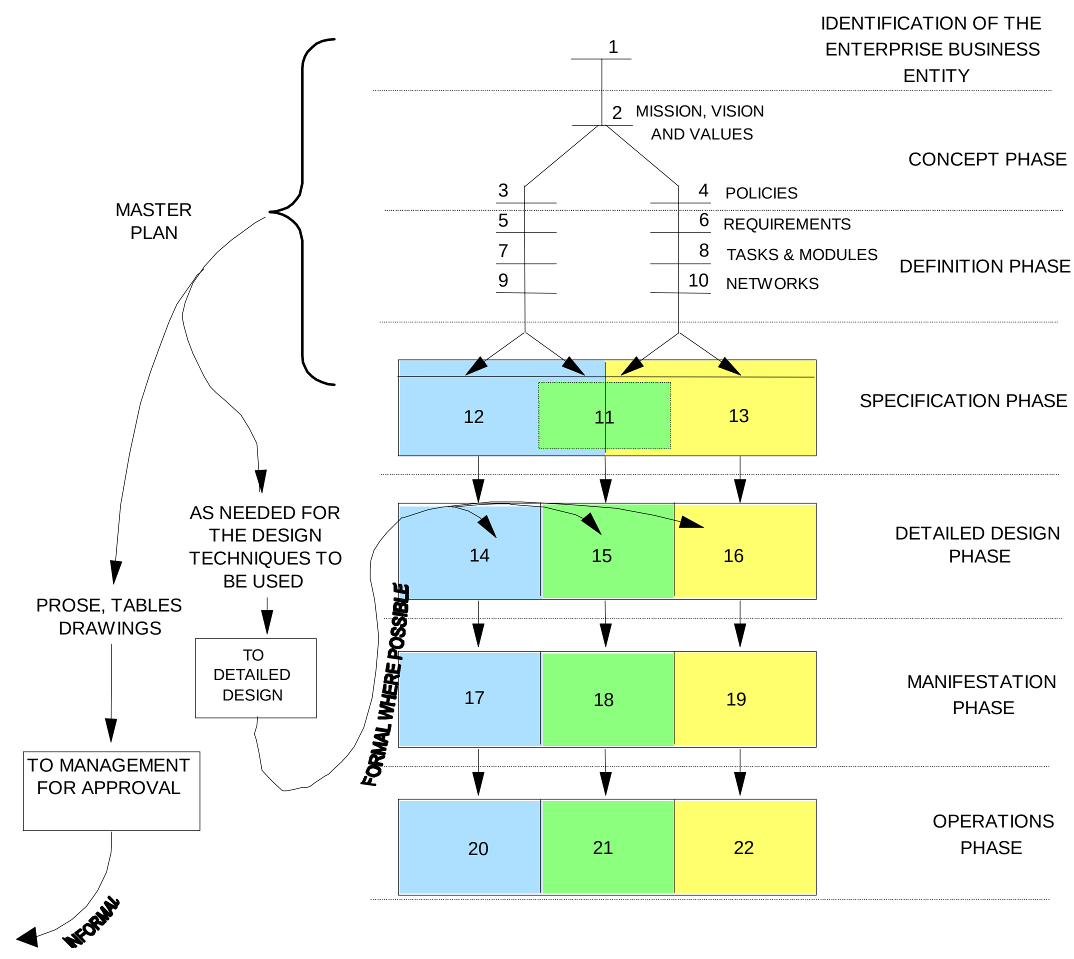


FIGURE 16 - THE PLACE OF THE MASTER PLAN IN THE PERA STRUCTURE

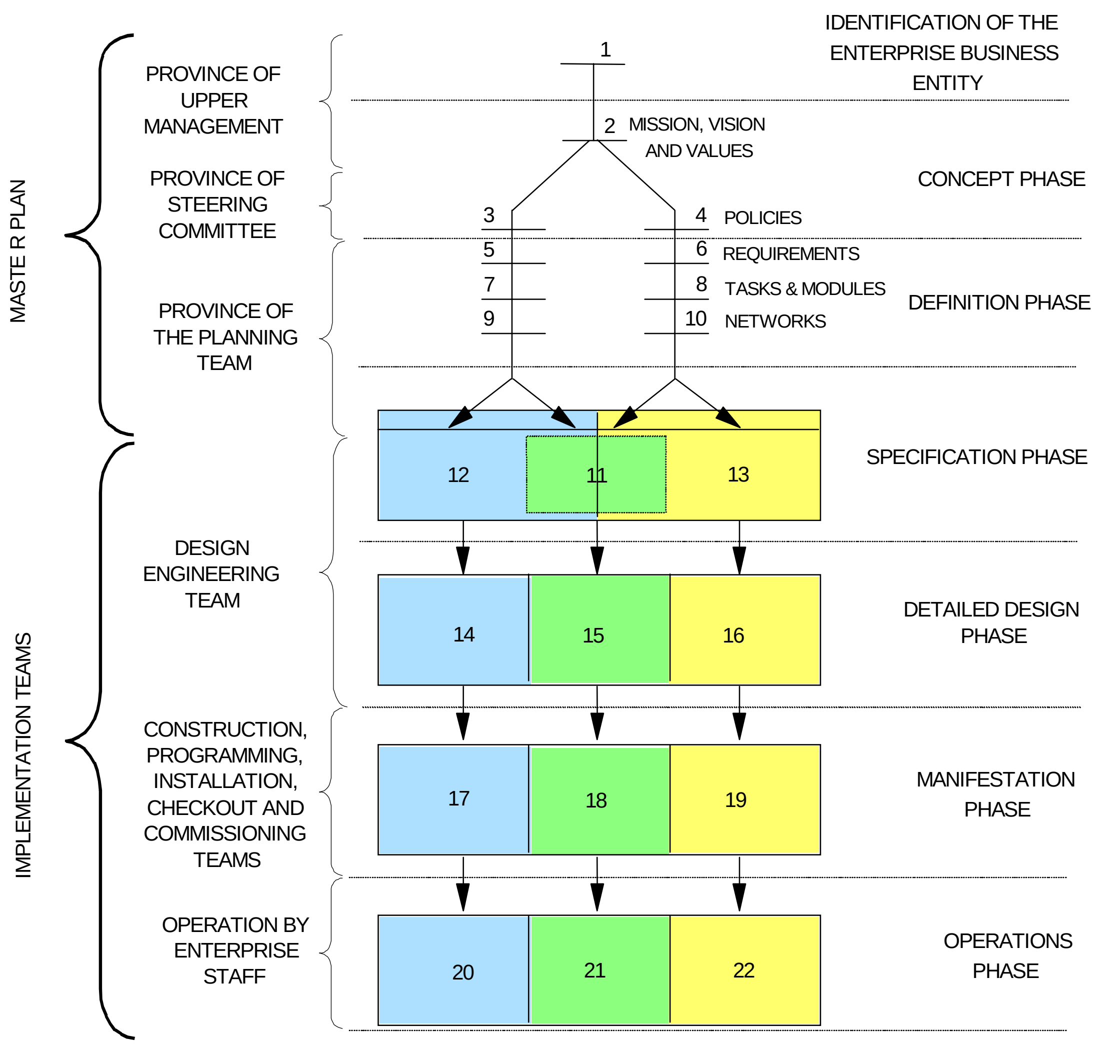


FIGURE 17 - WHO CARRIES OUT THE TASKS INVOLVED

EXECUTIVE SUMMARY

The Master Plan is that document which gives Enterprise Management the fullest possible details of the proposed project's potential benefits, risks, costs, schedule, and specifications just before major project funding must be instituted for program detailed development and final completion. Thus Management has the chance for major study of the potentials of the proposed program with minimal necessary expenditures and the maximum possible confidence of the projections of the study before making the necessary decision to go ahead or halting the project or program.

This Handbook gives a basic description of one such methodology for carrying out the Master Plan preparation for any systems engineering project. It makes use of the Fluor Daniel-PERA Enterprise Development Methodology, the Purdue Enterprise Reference Architecture, and the Purdue Guide to Master Planning, an earlier version of this Handbook.

This Handbook on Master Planning uses an extensive discussion and check-list system to guide the ready production of complete integrated manufacturing enterprise development plans or Master Plans for any industry. The Handbook and its related documentation should enable any enterprise or consultant to follow a straight-forward, detailed procedure for developing all requirements for an enterprise integration system for any factory, and highlight all critical decisions involved. It should regularize and routinize the production of enterprise integration system specifications and implementation plans or Master Plans since it includes an example format and discussion and check-list system to prompt the Enterprise Integration Planning Team throughout their preparation of the Master Plan.

0.3.3 Background of the Master Planning Project

Let us first define a number of terms as they are recommended for continuing use with this Handbook.

Organizational Entities

Three separate organizational entities are involved in our initial discussion here. They are: the Enterprise, the Business Unit, and the Manufacturing Site. The Enterprise Business Entity is chosen by considering them. They are related as shown in Figure 18.

The Enterprise is the company itself and its associated organizational entities.

The Business Unit is the lowest level of the company that contains the set of functions that carry a product through its life span from concept through manufacture, distribution, sales and service.

The Manufacturing Site is that physical entity where production of the product or products is actually carried out. It may include one or more Business Units, or indeed may be deficient in some category that prevents it from being a complete Business Unit itself.

Enterprise Integration

Enterprise integration is a term that can have a widely different meaning to different people. Enterprise integration as used here is a way of doing business not just a specific system or set of applications. In its most comprehensive sense enterprise integration automates the flow and use of information between the operations and business activities of the manufacturing firm or other enterprise, optimizes the design and operation of the customer product and service enabling units, and makes the most effective use of the human component of the enterprise. The focus of enterprise integration is on: (1) the sharing of information by engineering, production, marketing, and support groups; (2) eliminating no-value added steps in the manufacturing and processing of enterprise products; and (3) making manufacturing more customer responsive, i.e., short cycle manufacturing, while (4) improving asset management.

For the purpose of this Handbook, the definition and objective of enterprise integration are as follows:

> *Enterprise Integration is manufacturing supported by an integrated information, manufacturing and human architecture operating as an overall system responsive to the human and economic environment at all levels.*

The objective of enterprise integration is the development of a system whose goal is to utilize the plant-wide management of information, along with the use of human resources and automation in any industrial facility for assuring the achievement of enterprise objectives and goals in an optimal manner.

An effective enterprise integration implementation will improve the manufacturing plant's capability for:

1. Management
2. Product quality
3. Cost effectiveness of the manufacturing system
4. Accountability and management of assets
5. Productivity
6. Predictability or reduction of variability in the manufacturing process and
7. Reliability

Table IV further explains why enterprise integration is important.

TABLE IV

WHY IS DEVELOPMENT OF ENTERPRISE INTEGRATION SYSTEMS IMPORTANT?

1. The manufacturing environment is extremely competitive.

2. Manufacturing must adjust to contemporary standards of quality, reliability, higher productivity, lower delivered cost and improved market responsiveness.

3. The best non-enterprise integration manufacturing systems are often not efficient enough to generate the above mentioned improvements in parallel and in a short time.

4. The integration of all manufacturing functions is required to optimize industrial activities.

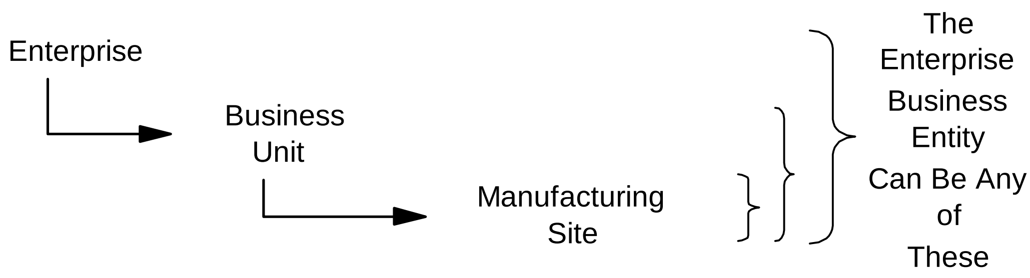


FIGURE 18 - RELATIONSHIP OF ORGANIZATIONAL ENTITIES INVOLVED IN ENTERPRISE INTEGRATION PLANNING

Enterprise Integration Business Entity

Depending upon management's desires, on the existing economic and business climate, on the expected returns from the proposed project, and especially on the availability of economic and technical resources; the size of the system covered by the proposed enterprise integration program may range from a single production line, through major plant units, to whole manufacturing plants, or even to whole companies. In any case, the overall unit, division, plant or complete company involved in the chosen study will be called the Enterprise Integration Business Entity.

The Enterprise Integration Business Entity or more briefly, the Enterprise Business Entity (EBE) is therefore that agreed upon selection of products, functions and locations that are the basis for the Enterprise Integration Master Plan. An Enterprise Business Entity may consist of anything from a part of a Business Unit, to several Business Units, up to and including the whole Enterprise.

Master Plan

The development of a Master Plan requires a comprehensive look at the business goals and critical success factors of an enterprise as well as a review and study of its processes, equipment, facilities, customer/market demands, personnel structure and roles, and the scheduling and control requirements (the enterprise integration component), among others. This results in a detailed plan, the Master Plan, to carry out the necessary coordination and integration action to provide enterprise integration for the factory, plant or other business entity. This Handbook will provide direction for the preparation of the above set of detailed plans. Table V presents a listing of the benefits of use of the Master Plan.

Note that the Master Plan is specifically for the Enterprise Business Entity, of whatever size. As will be brought out in this manual, the Master Plan may contain too much detail for ready use by Business Unit or Enterprise management. In addition, available company resources may not permit the implementation of all of the recommendations from the Master Plan at one time. Therefore, it will then be necessary to propose a series of shorter projects, all coordinated by the Master Plan, within the available capabilities of the company. The document presenting this series of projects will be called the Enterprise Integration Implementation Proposal as described below. The Enterprise Integration Implementation Proposal includes a performance specification for each sub-project proposed.

TABLE V
BENEFITS OF AN ENTERPRISE INTEGRATION MASTER PLAN

1. Rapid achievement of system integration and thus realization of the most significant enterprise integration benefits of:
   a) Increased customer service and heightened awareness of customer and market demands
   b) Reduction and/or reorientation of indirect labor and overhead
   c) Improved responsiveness to technical, economic and environmental changes
   d) Improved product quality and robustness at a lower cost

2. A total organizational understanding and commitment to the strategy

3. Improved probability that a truly integrated information and control system is achieved

0.3.4 Enterprise Integration Implementation Proposal

In order to establish further the desired purpose of the Handbook on Master Planning it is necessary to clarify the terms Master Plan, Program Proposal, and Implementation Proposal as used in the context of this handbook.

First, we must emphasize that there are three distinctly different documents that one should develop in relation to enterprise integration development programs. They are:

1. An overall priority list of future company projects based on:
   a. Market analysis
   b. Competitive factors
   c. Technology trends
   d. Company resources
   e. Economic payout, of each
   f. Critical success factors
   g. Product Strategy
   h. Quality
   i. Customer Satisfaction

   For the purpose of this Handbook, it is suggested that this first document be called an "Enterprise Integration Program Proposal" or other term distinct from that of "Master Plan" to avoid confusion of its different purpose. It is also called the "Initial Study Proposal" , and "Feasibility Study" elsewhere in this document.

2. The overall plan for the technological implementation for enterprise integration in the enterprise or other business unit concerned, including all of the projects on the priority list noted in Item 1 above. The object of the Master Plan development study may range from complete factories or manufacturing plants to selected parts of them. This second document will be the one referred to in this Handbook when the term Master Plan is used.
3. When the integration plan proposed in the master plan is too large for the current personnel or economic resources to implement as one project, the overall project must be broken up into a set of smaller projects, whose individual implementation follows the Master Plan and whose totality when completed implements the original needs. This document was mentioned earlier as the Enterprise Integration Implementation Program.

The Enterprise Integration Program Proposal (number 1 above) serves as an important input to the work of the Master Plan Development Team and also gives management an early chance to review the proffered proposal and approve or cancel continued work on it.

Figures 19 and 20 show the relationship of the latter two distinct documents to each other. Successful implementation of enterprise integration projects by a company obviously involves both. Note that Figure 19 indicates the possibility of a further prioritization and implementation breakdown in terms of sub-projects, etc. It should be particularly noted that the development of the details of the factory or manufacturing plant Master Plan is necessary to produce the information required for the development of the company's Enterprise Integration Program Proposal (see Figure 21). Each site might have its own enterprise integration implementation plan. In some situations a single site will have separate plans for different production lines. The company-wide Enterprise Integration Implementation Proposal document may thus be the distillation of information from Master Plans for several different factories if the company is large.

The definition of the Enterprise Integration Implementation Proposal is given as follows:

The Enterprise Integration Program Proposal outlines and prioritize the list of high priority projects developed by the Enterprise Integration Planning Team in the Master Plan with a short description including priority, scope, costs, justification, proposed schedule, and benefits of each.

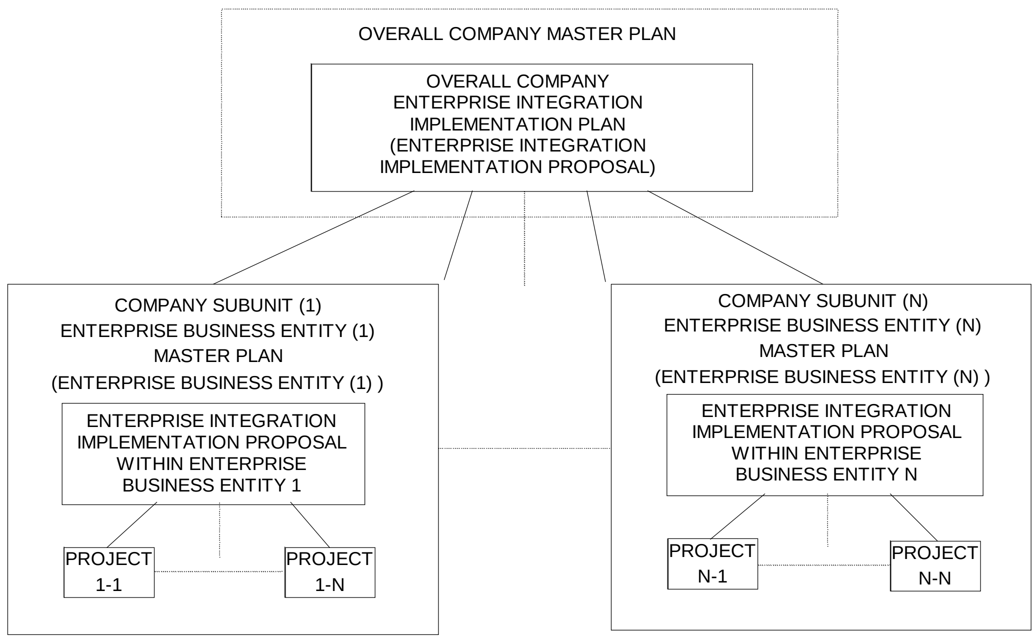


FIGURE 19 - DIFFERENTIATION OF THE TWO TYPES OF ENTERPRISE INTEGRATION PLANNING DOCUMENTS

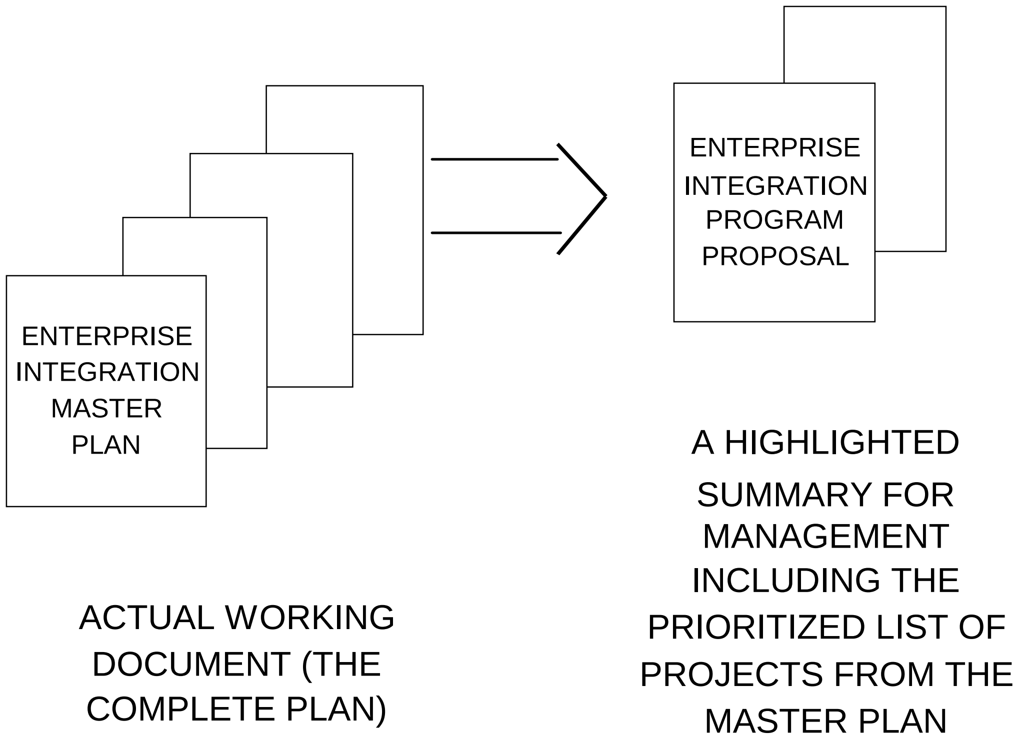


FIGURE 20 RELATIONSHIP OF THE ENTERPRISE INTEGRATION MASTER PLAN TO THE ENTERPRISE INTEGRATION IMPLEMENTATION PROPOSAL FOR THE ENTERPRISE BUSINESS ENTITY

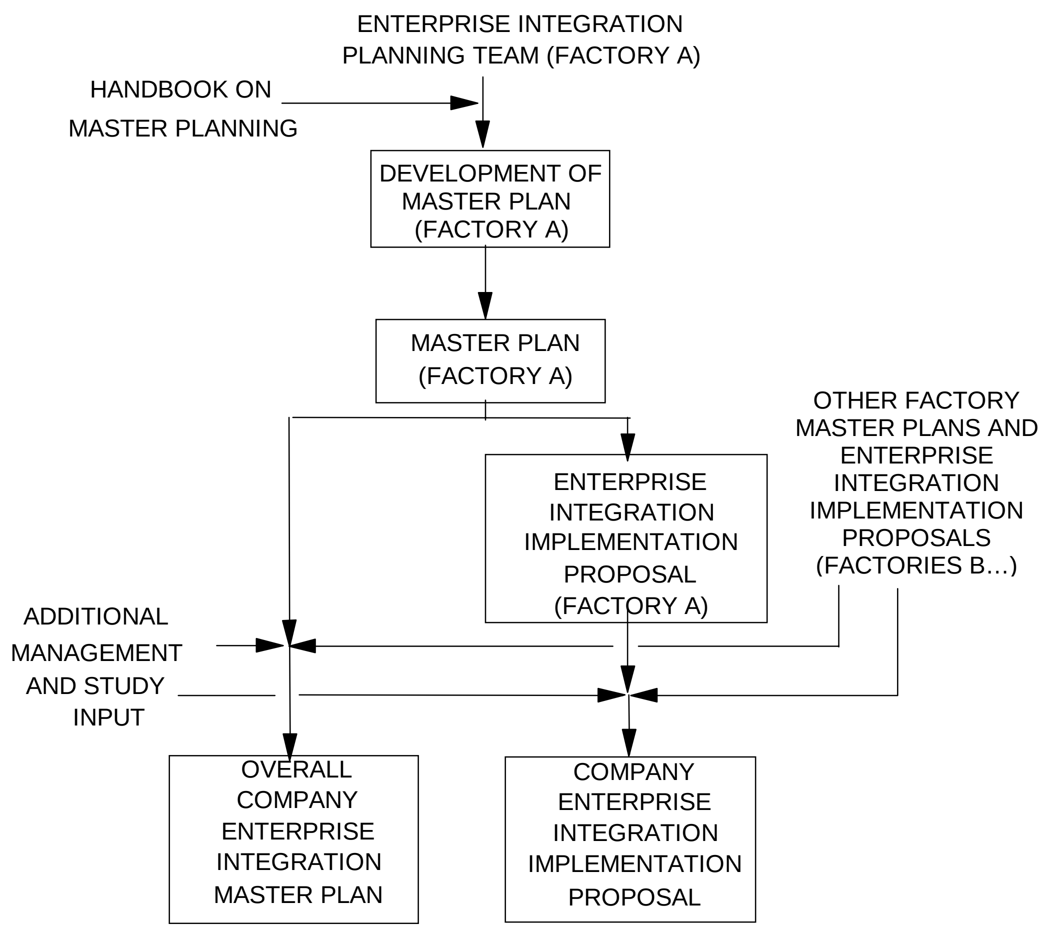


FIGURE 21 - RELATIONSHIP OF THE DEVELOPMENT OF FACTORY MASTER PLANS AND THE COMPANY'S OVERALL ENTERPRISE INTEGRATION IMPLEMENTATION PROPOSAL

Development of the Master Plan
The development of a Master Plan requires a critical but restricted look at the present state (AS-IS) of three major aspects of the Enterprise Business Entity;

1. The plant's information and control hierarchy
2. Its process equipment, plant layouts; and material energy and product flow; and
3. Its personnel structures, functions and roles.

These must be compared to the desired future state of each (TO-BE) and transition plans developed to carry out each required transition. This is the essence of the Master Plan as noted in Figure 22.
A Master Plan needs to answer a series of basic questions in order to evaluate existing processes and information flows, and to determine how adequate they are to meet future needs. This allows us to define Enterprise Integration projects, assess benefits, and assign priorities. A partial list of these basic questions is presented in Table VI.

TABLE VI
SOME THINGS THAT THE ENTERPRISE INTEGRATION MASTER PLAN SEEKS TO FIND

I. How well are we using our current systems and technologies?

II. How adequate are they for today's business activities?

III. How well will they serve us in the future?

IV. Do we have the systems in place that one would expect to find, given our competitive issues and strategic objectives?

V. Do we have the operating practices, procedures and the organization to be effective in this environment?

VI. How effective are our manufacturing and support facilities in achieving business and manufacturing goals?

VII. How does our use of systems and technology compare with the state of the art? With the state of our industry? With other units of our own company?

VIII. What specific capabilities are missing from today's systems, practices and procedures?

IX. What initiatives are already underway to improve upon current conditions and address known problems?

A critical factor to starting the plan development is to ensure that plant management understands the magnitude as well as the resources required to implement an enterprise integration strategy. Management must initially commit to the dollar and personnel resources required to develop an effective and meaningful Master Plan**..**

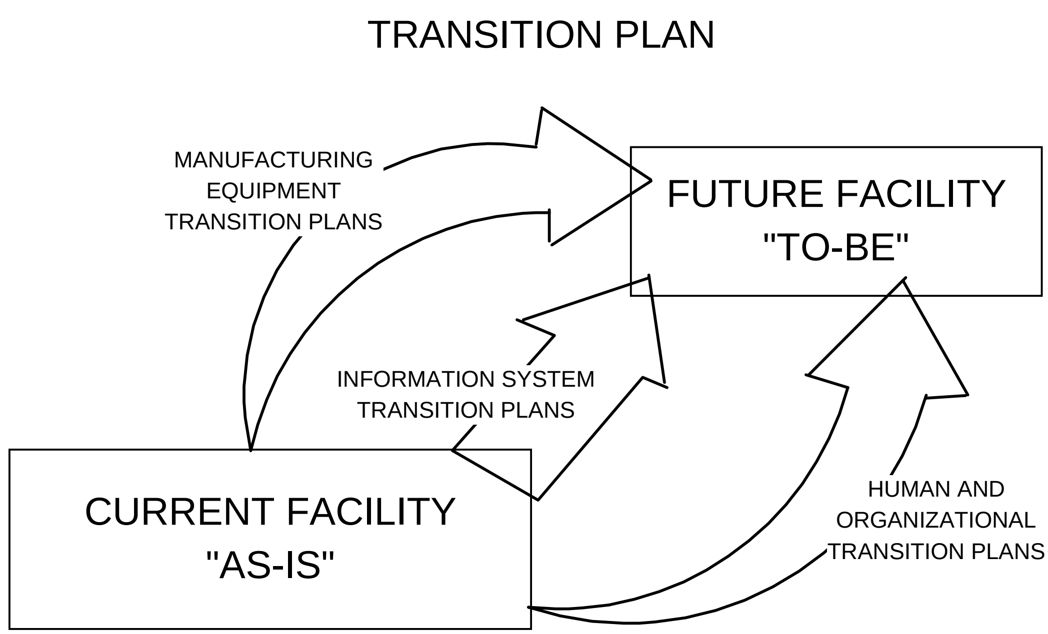


FIGURE 22 - TRANSITION PLAN

Development of a formal Master Plan involves:

1. Affirming the critical success factors, goals and objectives of the Enterprise Integration Business Entity.
2. Identifying and defining all major projects and fast track opportunities.
3. Investigating and recommending alternative solutions for key problems.
4. Defining performance measurements.
5. Developing resource requirements, costs, and an investment analysis.
6. Defining intangible benefits.
7. Prioritizing projects and opportunities based upon agreed to guidelines.
8. Defining the organizational, procedural, and management impact on the facility.
9. Publishing the detailed plan and schedules.

10. Inhibiting factors and barriers to implementation.

Since Master Plan development is the task that this Handbook on Master Planning addresses, it is written specifically for the use of the Enterprise Integration Planning Team who will be developing the plan.

The Purdue Reference Model for Computer Integrated Manufacturing [7] helps provide a, "- Design Guide for the Development of a New Information Management and Automation Architecture -", and it can, "- Help Provide a Migration Path -". These functions are then applied to guide the development of the Master Plan for carrying out all the steps necessary for implementing each specific enterprise integration project related to the information system of the enterprise. The Reference Model thus serves as the basis for assuring the accuracy and completeness of this part of the resulting Master Plan(s). This Master Planning Handbook converts the guidance of the Reference Model to a detailed discussion and check-list system to assure the availability of accurate and helpful guidelines in the Master Plan's development for this and all other parts of the Enterprise.
It is reiterated here that Enterprise Integration must include all aspects of the enterprise – the Human and Organizational Architecture, and the Customer Product and Services Architecture (Manufacturing), as well as Information Systems. The detailed discussion and check-list system detailed herein will carry out these tasks. The Purdue Reference Model for CIM, while valuable in itself, is insufficient for the overall integration task, hence the development of the Purdue Enterprise Reference Architecture and its accompanying Methodology.

The Master Plan as thus developed should then become the guiding document for the actual implementation of the enterprise integration implementation program for the specific manufacturing plant.

The Master Plan includes:

1. Definition of business functions (information and customer services) and scope definition to the degree necessary to estimate cost of each project
2. Definition of future overall systems architecture and required internal and external standards
3. Definition of current state of manufacturing and information & control systems
4. Allowance for modification to accommodate changes in business requirements, project results, and technology
5. Transition plan for each project
6. Cost, benefit, justification, priority, risk assessment and timing of each project
7. Performance tracking for the specific business entity
8. Education and training plan and other human relations concerns

0.3.5 Relationship of PERA to Master Plan

Figure 23 presents a sketch showing that portion of the Enterprise Integration Program that is covered by the process of developing the Master Plan. Also shown is the fact that the Enterprise Integration Implementation Proposal specifies how the remainder of the life cycle of the Enterprise Business Entity is covered down to the Operations Phase. The reader should compare this figure with Figures 6, 16, and 17 to show other information that was not included in Figure 23 to assure the clarity of this figure.

The Master Plan development covers the first four phases of the Enterprise Life Cycle since this allows the Enterprise Integration Planning Team to prepare all the information required for a management decision on whether or not to proceed with the Enterprise Integration Program while incurring the minimum necessary costs. Functional Specifications (Functional Design Phase) are required in order to be able to make the necessary cost estimates for realistic decisions by Management. At the same time the much higher costs of the Detailed Design work is postponed until after the decision to proceed has been made.

Figure 24 shows a representation of the Enterprise Business Entity and the four three phases of the Life History of the TO-BE or proposed future Enterprise on the left side of the dual diagram along with corresponding representation of the Functional Analysis and Specification Phase of the AS-IS or currently existing Enterprise on the right. As indicated on the figure the Transition Plan then compares these two conditions of the Enterprise Business Entity in order to develop and propose the set of projects necessary to accomplish the transition work desired in the Enterprise Integration Program. This diagram is the essence of the Master Plan activity. Note that each region contains a brief summary of Table II indicating the activities carried out at that area.

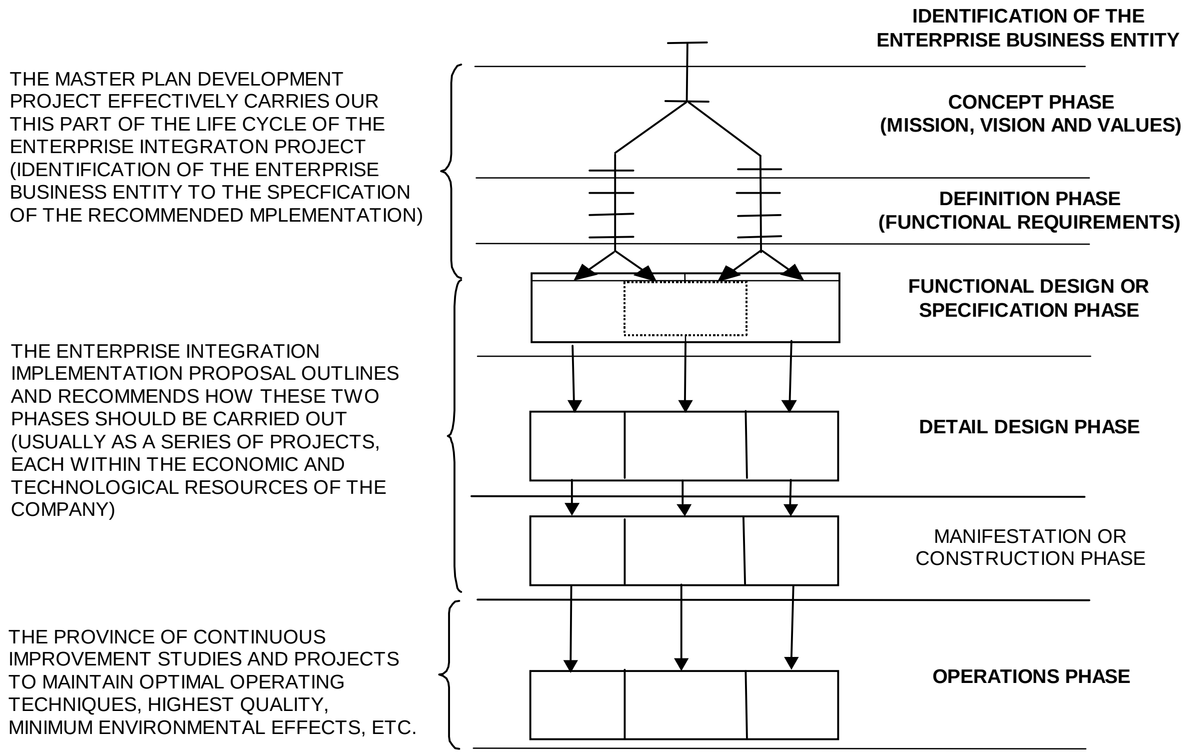


FIGURE 23 – RELATIONSHIP OF THE MASTER PLANNING PROCESS, THE ENTERPRISE INTEGRATION IMPLEMENTATION PROPOSAL AND CONTINUOUS IMPROVEMENT STUDIES AND PROJECTS, TO THE ENTERPRISE LIFE HISTORY AS DIAGRAMMED BY PERA

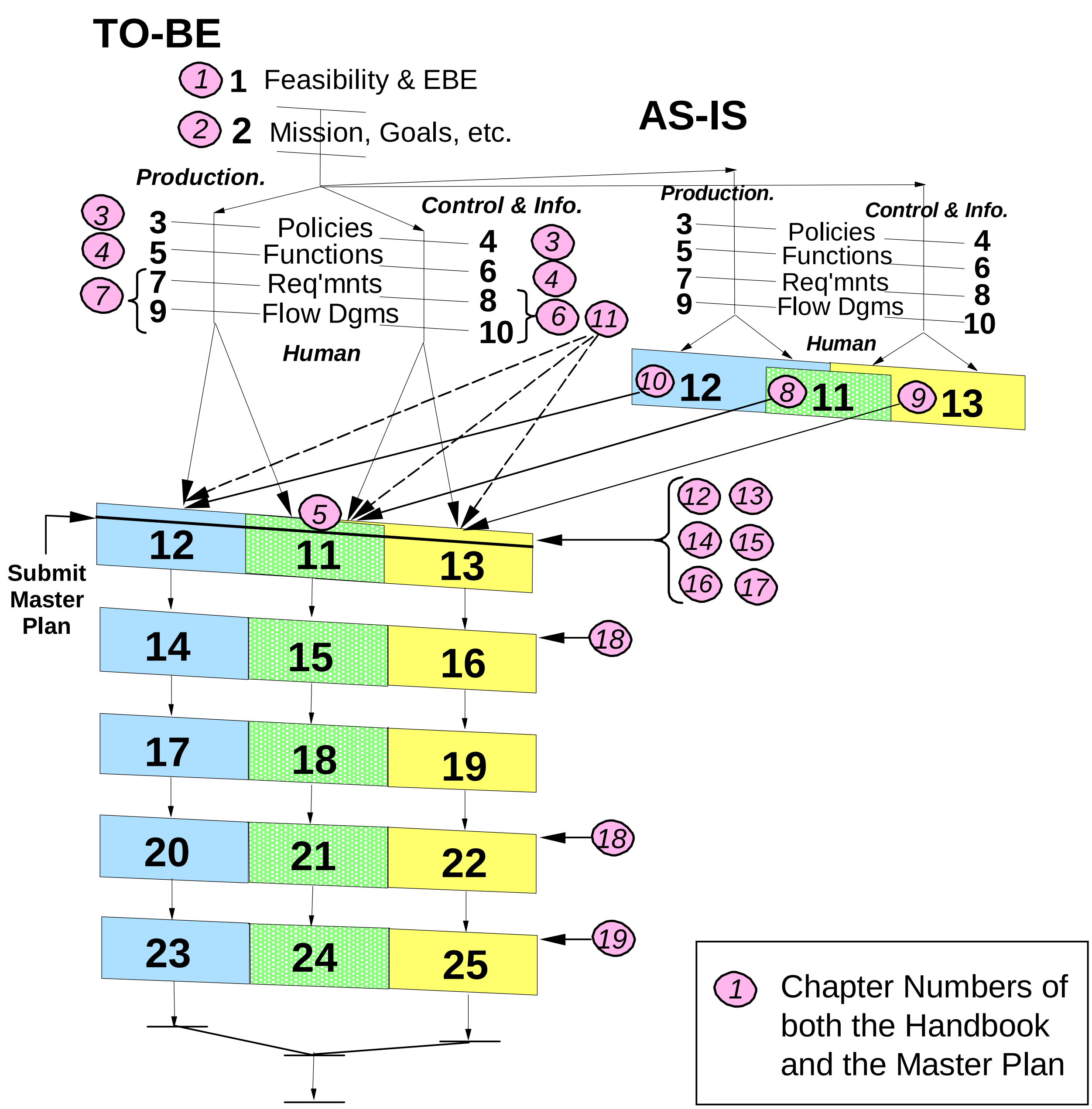


FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

Represented on this diagram are areas or regions i.e., mappings, of the work content of the overall Master Plan Development as described by each Chapter of this Master Planning Handbook. The numerals in each region give the corresponding Chapters involved at that region of the diagram. Only the Functional Analysis and Functional Design or Specification Phases are shown for the AS-IS Entity since all other information in the Master Plan must be concerned with the proposed TO-BE entity.

This correlation of the subject matter of the Architecture sections with the corresponding subject matter of this Guide to Master Planning and with the Master Plan itself was a major factor in the acceptance of the Architecture by the members of the Consortium.

Figure 25 shows still another method of illustrating the subject matter flow through the manual and the suggested Master Plan format. This figure charts the information flow in the Master Plan if the suggested subject matter and chapter numbers for it as presented in this Handbook are used. The numbers shown correspond to the chapter numbers of the Handbook. The headings on the right indicate the major topics involved in the respective chapters at that level in the diagram.

0.3.6 Diagrammatic View of the Guide to Master Planning

The remaining chapters of this manual are presented as a set of twenty-one Master Plan development topics that guide the preparation of the Master Plan. To further aid the reader, each topic is also represented in an $IDEF_0$-like flowchart [11]. Figure 26 shows the pattern for these diagrams that will be included to illustrate the work of each chapter.

One aspect of the $IDEF_0$ diagram (see Figure 26) should be explained at this point. At each and every point of the study the Enterprise Integration Planning Team is influenced (CONTROLS) by the requirements entering the top of the diagram of Figure 26 (i.e., potential Customer Requirements, Company Standards, and Legal Requirements). Since these are generic and apply to the diagram representing every topic or set of chapter material, this fact is indicated by the parenthesis on each of the entering arrows of the figure. Thus they are then not physically shown on the succeeding diagrams but are considered to be present nevertheless per the use of this symbology.

Likewise, the arrows entering the bottom of the diagrams represent sources of information or direction (MECHANISMS), here the key sponsorships and the Champion. As before these are generic and are again indicated by the parentheses about the entering arrows and are also not reproduced in the following diagrams associated with each succeeding chapter.

Note that Figure 26 is considered the overall summary diagram of the whole development process for the Master Plan. Thus its inputs are all the sources of data for the study (here not specified) and the outputs are the final Master Plan and Enterprise Integration Program Proposal themselves. Displayed on each of the separate diagrams which are then developed to illustrate the work of each separate chapter are the major information inputs to and out-puts from the development processes identified with that chapter. There are no diagrams for Chapters 18 and 19 since they are outside the Master Plan development flow.

In order to better comprehend the total number of individual activities and their relationships, they can also be grouped to represent phases (here called blocks) in the development of an Enterprise Integration Master Plan as has already been represented in Figure 6 of this chapter.

0.3.7 Section Summary

As noted earlier in this Section, the Industry-Purdue CIM Consortium in preparing the original Implementation Procedures Manual [8] acknowledged that any enterprise integration development effort is a very complex task.

However, all indications from current and past successful projects also indicate that such endeavors are extremely rewarding to the company involved in terms of the controllability, flexibility of operation, quality of product produced, and financial return obtained. Therefore, the Consortium group advocated that any enterprise integration program be preceded by a detailed and objective planning process to produce the Master Plans and Enterprise Integration Program Proposal to assure that the overall project, when completed, will meet the aspirations and desires of all concerned.

This Handbook has been developed to make the required planning process as complete, accurate and easy as possible. It will assure that as a result, management will have all the information necessary to make the best possible decisions concerning the enterprise integration program.

0.3.8 Implementation -- The Work After the Master Plan Is Approved

Once the master plan, and correspondingly the overall project, are approved by management, the major work of detailed design, construction and eventual operation of the integrated enterprise can proceed. Note that personnel numbers and project costs will increase dramatically at this point compared to work earlier in the life cycle (developing the master plan, etc.). Figure 27 indicates the types of information, tools, computer programs, other work aids, etc., available at each phase. Note that this is a summary of the material presented in Figure 15 and Table II. Here the degree of formality in expressing each tool or aid is indicated. Further, Figure 28 is another summary of Table II and Figure 15 showing again a summary of the tasks involved in each region or area of the architecture diagram. Note that Figure 24 carries equivalent information to Figure 28.

Many companies, such as Fluor Daniel [12], have developed elaborate Work Benches composed of suitable computer-aided and automated design tools, optimization programs, drafting, databases etc., to organize and automate these steps as much as possible to reduce the necessary human input. These can be readily illustrated by the architectural diagrams as noted in [12]

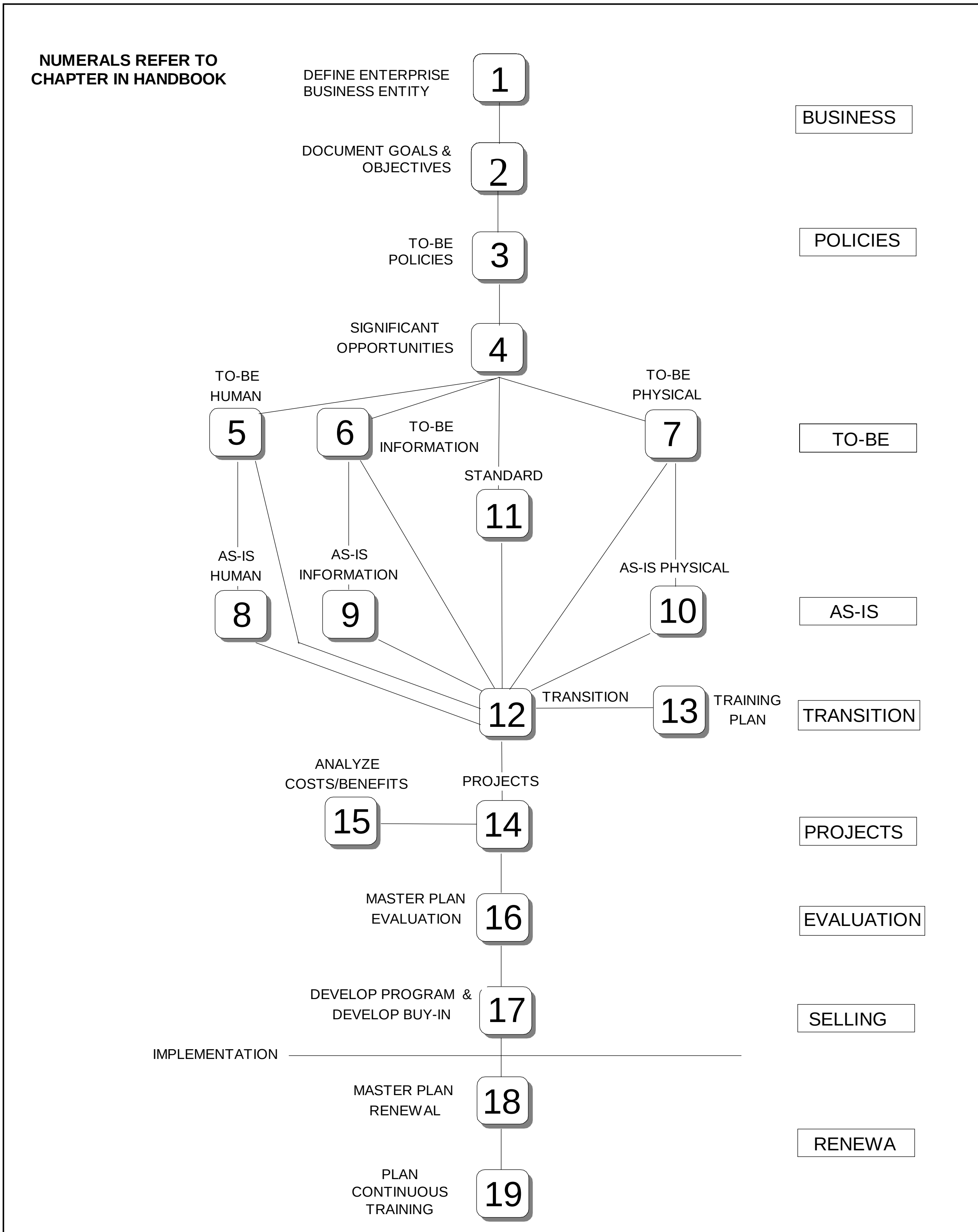


FIGURE 25 – PERA MASTER PLANNING WORK FLOW

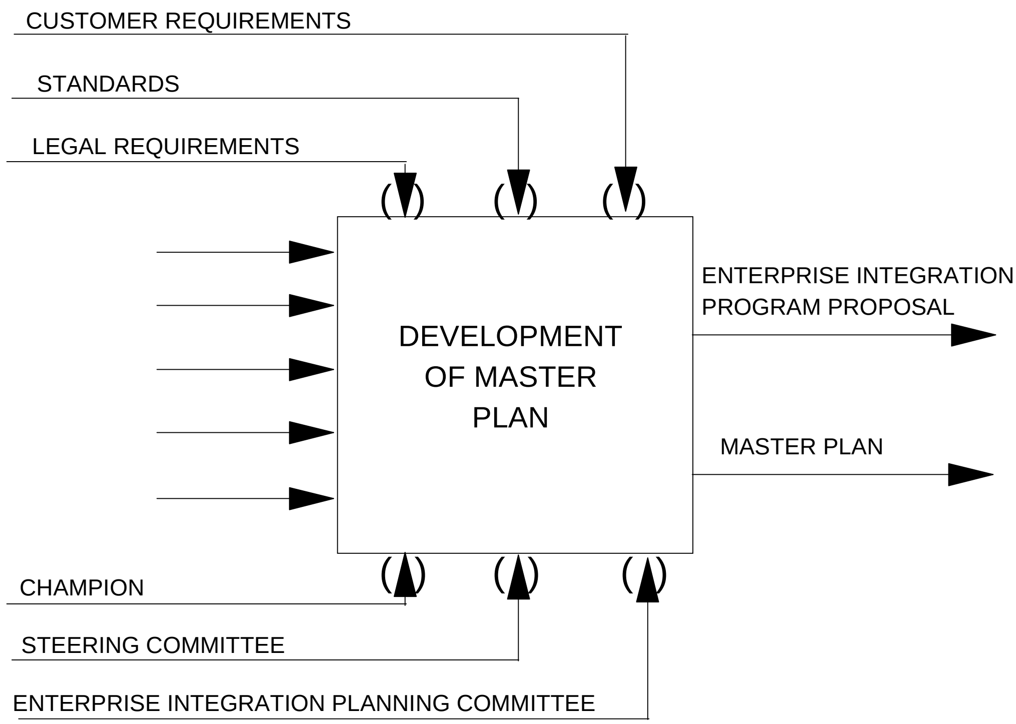


FIGURE 26 – GENERIC CONTROLS AND MECHANISMS INVOLVED IN THE DEVELOPMENT OF ENTERPRISE INTEGRATION MASTER PLAN

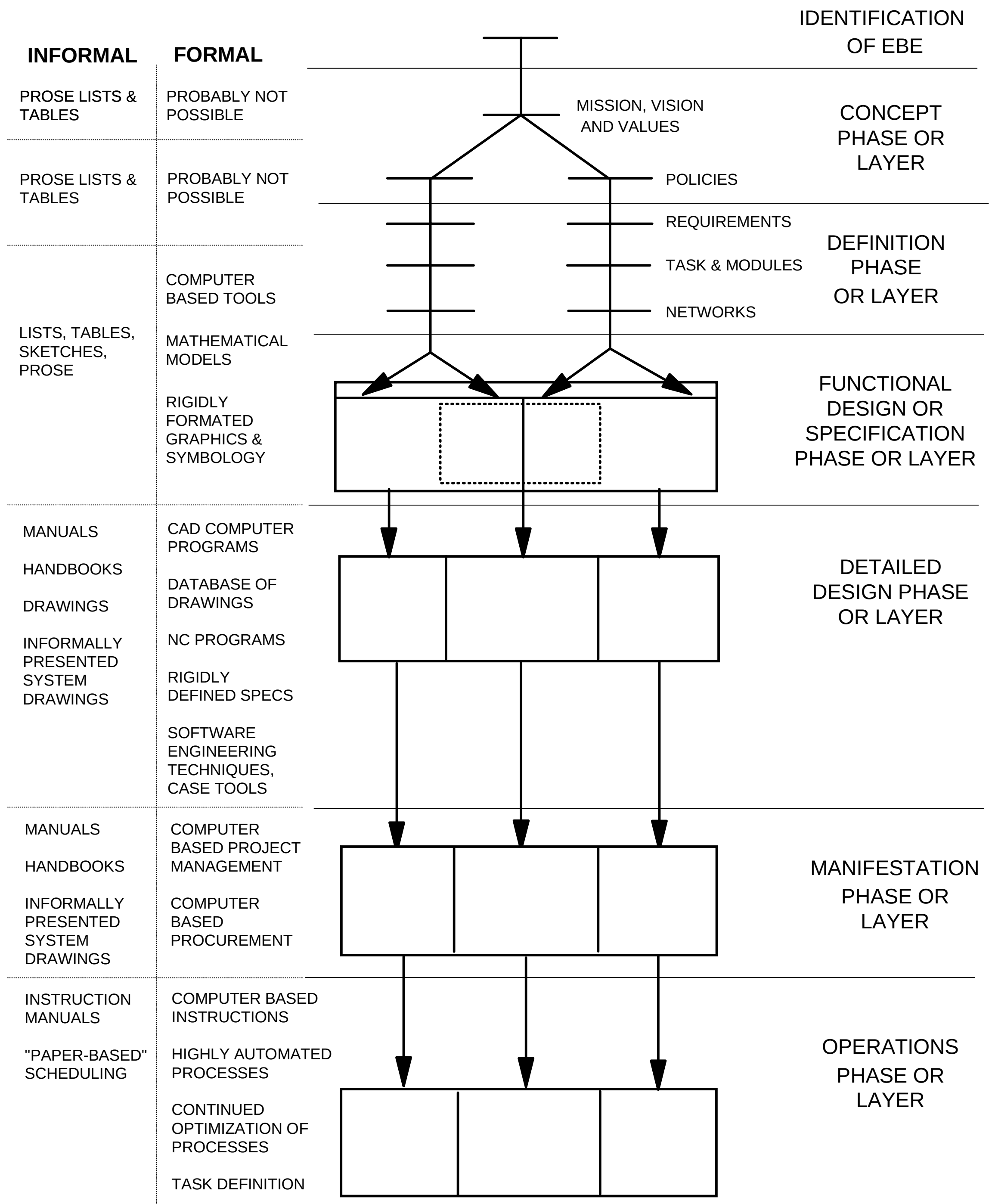
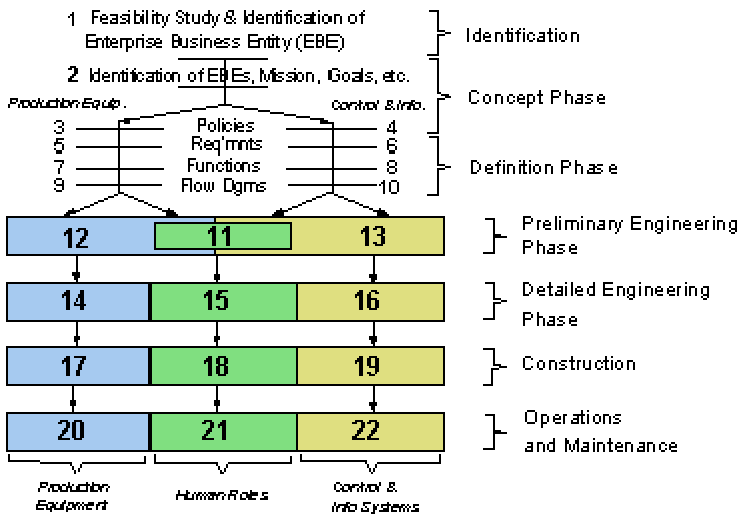


FIGURE 27 TYPES OF MODELS AND TOOLS INVOLVED AT EACH PHASE OF THE LIFE CYCLE



1. Identification of Enterprise Business Entity		
2. Definition of Business Entities, Mission, Goals, etc.		
3. Production Policies e.g. Distributed Manuf.	4. Info. Policies – e.g. Corp. Network Standard	
5. Prod. Requirements – e.g. OSHA, Underwriters	6. Info Requirements – e.g. Maint. Mgt. System	
7. Prod. Functions – e.g. Generic Unit Operations	8. Info Functions – e.g. Work Order Tracking	
9. Process Diagrams – e.g. PFD, Mat'l Balance	10. Info. Diagrams – e.g. Dataflow, Systems Arch	
12 Functional Design Production Equipment e.g. P&ID's Plant Layouts	11 Functional Design Human Roles & Org. e.g. Organization Chart, Staffing Levels	13 Functional Design Control & Info. Systems e.g. Entity Rel. Dgms, ISA Logic
14 Detailed Design Production Equipment e.g. Piping & Conduit Drawings	15 Detail Design Tasks, Training Plan e.g. Operation & Maint. Manuals	16 Detail Design Hardware & Software e.g. Configuration, Programming
17. Construct, Checkout & Commission Production Equip. e.g. Machinery Install & Test	18. Staffing, Training Checkout Plant Procedures e.g. Simulator Training	19. Assembly, Test & Commiss. Control & Info. Systems e.g. DCS Checkout, Program Testing
20. Production e.g. Debottlenecking Cost & Quality Improvement	21. Operate & Maintain e.g. Ongoing Training, Performance Improvement	22. Operation of Info & Control Systems, e.g. Maintenance Debug & Upgrade

FIGURE 28 – PERA ENTERPRISE LIFE-CYCLE MODEL

0.4 *Summary and Conclusions*

The field of architectures for development of CIM and Enterprise Integration systems has developed very rapidly in the past few years. It has branched out from a relatively restricted view of discrete manufacturing to encompass the whole world of systems engineering projects of which CIM and even enterprise integration engineering are only a small part.

These architectures have also shown their capabilities for illustrating many aspects of, and answering numerous questions about, enterprises in general that were not even dreamed of by the early practitioners of CIM.

Industrial personnel who have made extensive use of the Purdue Enterprise Reference Architecture and the Purdue Methodology (PERA) believe it to be important for the following reasons:

1. It provides a full "life cycle" for the facilities being developed in the company's projects.
2. It provides a means for handling human and organizational factors inherent in these projects and in the company's approach to these projects.
3. It presents a "phased" approach to reduce rework in carrying out projects.
4. It provides an understanding of the dynamic interfaces between the many disciplines of engineering and management working on a particular project.
5. It provides informational models of each phase to improve understanding and to monitor the work in progress.
6. Perhaps best of all, the PERA diagram looks intuitively correct, and presents the life history in a way that follows the conception that most engineers and managers in industry have of their plants and companies.

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1. Define Enterprise & Establish Initial Program

1.1 *Introduction*

This chapter emphasizes the necessity of having full management support and encouragement before tackling any program as complex and difficult as an Enterprise Integration Master Plan.

This material follows the outline diagrammed in Figure 1-1 showing the use of information from other company programs, the necessity to include the solution to existing or foreseen critical business problems, plus the need for data from preliminary internal economic and technical studies to generate the information necessary to justify initially a study of the proposed program. This then allows the Champion or other responsible personnel to secure the sponsorship of appropriate management levels, to identify enterprise integration opportunities within the company, to identify potential business entities where enterprise integration is vitally needed and could be successfully applied and to generate preliminary program plans for consideration. Only then should an enterprise integration program study be officially initiated.

The activities described here are important precursors to, and form the bedrock material for, all enterprise integration master planning efforts. These efforts must be well documented and should form the "contract" between the Steering Committee and the Enterprise Integration Planning Team.

1.2 *Key Elements in Starting*

Several key elements should be considered before any company would undertake an enterprise integration project. These key elements should be in place even before attempting the preparation of a Master Plan for an enterprise integration program. The first of these is the following individuals or groups.

(1) A Champion
(2) The Initiating Sponsor
(3) The Steering Committee
(4) The Enterprise Planning Team

Initiating Personnel Involved

1. A <u>Champion</u>, an individual, knowledgeable in enterprise integration technology, who is anxious to promote it, and who serves as a catalyst to push towards such applications. This person must have sponsorship as defined below.

<u>Sponsorship</u>, or support of upper management and user management personnel who, either separately, or as influenced by the Champion, see the potential benefits of enterprise integration, and are willing to lend their prestige and influence to investigate and, if viable, promote the enterprise integration program. <u>Sponsorship</u> is required from the Initiating Sponsor (2), and the Steering Committee (3).

2. The <u>Initiating Sponsor</u>, a high-level management individual who lends support and prestige to the work of the Champion and clears corporate obstacles, and

3. The Steering Committee, a group of stakeholders in the business unit for which the enterprise integration program is being developed, who lend direct management guidance and support to that effort.

4. The Enterprise Integration Planning Team. This group does the actual analysis and preparation of the Master Plan itself under the guidance of the Steering Committee.

The relationship of the Champion, Initiating Sponsor, Steering Committee (Sustaining Sponsors or Stake Holders) and the Enterprise Integration Planning Team are shown in Figure 1-2. The following discussion presents some additional information concerning the requirements for and the tasks expected of these individuals or groups.

Champion (e.g. Integration Manager)

Implementing a plant-wide information and control system (for example) for enterprise integration can represent a major change for a manufacturing facility. Often, upper level corporate management personnel have not had the opportunity to become knowledgeable in computer systems, distributed computer control and advanced control techniques. Although they often recognize this lack of expertise, there is also an awareness that they can do very little to increase their level of understanding because they cannot take the necessary time away from their present duties. Because of this dichotomy between the upper level manager's most common type of experience, skills and knowledge and those required for the technical development of the requirements for an enterprise integration system, the initial work of developing and promoting proposals for an enterprise integration system must usually be carried out by another individual. This individual is usually a technologist rather than a senior manager, and is commonly called the Champion.

Since plant-wide integration must be "sold" in the sense that the plant staff must be convinced of the value of the program, the reputation of the technologist who is to be the Champion is critical. Clearly, the acceptance of the project is more palatable if the plant has a high degree of confidence in the technologist. Initially, the technologist will also be credited with the reputation of the organization that person represents. Therefore, the reputation of the individual and the specific organizational entity to which the person reports are the most important factors affecting the transfer of technology involved here. Beyond his or her own initial knowledge the Enterprise Integration Champion should also survey the literature and talk with others in the industry to find real examples of how problems have been solved by applying enterprise integration. This will identify the types of problems amenable to solution by enterprise integration as well as methods of attack, problems encountered, and benefits realized. A look into the organization should then reveal opportunities to apply enterprise integration successfully. These can then be brought to the attention of the Initiating Sponsor and other potential sponsors in the various functional groups of the company.

Initiating Sponsor

The Initiating Sponsor must be an individual at a senior management level who has budgetary influence, technical credibility, and both formal and informal political strength in the corporation. This individual must provide the overall leadership of the program in its early stages.

The Initiating Sponsor must know and understand the critical business needs and success factors and how they can be enabled by enterprise integration. A case must be developed showing both direct financial benefit and quantifiable strategic benefit. Credibility can be improved by citing the successes of others.

The weaknesses and faults in the current manufacturing environment must be recognized. A description of how enterprise integration might address each of these should be developed. All functional groups in the business should be addressed so that each can relate to a significant benefit.

The above information and needs may be supplied from the Initiating Sponsor's own efforts or with the help of the Enterprise Integration Champion described above.

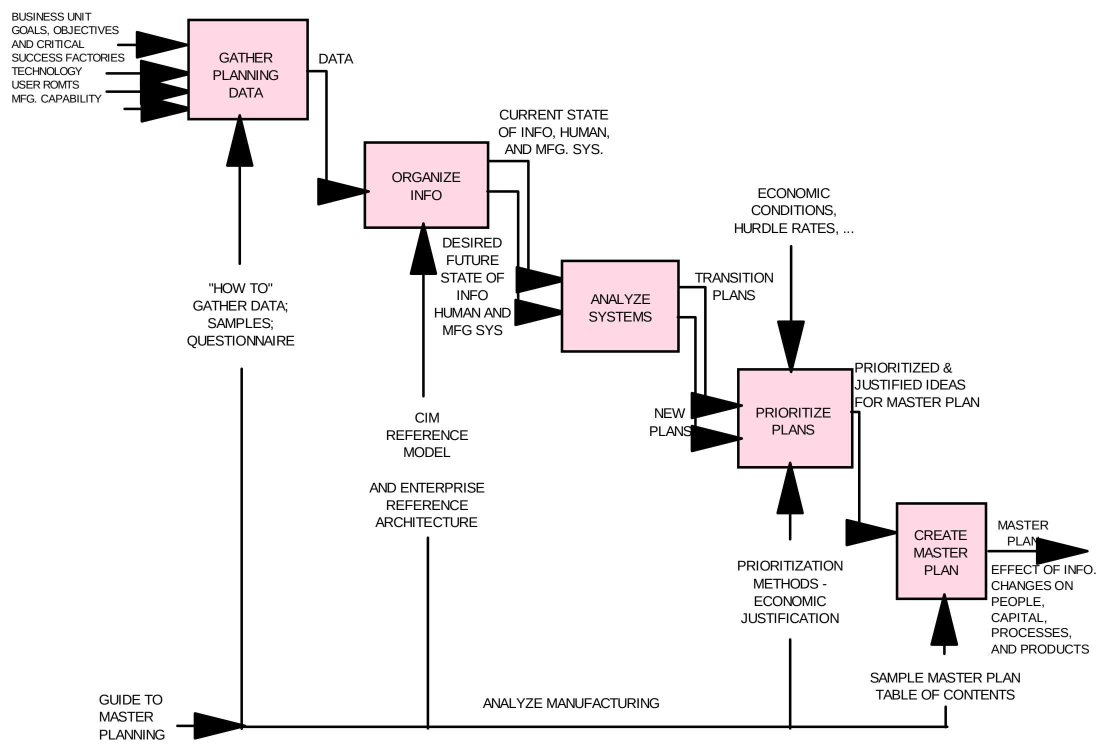

FIGURE 1-1 AN OVERVIEW OF THE PREPARATION OF AN ENTERPRISE INTEGRATION MASTER PLAN

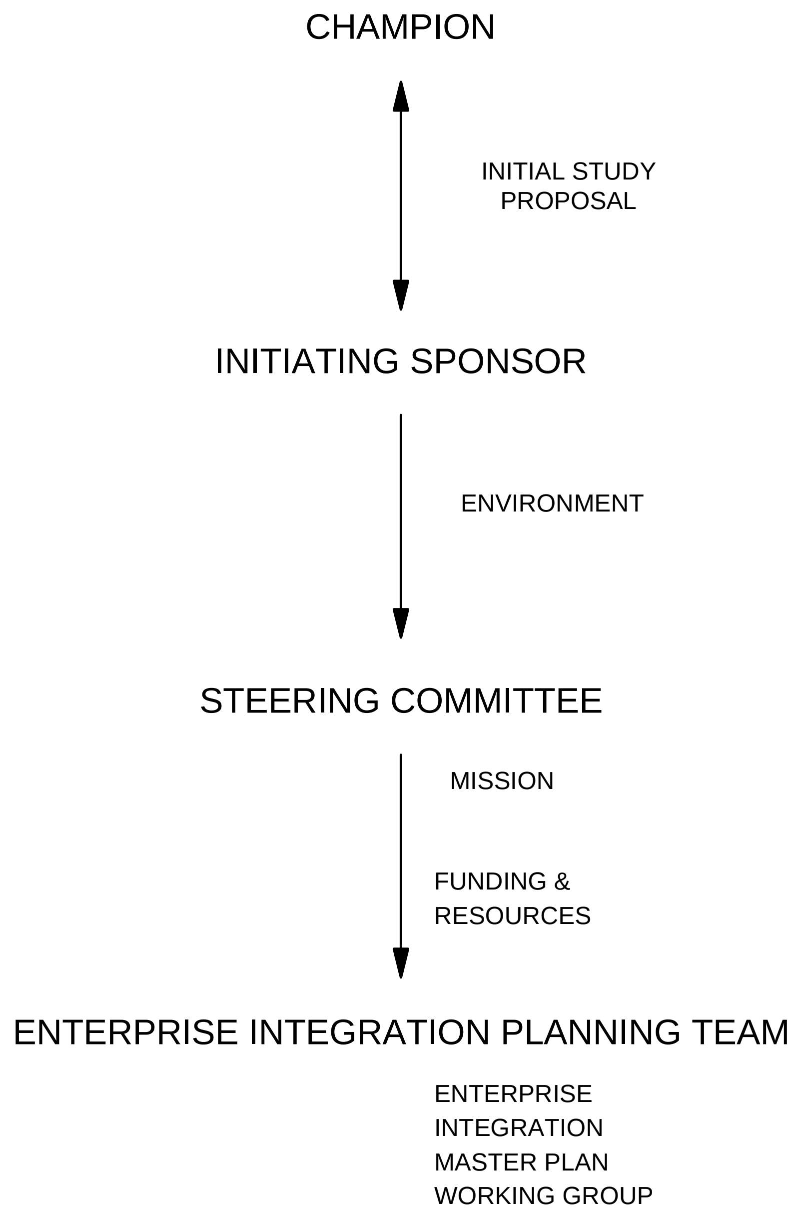

FIGURE 1-2 RELATIONSHIP OF KEY PLAYERS IN THE INITIAL ENTERPRISE INTEGRATION PROJECT PROGRAM DEVELOPMENT

Steering Committee [41]

The first stage of any major functional, technological, or organizational change in a company requires the identification of the stakeholders in the project under consideration along with the performance of a thorough strategic review, that considers an organization's culture, values, change readiness, and human resource plan. Also critical to this stage is the creation and documentation of a "vision" (a written description of the desired future state) plus the scope and objectives of the change. And, of course, a prerequisite for these steps is the active sponsorship of the organization's key members, who can work to lead (sell) the change to others within the organization.

A second stage, which is called program strategy development, is the work for which this Handbook is written. It involves selecting a core group of stakeholders for project participation and supervision, finalizing a project team to do the proposed development work, identifying changes required and preparing a change plan (or Master Plan as it is called here). The several groups and individuals involved in this work must constantly bear in mind that it is human communication that is most needed to facilitate the application of enterprise integration concepts within any organizational setting. For many companies that are now implementing new or advanced process control technologies, this human communication has been the key to establishing cooperation and building sponsorship and ownership across cultural boundaries [2,41,54,66,70].

Enterprise Integration Planning Team

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

The Enterprise Integration Planning Team (the team) members should be full-time members for the duration of the master planning effort. If this is not possible, expect a minimum of at least 50% as the time requirement. They should be from the chosen business entity, be knowledgeable of the current operations, be respected by their peers, be influential and be 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 their parent organizations. A member could represent more than one area so as to reduce the size of the overall team. Members should have a thorough understanding of the business in at least their operating areas. They should be 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 in this way will the personnel of the Business Entity feel that the enterprise integration program is "theirs" and thus assure "buy-in" to the program by them.

1.3. Developing the Enterprise Integration Program

Developing a corporate program to achieve the types of benefits possible from an enterprise integration program can be a daunting task in many cases because of the magnitude and complexity of the final project program and the human and organizational impacts involved. The following are some prerequisites for successful implementations:

Top Management Involvement
Top management involvement is always a critical factor in any major program for change in an organization. Not only should they be committed to the program, but they should also be actively involved in enterprise integration planning itself. Many decisions can only be made at their level, e.g. decisions that involve what types of plants the company might have in the future, how they are operated, what their capacities might be, etc. In addition, they must also clearly communicate their own as well as the company's goals and objectives to those under their supervision. Implementing enterprise integration requires strong, forward looking, management support because, to be successful, enterprise integration not only requires an integrated information system, but usually also a new pattern of organization and a change in the overall company culture. These last two especially require time, careful planning, and long-term commitment by management to be successful.

A Knowledgeable Work Force
The knowledge which employees bring to the company consists of their current skills, experience and talents. This includes not only what they can do at present, but also their basic talents and ability to learn. This ability to acquire and incorporate new knowledge is highly relevant to enterprise integration implementation because of the major training requirements that may have to be incorporated in the overall integration program.

A Smooth, Functioning Enterprise with a High Readiness for Change
The day-to-day operations of any company should normally be carried out in a planned thoughtful way rather than in a crisis mode. If expediters abound, deliveries are late,- inventories are bulging, and rework is common, this means that more serious problems exist than just the technological ones and the prospects for enterprise integration are poor unless the causes of the disarray are incorporated in the enterprise integration program for change or corrected ahead of time.

An Organizational Culture Conducive to Enterprise Integration Implementation
The implementation of enterprise integration often demands major cultural change in the company organization. The internal resistance to such changes can be so great that enterprise integration will never receive a fair chance. Thus it is clear that the company culture must be changed first. That becomes a selling job for all management levels, accompanied with an unending education process for the work force. Effective changes can only occur through active participation by the ultimate users. Of course, none of these can take place without a serious top-level commitment that is evidenced by the presence of an involved and dedicated management team.

A Supportive Infrastructure
Enterprise integration often requires an infrastructure that is considerably different from that which exists in most companies today. So the organization of the company may have to be altered to make more effective use of the new technologies available. The rules and procedures of the company, and the set of systems (managerial control systems, work force supervision and reward systems, scheduling systems, quality assurance systems, etc.) that basically run the organization also may have to be revised to optimize the advantages of new technologies.

Adoption of Industrial Standards

Industrial standards (e.g. standards for data communication, data exchange, data integration, graphics exchanges), when widely adopted by vendors and users, generally lower the cost of systems and equipment. They increase the options for users when sourcing systems and equipment, and simplify the tasks of system development and integration. They facilitate ready accessibility and free flow of information and also allow for flexibility to make partial upgrades and replacements of integrated systems when new technologies appear.

Summary of Development Considerations

Since introducing an advanced manufacturing technology project may cause resistance, a well managed implementation process can minimize this resistance and increase the chances of success. In general the following guidelines should be followed in implementing an advanced manufacturing technology project:

1. Evaluate possible organizational impacts and develop plans to offset them before hand.
2. Establish explicit senior management support.
3. Encourage all potential users (including hourly associates) to get involved in the whole implementation process, from the planning phase through to the performance evaluation phase and final use.
4. Assign responsibilities to each related group and person to enforce Item 3 above.
5. Provide sufficient training to all users.
6. Look for ways to introduce the system with minimum interruption to existing production operations.

One possible approach then to the development of the enterprise integration project is as follows:

1. Enlist top management support.
2. Develop a mission, goals, and objectives for a enterprise integration steering committee related to the Company's overall goals and objectives including a vision of the plant of the future.
3. Develop a conceptual preliminary enterprise integration plan and identify projects, priorities, benefits, technical risk, etc., to assure that a viable preliminary program exists.
4. Create a multi-function enterprise integration planning team to carry out the detailed planning necessary for the finally approved overall program.
5. Select a methodology for doing the required Master Plan (including a consultant, if appropriate).
6. Develop the detailed plan including a set of prioritized projects for implementation. As these projects are approved, assign implementation teams to accomplish them.

1.4. Key Considerations

The Initiating Sponsor and the Champion will need to work together to identify the pressing business problems facing the company and/or this particular business unit. They also should research any other early enterprise integration projects attempted within the company and eventually take a cut at the general costs and benefits of enterprise integration within their area of influence.

The Champion and Initiating Sponsor should develop a plan to proceed with the enterprise integration study, identifying the key check and decision points, resources, potential sites, benefits and order-of-magnitude costs. Much of the actual work will be led by the Champion but with frequent communications and up-dates to the Initiating Sponsor.

Some key points to consider in developing and implementing an enterprise integration program (reiterating earlier points) are:

1 Business and manufacturing strategies provide the focus, direction, and priorities for enterprise integration planning.

2. Enterprise integration begins with the business plan
    a. Focus on critical business issues
    b. Define strategic role of manufacturing

3. Enterprise integration requires a clear manufacturing plan
    a. Determine what things you need to control to meet business objectives
    b. Be sure that you:
        (1) "Simplify first, automate later"
        (2) "Don't automate a mess"

4. Enterprise integration is a way of doing business; its focus is sharing information to eliminate steps in the processing of products that do not add value.

5. For a facility, the plant management must drive enterprise integration and be held accountable for its implementation.

6. Enterprise integration planning horizons should be long-term
    a. Need a vision of enterprise integration long-term requirements and benefits.
    b. Short-term plans should build toward accomplishing the vision

7. Enterprise integration must involve all employees. What enterprise integration is and company progress toward it must be clearly communicated.

8. Many functional groups should be involved in enterprise integration planning to obtain "buy-in" and develop a more credible proposal.

9. Education and training are critical to success.

10. Justification can be made using a combination of financial benefits (e.g. productivity improvement), and strategic benefits (e.g. improved customer service). However, intangibles should not be quantified since this detracts from the credibility of a project proposal.

11. The credibility of "soft" benefits is increased if a Business Manager with profit/loss accountability is enrolled to help sell executives. If a traditional cost-justification approach is taken, this is a good strategy as well because of floating hurdle rates and other management constraints.

12. Enterprise integration projects may be linked to "hot" business issues to obtain approval without rigorous quantitative back-up.

13. Enterprise integration requires effective project management

    a. Implement in modules - "be realistic"
    b. Set quantifiable goals (e.g. productivity, cost of quality, delivery interval)
    c. Insist on regular progress reports

14. Proponents should follow the enterprise integration vision, drawing from specific needs, available enterprise integration technologies, and early enterprise integration applications that worked.

15. The company should be educated about enterprise integration and typical success stories (both internal and external).

16. Successful Approaches

    a. Work within an existing capital budgeting framework
    (1) May need to predict impacts (e.g. reduction in rework)
        (2) ROI may not meet hurdle
    b. Document historical benefits of information systems investments (e.g. present value of cost savings per employee)
    c. Sell total, long-term project benefits rather than individual components
    d. "Get an early success with enterprise integration, any way you can."
    e. Provide seed capital (e.g. steering committee discretionary budget to fund enterprise integration planning and education and selected pilot projects).
    f. Don't focus on accounting techniques, educate senior management

17. Enterprise integration is one of those entities we can approach, but never fully achieve.

18. However, without senior management commitment to enterprise integration, the above approaches may not be adequate. A major check point will be reached when the potential opportunities and organizations have been identified and analyzed.

19. Taking into consideration all previous points, required quality procedures should be maintained.

1.5. Preliminary Economic Analysis

A preliminary cut at the economic analysis of the proposed enterprise integration effort will be necessary to gain and maintain the support for the integration program. This effort should be led by the Champion with help from wherever he or she can find it. It should consist of order of magnitude cost and benefit estimates. Both will likely require a "non-traditional" look at savings and business impacts. The enterprise integration program should be tightly linked to future business objectives and plans, and the long-term capital plans for the business entity. There are many sources for help with this task: trade journals, the manufacturing consulting arm of many of the larger accounting firms, colleges, computer and controls suppliers, professional organizations, and engineering consultants. Enthusiasts or Champions should first look for expertise within their own organization, because these are the people who will have the respect of and a working knowledge of the company and its personnel.

The Initiating Sponsor and the Champion must select an initial candidate Business Entity for this preliminary economic analysis. Only if this initial analysis shows the potential of a significant set of overall benefits attributable directly to the proposed enterprise integration system should the study be continued with that particular business entity. Failing this, another choice of business entity should be made or the whole initiative should be terminated. Committing the major resources necessary for an enterprise integration project without a clear indication of substantial returns would be folly.

Enterprise Integration Benefits

What benefits will implementation of an enterprise integration plan allow us to attain? In general, the benefits are primarily long term, and brought about through the implementation of major, key projects. However, an important step in the plan development is to identify any fast track opportunities. By this we mean high pay-out, short time to implement, low technical risk projects that can and should be done as soon as possible. It is usually important to demonstrate some short-term gains to management to ensure their continued support for subsequent project funding and workforce resources.

Areas for potential benefits from an enterprise integration system are:

1. Improving manufacturing yields of first quality product in all areas. Improved yields would be accomplished through effective use of process monitoring and trouble identification tools, effective use of process modeling tools, implementation of advanced control techniques and emerging technologies in plant processes, quick access to improved information for decision making, and integrated manufacturing planning and scheduling.

2. Improving customer support and achieving preferred supplier status with key/major customers. This can be achieved through knowledge of customer requirements, providing quicker response and increased flexibility in dealing with customer requests, and ensuring consistent/first quality product is always supplied to these customers.

3. Reducing cost of products sold by minimizing no-value added steps in the manufacturing processes and support areas, reducing the inventory of products maintained for sales, attaining JIT status with key vendors and suppliers, controlling investment priorities, and the elimination of redundancy in data, systems, and support.

4. Reducing process and machine interruptions through more effective preventive maintenance, predictive maintenance, optimal equipment scheduling (within tolerances and constraints), and improved and consistent supplier quality of raw materials, parts, and equipment.

5. Providing a competitive edge in developing new products for customers and decreasing the manufacturing lead time to supply them. Overall lead time reduction, i.e. "concept of total time to market," is the important key here.

6. Promoting greater employee involvement at all levels in the organization through improved communications, organizational and procedural changes to ensure decision making is at the lowest practical level (such as self-directed work teams), reallocation of resources to value-added jobs, elimination of the management versus labor attitude, and new roles for management.

Some quantitative examples of enterprise integration benefits as presented by various authors are given in Appendix II.

1.6. Choice of Business Entity

The candidate Business Entity can be described as shown in Figure 1-3. It should provide as complete and self-standing a unit as possible in terms of containing each of the major plant functions of the CIM Reference Model [81]. As might be concluded from the diagram, an enterprise integration business entity may be as small as a sub-plant, but may be as large as a business unit of a company, that is, having multiple manufacturing sites, or even be the enterprise itself (company as a whole).

The essential Enterprise Business Entity elements are:

1. It should be considered strategic
2. Merits continued investment
3. A cohesive/motivated management team

It is recommended that it be selected with the following subjects considered:

Organizational Readiness
This is a subject that could have large dimensions and much uncertainty, but might be summarized by answering the question "Is the organization ready to make some major changes in the way things are done and decisions are made?" If yes, then one should pursue questions as to the magnitude - of change anticipated, and the degree of readiness. Are flexible work rules worked out with the labor force? Are managers becoming Coaches and Trainers, as opposed to THE decision makers? If no, then questions related to how this climate for change could be generated and some appraisal of probability of success must be made. If a believable plan cannot be developed, it will be prudent to abort.

Flexible Manufacturing Platform
This is to appraise the current manufacturing base, relative to modern manufacturing equipment, material flows, and flexibility. If modern equipment and concepts such as continuous flow and

make-to-order already exist, this consideration has been met. If equipment is old, materials are frequently shuffled in and out of inventory, finished product spends long periods in warehouses, etc. These are caution signs. If the existing situation is like this, one will need to appraise the organization's ability, willingness, and resources to change to modern manufacturing concepts and practices.

Modern Methods and Procedures
This category is measured by concepts such as Just-In-Time and Total Quality, which can be combined with the above two categories and enterprise integration. The real question here is - Is there a program of continual improvement in place? If not, an appraisal of what must be put in place to begin one needs to be done.

If multiple sites are under consideration, it would be prudent to select one that has most of these concepts established. **It is important that the first enterprise integration effort under-taken be an unquestioned success.** For this reason it also may be prudent to do enterprise integration planning from a business unit level, but begin the implementation in an advanced plant, one that improves the chances of providing a good example and template for reapplication.

It is the Initiating Sponsor who makes the decision on the identity of the Enterprise Business Entity to be chosen and thus the boundaries of the Enterprise Integration program study. The Sponsor should look to the Enterprise Integration Champion for most of the detailed investigation.

1.7. Work of the Steering Committee

Once the Enterprise Business Entity is agreed upon the Steering Committee should be selected. This group should represent all of the major manufacturing, business, and support functions and have an in-depth knowledge of the plant, its processes, and its systems. In addition, the Committee should share a vision of where the company wants to be in the future to ensure their competitive position in the business. Several approaches to development of an enterprise integration plan are possible.

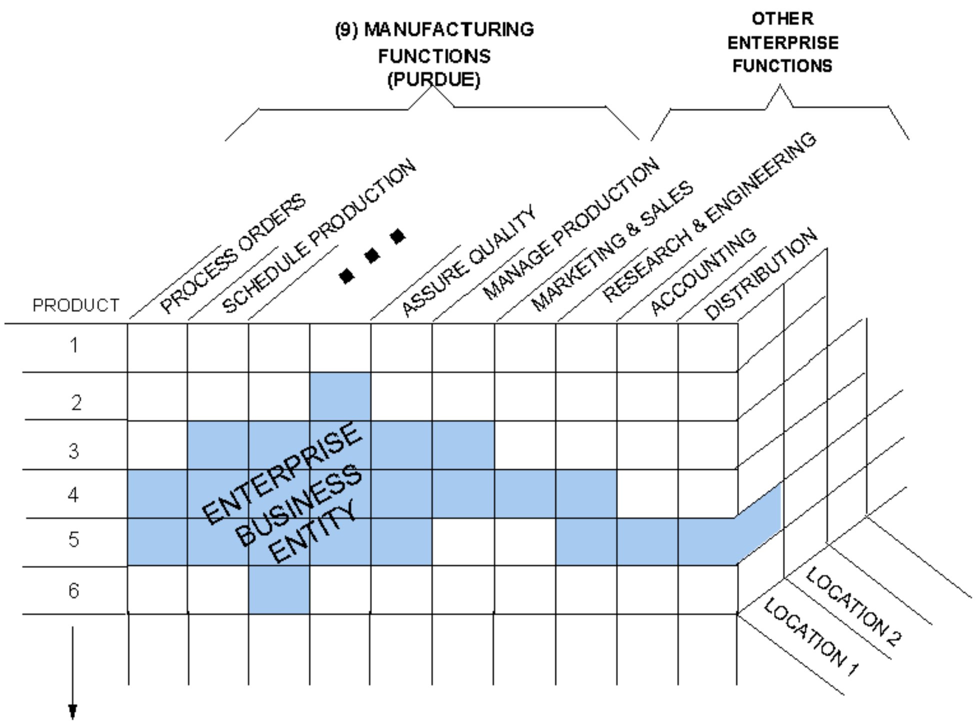

FIGURE 1-3 DEFINITION OF ENTERPRISE BUSINESS ENTITY

Note that the Steering Committee probably will be selected by the Initiating Sponsor but only after the initial selection of the Business Entity involved has been made. This is because the Steering Committee members, as mentioned above, should have a personal and career involvement in the Business Entity that is the basis for the enterprise integration program involved.

The overall mission and responsibility of the Steering Committee is as follows:

Mission

The Enterprise Integration Steering Committee will develop and recommend to plant management an enterprise integration strategy and plan to provide the plant site with cost-effective processes, systems and technology that will enhance its competitive position. Key components will include integrating manufacturing systems, linking process control and business systems, and applying "state of the art" technology. This approach can be an integral part of the total quality process and as such requires the proper focus and coordinated effort, future vision, and a commitment of resources. This Enterprise Integration Strategy and Plan will be of the relatively "broad brush" form indicating the plant to be involved and assuring that an economically viable Enterprise Integration Program is possible there. The follow-up work of preparing a much more detailed operational plan, the Master Plan, for this program will be entrusted to the Enterprise Integration Planning Team (to be named later) who will serve under the Enterprise Integration Steering Committee.

As noted above, the members of the Enterprise Integration Steering Committee should have a wide range of training and experience to be more able to supervise the preparation of the Enterprise Integration Master Plan. Table 1-1 presents the background and responsibility of the individuals on one company's Enterprise Integration Steering Committee [41].

Once the preliminary plan for the proposed enterprise integration program has been prepared, the major task of the Enterprise Integration Steering Committee evolves to that of supplying resources and strategic direction to the work of the Enterprise Integration Planning Team.

TABLE 1-1

AREA ASSIGNMENTS - ENTERPRISE INTEGRATION STEERING COMMITTEE

REPRESENTATION	SPECIAL EMPHASIS
Special products	Process control New technology at supervisory level
Purchasing & Stores Warehouse & Distribution	General planning & integration Material management Employee involvement
Plant laboratory	Laboratory & analytical data Quality assurance Employee involvement
Engineering, Process control, Maintenance, Utilities Production services	Strategic planning for process supervisory, area management levels Expert Systems
Commodity products	Process control New technology at supervisory level
Information systems Accounting, Finance	Strategic planning for area management Plant & group levels
Human Resources	Specialized computer applications Human related statistics Public relations
Manufacturing Administration	Planning & scheduling, inventory control Headquarters liaison
Quality management relations	Education, training and public relations Vendor interaction Total Quality
Plant	Business strategy Committee sponsorship
Corporate	Corporate business

1.8. Building Commitment to Proceed

Defining Consensus

Consensus is the best method for producing an innovative, creative and high quality decision that:

1. All members will be committed to implementing,
2. Uses the resources of all group members, and
3. Increases the future decision-making effectiveness of the group.

Consensus is not easy to achieve but it is worth the time and trouble even though it is characterized by more conflict among members, more shifts of opinion and a longer time to reach a conclusion because it results in more confidence by members in the correctness of their decision.

Consensus requires a fairly sophisticated understanding of the dynamics of controversy, of distributed participation and leadership, of communications, and of all other group and interpersonal skills. All group members must contribute their views on the issue and their reactions to proposed alternatives for group action; no one should be allowed to remain silent.

Consensus Building

1. Clarify any difference in opinions so each person understands what is being said.
2. Identify the higher goal to reach.
3. Seek the common ground by:
   a) Pointing out similarities
   b) Pointing out advantages of the different opinions
4. Argue for the other's view.
5. Document areas of agreement.
6. Seek new information.
7. Revisit areas of disagreement or differences.

In reaching consensus, group members need to see differences of opinion as a way of:

1. Gathering additional information.
2. Clarifying issues.
3. Forcing the group to seek better alternatives.

Basic Guidelines for Achieving Consensus

1. Avoid arguing blindly for one's own opinions. Present the position as clearly and logically as possible, but listen carefully to the other members' reactions and consider them carefully before you press your point.

2. Avoid changing opinions <u>only</u> to reach agreement and avoid conflict. Yield only to positions that have objective and logically sound foundations.

3. Avoid conflict-reducing procedures such as majority voting, tossing a coin, averaging, and bargaining.

4. Seek out differences of opinion. They are natural and expected. Try to involve everyone in the decision process. Disagreements can improve the group's decision because they present a wide range of information and opinions, thereby creating a better chance for the group to hit upon more adequate solutions.

5. Do not assume that someone must win and someone must lose when discussion reaches a stalemate. Instead, look for the next most acceptable alternative for all members.

6. Discuss underlying assumptions, listen carefully to one another, and encourage the participation of all members.

Majority vote as a method of decision making has the disadvantage of usually leaving an alienated minority which damages future group effectiveness; relevant resources of many group members may be lost; full commitment to implement the decision is absent; full benefit of group interaction is not obtained.

Despite the popularity of enterprise integration as a discussion topic, there are still many obstacles in the way of a successful application. Many of these are in the areas of social-technology interaction and sponsorship.

Obstacles to Internal Support

1. Senior management commitment may be difficult due to
   a) Lack of understanding of enterprise integration benefits and
   b) An unwillingness to make long-term investments.

2. Inter-functional coordination may be poor due to
   a) Lack of cooperation between Manufacturing and MIS
   b) Lack of understanding of information/communication needs across all functions.

1.9. Human Resources in Enterprise Integration

In the area of human resource management, issues relating to automation and job security (enterprise integration may be "loss of jobs" to some) and the new roles of management (coaches, trainers, team members) must be addressed with those affected. While initial enterprise integration efforts are focused on the technology, a parallel human resource plan also will be necessary. This plan must address the new role of the employee in terms of:

1. Broader spans of control
2. Self-management
3. Blurring of management/labor distinctions (e.g. all salaried workforce)
4. New access to/sharing of information; otherwise, the full benefits of Enterprise Integration are not realized
5. Emergence of "new generalists"
6. Realignment of traditional organizational responsibilities (e.g. HR, MIS, selling, product management)
7. Unprecedented levels of training

The bottom line is that the people in the organization must change. It is not enough to simply make a systems change. These changes will be resisted because of management cultural barriers:

1. Ability of managers to accept new roles, especially when middle management is eliminated.
2. Willingness of managers to share responsibility and information.

Human absorption is also a limiting factor, you can't "push" change through a resistant organization. Therefore changes are time consuming and involve training, development and lots of genuine communication.

Conventional "wisdom" in executive seminars and trade publications seems to imply that a top-down directive is the way to realign everyone's objective toward enterprise integration. That may indeed occur in some enterprises, but the vast majority of employees must still develop and justify every proposed improvement in their own minds before their own approval is granted. How then is the best way to obtain the workforce resources necessary to envision, develop, and "scope out" the enterprise integration requirements? The answer is NOT to expect the project engineering group or the computer staff to complete the task by themselves, but to solicit the commitment of the manufacturing management and all of the impacted employees.

If enterprise integration is to succeed, it will succeed because the lower-to-middle-level personnel want it to succeed. These are the technicians, the engineers, the supervisory staff, anyone who improves their job by optimizing the status quo - envisioning new correlations to push the envelope of learning just a little bit farther. Enterprise integration can provide the tools to enable those motivated individuals to operate in a larger domain of effectiveness. Enterprise integration will not become a reality all at once, but incrementally as these individuals fight for and justify each specific data-integration need.

Some suggested ways to overcome organizational inertia are:

1. Create a "significant event" or crisis to focus attention on the need for change and make people more receptive to change.
2. Use employee teams to identify and, if possible, resolve problems.
3. Although people will inevitably have to be shifted to new functions, ease the transition with volunteer transfer programs and reward systems.
4. Implement a retirement program to provide an attractive alternative to resistant personnel.
5. Be prepared for transition problems and an initial fall in productivity.
6. Communicate goals to all levels of the organization.

1.10. Other Important Considerations

The enterprise integration planning process must also involve the introduction of modern manufacturing concepts and methods as well as the socio-technical aspects. Particularly important here are new attitudes toward management and worker involvement and decision making. The latter should include the new role of the manager, team-type work systems and the concepts of a self-directed crew and of all skills on shift if this is to be part of the management's goals for the new system.

1.11. Summary

Attachment 1-I presents a checklist designed to help guide the Enterprise Integration Planning Team in assuring themselves that all required information on the Enterprise Business Entity has been procured. These questions may form the basis for much of the interviews just discussed. Figure 1-4 assists in this overall review of the tasks involved. Attachment I-II presents another view of the overall process being carried out in this first phase of the enterprise integration master plan project. These and similar tables in the chapters to follow are used by the Fluor Daniel Company to explain the Purdue Methodology to their employees. It forms another way to emphasize the points made in this and following chapters. In addition, we will repeat the form of Figure 24 of the Introduction Chapter in each chapter to follow to indicate where the work discussed in the respective chapter fits on that diagram. This figure here is Figure 1-5.

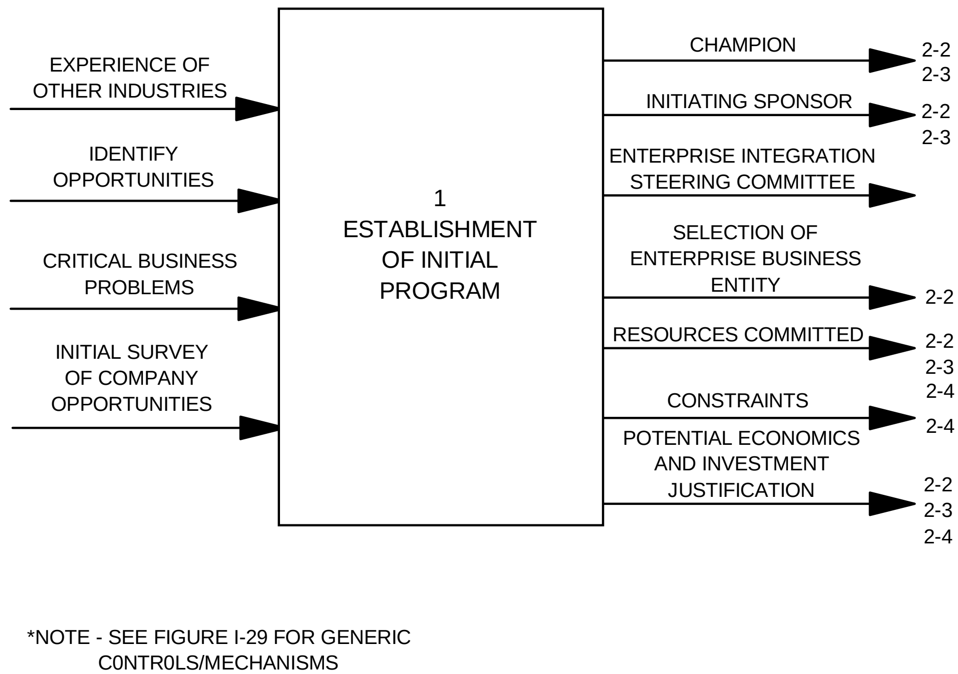

FIGURE 1-4 THE TRANSFORMATION TASK OF CHAPTER 1 - ESTABLISHMENT OF INITIAL PROGRAM

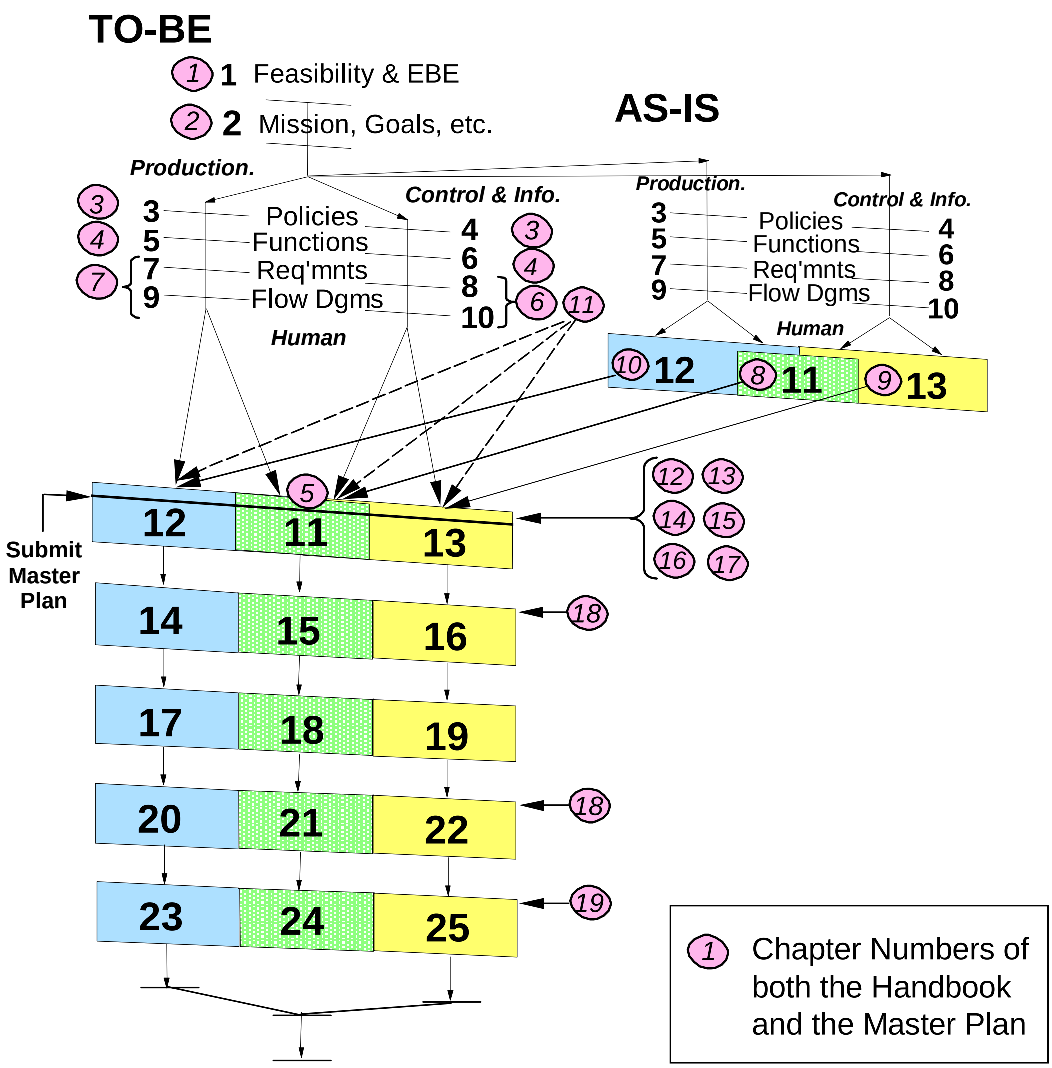

FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

ATTACHMENT 1-I
CHECKLIST FOR DEFINITION OF THE BUSINESS ENTITY

I. IDENTIFY - KEY ENTERPRISE INTEGRATION PLANNING PERSONNEL

1. Name, title, and address of Champion.
2. Name, title, and address of Initiating Sponsor.
3. Name, title, and address of Sustaining Sponsors.
4. Are Sustaining Sponsors also the Enterprise Integration Steering Committee? If not, name exception(s) and explain.
5. Name, title, and address of Project Manager.
6. Names, titles, and addresses of Enterprise Integration Planning Team.

II. IDENTIFY THE ENTERPRISE BUSINESS ENTITY

1. Name and address of this Enterprise Business Entity?
2. What is the major business activity of this Enterprise Business Entity?
3. Is it the only business activity of the company at this address? If not, explain the organization and process relationships (or independence).
4. What is the major company purpose accomplished by this unit?
5. What is the management structure of this Enterprise Business Entity? Give organizational diagram, names of present incumbents, etc.
6. Document the physical and functional boundaries of the Enterprise Business Entity.
7. Does this Business Unit consider this Enterprise Business Entity as strategic? Will capital be committed to maintain and enhance this Enterprise Business Entity?

III. RELATIONSHIP OF THE ENTERPRISE BUSINESS ENTITY TO THE BUSINESS UNIT

If the Enterprise Business Entity is the same as the Business Unit, skip this section.

1. Name and address of the Business Unit?
2. What is the major business activity of this Business Unit?
3. What is the major company purpose accomplished by the Business Unit?
4. How does Enterprise Business Entity relate to Business Unit ?
   a) What is place in company reporting structure?
   b) Amount of autonomy in decision making?
5. Is the Business Unit management supportive of proposed enterprise integration planning activity at this Enterprise Business Entity?
6. Document the Business Unit organization and work system vision.

ATTACHMENT 1-II
SUMMARY OF PLANNING STEP 1
DETAIL PROGRAM & BUSINESS ENTITY

➤ **Identify:**
- Program Sponsor
- Program Champion
- Steering Committee
- Planning Team

➤ **Define Enterprise Integration Program**
- Boundaries and Vision

➤ **Resources Available:**
- Existing Business Plans
- Entity Mission, Vision & Values
- Organizational Structures
- Business Entity External Linkages

2. Goals of the Program and Enterprise Business Entity

2.1 *Introduction*

Once it has been shown to management's satisfaction that significant opportunities exist, it is important to document management's expectations from the proposed project. These expectations must be well understood by both management and the Enterprise Integration Planning Team. This has the further benefit of ensuring that the right questions have been asked for management's further decisions and, indeed, that these further questions do not change in management's mind while the planning work is progressing. Should the latter occur, it would mean that the Planning Team would be aiming at a "moving target".

The driving force behind enterprise integration must be the business and manufacturing goals and objectives of the company and the selected Business Entity. The business strategy furnishes a foundation for building an enterprise integration plan that ensures the viability of the resulting enterprise integration program. It is vital to integrate the corporate, business, and manufacturing strategies into a single implementation plan. The corporate and business strategy defines the economic contribution expected from the manufacturing facility. The manufacturing strategy determines the manufacturing methods or processes to be used, defines the plant role in implementing the manufacturing strategy, and allocates resources to accomplish it.

Although enterprise integration is considered technical, the process of developing the Mission, Vision and Values of the Enterprise Business Entity requires understanding the concepts of strategies and plans. This process is not envisioned as technical but as one of business orientation. On selecting a business entity for the enterprise integration program, it becomes very important to understand and know what the current business principles and directions are for that entity. Figure 2-1 diagrams how the various business principles need to be evaluated upon selection of the Enterprise Business Entity.

Enterprise integration should be implemented from a position of strength, not weakness. The Enterprise Integration Steering Committee needs to be able to decide how the company can develop a strong position to implement enterprise integration. This is determined by knowing what the business unit strategies are, what the organizational climate is and will be. As stated before, the business strategy furnishes a foundation for building an enterprise integration plan that ensures it's viability. These contexts are outlined in this chapter to ensure a position of strength.

2.2 *Business Principles*

Figure 2-1 shows the relationship of the key terms used in defining business principles. One will find that, depending on the company's use of the terms, they might have a different meaning and importance to individuals in different parts of the company. It is strongly suggested that a common definition be agreed to by those involved in the Enterprise Integration Master Planning exercise. Table 2-I presents a definition of each of the terms of Figure 2-1 as they will be used here.

TABLE 2-I
BUSINESS PRINCIPLES DEFINITIONS AND RELATED TERMS

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

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

VALUES: 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.

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.

STRATEGY: a plan of action resulting from the objectives of the firm with a long-term focus. 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.

GOALS: specific targets that it is intended to reach at a given point in time. A goal is thus an operational transformation of one or more objectives. Thus goals are way stations on the road to the objectives with specific accomplishments and times specified.

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. 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.

CRITICAL SUCCESS FACTORS (CSFs): 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 management goals to be attained. Critical success factors are popular ways of expressing objectives - almost as slogans.

POLICY: a definite course or method selected from among alternatives to guide and determine present and future decisions. Established at the beginning of the master plan, Policies are not re-examined, but rather accepted as “ground rules”.

CHAPTER 2 – Goals of Program

It is essential to align the Enterprise Integration Program and therefore the Enterprise Integration Master Plan to the Enterprise Mission, Vision and Values and the other succeeding principles displayed on Figure 2-1.

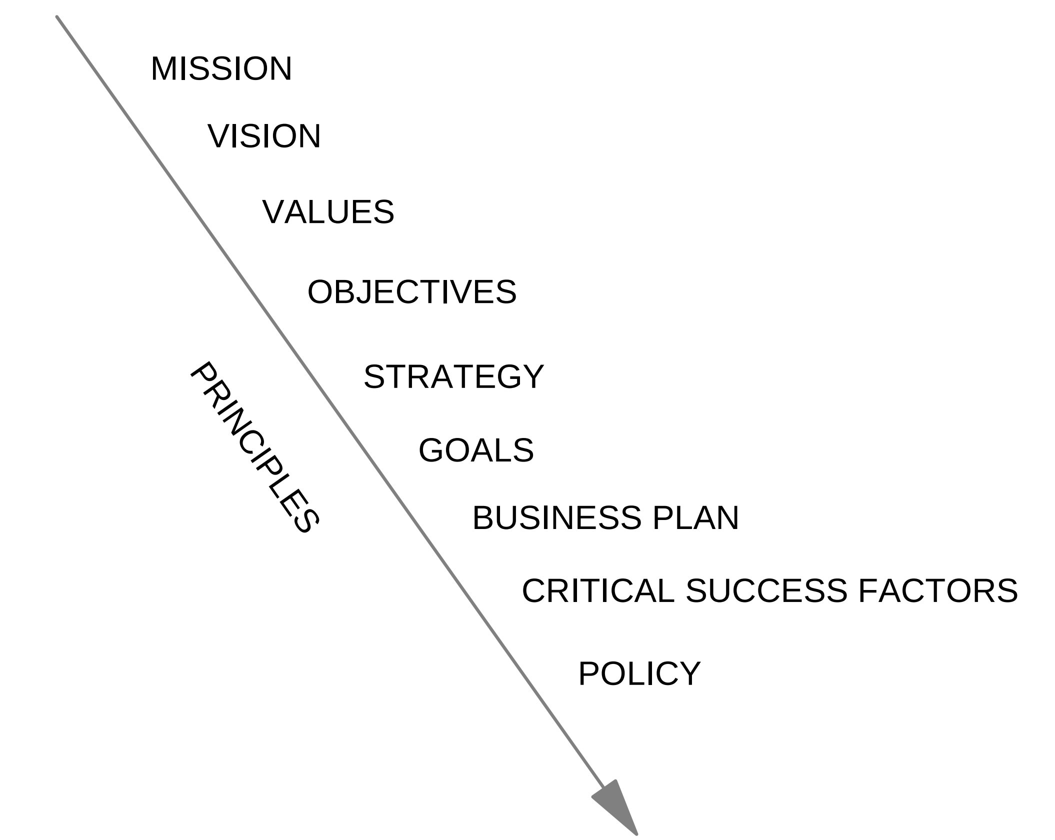

FIGURE 2-1 REPRESENTATION OF BUSINESS PRINCIPLES AND RELATED TERMS

Figure 2-2 shows where this discussion fits in the scheme of development of the Enterprise Integration Program as modeled by the Purdue Enterprise Reference Architecture.

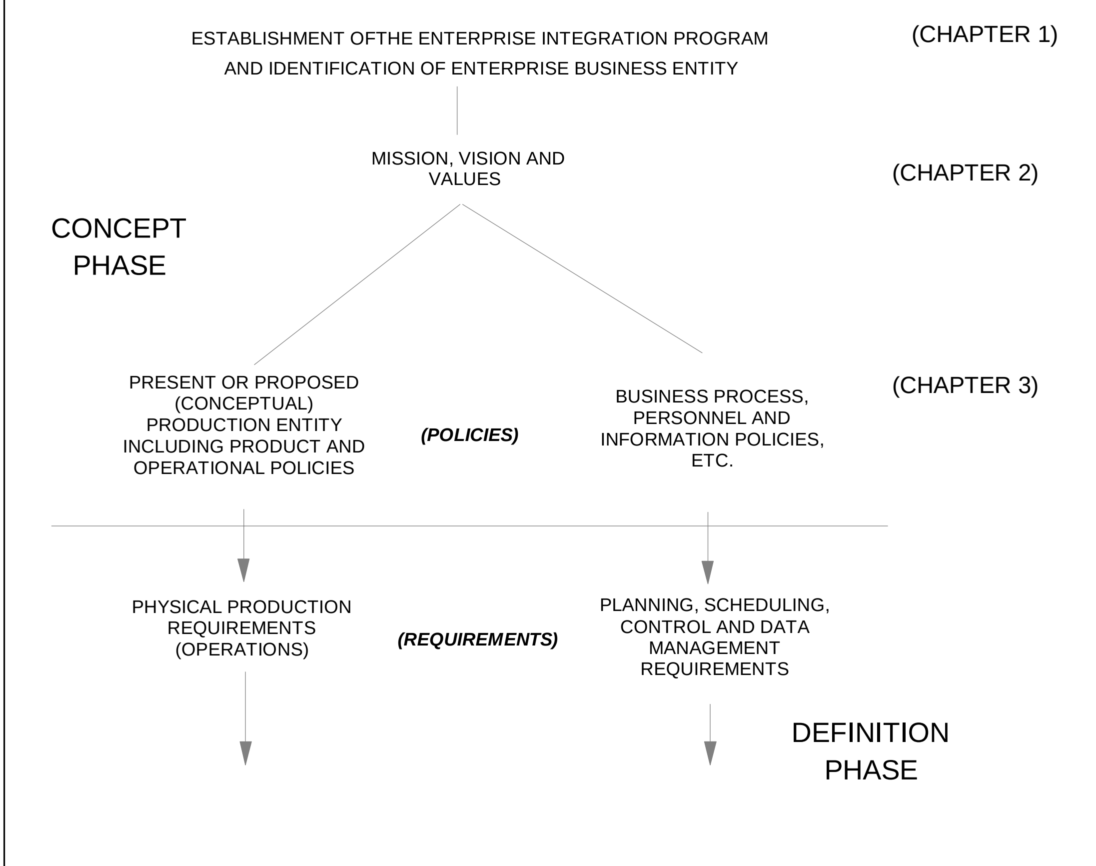

FIGURE 2-2 – THE PLACE OF THE MISSION, VISION, AND VALUES DISCUSSION IN THE DEVELOPMENT OF THE INTEGRATION PROGRAM

2.3 *Elaboration of the Mission*

The Company first defines the business it wants to be in, in terms of the nature of the products, and the market. This is defined by a mission statement. It then defines its desired future position in terms of growth, profitability, etc. This would be defined by 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.

Strategies that outline the best way of achieving the objectives and accomplishing the mission, given the constraints of the market and the resources of the company, are then set. These strategies are elaborated upon in a business plan that shows the specific targets to be sought at specified points in time. The targets are defined as goals to be reached at a given point in time. A goal is thus an operational transformation of one or more objectives.

Note that objectives, "are general statements of directions," in which the business enterprise wishes to go, without naming specific targets or specific times at which particular points along the way should be reached. Note that all sub-units of the enterprise also have objectives that reinforce those of the enterprise. In order to achieve these objectives, both the enterprise and its sub units develop strategies that define goals to be achieved. Again this development is carried out for all levels of the organization involved. These goals define specific targets to be achieved and the specific times for their completion to implement the strategy. This thus puts considerable detail and body on the relatively non-specific objectives.

For the given strategies and goals, critical success factors define those individual conditions which must be present or events which must occur to assure attainment of the chosen goals and eventually of the overall objectives. The enterprise integration project program of the Enterprise Business Entity for which the Enterprise Integration Planning Team is preparing a Master Plan must have a set of objectives and a set of goals for achieving those objectives. Hence that portion of the overall task of developing the Master Plan which is described by this chapter is that of assuring that these objectives, goals and critical success factors do exist in the Enterprise Business Entity and its enterprise integration system and documenting them for the benefit of all concerned with the Enterprise Business Entity and its enterprise integration system.
It can readily be seen that these are very high level, brief and complete statements, and often of a philosophical and "good citizen" nature. They do, however, form the basis from which the more complete objectives, etc., are developed. Because of their incomplete nature, they must be expanded and supplemented as shown in Figure 2-3.

2.4 *Some General Principles*

As just stated, the task here is one of verification and documentation of the objectives, strategies, goals, business plans and critical success factors (hereafter called business principles) of the Enterprise Business Entity and Related Business Units and of the proposed Enterprise Integration Project Program.

All of these must have previously been articulated by higher management since the Enterprise Integration Planning Team has neither the authority, nor stature in the company, nor the access to company operations to attempt such an endeavor. The task at hand is merely assuring that these are in place, are consistent with each other, and achievable within the program being planned. Any failure to conform to the needs just noted requires the Enterprise Integration Planning Team to go back to the Steering Committee to have them secure the corrections and adjustments needed.

2.5 *Documentation of Objectives, Goals and Critical Success Factors*

Despite the entreaties of Chapter 2.2, the Enterprise Integration Planning Team is sure to find that in many cases the material desired here is missing or is presently very poorly developed and recorded. This is particularly true at the lower levels of company organizations.

When written sources of information fail, it will be necessary for Enterprise Integration Planning Team members or their representatives to interview the members of the Steering Committee, upper management and others having a vital interest in the enterprise integration project program. The purpose is to determine each individual's list of objectives, goals and critical success factors. These can then be coordinated to give the best overall expression of them and taken back to the individuals who were interviewed to get their individual modification and enhancement of them and eventually their joint approval of the final list.

Before finishing their task here, the Planning Team should evaluate the completeness and correctness of their analysis and collection of the objectives, goals and critical success factors. Two measures here are the quality of the items proposed and the completeness of coverage of the different facets of operation of the Enterprise Business Entity.

In terms of quality, each critical success factor proposed can be analyzed in relation to its:

1. Significance to the overall success of the Enterprise Business Entity.
2. Relevance to the problems at hand.
3. Timeliness in relation to the problems of the moment, and
4. Comprehensibility by all of those involved.

Attachment 2-I presents a checklist designed to help guide the Enterprise Integration Planning Team in assuring themselves that all information on the Enterprise Business Entity has been procured. Figure 2-4 along with Figure 2-5 presents the corresponding diagram of the tasks required here and Attachment 2-II summarizes the steps involved.

Appendix III gives several examples of Mission, Vision, and Values; and the strategies, goals, critical success factors.

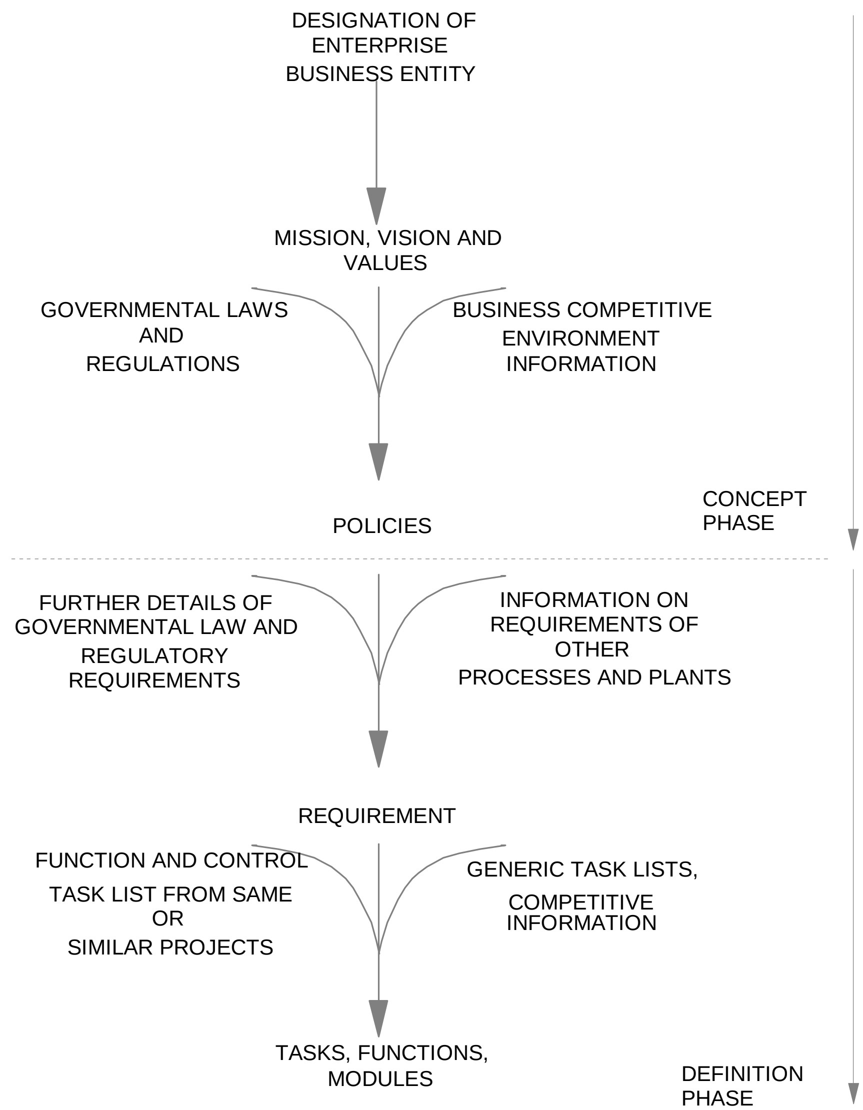

FIGURE 2-3 – DEVELOPMENT OF ENTERPRISE REQUIREMENTS

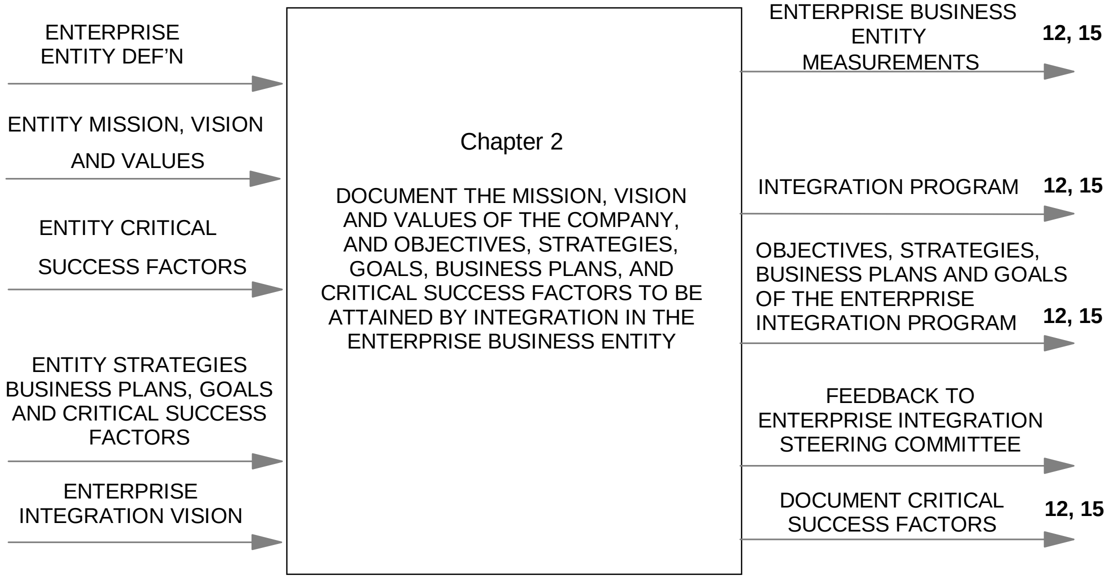

FIGURE 2-4 THE TRANSFORMATION TASK OF CHAPTER 2 - DOCUMENT THE MISSION, VISION AND VALUES OF THE COMPANY AND THE OBJECTIVES AND GOALS AND CRITICAL SUCCESS FACTORS TO BE ATTAINED BY ENTERPRISE INTEGRATION IN THE ENTERPRISE BUSINESS ENTITY

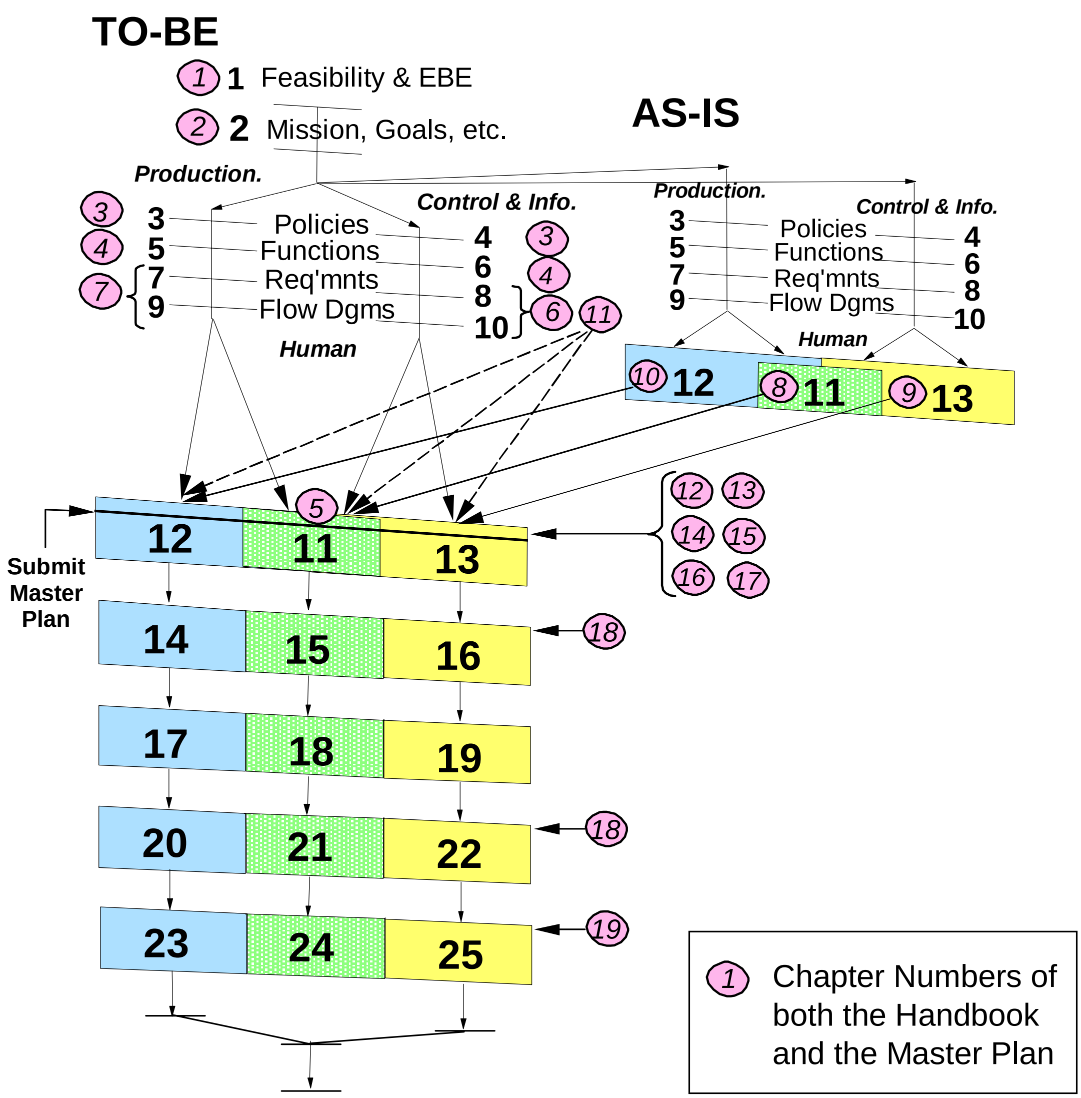

FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

2.6 *Measures of Success*

The enterprise integration program, of all improvement programs in a manufacturing company, must have a measure of, "how well it is doing." The publicity and visibility of any such program demands such reporting. Thus measurement of the attainment of the objectives, goals and critical success factors discussed here becomes one major way of attaining such a reading. The objects to be measured, other than monetary return itself, will vary from industry to industry and company to company.

Because of the differing nature of the details of each program, individual such measures will have to be devised in each case. The members of the Enterprise Integration Planning Team, through their overall thorough knowledge of the Enterprise Business Entity, are probably in the best position of anyone to make suggestions concerning the identity and use of measures for the particular case at hand.

2.7 *Management Review*

Because of the critical nature of the proprietary information included in the tasks described in this Chapter, Steering Committee and upper management approval of the results before completion is essential.

Likewise restriction on distribution and open discussion of some of the materials involved may be necessary because of their value to competitive companies, customers, financial institutions, etc. Care in handling and storage and consultation with management on all details are mandatory here.

ATTACHMENT 2-I

CHECKLIST FOR DOCUMENTATION OF THE MISSION, VISION, VALUES, OBJECTIVES, STRATEGIES, GOALS, BUSINESS PLANS AND CRITICAL SUCCESS FACTORS TO BE ATTAINED BY ENTERPRISE INTEGRATION

III. DEFINING THE ENTERPRISE INTEGRATION VISION, AND THE MISSION, VISION AND VALUES OF THE BUSINESS UNIT

1 Document Mission of the Business Unit of which this Enterprise Business Entity is a part.

1 Document Vision of the Business Unit of which this Enterprise Business Entity is a part.

2 Document Values of the Business Unit of which this Enterprise Business Entity is a part.

3 Document Enterprise Integration Vision of the Enterprise Business Entity.

4 How will the proposed enterprise integration system improve the company's responsiveness to customer requests?

5 For this Enterprise Business Entity, what is the Business Unit vision relative to:

- **a** Quality?
- **b** Flexibility?
- **c** Customer Service?
- **d** Automation and Information Systems?
- **e** Role of the Manager and the Management Organization?
- **f** Maintenance?
- **g** Etc.

IV. COMPANY MANAGEMENT OBJECTIVES AND GOALS

6 What are the company's management objectives and goals in relation to the implementation of an Enterprise Integration Master Plan for the chosen Enterprise Business Entity?

- **a** In terms of the Enterprise Business Entity's return on its overall total capital investment?
- **b** In terms of the capital investment in the enterprise integration system itself?
- **c** In terms of other benefit areas such as increased productivity, enhanced quality, greater flexibility, quality of working life for personnel, environmental impact, etc.?
- **d** How is the proposed enterprise integration program proposal expected to enhance the attainment of any and all of the above objectives and goals?

ATTACHMENT 2-I (continued).

7 How does company management expect the above economic returns to be achieved?

a Via productivity increase?
- i In percent of total return.
- ii In terms of percent productivity increase.
- iii Through what means will this goal be attained?

b Via energy savings
- i. In percent of total return.
- iv In terms of percent productivity increase.
- v Through what means will this goal be attained?

c Via quality increases.
- ii. In percent of total return.
- vi In terms of percent productivity increase.
- vii Through what means will this goal be attained?

d Via raw material savings.
- iii. In percent of total return.
- viii In terms of percent productivity increase.
- ix Through what means will this goal be attained?

e Via personnel cost savings.
- iv. In percent of total return.
- x In terms of percent productivity increase.
- xi Through what means will this goal be attained?

f Via improved maintenance methods.
- v. In percent of total return.
- xii In terms of percent productivity increase.

V. STRATEGIES

8 Document the Business Unit's strategy or strategies.

1 Document the Enterprise Business Entity's strategy or strategies.

2 Document the reasons for any difference between Items 1 and 2 above.

ATTACHMENT 2-I (continued).

VI. BUSINESS PLANS
Document the Business Plans developed to meet the strategies identified in Item II above.

VII. CRITICAL SUCCESS FACTORS

9 Document the Enterprise Business Unit's critical success factors particularly those that impact the Enterprise Business Entity and the proposed Enterprise Integration Program Proposal.

10 How is the proposed Enterprise Integration Program Proposal expected to specifically impact the attainment of the critical success factors of the Enterprise Integration Business Unit?

11 List the critical success factors for this Enterprise Business Entity, the units of measure used for evaluating their success, and the level expected for success in terms of the following tabular form.

12 List the objectives of this Enterprise Business Entity, including quantifiable measures

13 List the goals of this Enterprise Business Entity, including quantifiable measures and time lines

ATTACHMENT 2-11

SUMMARY OF PLANNING STEP 2
DOCUMENT PROGRAM & ENTITY GOALS

Define:

- Program Ownership of Business Entity
- Business Measurements of Program
- Objectives, Strategies and Goals
- Program Business Plan
- Program Critical Success Factors

Resources:

- Previous Step Documentation
- Business Critical Success Factors
- Business Objectives, Strategies and Goals
- Enterprise Integration Entity Business Plans

3. Affirm the TO-BE Business Process and Manufacturing Policies

3.1 *Introduction*

Before the Master Plan progresses too far, it is important that the business process and manufacturing policies prepared by the Steering Committee for the Enterprise Business Entity be documented, complete and without contradictions or ambiguities. It is also important to be sure that the developing Master Plan stays totally consistent with these policies throughout the master planning cycle. Therefore, periodic review of the policies should be done through the planning cycle. Where necessary these policies should be challenged and changed via the Steering Committee as the need arises.

The business process and manufacturing policies to be affirmed are those of the defined Enterprise Business Entity, either preexisting or determined by the Sponsor and the Steering Committee as part of the preliminary work carried out prior to initiating the master planning activity as discussed in Chapter 2. As noted above, the purpose of the work discussed here is to document and review the policies for consistency and overall applicability before the Master Plan development begins and see that they are reviewed again periodically as the TO-BE details of the Master Plan develop.

It must be emphasized that the Enterprise Integration Planning Team should not attempt to make major modifications to the Enterprise Business Entity's manufacturing policies as presented to them without reviewing and seeking approval from the Steering Committee. Normally the Planning Team is neither commissioned nor qualified to make policy decisions. However, they must review them for any inconsistencies, duplications, ambiguities, missed topics, or conflicts as a result of the future vision. Changes to the policies should be recommended to the Steering Committee or other higher authority for ratification.

The purpose of affirming the TO-BE business process and manufacturing policies is to ensure that these manufacturing policies are aligned with other policy areas in the enterprise for the selected Enterprise Business Entity. Without a supportive policy infrastructure, business process and manufacturing policies will be difficult to carry out.

As was pictured in Figures 2-2 and 2-3, the architecture diagrams show that the work of the development of the task list to be carried out by the enterprise integration system proceeds from the Mission, Vision and Values work discussed in Chapter 2. It continues through the development of the Operational Policies of the company to a set of Enterprise Functional Requirements and finally to the Tasks necessary to fulfill the requirements listed. The Operational Policies are those needed to enable the achievement of the Mission, Vision and Values and their associated Objectives, Strategies, Goals, Plans and Critical Success Factors. The Requirements permit the enforcement of these Policies. As noted in Figure 2-3, each step in this development will involve the addition of external information to supplement the basic material supplied by management in its earlier pronouncements. The Steering Committee must, therefore, assure that their development of the Operational Policies ensures a complete list while incorporating the direction given by the Sponsor and other upper management through their articulation of the Mission, Vision and Values, etc. of the company.

Figure 3-1 shows how the Enterprise Business Entity goals and objectives map into a number of enterprise policies. It also shows that the policies must be cross-linked to all other enterprise policies. They must also be consistent and support the business process and manufacturing policies. Note that information policies exist in all bubbles. Note that the term “Business Processes” as used in Figure 3-1 and in other discussions is listed as “Information Tasks” in the Purdue Enterprise Reference Architecture and Methodology.

3.2 *Types and Places of Policies*

Business Processes are the operations involved in the management and direction of the company including Sales, Marketing, Engineering, etc. In other words, all of those tasks which would be included on the Information side of the Purdue Enterprise Reference Architecture. The policies involved here, thus relate to all those needed to establish and carry out the information-type functions. Manufacturing policies then refer to all of those needed to establish and carry out the manufacturing functions or the customer product and services functions of the company.

Figure 3-2 then shows that the manufacturing policies are linked into the lower manufacturing architectures described in the Purdue Enterprise Reference Architecture, consisting of the human and organizational, manufacturing equipment and information systems architectures.

As was noted in Chapter 2, each level of management in the company has its own set of strategies, goals and critical success factors based upon those of the management level above as well as their own particular function in the company. Figure 3-3 expands these concepts to show that a policy as presented by one level of management becomes a strategy for the one immediately below. As this figure indicates a particular strategy of the company such as S3 can produce several policies affecting the next lower level (Division of the Company). Policy P3 is followed here and results in Division Strategy S3-3'. Policy P3' has major effect on Strategy S3-2' of a Department which then produces Policy P2'', etc.

At the top of the organization strategies/policies are broad and deal with the mission, purpose, thrust, long-range objectives and program strategies. The major difference comes at the lower level of the organization where policies will deal with rules and procedures and operating plans, i.e., guides to carrying out action. Therefore, depending on the size of the Enterprise Business Entity the policies provided by management may be very broad or specific. If the policies are broad, the Steering Committee and Planning Team may follow the development of the strategy/policy stream down through the organization. In doing so, they will to expand these broad policies to an appropriate level of detail to form the operating policies at the lower level and insure that the TO-BE vision is consistent and complete.

Thus Figure 3-3 illustrated how strategies at one level evolve into policies at the next as they propagate down through the various organizational levels. This figure shows that on each planning level (for each policy issue) there may be several alternative strategies considered to meet specific goals and objectives. Then through a decision methodology, one strategy/policy is selected from the alternatives which when selected become the policy for the next level below. As shown, this process will continue down through to the operational level. At the lowest level, the policies are the rules and procedures for operating the manufacturing facility.

In order to completely cover the enterprise tasks to be considered in the Master Plan, all of the strategies/policies involved must be considered to be sure that the overall Requirements and the resulting task list is complete.

3.3 *Checklist and Summary*

Figure 3-4 shows the overall task of this Chapter as expressed by the IDEF-like figure we have previously adopted. Figure 3-5 shows the relationship of the work to the rest of the master planning process. Attachments 3-I and 3-II present a checklist for review of the progress of this Chapter's tasks as the work proceeds and a summary of the work required.

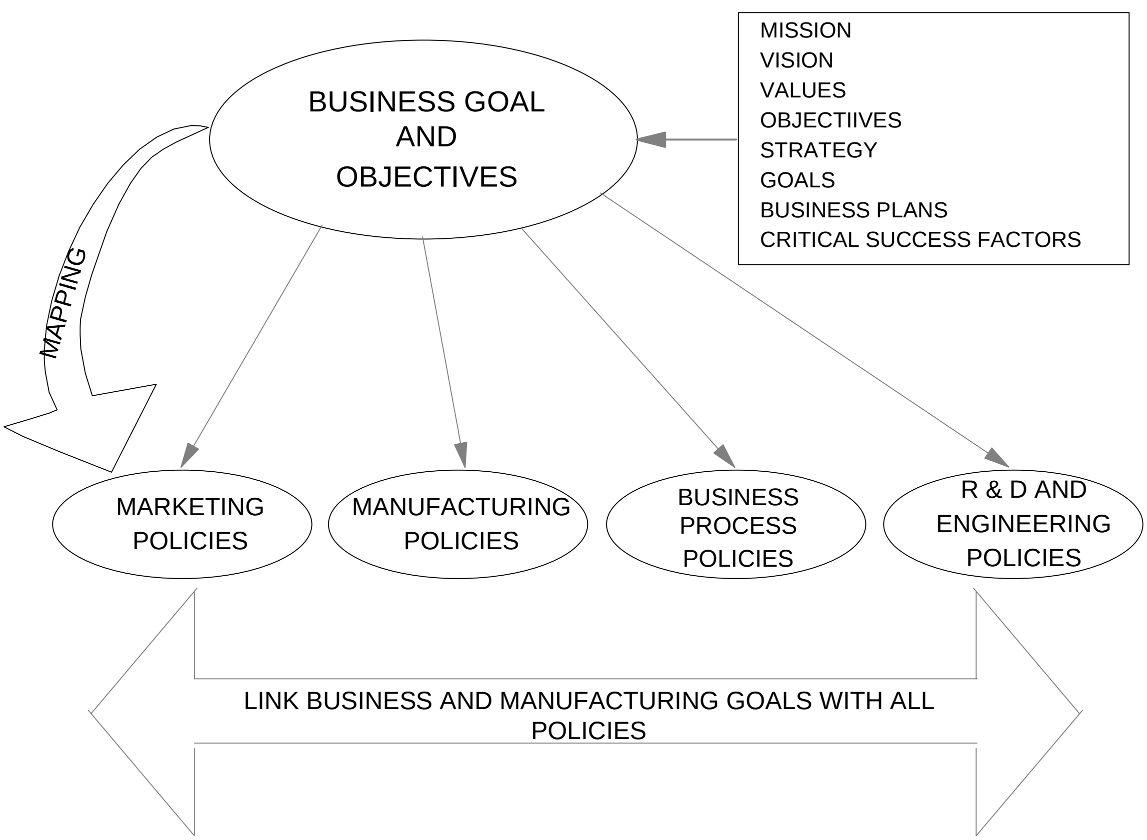

FIGURE 3-1 – HANDBOOK ON MASTER PLANNING LINKS BUSINESS OBJECTIVES WITH POLICIES

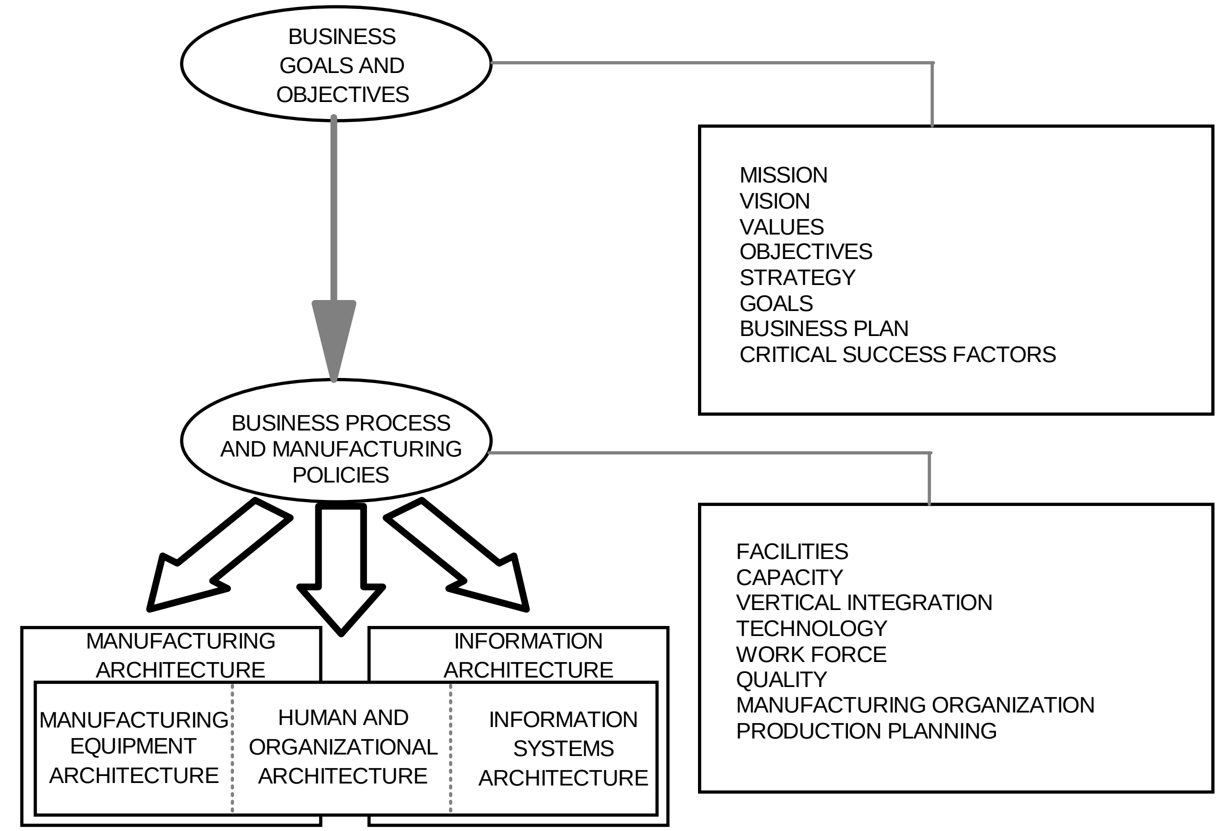

FIGURE 3-2 - PURDUE ENTERPRISE REFERENCE ARCHITECTURE MAPPING POLICIES TO RESOURCES

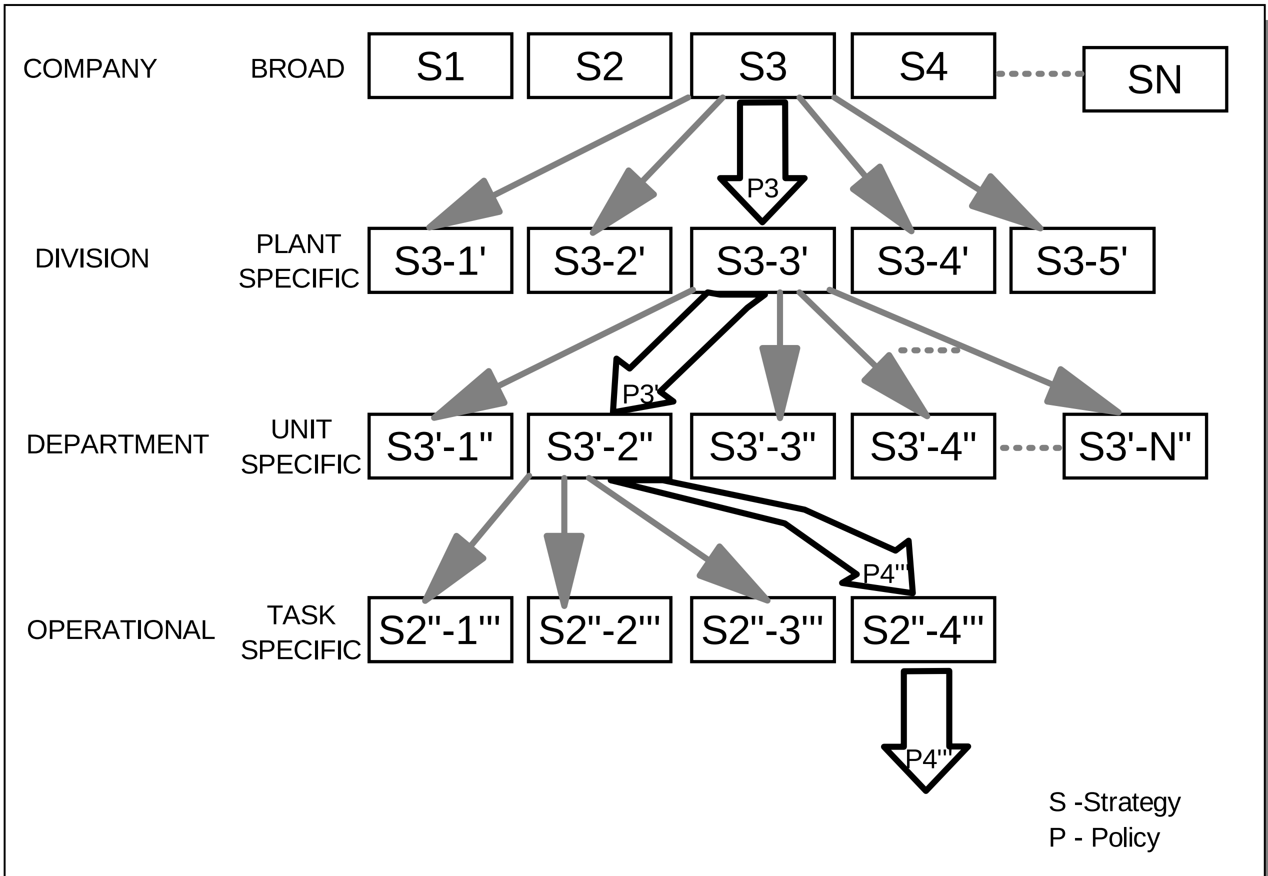

FIGURE 3-3 - STRATEGIES VS. POLICIES

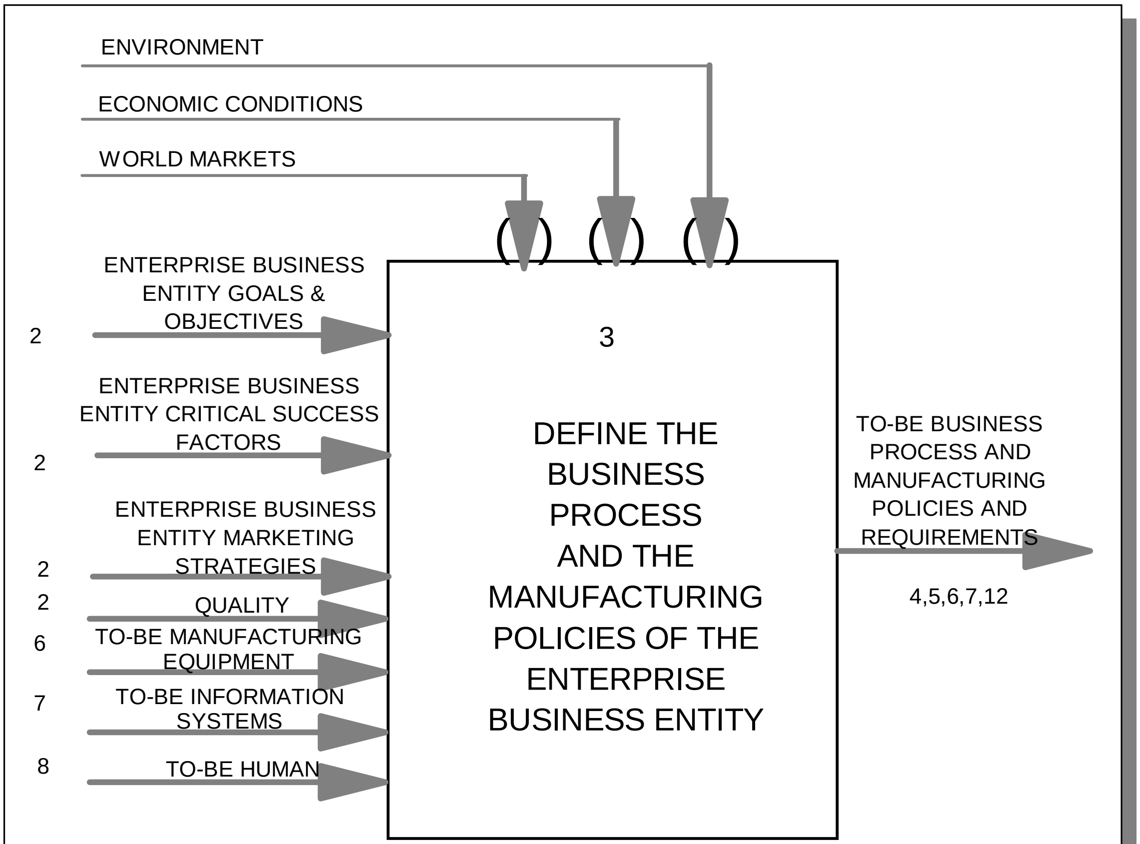

FIGURE 3-4 THE TRANSFORMATION TASK OF CHAPTER 3 -- AFFIRM TO-BE BUSINESS PROCESS AND MANUFACTURING POLICIES

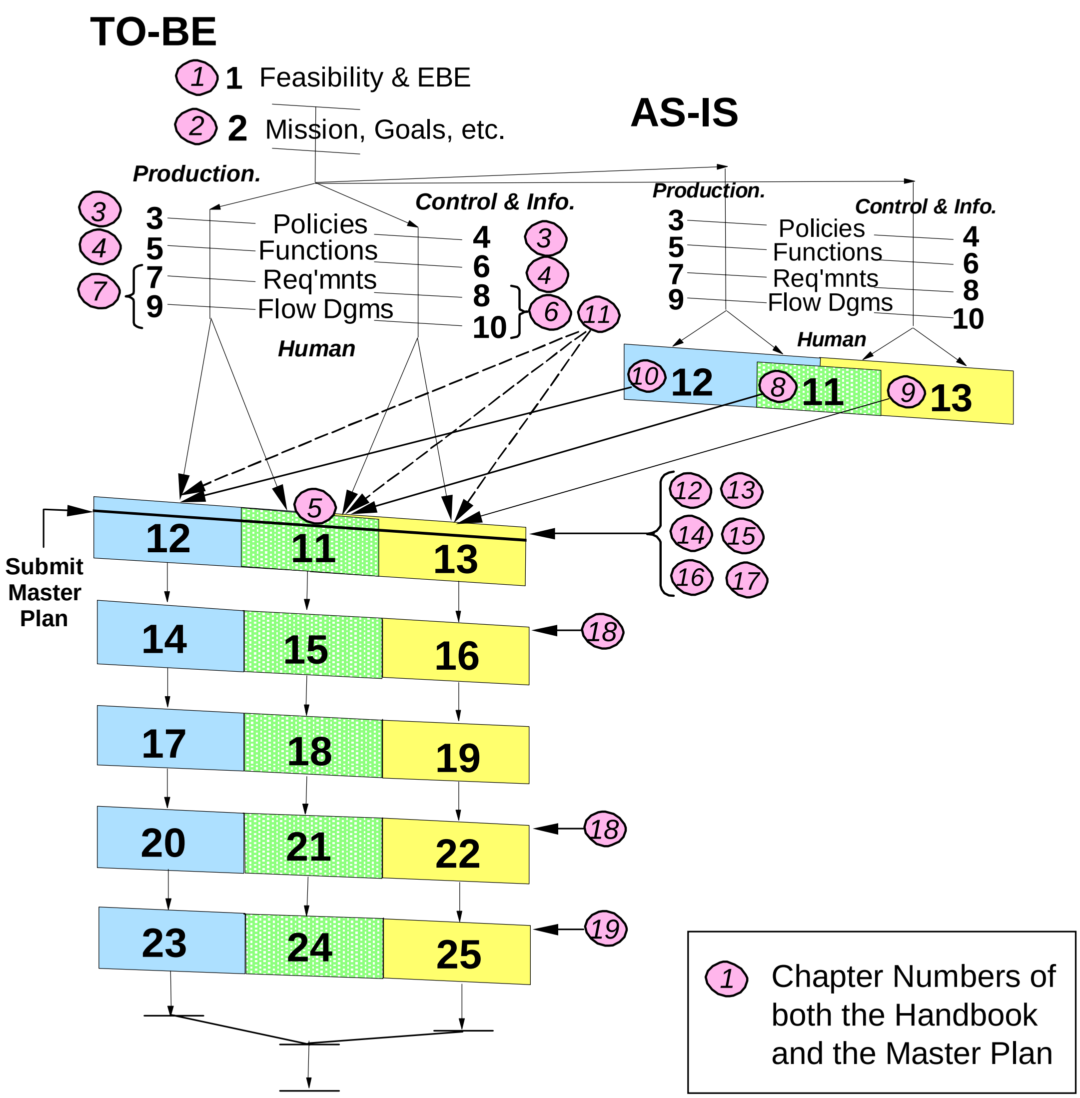

FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

3.4 *Conduct of the Review*

As noted in Figure 3-1, this review is to affirm the consistency and correctness of the business process and manufacturing policies already expressed by the Steering Committee and other management of the Enterprise Business Entity when compared with the Enterprise Business Entity's goals and objectives, critical success factors, and marketing and manufacturing strategies. Any discrepancies found between the proposed policies and the above listed goals and objectives, etc., should be called to the attention of the Steering Committee for modification as stated repeatedly above.

Likewise, it is important at this point to show that these same business process and manufacturing policies are also consistent with the already expressed TO-BE (Manufacturing Equipment, Information Systems and Human and Organizational Architecture) requirements. As before any discrepancies, which cannot be resolved through adjustment of the findings of the earlier chapters, should again be returned to the Steering Committee for clarification and adjustment.

The business process and manufacturing policies as finally collected and published should address how the Enterprise Business Entity's goals and objectives, critical success factors, and manufacturing strategies can be converted into directives of how to operate the plant to achieve the goals for the Enterprise Business Entity and the company.

In making the overall review, it may be helpful to the Enterprise Integration Planning Team to check the proposed policies against a functional task listing for the business process and manufacturing such as that of Appendix AI [81]. This can serve to assure the Team that all potentially critical points have been covered. This question of manufacturing function vs. policy should be considered for each function of each functional architecture, i.e. both information and manufacturing.

The Enterprise Integration Planning Team itself is best qualified to carry out this review since they are the one group which is conversant with all aspects of the proposed enterprise integration system. They are best qualified to note any discrepancies, etc., which may occur between the several documents already produced for inclusion in the Master Plan.

3.5 *Review Outputs*

The outputs from this activity are provided at appropriate levels of detail during the planning cycle: 1) early in the planning cycle to give broad and clear direction to the Planning Team, 2) a review after the TO-BE architectures and transition plans are completed to insure the policies link appropriately with the technology and the business goals and objectives, and 3) in a final report endorsed by the Steering Committee.

The final output of this review should be that set of Human Resource, Information and Manufacturing Policies as approved by the Steering Committee that converts the Enterprise Business Entity's goals and objectives, critical success factors, and marketing and manufacturing strategies into a set of procedures that make clear how the plant will be built and operated to achieve the goals.

The early results will affect the TO-BE Manufacturing Equipment, Information Systems, and Human and Organizational Architectures. Policies will vitally affect the transition plan as well and they will particularly affect the Information Systems Architecture. The former are important because of the iteration which may be necessary to achieve overall consistency. The latter are important because the manufacturing policies will determine to a large extent how the plant will be operated and controlled.

3.6 *Collection and Documentation of Policies*

Tables 3-I and 3-II present a listing of those areas of the manufacturing endeavor for which manufacturing policies are normally written. The listings here are at a high level but show the broad coverage of company concerns that must be addressed.

The business process and manufacturing policies as finally published should thus determine how the Enterprise Business Entity's goals and objectives, critical success factors, and manufacturing strategies can be converted into directives that determine how the plant will be operated

In making the overall policy analysis, it may be helpful to the Enterprise Integration Steering Committee to check the proposed policies against a functional task listing for manufacturing such as that of Table 3-III [81]. This can serve to assure the Team that all potentially critical points have been covered. This question of manufacturing function vs. policy should be considered for each function of each major operation of the company, i.e. both information and manufacturing functions.

The Enterprise Integration Planning Team itself is best qualified to carry out this review since they are the one group which is conversant with all aspects of the proposed enterprise integration system. They are best qualified to note any discrepancies, etc., which may occur between the several documents already produced for inclusion in the Master Plan.

TABLE 3-I

AREAS WHICH MANUFACTURING POLICIES SHOULD IMPACT

1. The manufacturing mission
2. Manufacturing goals ("Low Cost Producer," "Quality is Job 1," etc.)
3. Safety and security
4. Quality aspects (product and process operation)
5. Energy and other utilities use and conservation
6. Inventory
7. Maintenance
8. Scheduling priorities
9. Customer relations (special orders, priorities, etc.)
10. Performance measurement
11. Buildings and grounds (appearance, cleanliness, etc.)
12. Environment
13. Waste and rework
14. Human resources (organization, skills, reward systems)
15. Technology (manufacturing, automation, control and information)
16. Product development
17. Suppliers and partnerships
18. Safety and health
19. Change management

TABLE 3-II
BROAD MANUFACTURING POLICY ISSUES

I. FACILITIES
   1. Location
   2. Size

II. CAPACITY
   1. Size
   2. Yield

III. TECHNOLOGY
   1. Choice of manufacturing processes
   2. Control and information systems
   3. Automation
   4. Licensing
   5. Use of R & D
   6. Environmental

IV. VERTICAL INTEGRATION OF PRODUCTS

V. WORK FORCE
   1. Size
   2. Skill level
   3. Work concepts
   4. Training
   5. Health care

VI. QUALITY
   1. Product specification
   2. Delivery systems
   3. Level of quality control
   4. Manufacturing equipment performance

VII. PRODUCTION/MATERIAL PLANNING

VIII. ORGANIZATION
   1. Structure
   2. Culture and beliefs
   3. Management of technology
   4. Support functions

IX. PLANT INTEGRATION WITH OTHER POLICY AREAS
   1. Marketing and Sales
   2. Financial
   3. Engineering
   4. R&D
   5. Key suppliers
   6. Joint ventures

TABLE 3-III

MANUFACTURING FUNCTION VS. POLICY ANALYSIS

PURDUE REF.MODEL	APPLICABILITY OF PROPOSED POLICIES							
MANUFAC. FUNCTIONS	1	2	3	4	5	6	●●●●●●●●●●●●●●●●●●●●	N
ORDER PROCESSING								
forecasting								
orders								
order acceptance								
order entry								
PRODUCTION SCHED.								
process orders								
forecasting								
scheduling								
inventory								
PRODUCTION CONTROL								
engineering								
maintenance								
operations ctl.								
operations plans								
RAW MAT'L. & ENERGY								
requirement ctl.								
inventory levels								
incoming ctl.								
routing								
inventory report								
movement ctl.								
meas. validation								
PROCUREMENT								
order placement								
process requests								
cost control								

TABLE 3-III (continued)

PURDUE REF. MODEL MFG. FUNCTIONS	APPLICABILITY OF PROPOSED POLICIES						
	1	2	3	4	5	6 ●●●●●●●●●●●●●●●●●●●●	N
QUALITY ASSURANCE							
stds. & methods							
raw materials							
product evaluat.							
class. & certif.							
QA meas. valida.							
lab analysis							
process cap.							
PRODUCT INVENTORY							
sup. inventory							
loss control							
inven.reporting							
shipping							
product routing							
product movement							
COST ACCOUNTING							
cost vs. budget							
accounts payable							
accounts receive							
production costs							
PRODUCT SHIPPING							
shipment sched.							
shipping costs							
shipment confirm							
invoicing							
release shipment							
shipping docum.							

ATTACHMENT 3-I

CHECKLIST FOR TO-BE BUSINESS PROCESS AND MANUFACTURING POLICIES

It is noted that the term "business process and manufacturing policies" as commonly used in industry, refers to all policies that affect the operation of the manufacturing facility involved not just those that pertain only to manufacturing equipment and the manufacturing processes themselves, although these latter are, of course included.

Thus, in terms of the Purdue Enterprise Reference Architecture, all policies which affect the proposed Enterprise Integration system (including both Functional Networks, and all three Implementation Architectures) must be included here. (See Figure 3-2.)

I. DISCOVERY AND DOCUMENTATION OF COMPANY POLICIES RELATED TO THE MANUFACTURING FACILITY (OR FACILITIES)

A. Use the listing of Areas of Concern given in Table 3-I to form a basis for collecting and listing all existing company policies which directly impact the manufacturing facility(ies) to be involved in the proposed master planning effort.

B. Use the listing of Table 3-II to help define the subjects covered under each area listed in Table 3-I.

C. Also use the listing of Table 3-III (as supplemented by the material of Appendix A as derived from the Purdue Reference Model for CIM) [81] to be sure that all necessary functions of manufacturing facility(ies) are covered by policies where needed.

II. ANALYSIS OF THE COMPANY'S MANUFACTURING POLICIES

Answer the following questions concerning each of those policies collected under Item I above, both individually and in relation to each of the others:

A. Ambiguities in Manufacturing Policies

1. Are there ambiguities in the wording of the policy?
2. Will these ambiguities affect the development of the Master Plan and its implementation in the Enterprise Integration Program Proposal?
3. If so, what is the suggested rewording which should be called to the attention of the Steering Committee and higher authority for approval or amendment to correct the policy's lack of clarity?

B. Conflicts Between Policies

1. Does the wording of the policy in question conflict directly or indirectly with that of any other of the policies noted?
2. What is the suggested change of wording of one or both of the offending policies that should be called to the attention of the Steering Committee and higher authority for approval or amendment to correct the wording conflict(s)?

ATTACHMENT 3-I (continued).

C. Restrictions Imposed by Policies

1. Does the policy impose restrictions on the expected operations of the enterprise integration system?
2. Will these restrictions impair the attainment of the goals, objectives and/or critical success factors of the Enterprise Business Entity?
3. If so, are these restrictions mandated by government laws or regulations?
4. If so, should the afflicted goals, objectives and/or critical success factors be changed?
5. If not, can or should the policy be changed (eased or canceled) to release the operational constraint on the enterprise integration system operations?
6. Has this been called to the attention of the Steering Committee and higher authority for resolution?

D. Potential Missing Policies

1. Did the analysis versus the list of functions of Table 3-III uncover any areas where the existence of further policies would enhance the operation of the proposed enterprise integration system?
2. Have these been called to the attention of the Steering Committee and higher authority for consideration?

ATTACHMENT 3-II

SUMMARY OF PLANNING STEP 3
"TO-BE" PROCESS / MANUFACTURING POLICIES

Define:

- Business Process Policies
- Manufacturing Policies
- Corporate Policies
- Regulatory Policies
- Policies of Interfacing External Entities

Resources:

- Previous Step Documentation
- Enterprise Integration Entity Marketing Strategies
- Business Objectives, Strategies and Goals
- Enterprise Integration Entity Business Plan

4. Identify Significant Initiatives and Opportunities

4.1 *Introduction*

Initiation of Master Planning for the Enterprise Business Entity offers an opportunity for the Enterprise Integration Planning Team to take a fresh look at several potential sources of economic and technological benefits from the forthcoming program, that might not be routinely considered in the planning work described in the other chapters of this manual. Some of these are:

1. Detailed comparison of the subject Enterprise Business Entity and its processes against the best managed and best operated of its peers. This allows the Enterprise Integration Planning Team to assess potential improvements that might be made to bring the Enterprise Business Entity onto a par with these best examples. This is known as competitive benchmarking.

2. Comparison of the level of technology and its potential payback of the manufacturing and information system against the best available technologies. Does the potential increased gain from the use of these technologies merit consideration of replacement of the original equipment and processes with the new? This is known as technical or functional benchmarking.

3. The effect of the application of evolving technology to reduce costs and enhance benefits on potential expansion or improvement projects which may have been dismissed earlier for excessive costs over benefits using the then existing technology. Does new technology now validate previously rejected proposals?

4. The effect of evolving technology to render possible new potential projects not technically feasible earlier.

5. The possibility that several small scattered projects might become feasible and economically attractive if "integrated" within the program to be proposed.

6. The potential of new or improved tools (both design and operational) to reduce development and/or operational costs to increase the economic feasibility of potential projects.

7. What developing standards will lead to enhanced portability of proposed hardware and software components of the system - again with both developmental and operational economic benefits?

The other chapters of this Guide have outlined the collection of information and the required planning to achieve the Master Plan for the Enterprise Business Entity through all of the generally obvious paths. The object of this chapter is to be sure that:

1. "All bases are covered";
2. That all reasonable ideas get a hearing;
3. That the suggestions made by the operating personnel for plant improvement are heard;
4. That someone has kept abreast of new processes, new process equipment, new information and control technology, etc., in the field of the work of the subject plant; and
5. That all of this information gets evaluated in the course of the development of the Master Plan.

One must truly assure that the Master Plan and the accompanying Enterprise Integration Implementation Proposal being developed for the Enterprise Business Entity is the best possible and that any deficiencies will not be caused by any lack of attention to proffered ideas.

Figure 4-1 shows a diagram describing the assessment and evaluation to be carried out under the heading of this chapter. Figure 4-2 also helps to explain the place of this topic in the overall project.

It is also important to keep in mind the following questions when making the assessments and evaluations discussed here:

1. Which business activities of the Enterprise Business Entity have the greatest potential to contribute to the business objectives and critical success factors of the entity.

2. Likewise which of the manufacturing processes have the greatest potential to contribute to the business objective and critical success factors of the Enterprise Business Entity.

4.2 *Cooperation with Other Planning Tasks*

The enterprise integration planning tasks encompassed by Chapters 7, "TO-BE Information Systems Architecture"; and 12, "Transition Path from AS-IS to TO-BE"; of this Guide to Master Planning are both involved in the investigation of and eventual selection of hardware, software, and systems components for the proposed enterprise integration system. Correspondingly, developments related to the manufacturing and the human relations and organizational areas are well covered under the work discussed in Chapters 5, "Document TO-BE Human and Organizational Functional Architecture" and 6, "Define TO-BE Manufacturing Functional Architecture."

Likewise Chapter 15, "Costs, Benefits, Risks" is involved to evaluate potential costs and benefits of each proposal made by the other chapters.

Thus an active interaction and cooperation between the members of the Enterprise Integration Planning Team taking part in the analysis discussed here and in each of the task areas above are vital to the development of a successful Enterprise Integration Project Program for the Enterprise Business Entity.

4.3 *Sources of Information*

Therefore, those carrying out the task outlined in this chapter will have, at least to some extent, the job or privilege of unearthing those ideas, some on the edge of practicality, that might not otherwise get considered and would therefore be lost to the project.

In addition to these, however, there are several important investigations that the Enterprise Integration Planning Team should include in their analysis which may not be directly discussed in the other chapters of this manual. The next several sections will discuss some of these.

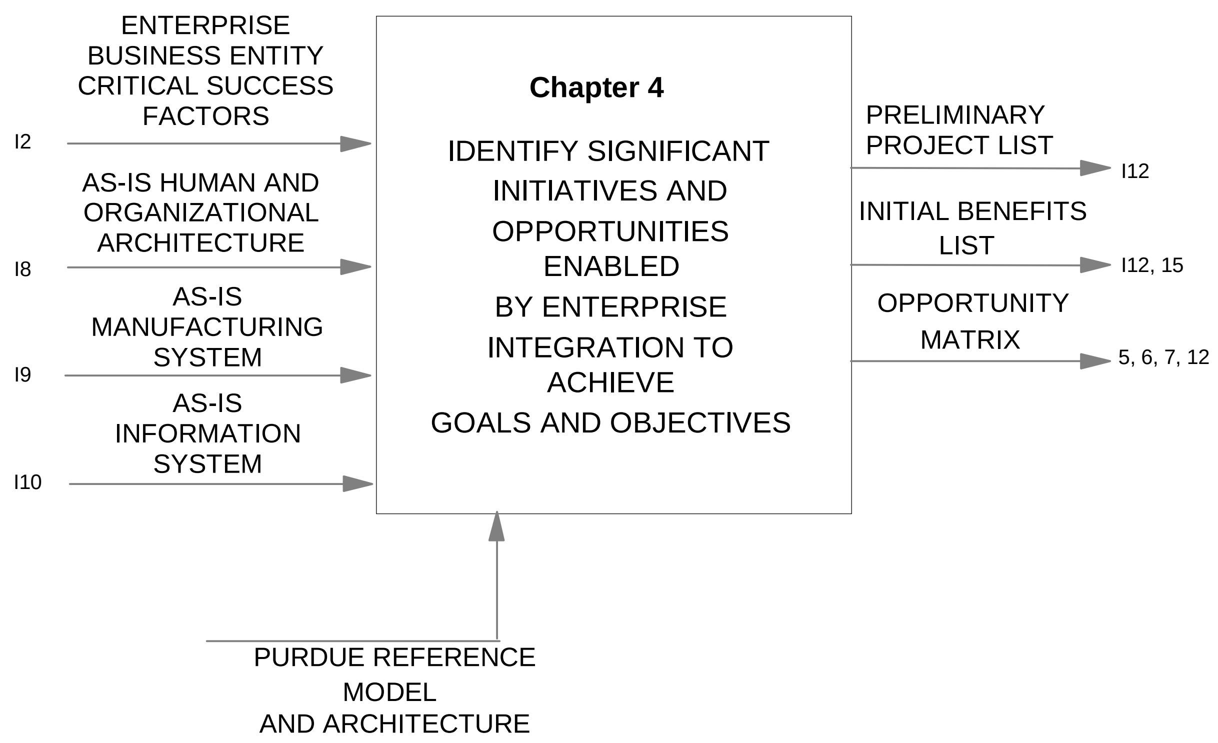

FIGURE 4-1 THE TRANSFORMATION TASK OF CHAPTER 4 -- IDENTIFY SIGNIFICANT INITIATIVES AND OPPORTUNITIES ENABLED BY ENTERPRISE INTEGRATION TO ACHIEVE GOALS AND OBJECTIVES

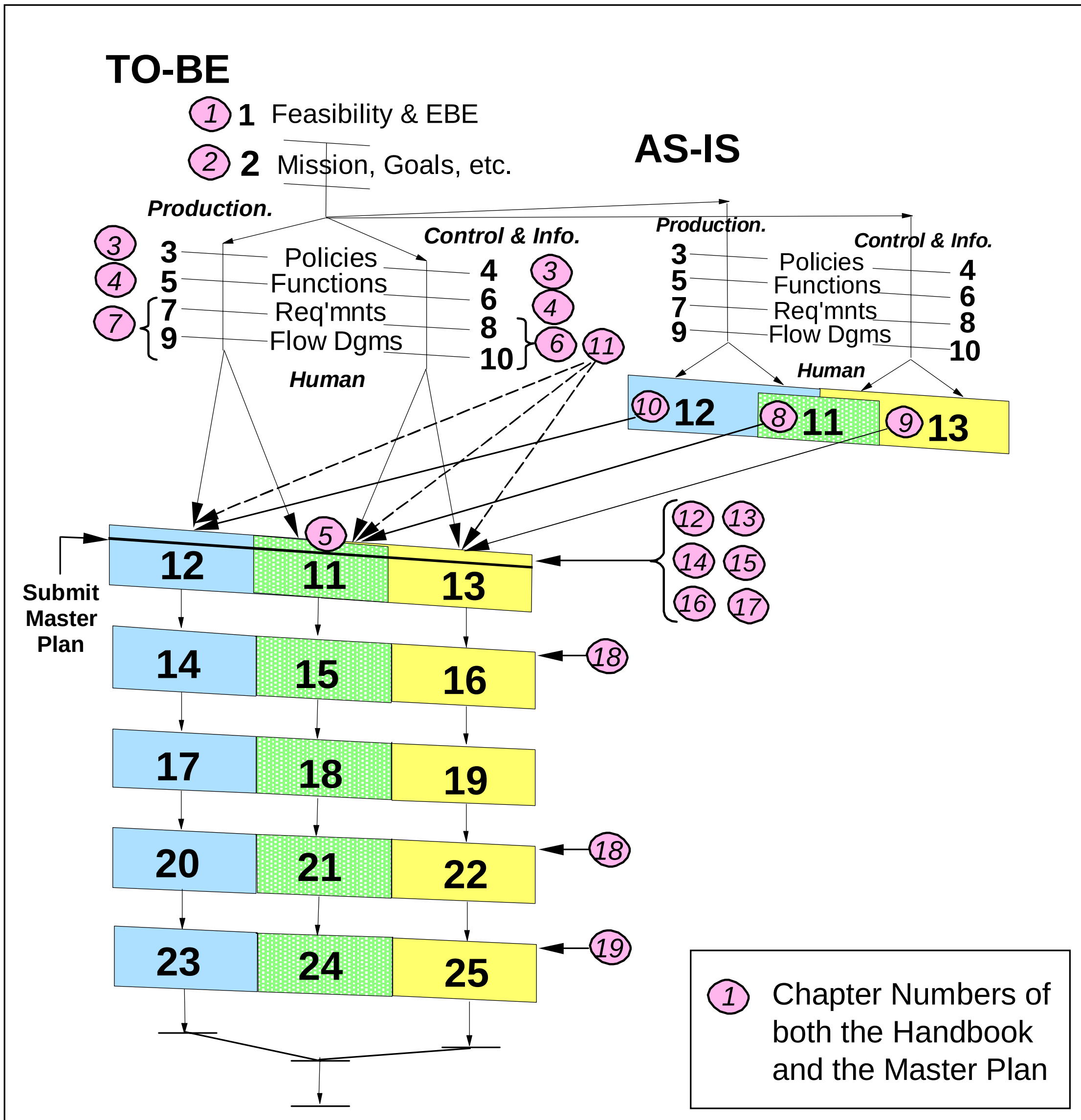

FIGURE 4-2 THE WORK OF CHAPTER 4 DEFINES BUSINESS AS SHOWED BY THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

CHAPTER 4 – Identify Opportunities

Program Opportunities Arising from the Assessment of Current Systems

An obvious candidate for the evaluation considered here is an assessment of the current performance of the system (the AS-IS) in the existing plant being considered for enterprise integration up-grading. If this is a new grass-roots project a corresponding study of an existing sister plant can be made. Some of the questions to be investigated are listed below:

1. System assessment in terms of the capabilities, performance, costs, etc., of all three architectures of the AS-IS system: Information Systems, Human and Organizational; and Manufacturing Equipment
   a. How satisfied are people with each of the current systems?
   b. How much does it cost to maintain each of these systems?
   c. Which of these systems are at the end of their life cycle?
   d. Which of these systems overlap with each other in supporting business activities?

   The Team needs to be careful in assessing the above questions that they do not carry out a complete analysis of the AS-IS except for the case where such analyses are showing exceptionally high potential returns. In other words is the gain potentially attainable from the effort worth assigning key people to a detailed analysis team.

2. Information quality assessment
   a. How good is the information that people use to make their decisions? How can it be improved?

3. Information retrieval assessment
   (How much time do people spend trying to find the information they need to do their job?)

4. Identify the enterprise integration impact of management "hot spots" and pet ideas such as:
   a. Picking a group of high return small projects to assure early success of the program.
   b. Giving special attention to management's favorite topics for potential political gain in selling the rest of the program. Must have high probability of success, otherwise highly counter-productive.

   In this activity (Item 4) the Enterprise Integration Planning Team must guard against becoming an implementation group particularly for a group of small, relatively unconnected projects rather than the overall integration of the activities of the Enterprise Business Entity and thus become side-tracked by the results of this particular activity.

The net result of the above will be a list of problems concerning various aspects of the existing or proposed Enterprise Business Entity. An excellent way of making a comparative evaluation of each of these is through a problem analysis form such as that of Figure 4-3. Note the emphasis here on developing the root cause of each problem uncovered and thus going a long way toward developing its solution.

CHAPTER 4 – Identify Opportunities

Benchmarking

Benchmarking is an important means of assessing one's capabilities or standing against one's peers or competitors. Benchmarking may be either competitive, i.e., performance comparisons with competitor companies in the same field; or technological, i.e., how up-to-date is this installation in its use of the latest, proven technology. This latter comparison can be made against a company in any field, not just those in one's own manufacturing area.

In the case we are considering here, an evaluation of industry norms in the areas of information, automation and computer technology would be very important. To illustrate this the next section discusses the development of the necessary information for a technological benchmarking study.

Keeping Abreast of Technological Developments

While several of the members of the Enterprise Integration Planning Team may be well versed in many of the ongoing trends of developments in electronics and computers, it is difficult for even several members of such a team as a group to have a thorough knowledge of just what is appearing, what will be available in the near future, and what is already established industry practice today.

Therefore an analysis of the status of the field and the availability of various promising products should be undertaken by the team. Some of the sources of information on these factors are:

1. Trade journals of the enterprise integration, industrial and process control, computers and communications fields

2. Trade shows of the same fields as above. Each of these trade shows also features a conference of papers describing recent developments and the latest examples of installation and implementation practices and results obtained.

3. Interviews with other practitioners in the enterprise integration field particularly individuals from user companies which are not commercial rivals of the Business Enterprise. That is, members of the steel industry, for example, are usually willing to trade installation experiences with companies of the paper or chemical industries, but not other steel companies. Such interviews have been particularly helpful, especially in terms of uncovering areas of risk or potential problem.

4. Presentation by the staffs of computer and communications hardware and software vendors and systems houses. Here one must be cautious of the obvious commercial bias of the speakers. A combination of this and the previous source (other users) is thus particularly valuable to the Enterprise Integration Planning Team.

5. Review of past literature as well as current topics to reveal past errors which should not be repeated. While such papers are much rarer than those expressing positive results, they do exist and should be sought out. The adage of history that, "He who does not know the errors of the past is doomed to repeat them," certainly works overtime in the industrial control field.

IDENTIFIER #	PROBLEM STRATEGY	ROOT CAUSE	POSSIBLE SOLUTION	SOLUTION VALUE	AFFECTED FUNCTION(S)	CAUSE FUNCTION
349	PRODUCT FORECASTS DON'T REFLECT CUSTOMER DEMAND	SALES ARE LOST BECAUSE PROD'S INVENTORY DOESN'T MATCH NEW CUSTOMER REQUESTS	CAPTURE CUSTOMER SALES INFO SOONER (TO INCLUDE PREVIOUS WEEK'S FIGURES)	REDUCE SALES LOSS BY 1/2 ($10 M)	FORECAST PRODUCT REQUIREMENTS	ENTER & CONTROL CUSTOMER ORDER
		END EFFORT				
		~ 5% SALES ($20 M)				

FIGURE 4-3 PROBLEM ANALYSIS FORM

4.4 *Method of Procedure*

After completing the evaluations of the potential initiatives and opportunities as described above the Enterprise Integration Planning Team must organize their findings for presentation to the Steering Committee and make a selection of projects to include in the Enterprise Integration Implementation Proposal to present to management. A suggested procedure to accomplish this might be as follows:

1. Create a preliminary enterprise integration opportunities list and make a preliminary ranking, identifying bases for choices

2. In future consideration of these ideas focus work around business activities and ideas with the greatest potential

3. In viewing opportunities from the AS-IS plant, form a "contract" between the Enterprise Integration Planning Team and the Sponsors/Steering Committee on the level of improvement the team will need to identify quick hitters, etc., and:

    a. Secure commitment by the Steering Committee and other management for a follow-on of Enterprise Integration Planning Team proposals.

    b. Obtain Steering Committee support for the forecast gains proposed by Enterprise Integration Planning Team. Should consult with Steering Committee prior to publication of the list to establish level of expectation agreed to by both groups. What improvement target should the Enterprise Integration Planning Team shoot for in their final plan?

    c. Demonstrate how some of the estimates of potential gains are made as shown in Table 4-1 and Figure 4-4

4. Provide a decision point for the Steering Committee to continue the planning effort based on a more detailed estimate of the Enterprise Integration potential

5. Analyze quick return from available data on preliminary program list noted above

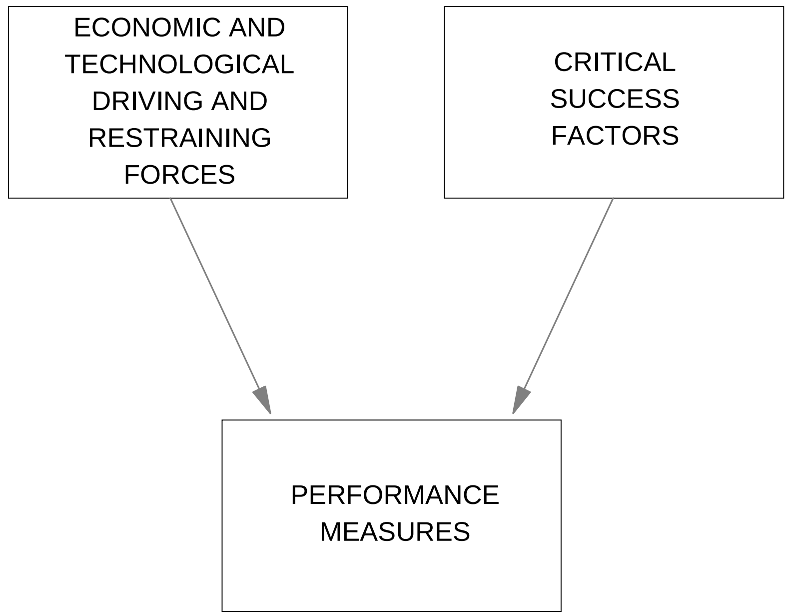

FIGURE 4-4 PERFORMANCE MEASURES ARE DEVELOPED FROM THE CRITICAL SUCCESS FACTORS AND ECONOMIC AND TECHNOLOGICAL DRIVING FORCES

TABLE 4-1

EXAMPLES OF SOME POTENTIAL PERFORMANCE MEASURES FROM ENTERPRISE INTEGRATION SYSTEM CAPABILITIES

PERFORMANCE MEASURE NAME	"AS-IS" LEVEL	TARGET LEVEL	IMPROVEMENT POTENTIAL
Customer Returns	30-40 Times Per Year	Reduce by 50-60%	Average
Employee Exposure to Product	10,000 Hrs/Yr in Packing	Minimal	High
Finish Goods Inventory	80 Million LBS	Reduce by 75%	Average
Frequency of Physical Inventory	12 to 16 Times Per Year	Reduce by 93%	High
Publicity and Media Awareness	High	Moderate	Average

4.5 *Analysis and Presentation of Results*

The final outputs of the work discussed in this chapter should be a list of opportunities which are enabled by the enterprise system to be proposed in the Master Plan. The following are some suggested methods for analyzing and presenting these opportunities in the Master Plan and in the Enterprise Integration Program Proposal.

VIII. Opportunity Matrices (A Tool)

- **1** Opportunities vs. critical success factors matrix (See Figures 4-5 and 4-6)
- **2** Opportunities vs. business activities (direct effect) (See Figures 4-7 [Acknowledgement 2] and 4-8)
- **3** Opportunities vs. business activities (propagation effect)
- **4** Opportunities vs. cost improvement.

IX. Problem analysis (a tool) (See Figure 4-2 and related discussion)

X. Summary matrices (Figures 4-9 to 4-12)

The matrix diagrams of Figures 4-5 and 6 give a visual comparison of the improvement potential possible from each opportunity uncovered. There would be a set of these drawings for each such case. Note that this diagram shows the <u>remaining</u> potential after the action considered has taken place. Thus in Figure 4-6 the new blocks are below and to the left of those of Figure 4-5. The gain achieved by this action has <u>removed</u> some of the potential available earlier.

The DuPont model (Figure 4-7) provides for a specific algorithm in chart form for assessing the potential economic return for a potential project, here an enterprise integration opportunity. Again this analysis would be carried out for each potential opportunity uncovered by the initiatives analysis discussed here.

Figure 4-8 is a simple graphical way to show the choice between several alternative solutions to a particular problem or opportunity.

The summary matrices of Figures 4-9 to 12 are again suggested ways by which the relative value of the several ideas for system improvement developed during this study may be summarized for consideration by management.

It is noted in passing that the evaluation techniques discussed here will also be valuable tools for the Preliminary Economic Analysis conducted under Chapter 1 and the Cost , Benefit, and Risk Analysis to be conducted under Chapter 15.

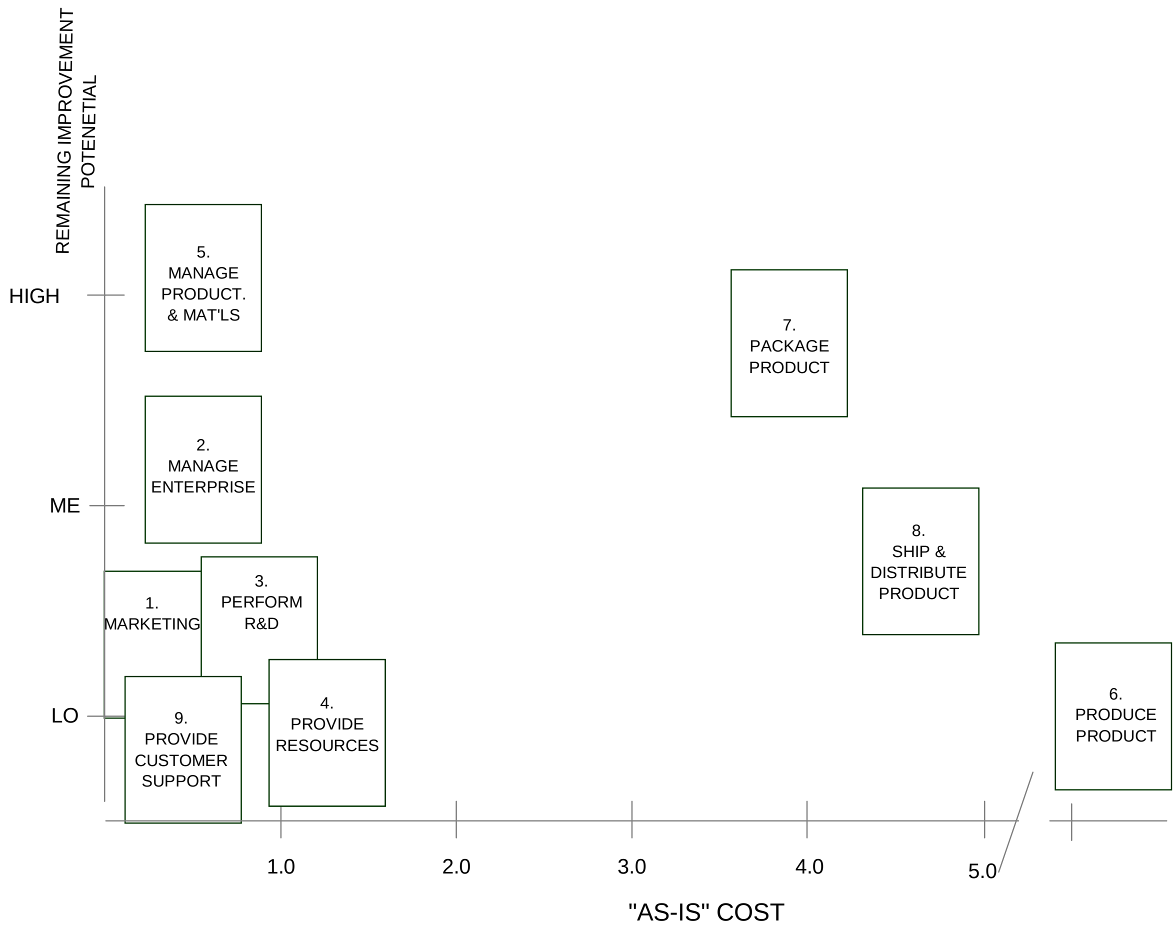

FIGURE 4-5
OPPORTUNITY MATRIX AS-IS COST

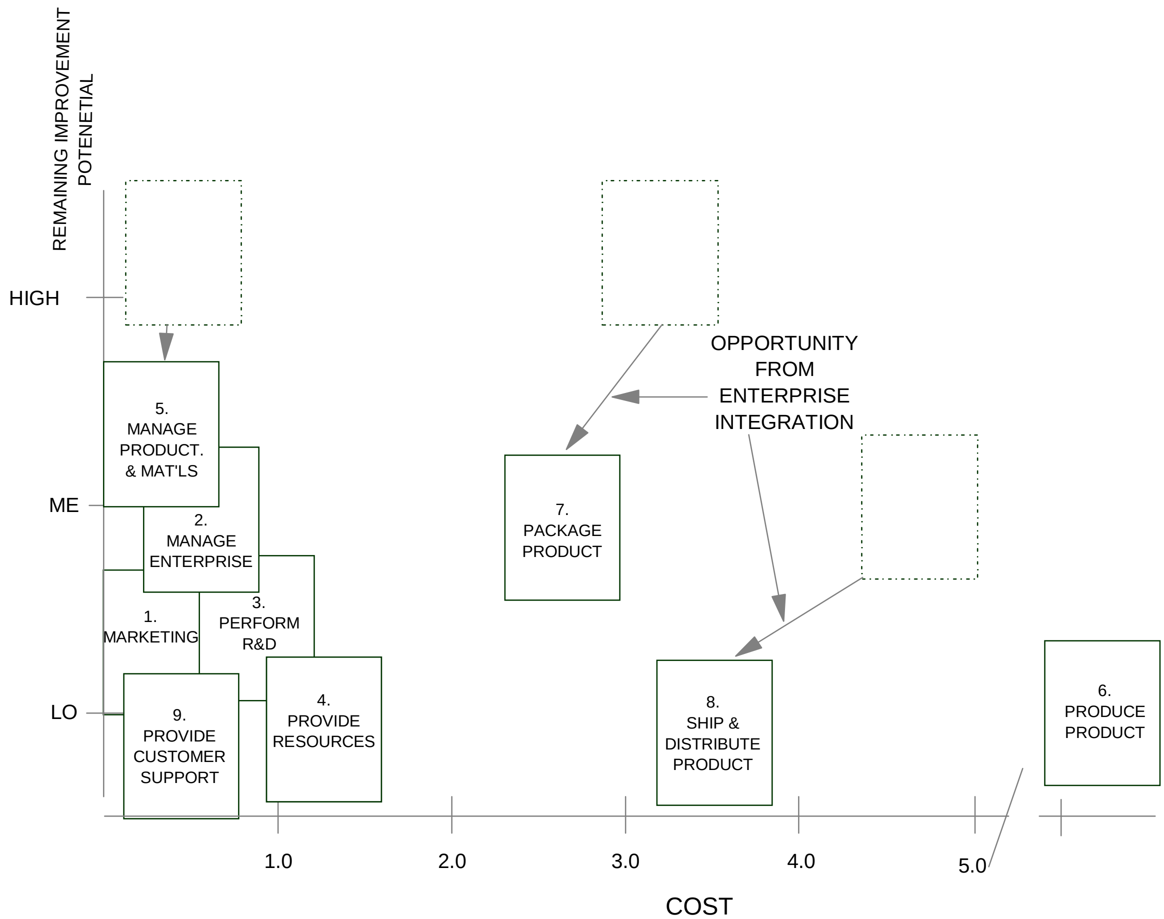

FIGURE 4-6
OPPORTUNITY MATRIX TO-BE

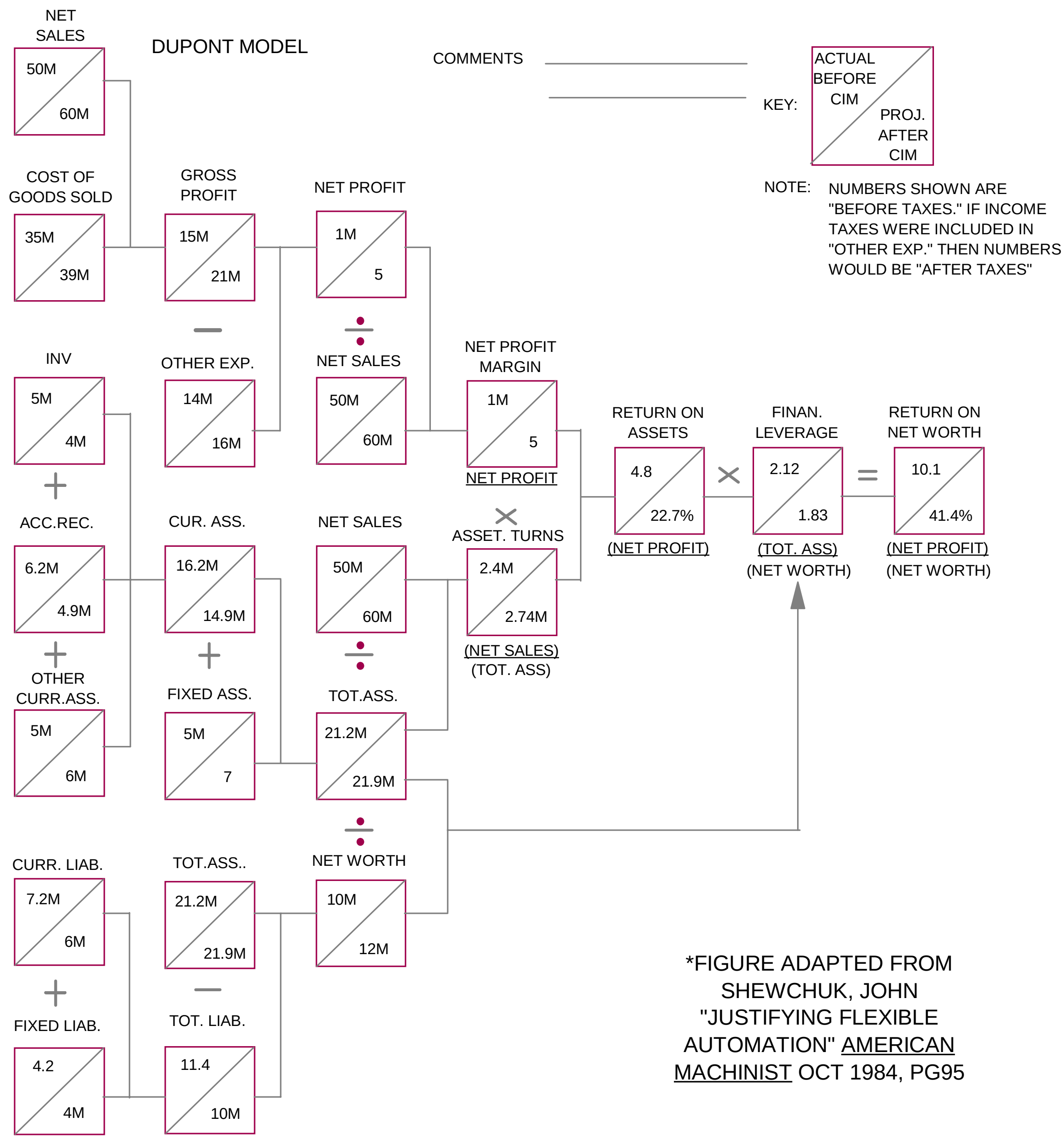

FIGURE 4-7
ENTERPRISE INTEGRATION TECHNOLOGY ASSESSMENT
AND FINANCIAL/SCOPING

PRIORITIZATION

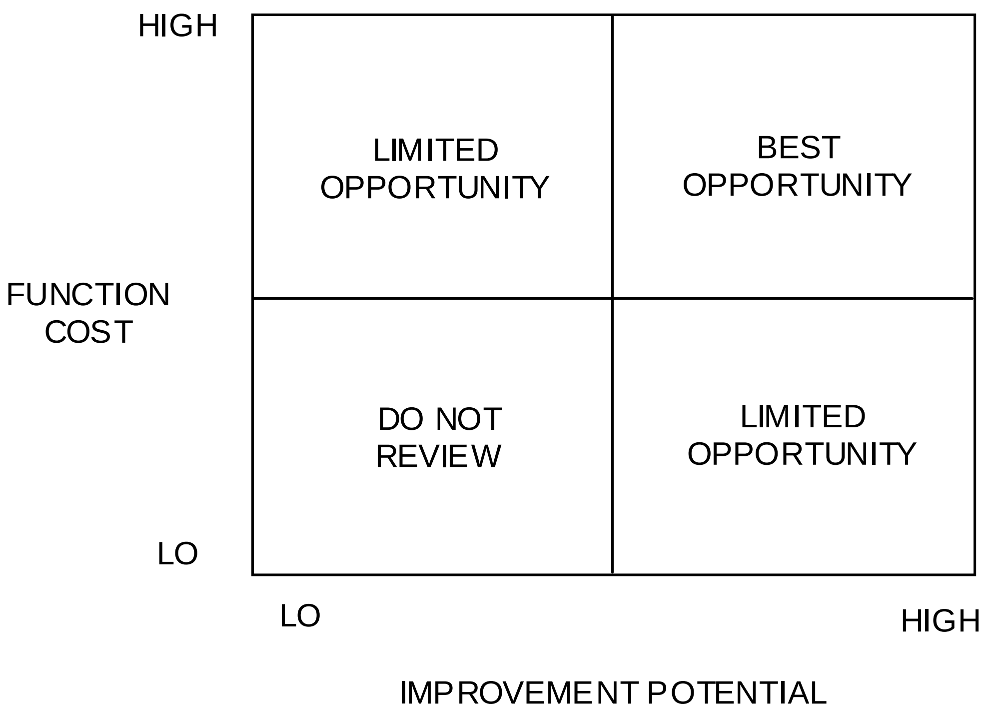

FIGURE 4-8
FUNCTION IMPROVEMENT POTENTIAL

4.6 *Some Potential Risks*

There are three major potential risks to the master planning effort and the resulting Enterprise Integration Program Proposal which may arise from the investigative task discussed in this chapter. These are:

1. The danger that the Enterprise Integration Planning Team members may get bogged-down in the details of the As-Is plant and of the potential technologies which might be applied in a possible problem solution. This could be detrimental to the overall planning task to which they were originally assigned.
2. The danger that the search for a group of short-term, high potential, quickly implementable, small projects to make a quick impression, will divert the group from the real task of finding the future high-return but probably larger and more long term projects which should form the bulk of the Master Plan findings and the Enterprise Integration Program Proposal.
3. That they may be enamored with the apparent potentials of new technologies or new, as yet untried, applications of existing technologies. They may then be tempted to recommend such for the proposed enterprise integration systems and thus put the resulting installations at a technological risk.

Obviously each of these risks must be avoided if possible or reduced to the minimum practical if risks are to be taken. Management should be made aware of the actual degree of risk involved.

In regard to Item 3 above the field of technology of computers and control systems is one of almost continual innovation and new development. At the same time it is also a field which is often fueled with “hoopla,” exaggerated claims, over-advertising, etc. Thus it is very difficult to keep up with the latest developments in order to know which of these emerging technologies are likely to be fully developed and commercially successful; and to know when it would be “safe” to choose such a technology for application in the proposed Enterprise Integration Project Program for the Enterprise Business Entity.

Further, the ever increasing complexity of proposed systems, particularly in Enterprise Integration, puts severe strains on the technology of software preparation to assure that no “fatal” programming errors (often called bugs) exist in the software for the system and that other such errors are kept to an absolute minimum.

The only truly safe path to follow is that of using only field proven components (computers and communications) and software programs. Attachment 4-I presents a checklist of questions concerning the sue of new technology in line with the thoughts above.

THESE FORMS ARE TO SUMMARIZE (FROM A PARTICULAR VIEWPOINT) WHERE THE OPPORTUNITIES AND/OR COST, ETC., ARE THE HIGHEST. FOR A SPECIFIC SITE AND PRODUCT VIEWPOINT, THE SYMBOLS USED CAN INDICATE WHERE THERE IS A FEELING THAT A SDIGNIFICANT IMPROVEMENT TOWARD A PARTICULAR BUSINESS OBJECTIVE OR CRITICAL SUCCESS FACTOR EXISTS WITHIN A BUSINESS ACTIVITY

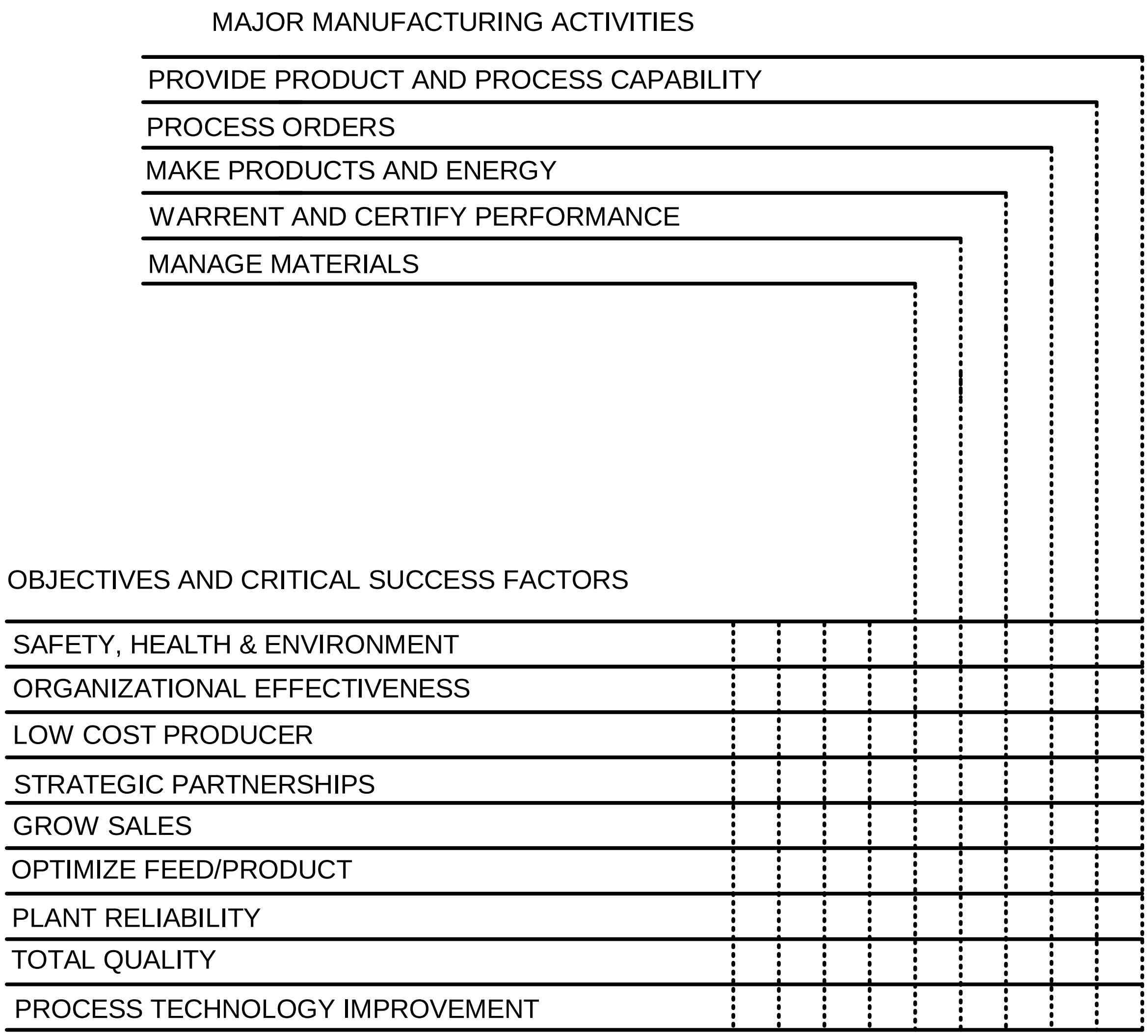

FIGURE 4-9

IMPROVEMENT SUMMARIES

SYSTEM NAME	KEY BUSINESS ACTIVITY USERS	ANNUAL MAINTAINENCE COST	DATE INSTALLED	USER SATISFACTION WITH SYSTEM
SYSTEM 1				
SYSTEM 2				
SYSTEM 3				
SYSTEM 4				
SYSTEM 5				

FIGURE 4-10

EXISTING SYSTEMS ASSESSMENT

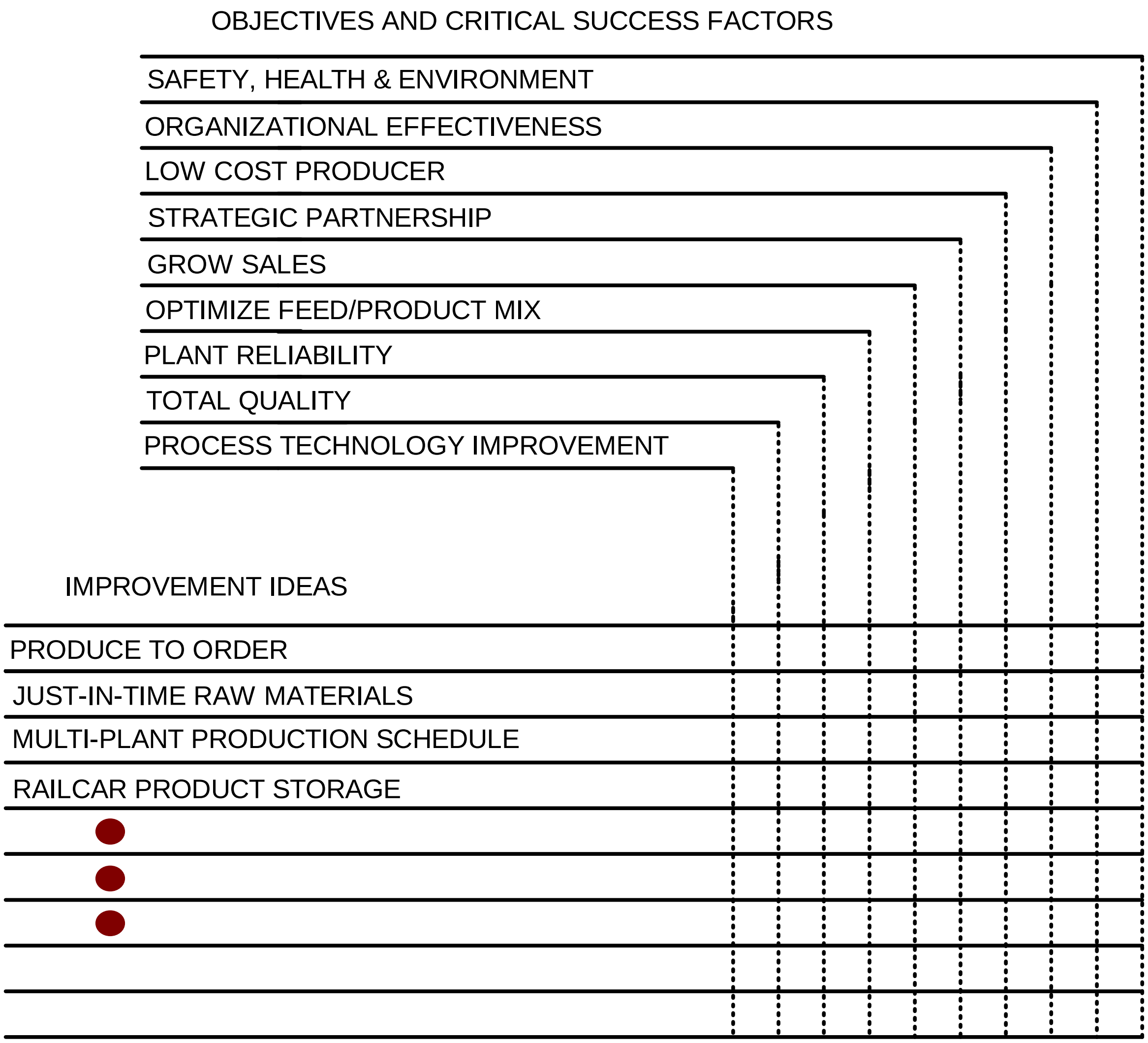

FIGURE 4-11

RELATIONSHIP OF IDEAS TO OBJECTIVES AND
CRITICAL SUCCESS FACTORS

THIS FORM IS FOR RELATING WHICH BUSINESS ACTIVITIES WILL BE AFFECTED BY THE GOOD IDEAS

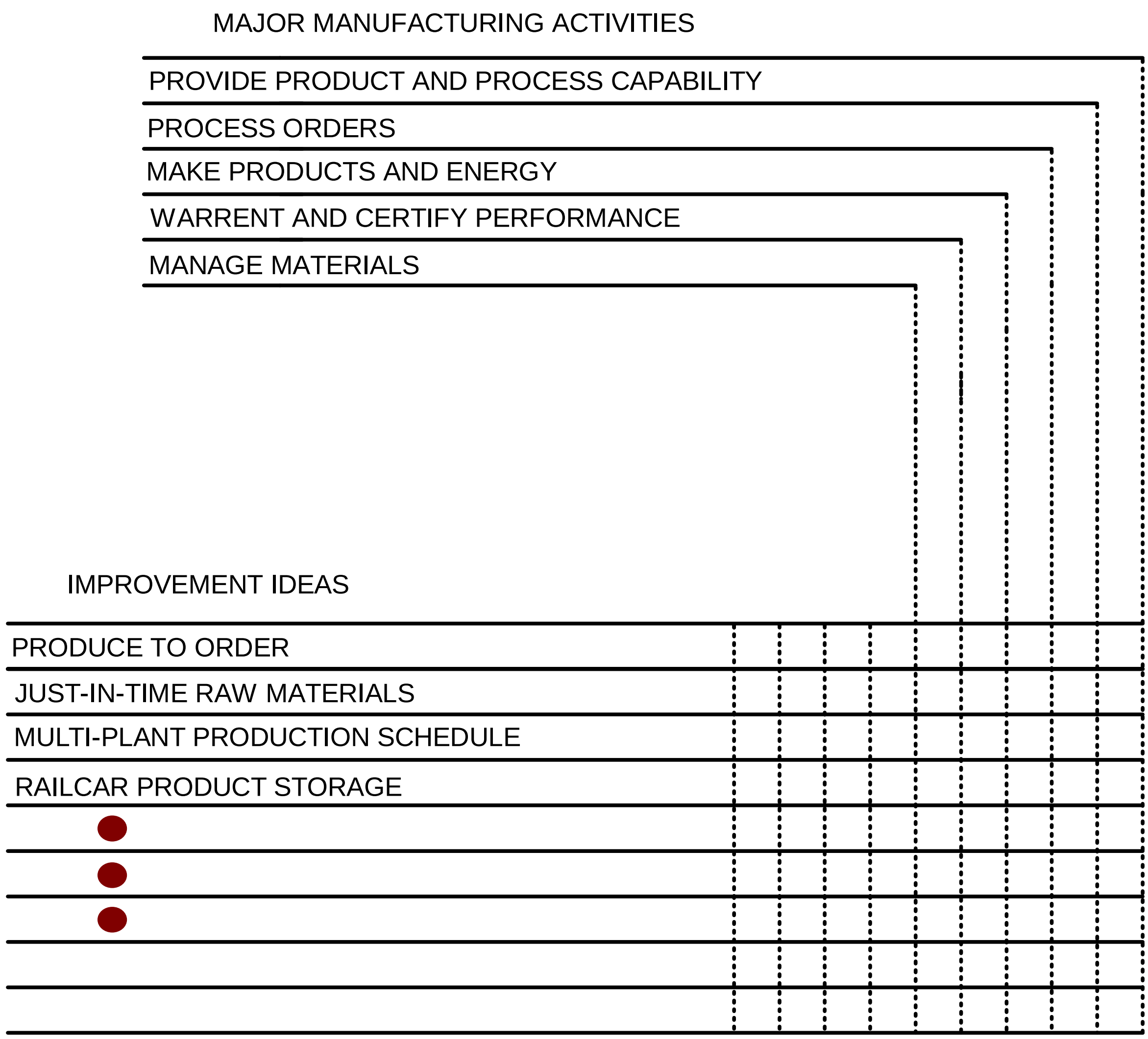

FIGURE 4-12

RELATIONSHIP OF IDEAS TO BUSINESS ACTIVITIES

Acknowledgements

4. Figures 4-3 through 4-6 are presented through the courtesy of Price Waterhouse Manufacturing.
5. Figure 4-7 is presented through he courtesy of the DuPont Company through IBM. Originally published in American Machinist they are also reproduced in the Enterprise Integration Handbook, McGraw Hill, New York. Figures 4-8 through 4-12 are also presented through the courtesy of IBM.

ATTACHMENT 4-I

CHECKLIST
HELPING IDENTIFY SIGNIFICANT INITIATIVES AND OPPORTUNITIES ENABLED BY ENTERPRISE INTEGRATION TO ACHIEVE GOALS AND OBJECTIVES

Information concerning new and significant initiatives and opportunities for application on the proposed enterprise integration system can come from a variety of sources as discussed in this chapter. This questionnaire will be organized on the basis of the different sources.

I. BENCHMARKING

A. Comparative Benchmarking

1. Has a comparative benchmarking study been run for this Business Unit and/or the Enterprise Business Entity in terms of the current or AS-IS condition of either?

2. What was the identity of the subject competitive system and how does it rank among its own peers? Is it of world-class status?

3. As the TO-BE condition of the Business Unit and the Enterprise Business Entity are developed has the benchmarking study been upgraded to show how well the proposed system approached world-class status.

B. Technological Benchmarking

1. Has a detailed technological benchmarking study been carried out for the Business Unit and/or the Enterprise Business Entity to show the gaps between their present technological capabilities and those of comparable world-class units carrying out the same functions.

2. How was the technological state-of-the-art established for the comparative study just above:
   a. From literature references?
   b. Identify these and judge their relative value.
   c. Discussions with vendors?
   d. Identify these and judge their relative value.
   e. Discussion with user companies in other industries?
   f. Identify these and judge their relative value.
   g. Consultant companies?
   h. Identify these and judge their relative value.
   i. Trade shows?
   j. Identify these and judge their relative value.

k. Do the sources used above classify as world-class in their access to the latest proven technology?

ATTACHMENT 4-I (continued).

C. Results of Benchmarking

1. What major recommendations can be made for inclusion in the proposed enterprise integration system which can be ascribed to the benchmarking studies noted above.

2. Are they sufficient to bring the proposed system up to world class status itself?

3. If not, what is preventing further enhancement of the capabilities? How might these limitations be circumvented?

II. ASSESSMENT OF CURRENT SYSTEMS

A. Contact with Current Unit Personnel

1. How have the ideas of current Business Unit and Enterprise Business Entity personnel been factored into the search for new and different initiatives, and opportunities for exploiting the capabilities of the proposed enterprise integration systems:
   a. Interviews with current operational and supervisory personnel?
   b. Suggestion boxes and other means to solicit anonymous ideas?
   c. Review past proposals for enhancements which were discarded at that time?
   d. Management "hot spots" or pet ideas?

2. How have these ideas been assessed for their potential contribution to the proposed enterprise integration system?

III. ASSESSMENT OF COMPARATIVE WORTH OF THE PROFFERED IDEAS FOR SYSTEM ENHANCEMENT

A. How was the list of potential ideas compiled for evaluation?

B. Did each idea get a thorough study as to its potential worth? If not, why not?

C. Which of the evaluation methods discussed in Chapter 3.4 were used for this evaluation? What was their relative worth as evaluation tools.

ATTACHMENT 4-I (continued).

IV. QUESTIONS CONCERNING NEW TECHNOLOGY APPLICATIONS IN AN ENTERPRISE INTEGRATION PROJECT

A. How radical is the new technology under consideration? Is it entirely new or an advancement of an already proven technology? If new, is it confined to a single vendor or offered by others as well?

B. What is the financial soundness of the company offering the new technology? How old is it? What is its sales history? Have any of its customer's been contacted concerning their opinions of the company, of its officers and developers, of the soundness of the invention and how well it matches advertised or professed capabilities?

C. How long has the new technology been in development? If it has been field tested, how long has the application been operating? What is the maintenance and performance history?

D. Is the proposed new technology compatible with other technology planned for the proposed enterprise integration system? Are elaborate and expensive interfaces required? How do they affect the system of either or both interface devices?

ATTACHMENT 4-II

A PROCEDURAL OUTLINE FOR CONDUCTING A STUDY ON THE TOPIC: IDENTIFY SIGNIFICANT INITIATIVES AND OPPORTUNITIES ENABLED BY ENTERPRISE INTEGRATION

I. METHOD OF INITIAL INVESTIGATION

  A. What are some significant opportunities?

    1. Program opportunities arising from the assessment of current systems

      a. Program Analysis Form of AS-IS system or plant (Figure 4-3)
        1. What are the product and operating criteria?
        2. How satisfied are people with the current system?
        3. What is the level of automation?
        4. How much does it cost to maintain the current systems?
        5. Which of these systems are at the end of their life cycle?
        6. How good is the information Quality?
        7. How easy is it to get information?

    2. Do comparative benchmarking
      a. Competitive
      b. Technological

    3. What are the latest technological developments?
      a. Potential of new tools in making potential projects feasible
      b. What are the risks?

II. ANALYSIS AND PRESENTATION OF RESULTS

  A. Opportunity matrices
    1. Vs. critical success factors (Figures 4-5 and 4-6)
    2. Vs. business activities (Figures 4-7 and 4-8)
    3. Vs. business activities (propagation effect)
    4. Vs. cost improvement

  B. Problem analysis (Figure 4-5)
    1. Comparison of levels of technology vs. potential payback

ATTACHMENT 4-II (continued).

III. CREATE A PRELIMINARY ENTERPRISE INTEGRATION OPPORTUNITIES LIST AND RANKING

A. Focus on greatest potential items

1. Which business activities have the greatest potential to contribute to the objectives and critical success factors of the Enterprise Business Entity?
2. Which manufacturing processes have the greatest potential to contribute to the objectives and critical success factors of the Enterprise Business Entity?

B. Identify "favorite topic," high return, small projects

C. Analyze items of quick return

D. Several small projects integrated into one

E. Avoid risk or keep to a minimum

1. Standards will lead to enhanced portability
2. Consider the effect of application of evolving technology vs. existing technology

IV. MEET WITH SPONSOR/STEERING COMMITTEE TO DETERMINE TARGET LEVEL OF IMPROVEMENT

V. REPEAT ANALYSIS TO REFINE PROJECT LIST UNTIL SPONSOR/STEERING COMMITTEE APPROVAL IS OBTAINED

VI. QUALITY CRITERIA CHECKLIST

A. Are all business functions included?

B. Are all business objectives and critical success factors addressed?

C. Is the level of detail correct?

D. Any problem areas or issues to discuss?

E. Any high risk issues? How feasible is it?

F. Any high cost options to discuss?

ATTACHMENT 4-II (continued).

VII. <u>DOCUMENTATION OUTPUTS</u>

A. Preliminary project list

B. Initial benefits list

C. Opportunity matrix

ATTACHMENT 4-III

SUMMARY OF PLANNING STEP 4
IDENTIFY SIGNIFICANT OPPORTUNITIES

Define:

- Preliminary Project List
- Initial Benefits List
- Opportunities Matrix
- Technological Development Matrix

Resources:

- Previous Step Documentation
- Purdue Enterprise Reference Architecture

5. "TO-BE" Human and Organizational Architecture

5.1 *Introduction*

Study of the Purdue Enterprise Reference Architecture reveals that it is initially divided into a manufacturing stream and an information stream. While the functional details only of the activities are being considered this is sufficient to develop the functional requirements of the manufacturing system and the information system of the entity. As soon as implementation is discussed, the place of the human in the operation of the Business Entity must be decided by allocating the separate tasks or functions between physical equipment and humans on both sides of the Purdue Reference Architecture. Thus the two divisions, Information and Manufacturing become three: the Information System Architecture (equipment carrying out information functions or tasks); The Manufacturing Equipment Architecture (equipment carrying out physical manufacturing functions or tasks); and The Human and Organizational Architecture (humans carrying out functions or tasks in either or both cases).

The first stage of implementation is that of functional design, i.e., preparation of functional specifications for the particular area of the architecture being considered. Thus we can make the functional design for the Information Systems, Human and Organizational and Manufacturing Equipment Architectures as desired.

The subject of the TO-BE Human and Organizational Architecture must be addressed with close coordination between the work described under the later TO-BE Information Systems Architecture (Chapter 7) and the TO-BE Manufacturing Equipment Architecture (Chapter 6). The human and organizational subjects have often been major detriments to the success of an enterprise integration program.

The literature has shown that as many as 75% of automation projects have been viewed as failures by the management of some companies as shown in Table 5-1 [37]. Further study has shown that 75% of these failures could be attributed to human-related as opposed to technological problems. See Figure 5-1 [37]. Still further estimates are that 60% of the original failures could have been avoided with proper pre-project human resource planning [58].

Therefore every effort must be made to preplan the human resource aspects of the enterprise integration program and to integrate them with the developing technology plan. In addition, it is equally important that the personnel who will be directly involved with the final enterprise integration system be involved as much as possible with this planning effort to establish their ownership and buy-in of the Enterprise Integration Master Plan and its features.

Studies have pointed out that it can take up to three and one half times longer to change an organization than it takes to change the associated technology [27].

TABLE 5-I

FAILURES OF ADVANCED MANUFACTURING SYSTEMS

American Productivity and Inventory Control Society and Organization for Industrial Research [A]	Up to 75%
Computer -Aided Manufacturing [B]	50%
Automotive Industries [C]	30 to 70%

References

A. Works, M., "Cost Justification and New Technology Addressing Management's No: To the Funding of CIM" In L. Bertain and L. Hales (Eds.), A Program for CIM Implementation, Second Edition, Society of Manufacturing Engineers, Dearborn, Michigan (1987).

B. Ettie, J., " Implementing Technologies Lessons from Experience," in D. D. Davis (Editor) Managing Technology Innovations : Organizational Strategies for Implementing Advanced Manufacturing Technologies, Jossey-Bass, San Francisco, California (1986).

C. Kalb, B. "Automation Myth Is CIM Threatening Today's Management?" Automotive Industries. Vol. No., pp. (December 1987).

TABLE 5-II

IF ALL OF THE FOLLOWING WERE TRUE ONE COULD AVOID THE NECESSITY FOR HUMAN RESOURCE PLANNING

1. Optimum enterprise integration performance can be achieved by technical factors alone.
2. Enterprise integration focuses on reduction of direct labor ignoring the role of the human.
3. Human resource issues can be narrowly defined simply as job description and training to the neglect of managing the human infrastructure of flexible automation.
4. Human obstacles will not occur on the factory floor to slow or prevent the utilization of technology.
5. Humans can adjust to technology rapidly because they are more flexible than equipment.
6. Management does not understand that human value judgments are embedded into the implementation and use of technology.

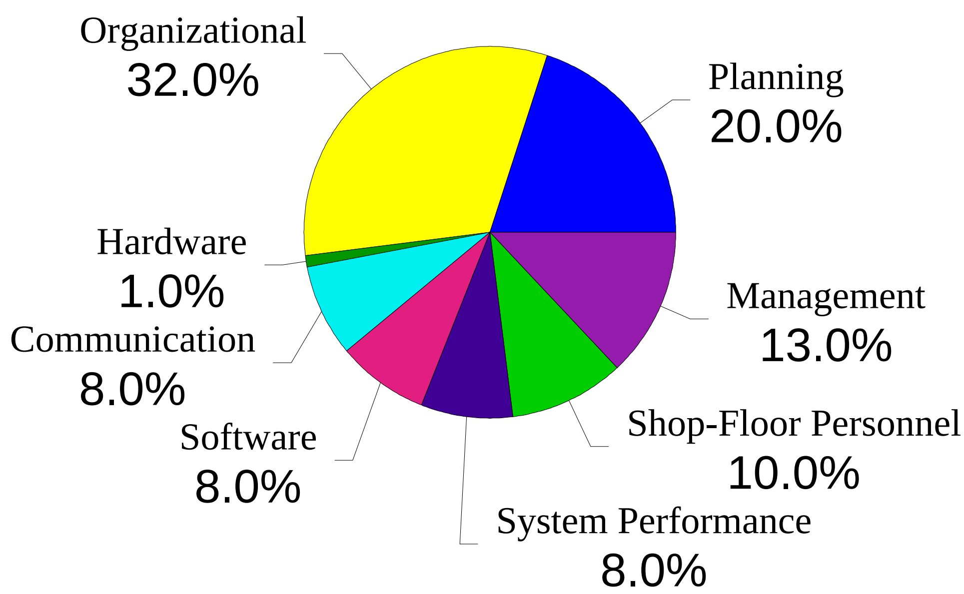

FIGURE 5-1 REASONS CONTRIBUTING TO THE DIFFICULTIES OF IMPLEMENTING ENTERPRISE INTEGRATION

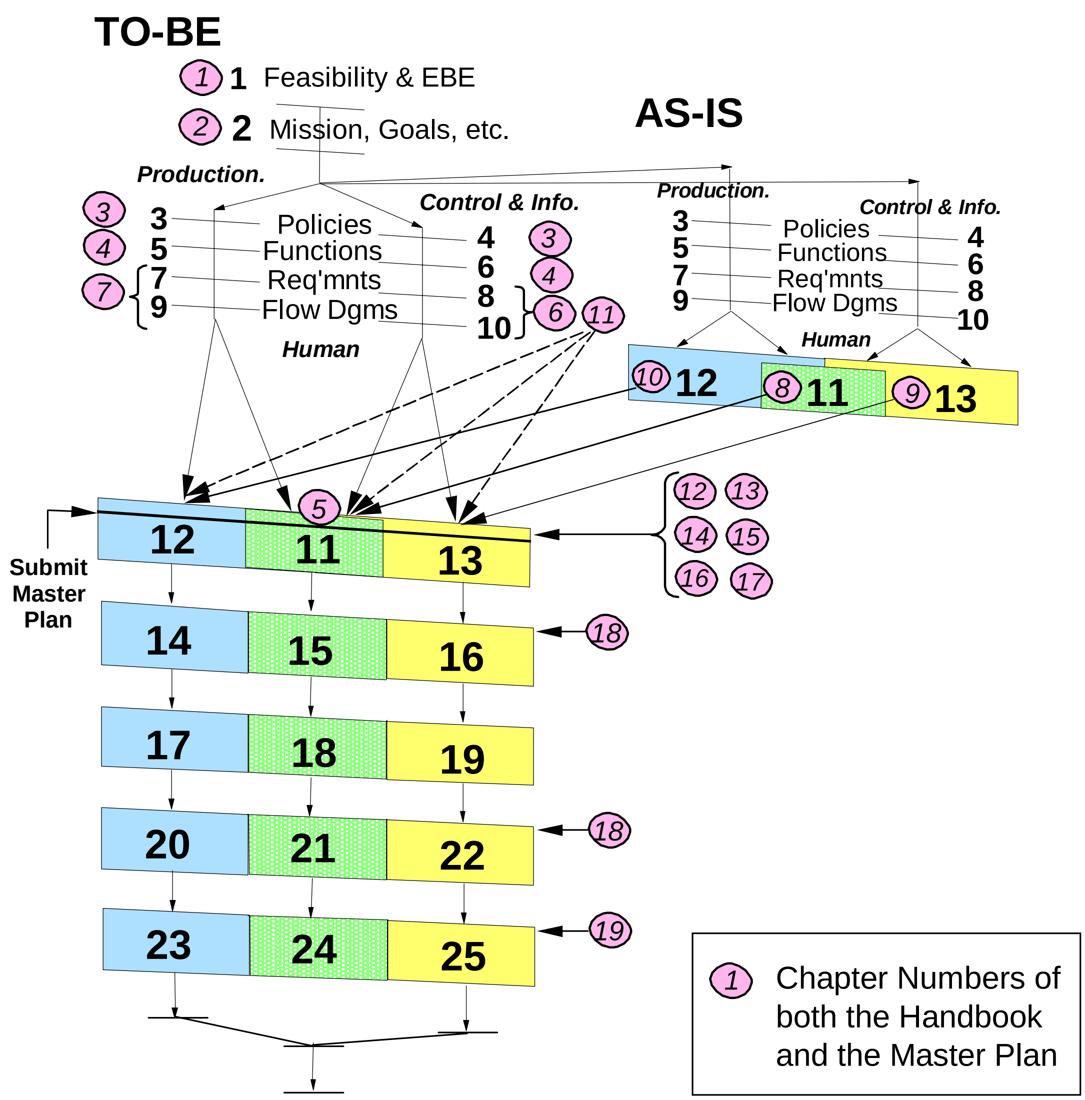

FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

Table 5-II presents a set of implicit assumptions management makes when they put minimal effort into human resource planning. [58, pp. 3-10]. Since these assumptions are themselves obviously all fallacies, the importance of human resource planning has been well illustrated.

This chapter will therefore emphasize those considerations which the Enterprise Integration Planning Team must take of human factors in developing their Master Plan for the Enterprise Business Entity. Only in this way can they avoid the roadblocks and pitfalls mentioned above that would be caused by their neglect of these considerations.

The level of effort that goes into developing the human resources can be as great or greater than the technology effort. The Enterprise Integration Planning Team must devote resources accordingly.

Relationship to Other Chapters

Figure 5-2 shows how the material of this chapter maps into the Purdue Enterprise Reference Architecture. Note the position of the extent of automation line and the policy directives in the sketch. Organizational aspects are contained in the central implementation block labelled as the Human and Organizational Architecture.

5.2 *Objectives*

The purpose of this chapter is to document and refine management's vision for human resources in the enterprise integration program of the Enterprise Business Entity and to integrate this with the corresponding technology vision. This is necessary in order to meet the business goals and objectives already set up for the Enterprise Business Entity through the discussion of Chapter 2. Thus the major objectives of this chapter can be summarized as:

1. Gain a thorough understanding of management's human resources policies and the corresponding human and organizational policies and vision.

2. Properly determine the location of the Extent of Automation line also discussed in Chapters 6 and 7.

3. Define the operation and maintenance tasks plus the direct staff support required by the Enterprise Business Entity.

4. Determine the organizational structure requirements for the Enterprise Business Entity.

5.3 *Background*

Concepts of the Human Worker in the Manufacturing Plant of the Future

Enterprise integration often is considered only in a technical context of the information system involved (computers, networks, data and software). However, these are only the tools needed to allow the information systems architecture to function. Unless an enterprise is organized, trained and has the mind set to use these tools properly, they will not generate the anticipated results. If nothing else, early experience has taught us that the human and organizational side of enterprise integration is extremely important.

In discussing the probable place of operational personnel in the industrial plant of the future one must bear in mind that there are two major considerations at work here. The first of these is that of the "quality of working life" of plant production personnel. They must be relieved of dirty, undesirable, and monotonous tasks; their health and safety must be strenuously protected; and the salary awarded must be high enough to assure a certain standard of living. They should be able to exercise their human innovation skills for the improvement of the working procedures, conditions or the product itself. Further they should have the opportunity and the necessary information to make and carry out decisions in the latter regard.

The second or counter factor to this is, of course, the economic one, that of the capital and operating cost of a mechanical and/or electronic device capable of carrying out those functions now assigned to these personnel.

At the plant floor level these decisions can be made "ad hoc" for each situation as it arises since the proposed control system described here can operate regardless of its actual plant production interface provided the necessary communications is established and maintained. That is, a process can either be manually operated or it can be completely computer controlled in the broadest sense, provided the necessary communications is assured.

However, where personnel must be involved, i.e., where innovative decisions must be made to assure the smooth operation of the manufacturing equipment (Level 1 and the upper levels of the hierarchy), an allocation of tasks must be made between man and machines at all levels and an organizational structure developed for the personnel involved. It is at each and every one of the information and control levels that the human resources, policies and organizational structures discussed in this chapter become of the utmost importance.

Mill Cultures and Human Resources

A committee of the Manufacturing Studies Board of the National Research Council [12] has found that certain basic characteristics of enterprise integration are fundamental to identifying human resource practices that are effective in implementing it. When compared with the technologies that enterprise integration replaced, the applications were characterized by:

1. Greater interdependence among work activities;
2. Fewer employees in a group responsible for each product, part or process;
3. Higher capital investment per employee;

4. More immediate consequences of the failure of part of the system on the whole production system;
5. More costly consequences of malfunctions in the system; and,
6. More sensitivity of process or plant output to variations in human skills, knowledge, and attitude, and to mental rather than physical effort.

These characteristics of enterprise integration have caused many manufacturers involved with implementing it to initiate or expedite pursuit of the following interrelated organizational objectives:

1. Develop a highly flexible, problem-solving, interacting and committed work force to permit the optimum use of the automation tools;
2. Develop a flexible and innovative human management organization with fewer job levels and job classifications to accommodate the employees needs to relate to the cultural aspects of the system;
3. Maintain a high retention rate of well-trained workers to maintain the work force; and,
4. Develop a strong partnership between management and the work force representatives (unions, where they represent the work force) to ease the adjustments to changes brought on by the new technology.

Thus, the human resource aspects of plant modernization are a significant dimension of the overall implementation task.

Innovation in the Workplace

As noted in the CIM Reference Model [81] the primary role assigned to most manufacturing plant personnel is that of a policy implementor, i.e., to carry out in the most expeditious manner possible the task or instruction assigned them by other plant entities, usually higher in the hierarchy. Personnel are usually assigned to such tasks because the actions involved are: (1) too complex in terms of dexterity, sensory information or intelligence required for machine implementation, or (2) humans are more cost effective in carrying out the task, or (3) the necessary machines are economically and technically feasible but have not yet been developed or procured for social or political reasons.

As noted under the above definition, the substitution of a human worker for a machine, and vice versa, in no way subverts the definition of the Enterprise Integration Reference Model for the resulting factory, provided only that the required information concerning the implementation of the task involved as needed by adjacent and upper level entities is provided in a timely and accurate manner by either.

The difficulty in defining the role of the human worker in the manufacturing plant arises when they have been assigned both an implementor and a policy role in the same task, i.e., some of the decisions assigned to them are pro forma and can be described by an algorithm that can potentially be carried out by a computer or other device, but others do require true innovation that must be captured in terms of a new policy (i.e., they become (policy makers)) or the resulting innovation will be lost.

The major requirement here to provide such a capability is to assure that the necessary information gathering and transmission facilities are present and used so that the resulting innovative decision and its corresponding actions are recorded and made available to all those plant entities that are affected by or need information concerning that decision or action.

Human Organization in the Factory

It is noted that there is a definite movement in some social quarters to minimize the number of management levels on the factory floor. This is usually carried out by the use of one or both of the following methods:

1. By distributing innovation, i.e., pushing decision-making to as low a level in the organization as possible, or,

2. Assigning the necessary innovative decision-making to committees or work teams composed of both management and worker personnel. It must be noted that this latter technique substitutes the committee's teams for the usual individual assigned the task in question and does not invalidate the normal CIM Reference Model allowance for the resulting decision.

The key to the incorporation of either or both methods into an effective enterprise integration architecture is the provision and use of the requisite communications facilities for all tasks within the enterprise integration structure as noted throughout the Reference Model and in this manual.

Applicability of the Newer Organization Structures

In establishing the human resources vision for the Enterprise Business Entity, management must, with the aid of the Steering Committee and the Enterprise Integration Planning Team and others, decide to what degree to incorporate newer management styles and structures, such as those described for the Monsanto Fibers Division [81], in the Enterprise Business Entity. Table 5-III summarizes the paradigms of these newer management techniques and models of human organization and human resource policies [45]. In addition, Table 5-IV lists the major factors to be considered in formulating any set of organizational and human relation policies.

A review of the paradigms on Table 5-III will immediately indicate to the reader the underlying assumptions regarding social attitudes, management/worker relationships and interactions, and so forth. At the same time it must be realized that these newer systems are not panaceas, otherwise they would have been developed and accepted long ago. Work teams often lead to a reduction of the effort and performance and initiative of high-performing workers, since extra effort is not rewarded and is often discouraged by other work team members. In addition, the place of the middle management personnel in the team system has not been definitely established - are teams used at this level as well? - how does the individual middle level manager, if retained, interface with the lower level teams?

Thus the Sponsor, Steering Committee, and probably the Enterprise Integration Planning Team as well must thoroughly examine the situation existing in the AS-IS Enterprise Business Entity to assure themselves whether or not the proposed enterprise integration program needs a thorough overhaul of its work force organization and whether the increased efficiency, quality, productivity, etc., usually associated with these endeavors will repay the major planning, training and execution effort necessary to achieve it.

Should such an overhaul be considered necessary the next major section of this chapter presents those considerations which should be taken into account in this task.

TABLE 5-III

A SUMMARY OF THE PARADIGMS OF RECENT HUMAN RELATIONS AND ORGANIZATIONAL POLICIES

1. Organizations should be redesigned as opposed to being incrementally improved:
   a. Incremental improvement generally results only in speeding up the existing processes.
   b. Speeding up the process does not usually address the fundamental performance deficiencies of a system.
2. The newer organizational patterns emphasize different criteria than those of the past.
   a. Past organizational structures focused on efficiency and control.
   b. The newer forms focus on individual innovation, worker satisfaction and human growth and development.
   c. The newer focus claims to give better speed of response, as well as better service and work quality.
3. Realization of the benefits of enterprise integration requires a shift in culture and the way people view and perform their job.
   a. If the workers have not helped to design their new tasks, their reaction may be to try to justify doing a better job the old way.
   b. In addition, the workers may be defensive and believe that the change was caused by poor performance on their part.
4. Achieving a total break from old rules, methods and procedures will require a whole new way of thinking on the workers' part.
5. The redesign of work must be carried out both from the aspect of the individual involved and of the organization from a cross-functional perspective. The needs of the process itself in terms of dynamic response, etc., must also be included. This will usually result in organizational change. This change is best carried out by a cross-functional team including technology and human resources experts.

TABLE 5-IV

FACTORS IN THE REDESIGN OF AN INTEGRATED ENTERPRISE WORKFORCE ORGANIZATION

1. Organizational structure
    a. Assessing departmental functions
    b. Reallocation of resources
    c. Solving cross departmental integration problems
    d. Grouping like processes or products
    e. Formal structure
    f. Informal structure
    g. Consideration of the individual

2. Job design
    a. Skills required
    b. Knowledge required
    c. Education level of employees
    d. Level of authority
    e. Level of decision making
    f. Division of machine and human tasks

3. Personnel policies
    a. Career development
    b. Reward systems or lack of
    c. Job security
    d. Shift work
    e. Union management relations

4. Management responsibilities
    a. Set and maintain the new organizational culture and beliefs
    b. Worker motivation
    c. Decision making style
    d. Human resource priorities
    e. Management trust

f. Communicate to the organization what the enterprise integration changes means to them.

Design Considerations for Human Systems

There is no single correct way to design the human organization in an enterprise integration system. However, there are some concepts that should be considered in such a design. The evaluation as to the applicability of each of these concepts has to be weighed by the company involved based on each individual company's organizational culture, its readiness to change, etc. The following is offered to provide some thoughts on where to look for solutions to these questions.

Redesign of the organization and associated work patterns can cause corresponding changes in plant culture, in related management systems, and in the collaborative efforts with other organizations. Its direct effect on people is in the areas of job ratings, compensation schemes, career paths, promotions, as well as recruitment and training. Redesign can be confusing and disruptive and can affect everyone. Table 5-V summarizes some of the concepts indicated above as presented by Hammer [45].

TABLE 5-V

SOME CONCEPTS FOR ORGANIZATION REDESIGN WITH ENTERPRISE INTEGRATION SYSTEMS

1. Organize around broad outcomes and not individual tasks.

2. Have those who must use the output of a process perform the process itself. Individuals will then perform more functions for themselves, thus reducing the time needed to complete a task.

3. Subsume information processing work into the real work that produces the information.

4. Treat geographically dispersed resources as though they were centralized. Use data bases and telecommunications to centralized information from a decentralized work force.

5. Link parallel activities instead of integrating their results. Coordinate parallel functions during the process in real-time vs. an after-the-fact report.

6. Put the decision point where the work is performed and build control into the process. Information technology can capture and process data and the use of decision making tools can empower people to make the necessary decisions.

7. Capture information once at its source and then make it available for all to share.

Enterprise Integration Support Infrastructure

In an enterprise integration environment people are usually expected to do less physical work and are often empowered to make more complex decisions. This reduces direct labor cost but often increases the need for support functions. This factor is important because of its impact on accounting methods which may be based on direct labor costs. One of the major support functions that will undergo change with the enterprise integration system is that of maintenance. It will play a more important and more complex role in the enterprise integration environment since maintenance of equipment will be more difficult with systems more complex to understand and with the process on-stream factor becoming more critical. Several potential different maintenance strategies that may be employed are:

1. Use "skills on shift." Here operators perform first level maintenance and the maintenance group serves as back-up.

2. Combine the maintenance department with production to better promote a team approach.

3. Place greater emphasis on preventative and predictive maintenance.

Operating in a more complex enterprise integration environment may require maintenance to:

1. Increase their training level to learn new equipment.

2. Broaden basic skills to include electrical, electronic, mechanical and hydraulic technologies and software configuration and programming skills.

3. Assume more risk taking in making judgment calls as to whether a repair must be made immediately or whether it could be postponed in order to be able to meet a customer's product delivery requirements.

Another support function which will change is quality control and scheduling. These functions will change since the organization and process should become more streamlined and should operate on an "as planned" basis vs. a "fire-fighting" or reaction mode. This latter should reduce the amount of quality control testing and production planning required.

Engineers will also be affected since they will need to develop a broader knowledge base concerning business implications, information systems, and the human side of automation. They will also need more expertise in control and information theory and basic enterprise integration concepts. Because of the specialization required in all engineering disciplines there is a limit to how multi-disciplined engineers can become. Therefore, it is very important that they learn to work together. Increased specialization, paradoxically coupled with increased collaboration among special knowledge disciplines, is likely to be the recipe for success!!

Programming is another area where support services will increase for the obvious reason that most automation devices are digital computer based. The major organizational issue here is that of who has control of the program and thus the machine or process; the programmers or production personnel. One remedy to any conflict is to rotate programmers, analysts, operators, maintenance personnel and engineers through each other's jobs to promote understanding and cooperation.

Personnel in the Integrated Enterprise Environment

Personnel policies usually change in an enterprise integration environment because the technology brings people together. As mentioned above job classifications tend to be broader and to focus on roles rather than narrowly defined tasks. Enterprise integration requires more team work. Thus the requirement for the redesign of the functions of the individual, the team and the organization.

If not addressed this can create problems in the reward system in terms of compensation, promotions, and career development policies. Employee motivation from a job security point-of-view and the protection of individual rights within the team are also prime considerations.

Changing Work Roles

Operators

The tasks and responsibilities of a factory floor worker undergo many changes in an enterprise integration system. The most visible is the change from physical to intellectual work. This has several implications in how the work is performed as well as how the workers contribution is measured. The norms of the past should change. Actually increased decision making, troubleshooting and coordination are added to the work of the enterprise integration operators. To assist them, technical tools are required, like SPC, SQC, on-line models which infer process performance and expert systems to assist in troubleshooting.

To be effectively used enterprise integration operators should not be de-skilled. Rather they should acquire higher perceptual and conceptual skills. Perceptual here being vigilance, concentration, attention, and judgment, and conceptual being interpretation, abstraction, comprehension of complexity and inference of subject matter.

Along with the above should come some level of discretionary problem solving and the freedom to exercise critical judgment concerning the level of action that can be taken. To do this effectively, the level of human communications between different organizational functions, the degree of team problem solving and the coordination of activities within and outside the immediate department must be increased.

Supervisors

Supervisors as a group can be the most difficult to work with when implementing enterprise integration. They see themselves as losing power and being placed in a work team environment where they have less effect on motivating people and judging performance. They feel much less comfortable being forced into the role of coach and counselor vs. their previous tasks of directing subordinates.

A survey [72, p 88, Exhibit I] has shown that supervisors do not believe that employee involvement groups benefit them:

Beneficial to companies	72%
Good for employees	60%
Beneficial to themselves	31%

Dealing with such a resistance to change is important.

Supervisors will be required to spend more time in coordinating other personnel, in solving complex problems and in managing complex systems. These complex systems include integrated business systems with multiple goals and including different types of technology.

Managers

Some managers will anticipate and orchestrate the changes in technology and in the organization. These managers are technology oriented and should grasp the technical, human and business goals and objectives and how they relate to the business process and manufacturing policies.

Their time will be spent finding problems, assigning priorities, setting targets for improvement, encouraging innovation and learning about production and business related problems.

Social Effects of Automation

One of the overriding factors in an effective Enterprise Integration Project is to consider humanizing the technology so that the rigidity of automation can be blended with the flexibility of humans. The Macintosh computer human interface is a good example of this concept. The objective here is not to allow the computer to get in the way of solving problems. Figure 5-3 shows one view of some of the differences between the concepts of man-machine systems alone vs. the total field of the social effects of automation.

VIEWPOINT OF MAN-MACHINE SYSTEMS		VIEW ON		VIEWPOINT OF SOCIAL EFFECTS OF AUTOMATION
DETERMINISTIC	←	TECHN DEVELOPMENT	→	INTERACTIVE
PARTIAL	←	MAN	→	HOLISTIC
MAN AS APPENDIX	←	INTERFACE	→	MACHINE AS TOOL
MECHANISM	←	ORGANIZATIONS	→	ORGANIC
IMPLEMENTATION	←	CHANGE	→	PARTICIPATION
CONTROL	←	SOCIAL OBJECTIVES	→	EMANCIPATION
NUISANCE	←	HUMAN VARIATION	→	ASSET
QUANTITATIVE	←	DATA	→	QUALITATIVE
EXPERIMENTAL	←	METHOD	→	INTERPRETATIVE
TECHNICAL	←	RESEARCH IDEAL	→	SOCIO-TECHNICAL
CLOSED	←	SYSTEMS	→	OPEN
SUBJECT-OBJECT	←	ROLE OF RESEARCHER	→	SUBJECT-OBJECT
MANIPULATE	←	FUNCTION OF RESEARCHER	→	PROCESSING FACILITATING
NEED FOR CONTROL	←	UNDERLYING PSYCHOLOGICAL DIMENSION	→	NEED FOR LESS CONTROL

FIGURE 5-3 CONCLUSIONS FROM THE DELPHI STUDY BETWEEN EXPERTS ON MAN-MACHINE SYSTEMS AND SOCIAL EFFECTS OF AUTOMATION

To minimize the effects of social change consider designing the technology system from the human side working toward the technical side. See Figures 5-3 and 5-4.

In considering the human centered design issues, the role of humans in an automated factory should be considered. The roles humans play are:

1. Maintainers of the system
2. Managers of the process and organization
3. Exercising skills, judgment, creativity and innovation
4. Assuming responsibility for the process operation and product quality
5. Assuming responsibility for the operation and performance of the automation system

To accomplish the above, the enterprise integration operator's systems view should go beyond a single human's specific domain of responsibility. This requires a change in culture to consider this wider scope. As the wider scope and view develops, communications becomes more important since people think more about the information available and how it relates to the results desired. To test new theories and conclusions more interaction between associated employees is required.

Organization

In the Informated Organization, as described in Reference [60], the concept used is to provide people at all levels with enough information so that decisions can be made on an immediate basis instead of after the fact. The role of technology then is to empower all employees (factory floor workers, supervisors, managers, engineers and researchers) to make the needed decisions. The central theme is to focus on empowering people rather than de-skilling them through automation. In this Informated Organization, people should continually improve their skills in order to exercise the needed critical judgments. Learning is an important result of this type of organization and ties in closely with The Total Quality Improvement process. Training is of utmost importance as discussed in Chapter 13.

With this dynamic organizational style, the establishment of a clear set of human relations policies, culture and beliefs is important. These need to include:

1. Management support for enterprise integration at all levels
2. A consistent set of behaviors and norms
3. Encouragement for cooperation between functional groups
4. Equitable treatment of all workers

In addition, a clear set of business process and of manufacturing policies (Chapter 3.3) are important.

An organization should be able to accommodate the paradigm shifts in manufacturing as shown in Figure 5-4.

FROM:	TO:
ONE BEST WAY	CONTINOUS IMPROVEMENT
PAY FOR THE JOB	PAY FOR SKILLS ACQUIRED
SUPERVISOR-DIRECTOR	SUPERVISOR-COACH
STAFF IS BEST	WORK TEAMS CAN DO IT
MUTIPLE VENDORS	LIMITED VENDORS
INVENTORY IS NECESSARY	INVENTORY IS UNDESIRABLE
QUALITY TOO EXPENSIVE	QUALITY PAYS FOR ITSELF
INSPECTORS NECESSARY	INSPECTION AT LOWEST LEVEL
BURDEN, % OF DIRECT LABOR	NEW COST SYSTEMS, ABC
LARGE RUNS	QUICK SETUPS, FLEXIBILITY
MAINTENANCE SPECIALISTS	TEAMS DO THEIR OWN
REWORK CENTERS	100 PERCENT QUALITY
GET PRODUCT OUT OF THE DOOR	MANUFACTURING STRATERGY
SEPARATE ENTITIES	COMPUTER INTEGRATION
USA IS OUR MARKET	GLOBAL MARKET
WORK ALONE EDUCATION	MUST WORK IN TEAMS
BUILD IT, THERE'S A MARKET	VOICE OF CUSTOMER

FIGURE 5-4 PARADIGM SHIFTS IN MANUFACTURING

5.4 *Implementation*

As will be pointed out in the discussion of the Manufacturing Functional Architecture (Chapter 6) and the Information Functional Architecture (Chapter 7), the implementation of an enterprise integration program involves three separate sub-architectures; the Information Systems Architecture, the Manufacturing Equipment Architecture and the Human and Organizational Architecture.

These three implementation architectures are interfaced with each other by lines defining the limits of automation employed in the Information Architecture and the Manufacturing Architecture. There are three ways of defining the limits of automation. These are: Automatability, or the technological limits of the application of automation; Humanizability, or the limits of task execution by humans; and finally, the Extent of Automation, the degree of automation actually applied. This latter is always between the other two. Its actual location is more a function of social, economic and political considerations instead of technical. See the Introduction and Overview Chapter .

If one can assure completion of task performance functions, the actual characteristics of the implementation of the Human and Organizational Architecture are not critical. That is, any successful method for motivation of the personnel staff to complete their assignments is acceptable provided only that it assures completion of the assigned tasks involved.

There is an extremely limited amount of data and methodology available in the public domain to help us do these tasks. The methodology described here is based on a composite of advice from expert human resource consultants, case studies and an attempt to associate these with the Purdue Enterprise Reference Architecture.

Figure 5-5 diagrams the overall procedures involved to complete the study described in this chapter. It is envisioned that there are four phases involved:

1. Phase one has three parallel parts.

    a. Detailed understanding and interpretation of the Enterprise Business Entity policy and human relations vision. It is expected that the policy and vision will be provided by management. These will often require interpretation and added detail, some of which will require pro-active input from the Enterprise Integration Planning Team; using available human resources and the background information in this chapter.

    b. Determine the Automatability and Humanizability lines of Manufacturing Architecture. The input here is the same set of inputs defined in Chapter 6 from the manufacturing functional architecture requirements and in Chapter 0.2 on the Architecture. The Enterprise Integration Planning Team should seek the help of an industrial engineer, a process engineer , an efficiency expert and a human resource specialist to debate and decide the location of the Manufacturing Architecture's Automatability and Humanizability lines for each of the major process areas of the Enterprise Business Entity. These will define the extremes to be considered in the next phase.

c. Determine the Information Architecture's Automatability and Humanizability lines. The input here is the same set of inputs as defined in Chapter 7, from the Information Functional Architecture requirements. The Enterprise Integration Planning Team should seek human relations help to debate and decide the location of the Information Architecture's Automatability and Humanizability lines for each major process and support area of the Enterprise Business Entity. These will define the extremes to be considered in the next phase.

2. Phase two has two parallel parts.

   a. Determine the Manufacturing Architecture's Extent of Automation. This task must be closely coordinated with Chapter 6 so that a clear and thorough agreement is reached with management (both production and human resources).

   b. Determine the Information Architecture's Extent of Automation. This task must be closely coordinated with Chapter 7 so that a clear and thorough agreement is reached with management (both production and human relations).

3. Phase three has two parallel parts.

   a. Determine the operation and maintenance tasks, from the Manufacturing perspective.

   b. Determine the operation and maintenance tasks from the Information perspective.

   It should be noted that many of these are the same tasks in both areas. Other tasks will be in one or the other area, especially support and staff positions. The output of this phase should be a composite set of the first level (line or staff) tasks, with associated skills requirements, etc., without regard for supervision.

4. Phase four is to determine the staff and management organizations, levels of supervision, etc. The concepts and principles as to how these personnel will work together should also be documented.

The Extent of Automation line lies somewhere between the Automatability and Humanizability lines. The exact location is determined by several factors: manufacturing policies, the workforce skill and knowledge, basic economics, equipment selections and business critical success factors. The organizational infrastructure is also important to define because it sets factors such as, areas of influence, decision making responsibility, interdepartmental relationships and degree of flatness of the organization.

Figure 5-6 shows the same material presented in the pseudo IDEF diagram form used in all of our chapters.

5.5 *Required Documentation*

Tables 5-VI and VII follow the lead of similar tables in Chapter 8 for documenting the AS-IS situation in the Enterprise Business Entity to record the proposed final work force and management organization, human relations policies, and needed human resources for the proposed enterprise integration system of the Enterprise Business Entity. A parallel format for the documentation involved from the two previous chapters is used in order to ease the task of developing the required transition path in establishing the desired enterprise integration system.

Note that Table 5-VI asks several questions necessary in establishing the justification for the proposed changes. Essentially how does one correct the problems which surfaced in examining the AS-IS situation?

5.6 *Checklist and Summary*

Attachment 5-I presents a set of questions to further aid the Master Plan Development Team in their task. Attachment 5-II summarizes the work involved here.

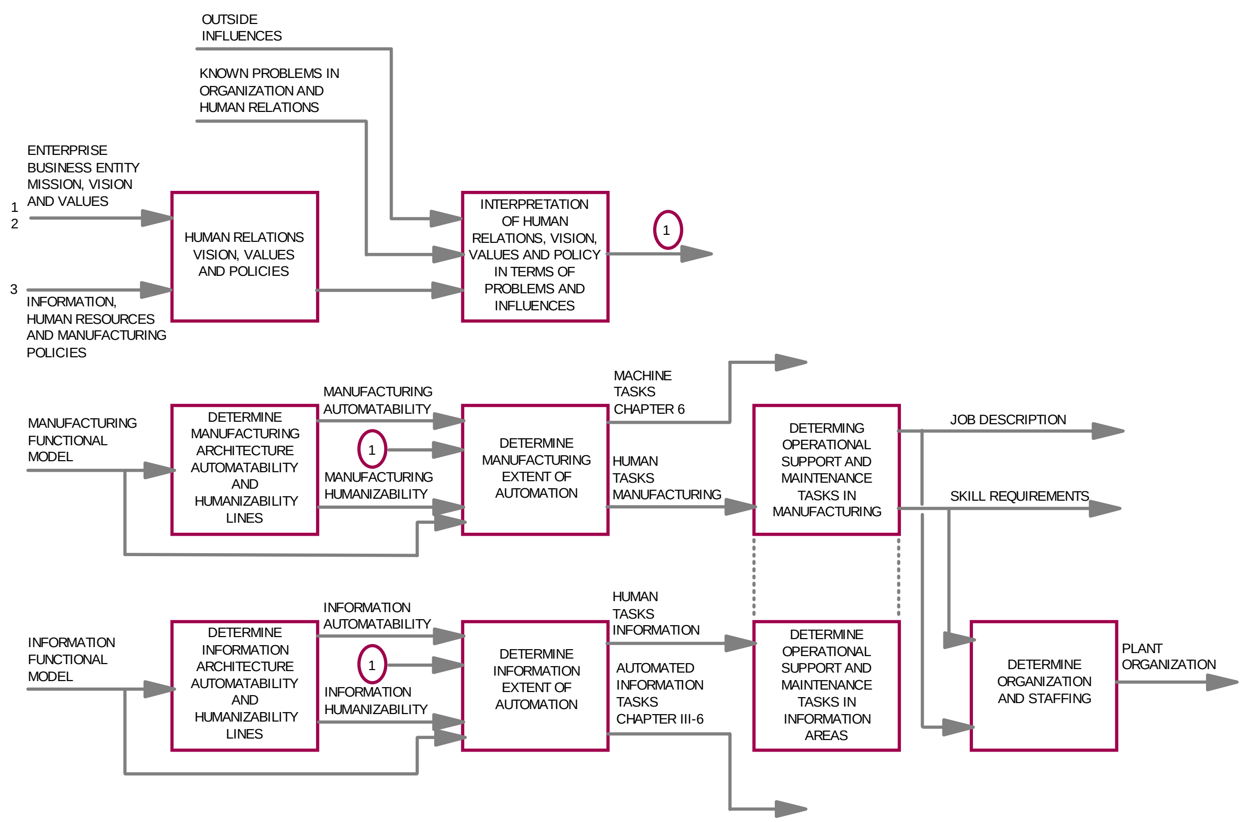

FIGURE 5-5 DEVELOPMENT OF THE HUMAN AND ORGANIZATIONAL ARCHITECTURE

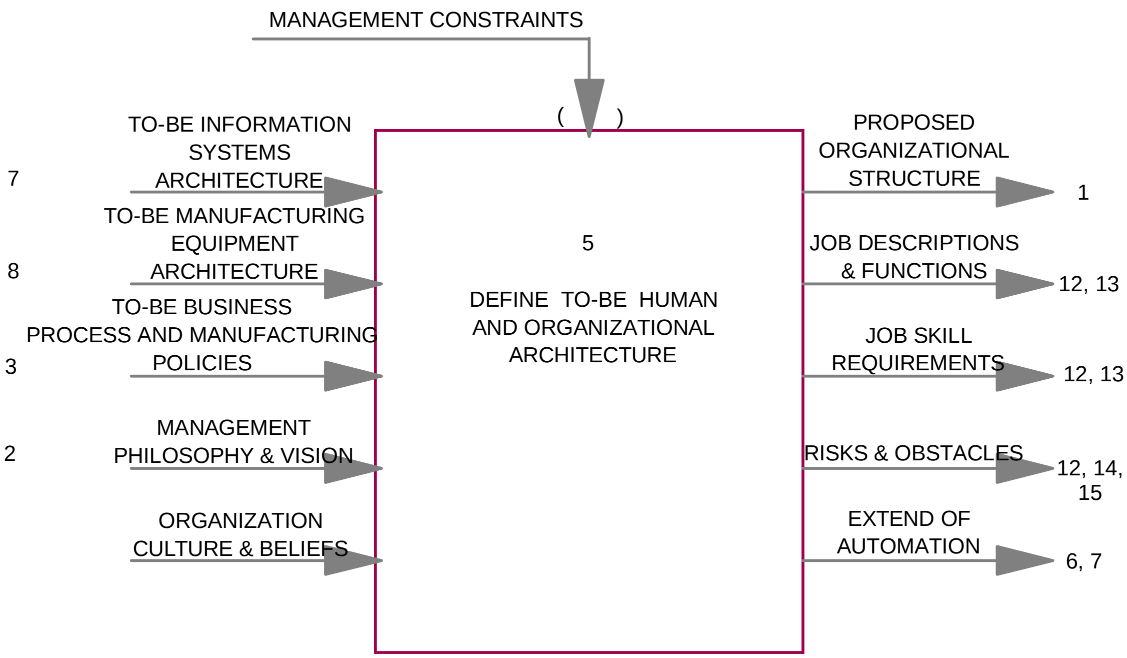

FIGURE 5-6 THE TRANSFORMATION TASK OF CHAPTER 5 – DEFINE THE TO-BE HUMAN AND ORGANIZATIONAL ARCHITECTURE

TABLE 5-VI

HOW DO WE EXPECT THE PROPOSED HUMAN RELATIONS POLICIES AND ORGANIZATION TO HELP CORRECT PROBLEMS UNCOVERED IN THE AS-IS?

1. Operational and management personnel attitudes toward automation in general and the proposed project in particular.
2. Management-operational personnel relations and attitudes.
3. Company-union relations.
4. Operational personnel grievances concerning the AS-IS human relations policies in general.
5. Resistance to change.
6. Identified deficiencies in work skills, human relations skills, etc.

TABLE 5-VII
FORMAL DOCUMENTATION REQUIRED OR HIGHLY DESIRABLE FOR THE TO-BE HUMAN RELATIONS POLICIES AND ORGANIZATION

1. Proposed organization charts of the Enterprise Business Entity including operations, maintenance and all support groups. A detailed description and expected performance scenario should be provided for each component of any organizational structure which has undergone major changes from the AS-IS structure.
2. A written description of all new or changed training programs to be used regardless of source or location at which given. The proposed company policy concerning eligibility, promotion credits, compensation, etc., should be articulated.
3. Promotion and progression policies for both management and hourly personnel including skill and experience requirements. Those affected by the proposed enterprise integration system should be particularly highlighted.
4. Any total quality control program to be used.
5. The compensation and reward system of the Enterprise Business Entity particularly any changes initiated because of the new enterprise integration system.
6. Any change in the company's automation policies different from the AS-IS situation should be highlighted, particularly those which relate to human relations and organization.
7. Requirements for transition organization and training activities to assure that new organizational structures and policies achieve buy-in by affected personnel.

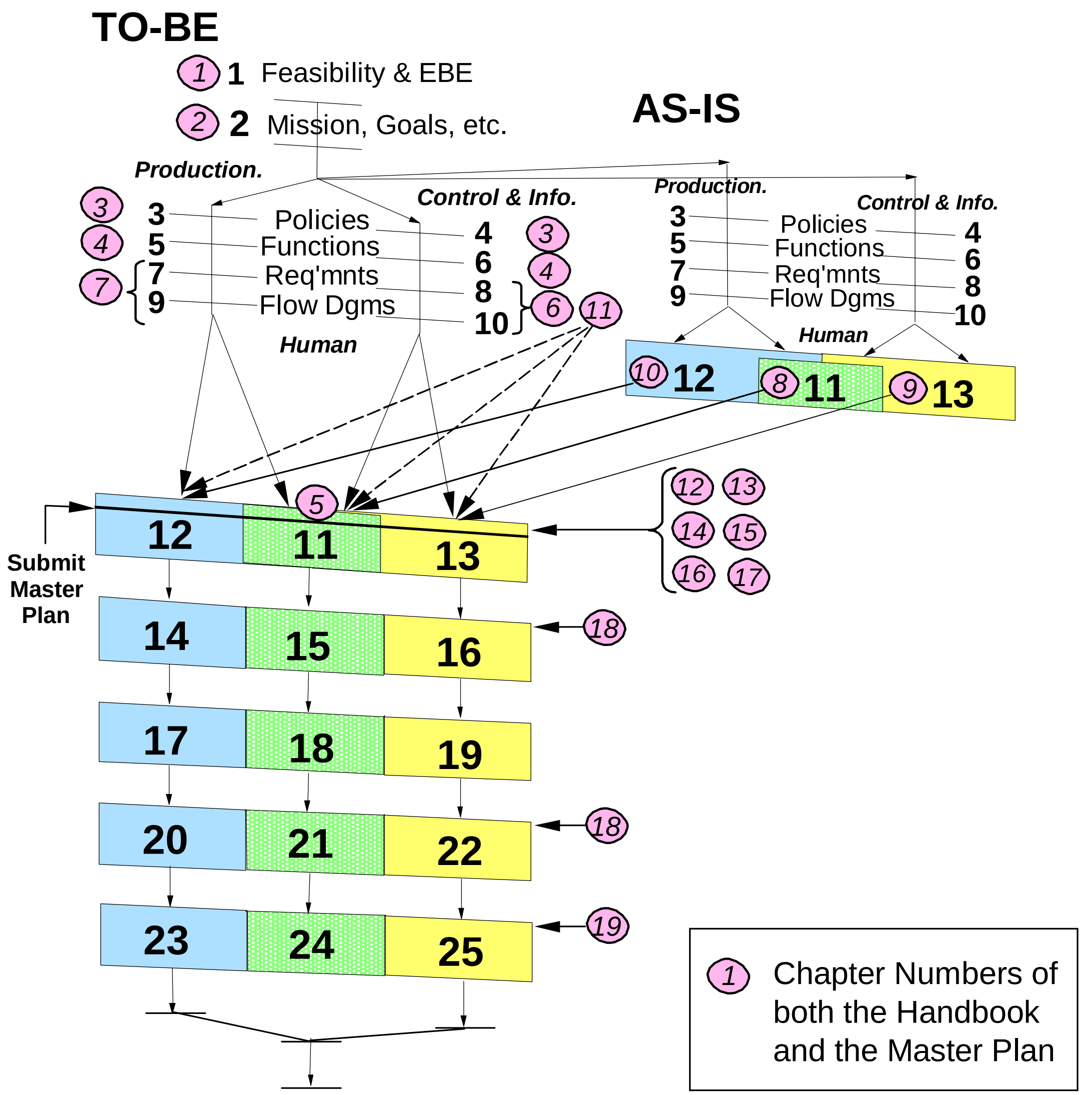

FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

ATTACHMENT 5-I

CHECKLIST FOR DEFINING THE HUMAN AND ORGANIZATIONAL ARCHITECTURE

1. Is the current contemplated enterprise integration program being used to launch any new initiatives in plant staffing and organizational policies, such as; "worker teams," "all skills on shift," etc.?
2. If so how will such policies affect how plant processes are operated?
3. List all management human resources mandates and policies.
4. List known problems as identified from the AS-IS human resources effort.
5. List all outside influences which will impact the TO-BE human resource policies such as government or OSHA.
6. Detail the description and attributes of the Information Automatability lines.
7. Detail the description and attributes of the Information Humanizability line.
8. Detail the description and attributes of the Manufacturing Automatability line.
9. Detail the description and attributes of the Manufacturing Humanizability line.
10. Detail the description and attributes of the Manufacturing Extent of Automation line.
11. Detail the description and attributes of the Information Extent of Automation line.
12. Identify all machine tasks.
13. Identify all automated information tasks.
14. Identify all human manufacturing tasks.
15. Identify all human information tasks.
16. List all job descriptions.
17. Identify all skill requirements.
18. Diagram the TO-BE plant organization.
19. Review each of the above and identify any risks or obstacles to achieving or implementing each.
20. Identify reward systems in terms of work systems and career paths.
21. Evaluate human organization in terms of achieving mission, vision and values.
22. Has there been an appropriate distribution of tasks between personnel and the computer system to take advantage of the capabilities of each?
23. Do present personnel possess all needed technical skills and educational background? What additional training is necessary and appropriate?

ATTACHMENT 5-II

SUMMARY OF PLANNING STEP 5
"TO-BE" HUMAN / ORGANIZATIONAL ARCHITECTURE

Define:

- Proposed Organizational Structure
- Job Descriptions & Functions
- Job Skill Requirements
- Risks & Obstacles
- Extent of Automation

Resources:

- Previous Step Documentation
- Management Philosophies and Vision
- Organization Culture & Beliefs
- "TO-BE" Personnel Policies

6. "TO-BE" Manufacturing Equipment Architecture

6.1 *Introduction*

The TO-BE Manufacturing Equipment Architecture requirements must be defined relatively early in the Master Plan development effort. These requirements are expressed in terms of the types of process equipments, capabilities, operational procedures, materials of construction, processes involved, etc., which provide the means for fulfilling the goals and objectives of the business entity in terms of its required production capability and range of products desired. Through the expressed connectivity of the components of the plant they also define its personality. This is also the place where the desired level of automation in terms of the manufacturing equipment is expressed.

The following requirements and important future capabilities are fulfilled here:

1. The TO-BE Manufacturing Equipment System is defined and documented at a functional level. This is the form in which it is most useful as guidance for the AS-IS to TO-BE transition planning, and for future project design and implementation. This functional definition will be termed the Manufacturing Equipment Architecture in the remainder of this chapter for its use in the Master Plan.

2. The results of this activity are very important in defining the scope of the overall planning activity that is needed to document the AS-IS Manufacturing Equipment Architecture (Chapter 9).

3. Thus it is recommended that this activity be completed early in the planning process because of its importance to the other planning activities.

Inputs and Outputs Planning Process

Figure 6-1 presents the IDEF-like diagram that represents the process of development involved with this chapter. As noted on the figure the following sources of information are vitally important for this task:

1. The Enterprise Business Entity vision, goals and objectives are the critical inputs to this planning activity as they reflect the business objectives that will affect the competitiveness of the manufacturing plant (Chapter 2).

2. Chapter 4 identified a set of significant opportunities to be enabled by enterprise integration in order to achieve the goals and objectives of the Enterprise Business Entity. These are important considerations in the TO-BE planning.

3. The TO-BE Enterprise Business Entity policies are the guiding principles established by the Steering Committee and are affirmed by the Chapter 3 activity.

4. The TO-BE Human and Organizational Functional Architecture (Chapter 5) will be required to determine the Extent of Automation which will occur in the TO-BE Manufacturing Equipment Architecture definition (For the Extent of Automation see Item 4a of the next tabular discussion below)

5. Requests for more detail from other planning activities will also most likely occur, especially during the transition analysis as described in Chapter 12.

CHAPTER 6 – TO-BE Manufacturing Equipment Architecture

It is expected that the TO-BE Manufacturing Equipment Architecture planning effort described herein will develop the following significant products for incorporation into the developing Master Plan:

1. A set of the TO-BE physical plant operating criteria as developed by the Steering Committee and other management.

2. A list of TO-BE physical processes involved including:
   a. Definitions of processes and products
   b. Operational constraints

3. A set of the information concerning the manufacturing functional modules involved covering the following important constituent elements:
   a. Unit operations
   b. Plant specifications
   c. Definition of the transformation (manufacturing) processes

4. The defined functional deployment of the TO-BE Manufacturing Equipment Architecture with respect to:
   a. The Extent of Automation for the Manufacturing side for the system under development. This specifies the division of work in implementing the functions shown by the network model between human and manufacturing equipment based agents [83].

5. The manufacturing functional design for the TO-BE plant including, where appropriate:
   a. Flow diagrams
   b. Product progression diagrams
   c. Actuator/Sensor lists
   d. Control strategy lists

Figure 6-2 diagrams the overall procedures involved in making the study described in this chapter.

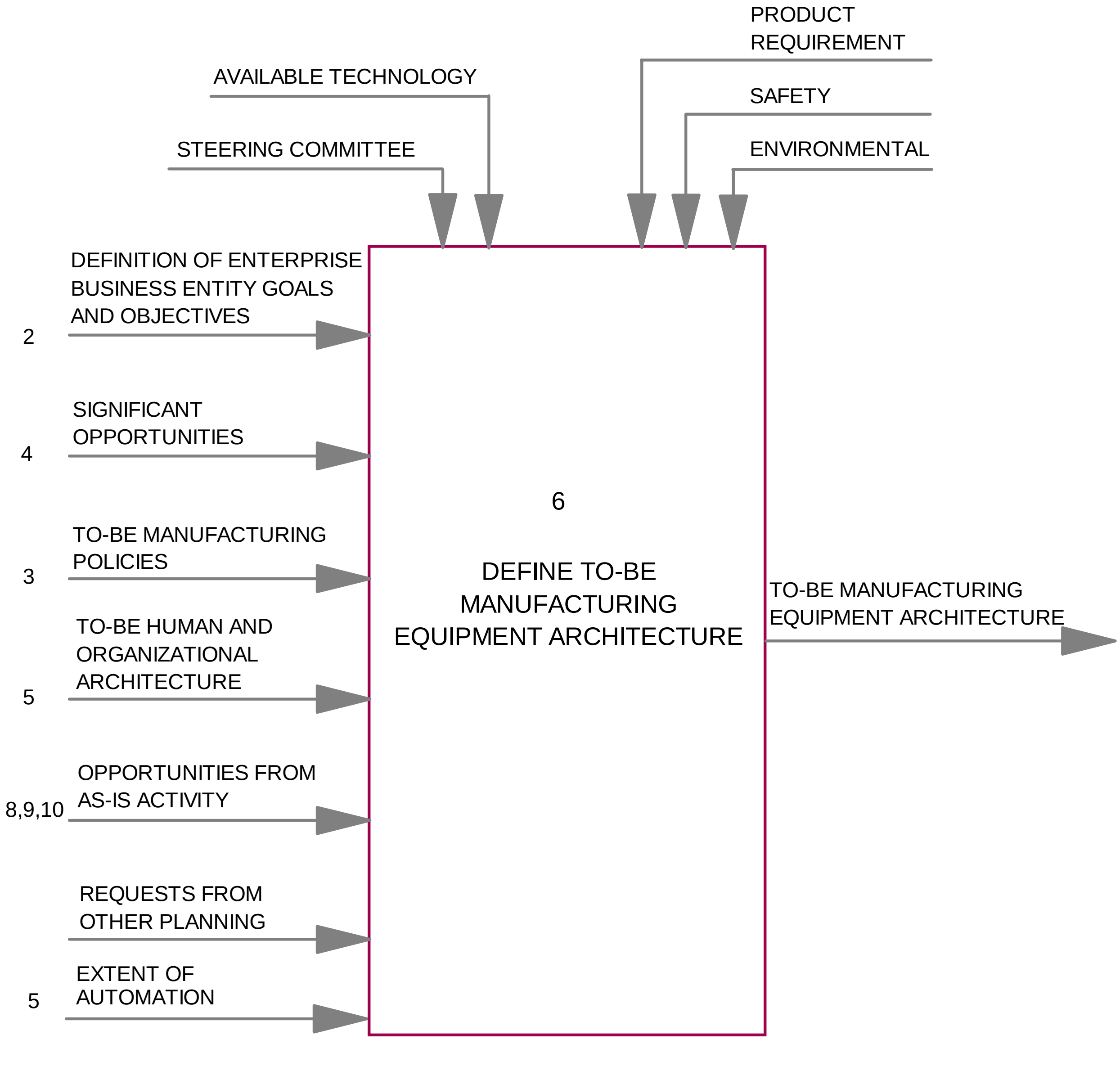

FIGURE 6-1 THE TRANSFORMATION TASK OF CHAPTER 6 -- DEFINE TO-BE MANUFACTURING EQUIPMENT ARCHITECTURE

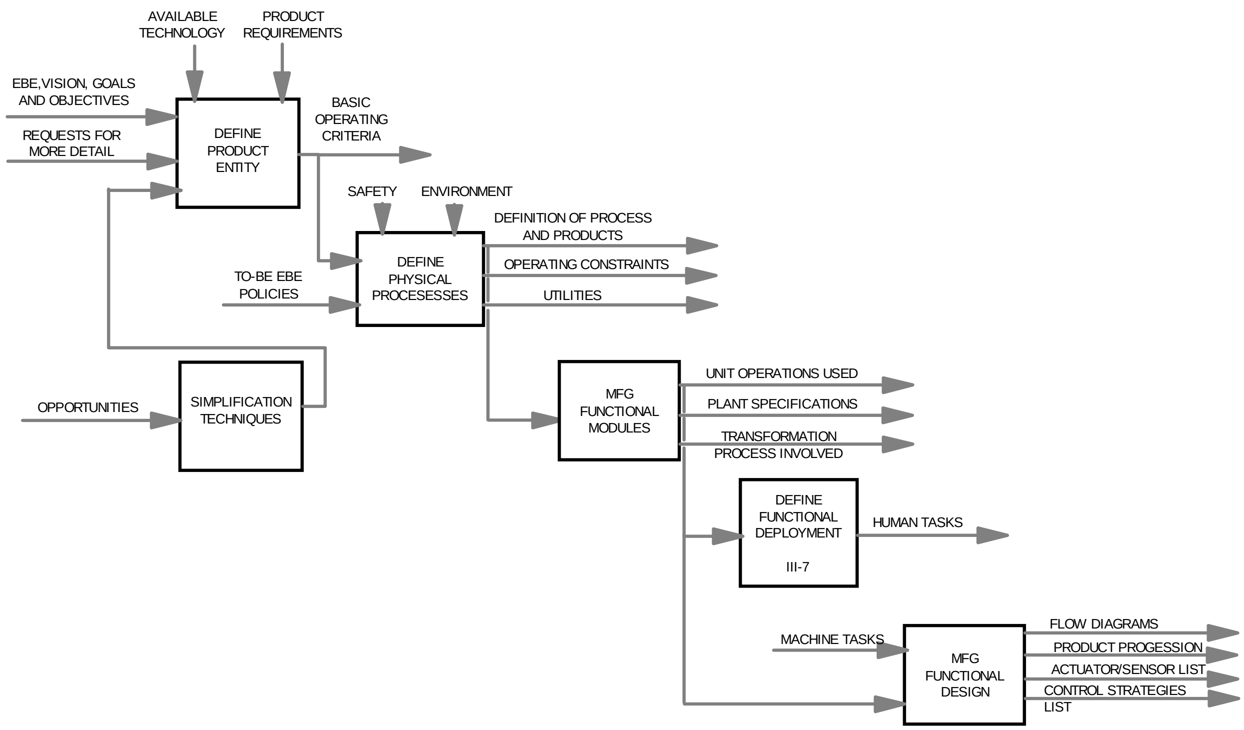

FIGURE 6-2 THE STEPS IN THE DEFINITION OF THE TO-BE MANUFACTURING EQUIPMENT ARCHITECTURE REQUIREMENTS

6.2 *Technical Background*

The Enterprise Integration Planning Team is responsible for defining explicitly the desired TO-BE status for each of the following: the plant Enterprise Business Entity itself; the physical processes involved; the manufacturing functional modules and their organization and connection into the plant flow or process diagram; the functional layout of the plant; manufacturing system functional design; and the Extent of Automation for each unit involved. The considerations related to each element above are as listed below:

1. Analysis of the existing manufacturing system (if a retrofit plant) or new facility design for compatibility with integration technology.
    a. Simplification of process paths and numbers of process steps where possible.
    b. Need for more advanced technology for certain process steps.
    c. Adequate material handling and inventory management facilities.

2. Detailing of the operation of the proposed TO-BE Enterprise Business Entity.
    a. This activity decomposes the inputs from the Steering Committee to produce a documented set of basic operating criteria. These criteria are the rules and assumptions that specify the Enterprise Business Entity plant or mill.
    b. The Enterprise Business Entity vision, goals and objectives, critical success factors, etc. need to be evaluated relative to available technology and product requirements. Some technology investigation may be required.
    c. The opportunities identified in Chapters 4 and 10 will need to be analyzed to determine their applicability to the TO-BE Manufacturing Equipment Architecture.

3. Listing and describing the functional tasks and functional modules involved.
    a. This requires prescribing and illustrating each of the manufacturing tasks and manufacturing functional modules included in the Enterprise Integration system. All needed data to thoroughly define these tasks and modules must be supplied.
    b. Each of these functional tasks and modules must be connected into a process flow diagram describing the plant's operation. These operations are then further specified in terms of a functional layout of the physical plant itself.

4. Degree of automation to be followed
    a. Each functional task or module and its associated physical equipment must be evaluated as to the desired degree of automation to be applied to that function or physical unit of the plant.
    b. A key consideration here is the details of the Human and Organization Architecture to be used. This information will have a major effect upon the degree of automation to be eventually applied to the function or unit. The following are some considerations in this regard:
        (1) Technology limits in accomplishing automation of the unit involved
        (2) Social issues involved and company management's response to them
        (3) Union agreements and/or union influence in management decisions
        (4) Enterprise Business Entity vision, goals and objectives
        (5) Safety requirements
        (6) Redundancy requirements for increased reliability
        (7) Human relations policy
        (8) Economic limits in terms of payoff requirements
        (9) Etc.

5. Manufacturing equipment functional design
    a. This step documents the Manufacturing Equipment Architecture defined in the previous steps.
    b. The specific deliverables for this definition are flow diagrams, product progression charts, actuator/sensor list, and control strategies list.
    c. The format and media of the documentation should conform to the format and media previously defined by the Planning Team in order to facilitate the work of defining the transition steps between AS-IS and TO-BE.
    d. Interaction should occur with other TO-BE teams to insure consistency in detail needed and recorded.

Deliverables

Because the material developed here is important to the succeeding sections and to getting Steering Committee buy-in to the whole project, the deliverables associated with the TO-BE Manufacturing Equipment Architecture as defined here may have to include considerable presentation-type material in addition to the usual technical report format.

As earlier, the format of all of these materials must be coordinated with those involved in the transition documentation to facilitate the latter group's efforts (see Chapter 17).

6.3 *Implementation*

Probably the easiest way to carry out the tasks listed above is to develop a high-level (i.e., minimum required detail) model of the TO-BE Manufacturing Equipment Architecture, i.e., the left hand side of the Purdue Enterprise Reference Architecture. This must be in a format which:

1. Supports the business objectives of the Enterprise Business Entity with proper selection of tasks and functions to be carried out by the system.
2. Identifies all functional and data integration requirements.
3. Forms a data source for comparison with a similar model developed for the AS-IS system to allow the functional transition planning performed in Chapter 12 to satisfy all functional information requirements of the Enterprise Business Entity in an accurate, timely and complete manner.

The model desired will probably be a network model. The development of these network models is thoroughly described in References [28,39,65].

Figure 6-3 shows the relationship of the material of this chapter to the overall planning project as shown by the Purdue Enterprise Reference Architecture. Attachment 6-I presents a checklist to help assure a complete treatment of the material of this chapter. Attachment 6-II summarizes the whole task involved.

Risks

Although most of the activities of Master Plan development, as documented in this manual, are designed to be non-sequential in their implementation, this task is an exception, in that, many other activities depend upon the early availability of the information generated here and in Chapters 5 and 7. Thus not completing this activity early in the planning process will lead to delays in the several activities following it.

This is one of the most critical steps in the enterprise integration planning process. Not having Steering Committee review of, and commitment to, the results of Chapters 5, 6 and 7 will only adversely affect the results obtainable from the follow-on tasks of the planning effort.

The results of this activity are important in the development of several other activities described above, thus its results will vitally affect the amount of detail involved possible in many of the follow-on design and machine capability activities of the later steps.

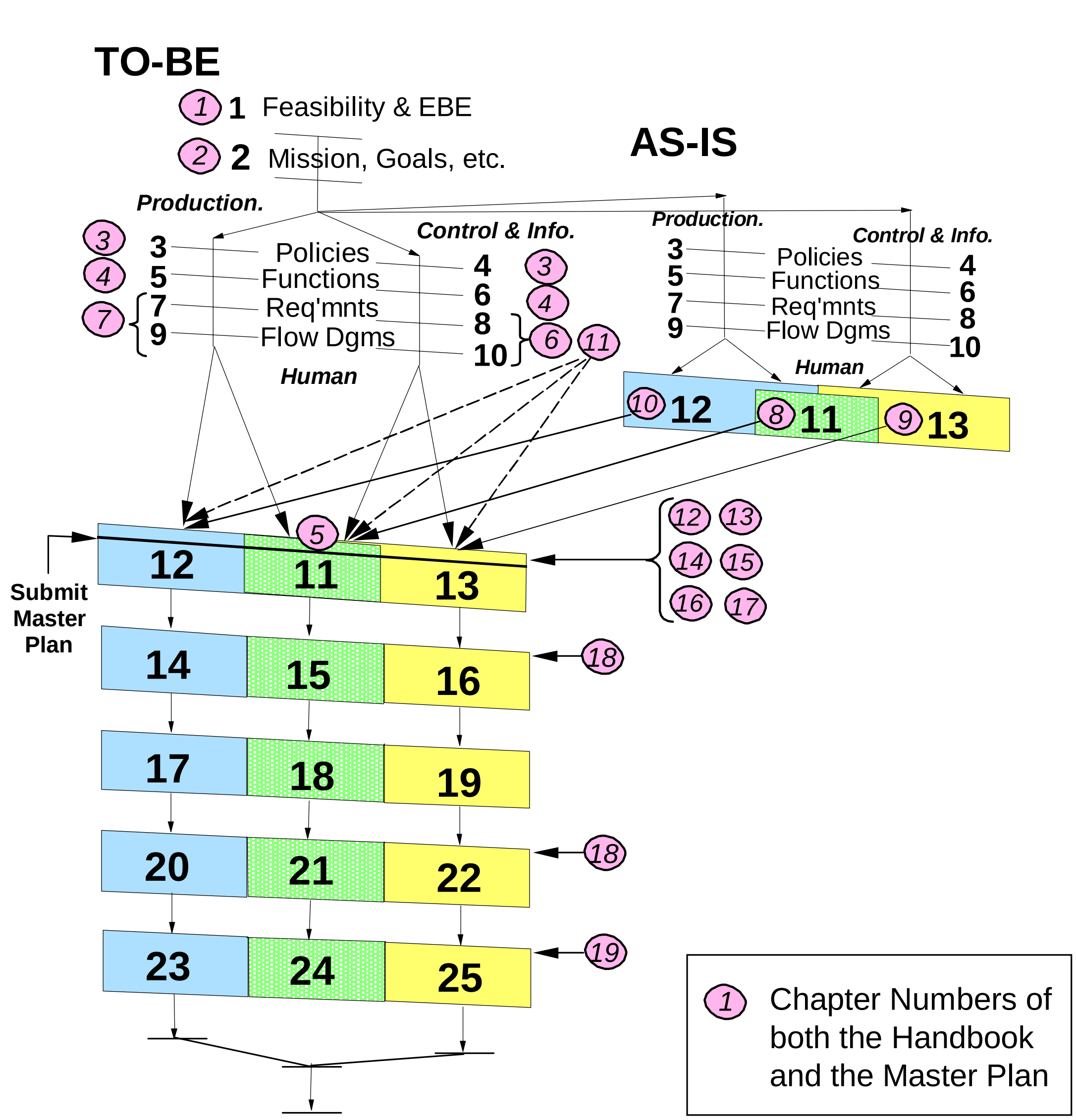

FIGURE 6-3 THE WORK OF CHAPTER 6 DEFINES TO-BE INFORMATION SYSTEM ARCHITECTURE REQUIREMENTS AS SHOWN BY THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

ATTACHMENT 6-I

A CHECKLIST ON THE TASK OF DEFINING THE TO-BE MANUFACTURING EQUIPMENT ARCHITECTURE

I. NEW PROCESSING EQUIPMENT

1. What new types of process equipment have been contemplated for the plant or factory as part of the modernization that this Master Planning Project will document?

2. How will these new processes affect:
   a. Plant throughput,
   b. Product quality,
   c. Flexibility of production in terms of range of grades possible and shortening of grade change times,
   d. Yields obtained,
   e. Amount of rework necessary?

3. What changes in operational procedures will be necessary?

4. Does the sum total of the above change result in a major reworking of the process area, or only a relatively minor difference from the current AS-IS condition of the physical plant equipment?

II. OTHER CONSIDERATIONS

1. Is it contemplated that the Extent of Automation line describing the current plant situation will be significantly changed? If so have these been documented for the Master Plan in terms of new or changed sensors, actuators, etc.?
2. Be sure all decisions made in Chapters 5 and 7 are reflected in the design of the process equipment.
3. Implementation task
4. Manufacturing requirements
   a. What is the functional process flow?
   b. What are the operating criteria?
      1. Capacity or yield?
   c. What are the physical processes and products.
   d. What are the unit operations, plant transformation process?
      1. Facility, i.e., grass-roots, expansion, retrofit?
      2. Process hardware?
      3. Utility requirements?

ATTACHMENT 6-1 (continued).

4. Quality criteria (checklist)
    a. Are all business functions included?
    b. Are all business objectives and critical success factors addressed?
    c. Is the level of detail correct?
    d. Any problem areas or issues to discuss?
    e. Any high-risk issues?
    f. How feasible is it?
    g. Any high cost options to discuss?
5. Documentation outputs
    a. Flow diagrams, product progression diagrams
    b. List of instruments
    c. List of control strategies
    d. Preparation of presentation-type materials

ATTACHMENT 6-II

SUMMARY OF PLANNING STEP 6
"TO-BE" MANUFACTURING EQUIPMENT ARCHITECTURE

Define:
- "TO-BE" Manufacturing Equipment Architecture

Resources:
- Previous Step Documentation
- Technology Availability Studies
- Environment and Safety Studies
- Product Requirement Reports
- Requests from Other Planning Efforts

7. "TO-BE" Information Systems Architecture

7.1 *Introduction*

The heart of the proposed new enterprise integration system for the Enterprise Business Entity is, of course, the TO-BE Information Systems Architecture. This would be defined in the same way as the Human and Organizational Architecture in the earlier chapter. This architecture develops the information system requirements which convert the following needs into potential hardware and software for the enterprise integration system:

1. Implementation of the business process, personnel and information policies.
2. Manifestation of the enterprise integration vision of the Enterprise Business Entity.
3. Expression of the enterprise integration philosophies and mandates of the Enterprise Business Entity.
4. Development of the task expressions and information flow connectivity needed to establish the information and control system to satisfy the above needs.
5. Development of a specification model to express the solution of the need of item 4 above.
6. Determine that portion of the task list and information flow of item 4 above that will be carried out by the physical information and control system (the Information System Architecture) and that part carried out by people. That is, determine the location of the Extent of Automation line in the corresponding diagram of the Purdue Enterprise Reference Architecture for the Information Architecture.

This chapter describes the work required by the Enterprise Integration Planning Team to satisfy the above needs in their development of the Master Plan for the Enterprise Business Entity. Figure 7-1 diagrams the information usually considered in developing the materials and the products resulting.

7.2 *Implementation*

Probably the easiest way to carry out the tasks listed above is to develop a high-level (i.e., minimum required detail) model of the TO-BE Information Functional Network, i.e., the right hand side of the Purdue Enterprise Reference Architecture. This must be in a format which:

1. Supports the business objectives of the Enterprise Business Entity with proper selection of tasks and functions to be carried out by the system.
2. Identifies all functional and data integration requirements.
3. Forms a data source for comparison with a similar model developed for the AS-IS system to allow the information functional transition planning as performed in Chapter 12.

The model desired will probably be a network model. The development of these network models is thoroughly described in References [28,39,65].

In addition to the network model just listed, two additional requirements are necessary to complete the task outlined here. These are:

1. Specify the Extent of Automation for the Information Architecture for the system under development. This specifies the division of work in implementing the functions shown by the network model between human and computer-based agents.
2. Develop an Information System Architecture model or "hardware model" to describe the hardware and software components required to support the information functional architecture.

The "hardware model" is best represented by an elaboration of the Purdue hierarchy form as described in the Purdue Reference Model and presented in Figures 7-2 and 7-3 [81] or by an even more hardware oriented version as shown in Figure 7-4 or even Figure 7-5. The tables of control and information systems tasks and functions versus hierarchical functional level and their coordination with the data-flow diagrams as presented in the Purdue Reference Model will be very valuable here. These are presented in this Guide in Appendix 1. They will, of course, have to be modified to cover the specific requirements of the manufacturing plant of the Enterprise Business Entity. Figure 7-6 (derived from Figure 24) shows how the material of this chapter maps onto the Purdue Enterprise Reference Architecture.

Development of Descriptive Models

It is envisioned that four (4) progressive steps will be involved in the development of the model and associated descriptive material discussed above. These steps will be fed from one to another with feed back processes being performed until all conditions have been satisfied. Refer to Figure 7-7, "Flow of the Modeling Process."

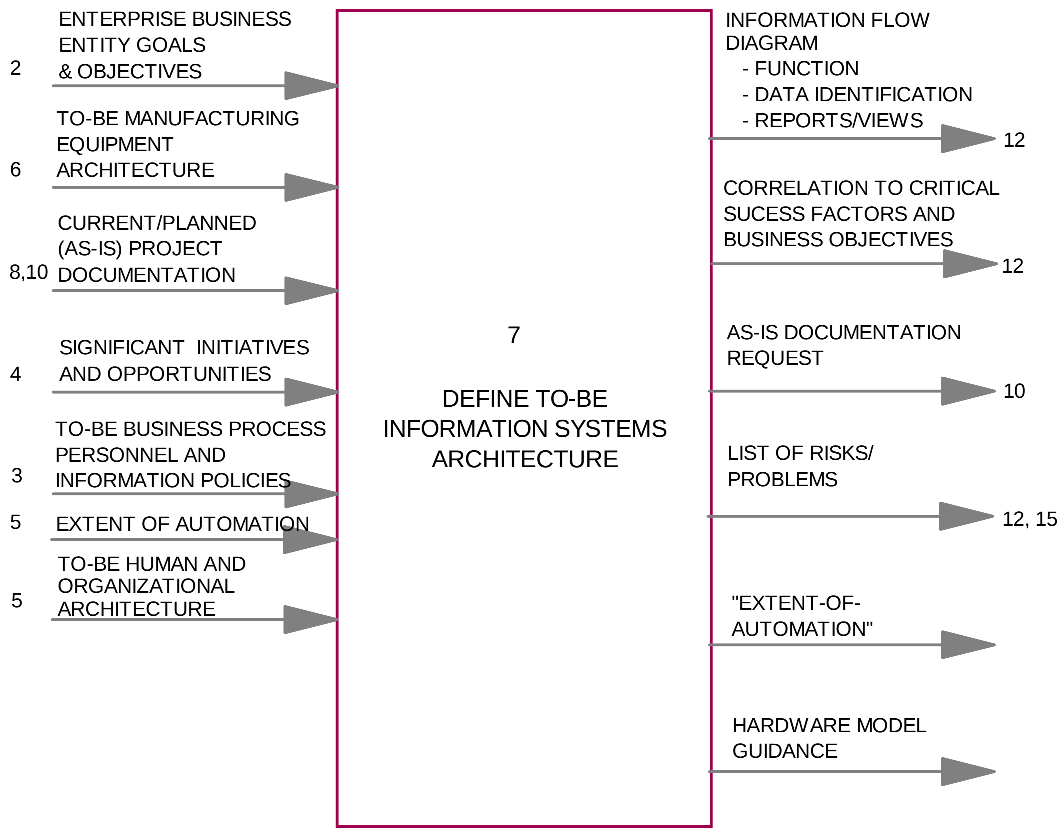

FIGURE 7-1 THE TRANSFORMATION TASK OF CHAPTER 7 -- DEFINE THE TO-BE INFORMATION SYSTEM ARCHITECTURE

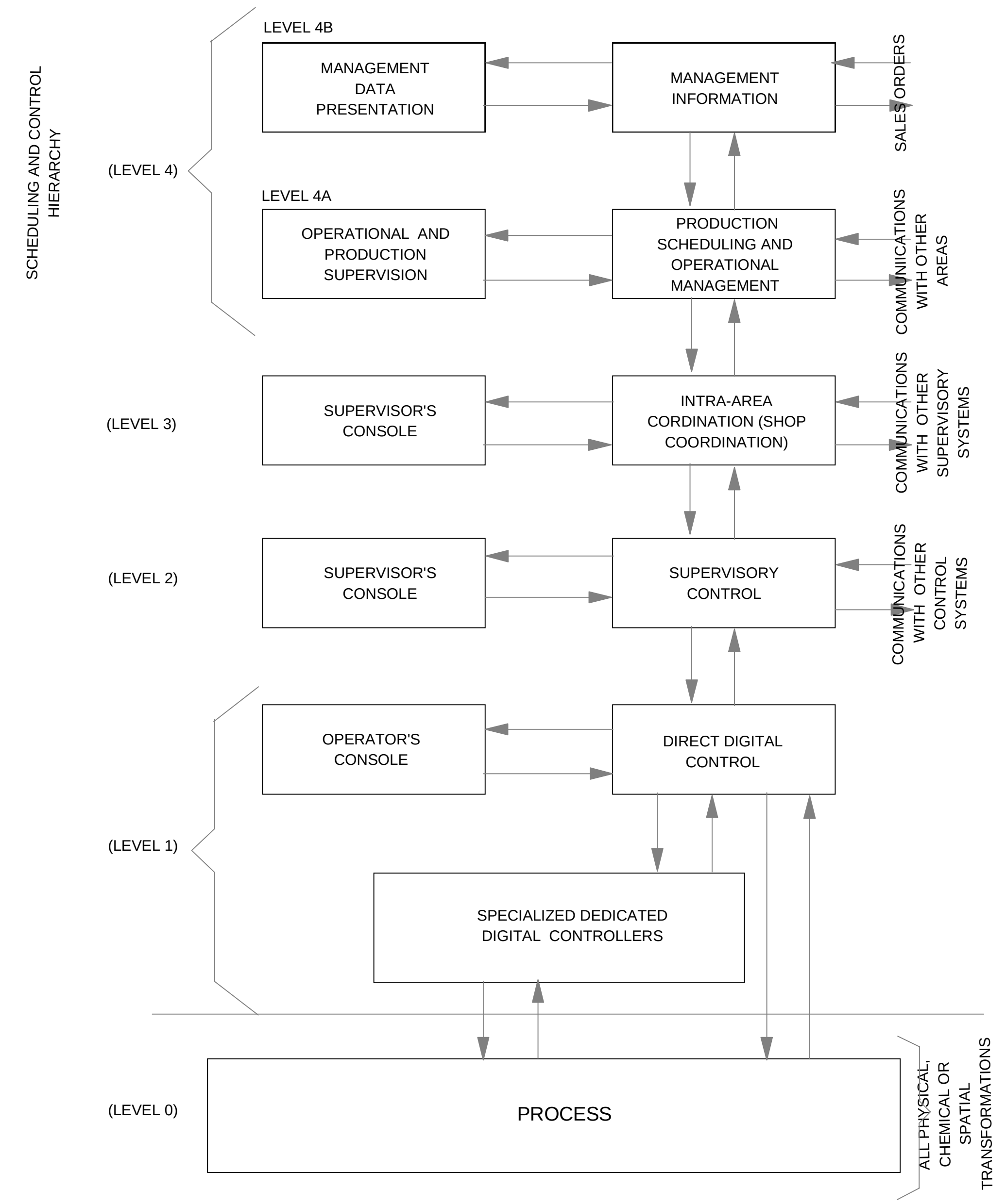

FIGURE 7-2 ASSUMED HIERARCHICAL COMPUTER CONTROL STRUCTURE FOR AN INDUSTRIAL PLANT (CONTINUOUS PROCESS SUCH AS PETROCHEMICALS)

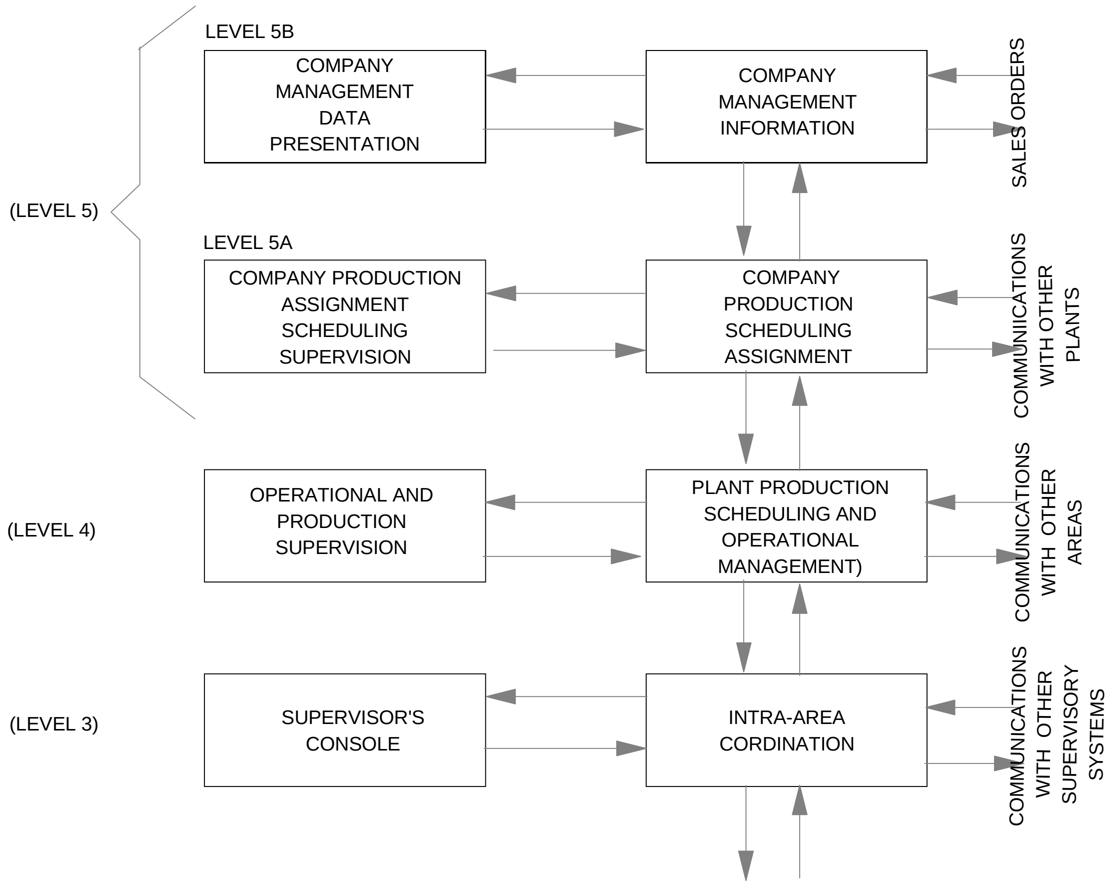

FIGURE 7-3 ASSUMED HIERARCHICAL COMPUTER CONTROL STRUCTURE FOR AN INDUSTRIAL COMPANY (MULTI-PLANT)

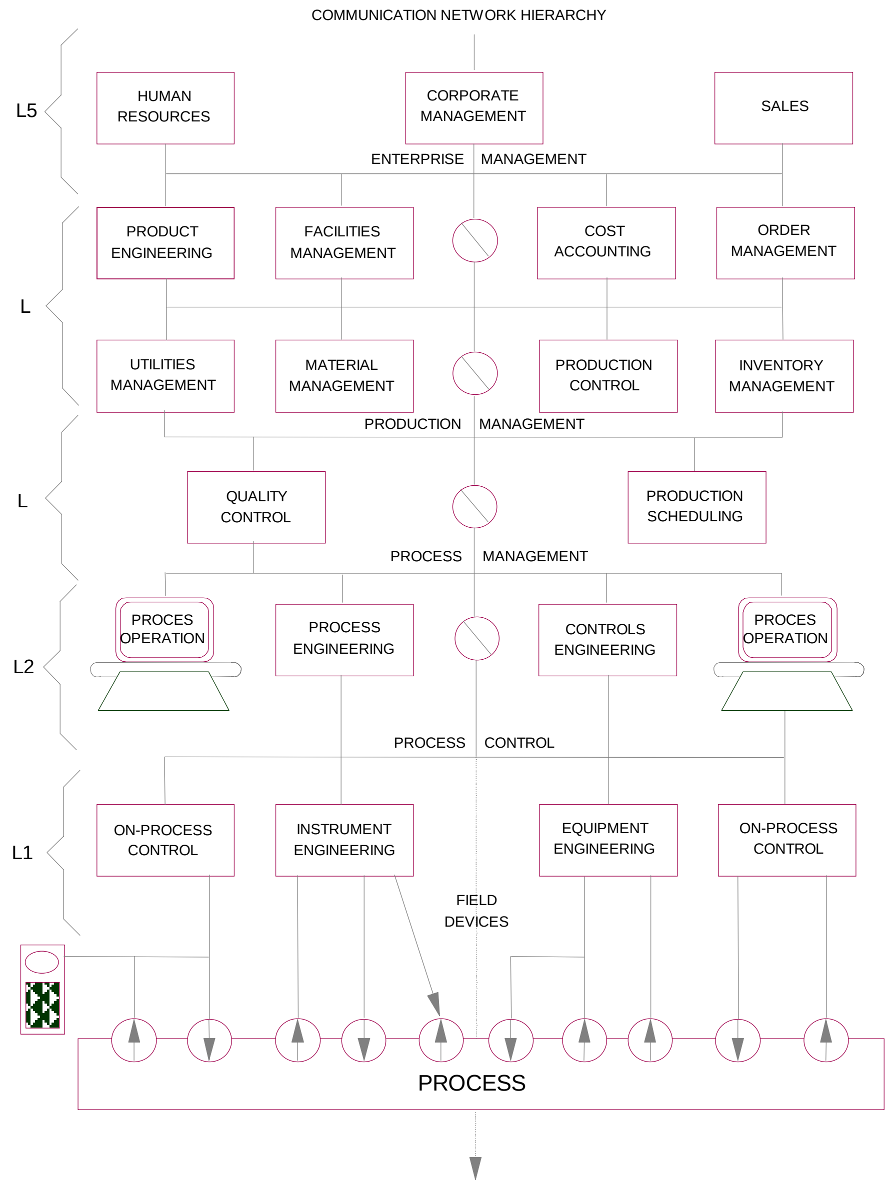

FIGURE 7-4 PARTIAL HARDWARE FORM OF THE PURDUE HIERARCHY

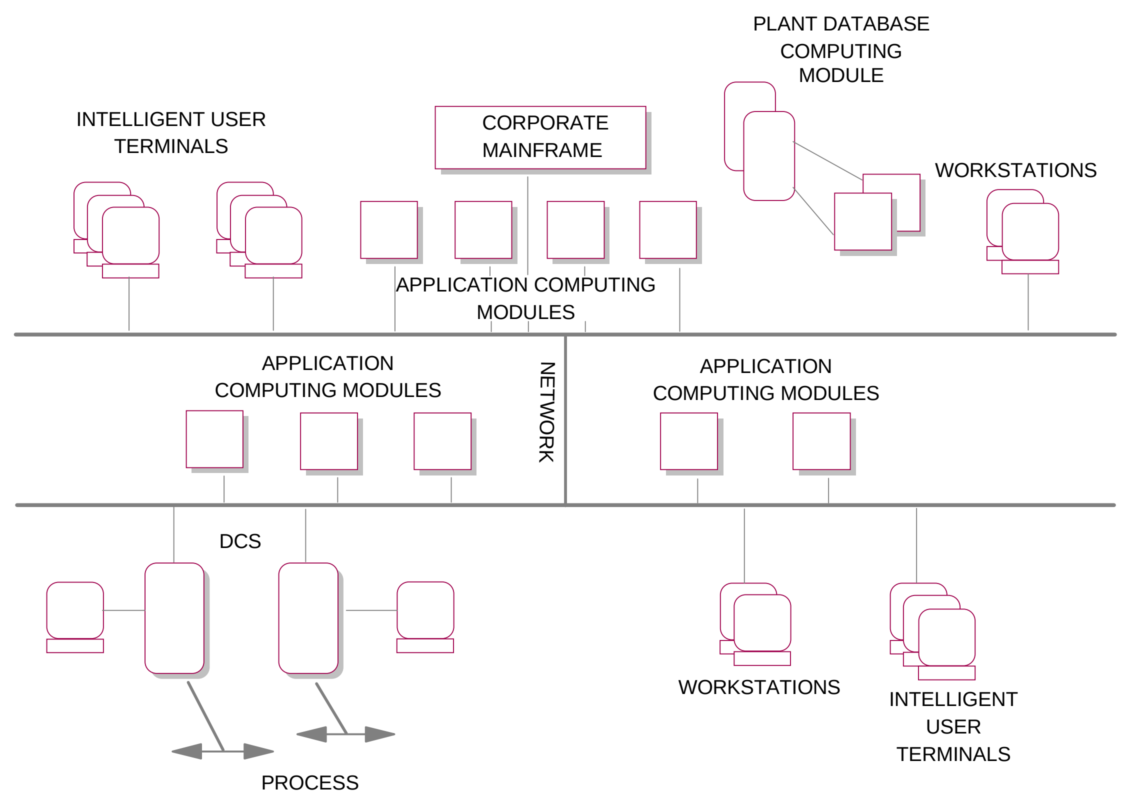

FIGURE 7-5 SYSTEM HARDWARE ARCHITECTURE (TYPE 1)

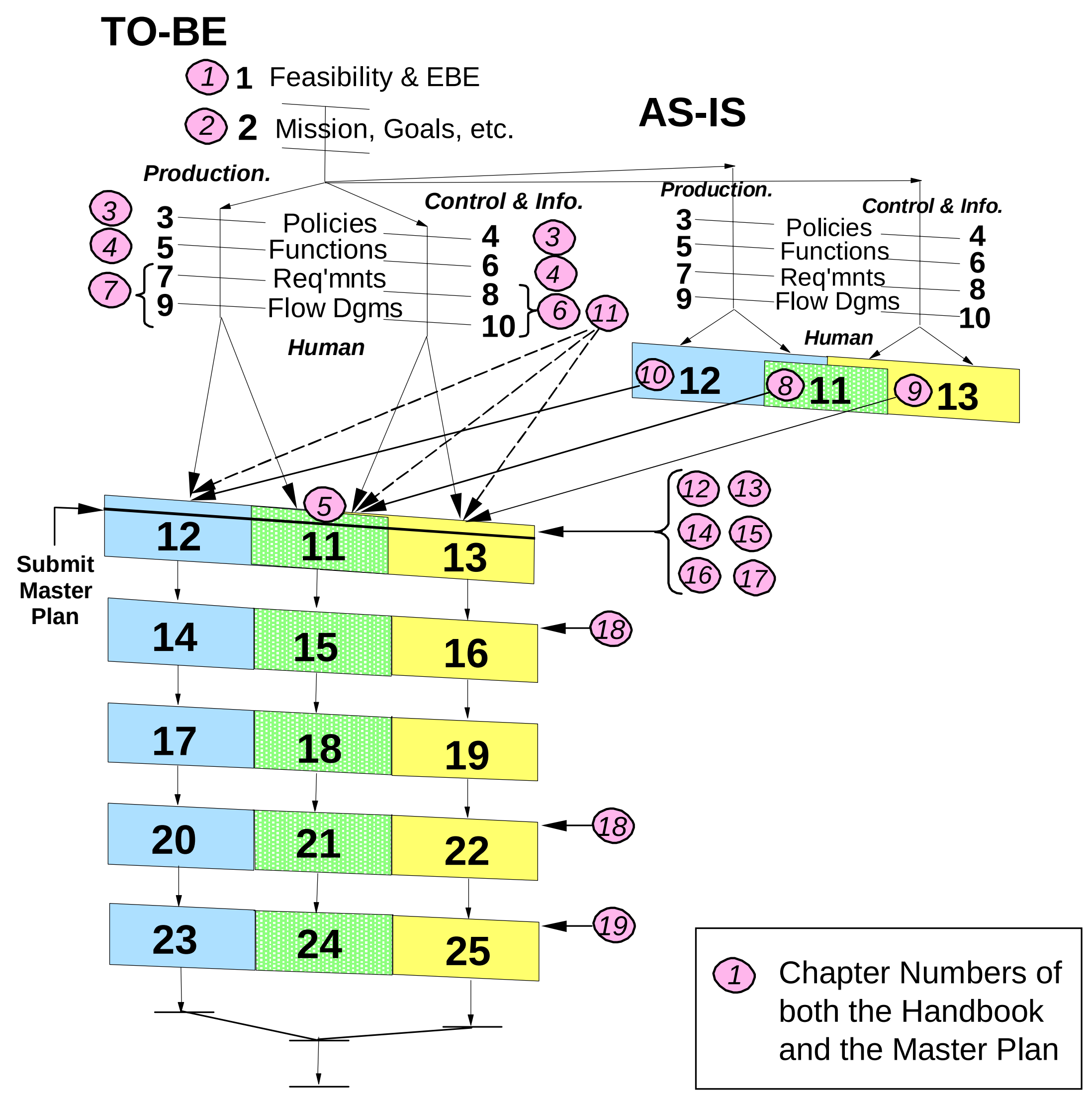

FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

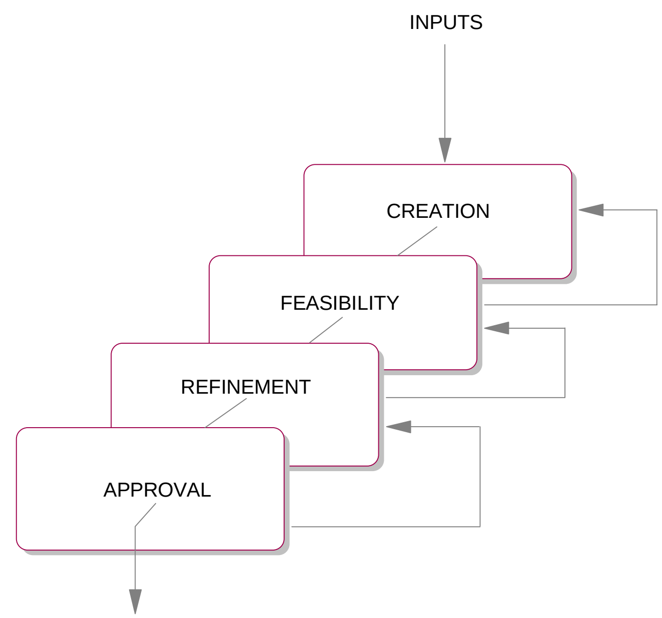

FIGURE 7-7 FLOW OF MODELING PROCESS

These steps are described as follows:

STEP 1: Creation Phase

This step is where all important ideas will be considered. A prime source of these will come from Chapter 4, "Significant Initiatives and Opportunities". This process should use the Purdue Reference Model's generic Yourdon diagrams (Figures AI-34 to AI-50) as a basis for further decomposition to define its specific Information System Architecture. This requires a participative type of process where all ideas are given due consideration as part of the Information Functional Network.

This phase will start out very free form, but as it progresses it should begin to focus more around selecting the best strategy from the suggested possibilities until one has been chosen for submission to the next step. It is considered that this will be performed in a structured top-down manner where the modeled architecture is referenced to the business objectives at each phase of its development. The methodology chosen is to support graphic identification of data flows, data descriptions, and functional task identifications. It is to also support layers of detail graphically.

The level of detail necessary in the model varies with the complexity of the solution. It is important that enough detail be provided so that it clearly identifies the solution set (the functional tasks and their respective integration). It is also important to achieve a detail level so that separate project initiatives can be identified for the following Chapters. This detail is to include an identification of the "Extent-of-Automation."

The necessary factors for this step are:

1. Business knowledge
2. Knowledge of AS-IS
3. Industry trends
4. Critical success factors and business goals
5. Business process, personnel and information policies

Note that this process IS NOT to create detailed designs as these will be performed as part of the separate projects when they are initiated.

Additionally, careful consideration needs to be given to the manner in which these sets of functions (applications) will be implemented. It is common to find several categories and/or levels of applications and their associated data. For example, they might be classified as follows:

1. Production measurement and control
2. Operational planning and scheduling
3. Business accounting and recording

Each of these classifications follow the Purdue Reference Model and they may imply different implementation (system hardware and software) considerations. All of these need to be considered in light of the information principles as outlined in the TO-BE manufacturing policies, Chapter 3. These included such items as:

1. Security and usage
2. Disposition of the associated data (measured, compensated or reconciled)
3. The timing and necessary responses required.
4. The abilities of the data storage agents (relational DB; distributed DB; object oriented, high response DB; etc.)
5. The required availability of the application/s
6. The usage of an application (many users, few users, selected users, etc.)
7. The grouping of closely integrated sets of applications
8. The hardware and system requirements of the applications:
    a. Compute intensive
    b. Graphics intensive
    c. Data access intensive
    d. High level of integration (network intensive)
    e. Etc.

These should be formulated to create a System Hardware and Software Model to support the implementation of the proposed functions. This may take the form of a set of "rules". This model is to guide the implementations of all projects.

It is important that a predisposition to a particular hardware or software vendor not be specified by the Implementation Model. Additionally, the model is to be able to adopt the applicable standards, Chapter 11, in all areas such as:

1. Protocols and other communications requirements
2. User Interfaces
3. Etc.

STEP 2: Feasibility Phase

This step views the proposed solution from several aspects:

1. Have the integration goals been met?
2. Have the timing requirements been achieved?
3. Have the necessary levels of accuracy been obtained?
4. Is the necessary technology available?
5. What are the risks and their magnitude?
6. Can the system be implemented in a cost effective manner?

Additionally, preliminary reviews need to be held with the associated stakeholders:

1. Steering Committee
2. The End Users

Any problems identified are processed back to the preceding step, Creation Process, until a satisfactory solution has been agreed.

STEP 3: Refinement Phase

The refinement phase considers the broader aspects of the proposed solution. One aspect involves the reconciliation of the proposed TO-BE for both the physical plant and the human resources. Once this has been completed, the proposed solution needs to obtain final approval/s.

If any difficulties are irreconcilable, then these would be processed back to the preceding step and the process would begin again once a proposed solution has been re-submitted from Phase 2.

STEP 4: Documentation Phase

This phase is to create the necessary output documentation that will complete the task of this Chapter. These outputs will be as follows:

1. The TO-BE functional documentation
   a. Information and Control Flow Diagram which documents at a high level:
      1. A decomposition of the major functional tasks to the detail necessary to clearly identify the respective functional application modules and their requirements.
      2. Identification of reports and related information views with respect to the application modules above.
      3. Data descriptions, flows, sources, timing, accuracy, verification, and usage relationships to respective functional modules, reports, and views.
   b. A correlating description and/or table to describe the relationships between the modeled data and functional models in the TO-BE Information System Architecture to the critical success factors of the Enterprise Business Entity and its business objectives.
   c. A document describing the AS-IS documentation requirements including the appropriate levels of detail to be performed.
   d. A descriptive list of all high risk areas.
2. A definition of the "Extent-of-Automation" for the Information System Architecture.
3. Hardware model guidelines and preliminary modeling.

7.3 *Quality Criteria*

The team developing the TO-BE needs a broad range of knowledge about the business aspects of the Enterprise Business Entity. The team needs to have experience from all of the operational areas of the business. It is expected that outside consultants may be required to help set the expectations and to provide experience for defining the envelope of capabilities, possible benefits, and associated risks. These consultants may either serve as full-time team members or be used on an "as-needed" basis.

The ability to clearly visualize and articulate the TO-BE concept will be fundamental to the success of the modeling process. In this process, commitments to past plans, investments and/or projects should not be a limiting factor.

Quality will be assured in the TO-BE Information System Architecture modeling task if the following functions and tasks have been satisfied in addition to the above skill availability:

1. Open and prompt access to other knowledgeable personnel in the organization.
2. Access to the required documentation.
3. A clear definition of what is to be provided and to what level the information needs to be documented. The Purdue Enterprise Reference Architecture should be used as a guide.
4. A check list of the information to be addressed:
   a. All business functions are to be included.
   b. All business objectives and CSFs are to be addressed.
   c. All inputs and outputs included in the process units for their control.
   d. Etc.
5. The integration and sophistication of the modeling tools.
6. The check lists of the paragraphs of ISO 9000.

It is important that senior management support and this commitment be perceived by the team. A substantial amount of senior staff's time will be necessary to address this task and the cooperation of senior managers will be required to secure a quality effort.

7.4 *Project Management*

Team management and the Steering Committee will wish to monitor the progress of the completion of the tasks of this chapter and assist the group conducting the work by:

1. Monitoring the progress towards completion.
2. Reviewing the level of detail being provided.
3. Monitoring the adherence to methodology guidelines and the application of the tools.
4. Reviewing produced or drafted results.
5. Scheduling preliminary review/s with the Steering Committee if required to discuss issues such as problem areas, identified high risks, high cost options, etc.

7.5 *Checklist, Example Data and Summary*

As has been our practice in all chapters, Attachment 7-I presents a set of checklist questions for the work of the chapter. Attachment 7-II presents another example of the type of data needed here, and Attachment 7-III presents a summary of the work involved.

ATTACHMENT 7-I

CHECKLIST FOR DEFINING THE TO-BE INFORMATION SYSTEMS ARCHITECTURE

I. NEW INFORMATION TECHNOLOGIES TO BE USED

The Enterprise Integration Program Proposal for which this master planning activity is being carried out will undoubtedly include major changes in the technology to be used for the Information Systems Architecture elements. The pace of modern technological change in electronic capabilities itself will demand this.

1. What effects will these have on:
    a. The process control functions to be carried out?
    b. The amount and types of advanced control techniques to be applied?
    c. Changes in communications procedures and capabilities?
    d. The capabilities and the response speeds of the man-machine interfaces involved?
    e. Sizes, search capabilities and ease of retrieval of information from the several data bases involved in the information system?
    f. Capabilities of scheduling systems installed as part of the suite of functions enabled by the computer system?
    g. Upon the manufacturing equipment and its interfaces with the control equipment.

II. NEW PERSONNEL PRACTICES

It is common practice today to use the Enterprise Integration Program as the medium for instituting new operator procedures, new plant floor organizational schemes such as "work teams", "all skills on shift", etc., as described under the several human and organizational architecture discussions in this text.

1. How will the man-machine interfaces and decision-support technology available influence the decision to empower the plant operators to make major process operational decisions?
2. Will these involve new operating procedures, new control systems, etc., needed? If so, has provision been made to develop such procedures, design the controls, etc.?

ATTACHMENT 7-I (continued).

III. DETAILS FOR EVALUATION OF THE OPERATIONAL INFORMATION TASKS OF THE ENTERPRISE SYSTEM

1. At Level (1), scheduling and control hierarchy (Figures 7-2 and 7-3). See also Table AI-X, Appendix I.
   a. List all tasks to be carried out at Level 1 - each and every individual process unit.
   b. List all input and computer variables versus process involved - each and every individual process unit:
      (1) Sampling rate of raw variable.
      (2) Data reduction function for each raw variable.
      (3) Database storage location of each reduced variable.
   c. List all output variables versus process involved - each and every individual process unit:
      (1) Output rate of each variable.
      (2) Storage location of each computer output variable.
   d. List the desired dynamic control function connecting each individual (set of) input(s) and each individual (set of) output(s).
   e. List the designations of all system parameters and coefficients necessary for the system's computations noted above, including their default values.
   f. List all needed communication facilities including relevant standards applicable.
2. At Level (2), scheduling and control hierarchy (Figures 7-2 and 7-3) See also Table AI-IX, Appendix I.
   a. Prepare a detailed list of all tasks to be carried out at Level 2 - each and every individual processing zone (collection of related processing units).
   b. List all computed functions versus task and processing zone involved. For each function:
      (1) List each individual (set) of process or computed variables used with each computed function.
      (2) List the designation and the use expected for each computed function result
      (3) List database element or storage location assigned for each computed result.
   c. List the designations of all system parameters and coefficients necessary for the systems computations noted above including their default values.
   d. List all needed communications facilities including relevant standards applicable.

ATTACHMENT 7-I (continued).

3. At Level (3), scheduling and control hierarchy (Figures 7-2 and 7-3). See also Table AI-VIII, Appendix I.
   a. Prepare a detailed list of all tasks to be carried out at Level 3 - each and every individual processing area (collection of related processing zones).
   b. List all computed functions versus task and processing area involved. For each Function:
      (1) List each individual (set) of process or computed variables used with each computed function.
      (2) List the designation and the use expected for each computed function result.
      (3) List database element or storage location assigned for each computed result.
   c. List the designations of all system parameters and coefficients necessary for the systems computations noted above including their default values.
   d. List all needed communications facilities including relevant standards applicable.

4. At Level (4A), scheduling and control hierarchy (Figures 7-2 and 7-3). See also Table AI-VII, Appendix I.
   a. Prepare a detailed list of all tasks to be carried out at Level 4A - for the entire factory.
   b. List all computed functions versus task involved. For each function:
      (1) List each individual (set) of process or computed variables used with each computed function.
      (2) List the designation and the use expected for each computed function result.
      (3) List database element or storage location assigned for each computed result.
   c. List the designations of all system parameters and coefficients necessary for the systems computations noted above including their default values.
   d. List all needed communications facilities including relevant standards applicable.
   e. List all data and information necessary from external entities versus the task to be accomplished:
      (1) List name of variable or data block involved.
      (2) Access rate for each variable or data block.
      (3) storage location(s) or data element(s) for each variable or data block.

ATTACHMENT 7-I (continued).

5. At Level (5A), scheduling and control hierarchy (Figure 7-3) if included in the proposed system. See also Table AI-VII, Appendix I.
   a. Prepare a detailed list of all tasks to be carried out at Level 5A - for the entire company if included in the integrated system.
   b. List all computed functions versus task involved. For each function:
      (1) List each individual (set) of process or computed variables used with each computed function.
      (2) List the designation and the use expected for each computed function result.
      (3) List database element or storage location assigned for each computed result.
   c. List the designations of all system parameters and coefficients necessary for the systems computations noted above including their default values.
   d. List all needed communications facilities including relevant standards applicable.
   e. List all data and information necessary from external entities versus the task to be accomplished:
      (1) List name of variable or data block involved.
      (2) Access rate for each variable or data block.
      (3) Storage location(s) or data element(s) for each variable or data block.

6. At Levels (4B) or (5B) scheduling and control hierarchy (Figures 7-2 and 20). See also Table AI-VI, Appendix I.
   a. Prepare a detailed list of all tasks to be carried out at Levels 5B and 4B - management levels of the company or factory.
   b. List all computed functions versus task involved. For each function:
      (1) List each individual (set) of process or computed variables used with each computed function.
      (2) List the designation and the use expected for each computed function result.
      (3) List database element or storage location assigned for each computed result.
   c. List the designations of all system parameters and coefficients necessary for the systems computations noted above including their default values.
   d. List all needed communications facilities including relevant standards applicable.

ATTACHMENT 7-I (continued).

e. List all data and information necessary from external entities versus the task to be accomplished:
   (1) List name of variable or data block involved.
   (2) Access rate for each variable or data block.
   (3) storage location(s) or data element(s) for each variable or data block.

IV. <u>IN CARRYING OUT THE WORK DETAILED IN ITEM III ABOVE BE SURE TO COMPARE AGAINST APPENDIX AI AS FOLLOWS:</u>

Evaluate all major tasks of the proposed computer system as listed in Tables AI-VI to AI-X, Appendix AI, against the specific requirements of the proposed plant. Expand each task with any increased detail as available and desirable. Justify any differences between the proposed plant and the generic one.

V. <u>PLANNING FOR DATA DICTIONARY AND USE REFERENCES</u>

For each storage entry in each and every separate database of the system, list the following data (note that this is more extensive than most data dictionaries):

1. Name or designation of each entry

2. List variable (raw or modified) needed for each entry. Indicate database where located.

3. For each database entry show:
   a. Source or original function values of entry variable,
   b. Data reduction function or algorithm used to develop each function,
   c. Use to be made of each entry.

It is noted that the above data duplicates that entered for each task. This then provides the Master Plan Development System utility for checking the completeness of both the task listings and the database entry listings.

ATTACHMENT 7-II

ANOTHER EXAMPLE OF THE KINDS OF DATA TO COLLECT FOR EACH PLANT VARIABLE

Identification

- Engineering Units
- Processing sequence
  - Routine processing interval
- No. of routine values to determine average
  - Use avg. for ref., delta and dev. checks

Current Value Processing

- Measured input
- Continuously monitoring max-min
- Measured input address
- ADC reading at bottom of scale
- ADC span
- Square root option in conversion
- Bias
- Coefficient
- Special current value calculation
- Intermediate special action

Limit Checking

- Process maximum limit
- Process minimum limit
- Process upper reference
- Process lower reference
- Delta limit for operator notification
- Special action when delta limit exceeded
- Delta required for a predictive adjustment

ATTACHMENT 7-II (continued.)

Target Value and Deviation Processing

Does variable have a target?

Min. time between two target calculations and/or dev. adj.

Action to evaluate new target value

Deviation limit

Action when dev. limit exceeded

Deviation for normal adjustment

Action for normal deviation adjustment per pass

Maximum set point adjustment per pass

Set point output

Controller address

Set point movement rate

Final special action

ATTACHMENT 7-III

SUMMARY OF PLANNING STEP 7
"TO-BE" INFORMATION SYSTEMS ARCHITECTURE

Define:

- Information Flow Diagram
  - --Function
  - --Data Identification
  - --Reports/Views
- Correlation to Business CSF and Objectives
- "AS-IS" Documentation Request
- List of Risks and Problems
- Hardware Model Guidance
- "TO-BE" Network Architecture

Resources:

- Previous Step Documentation
- Technology Availability Studies
- "TO-BE" Information Policies

8. "AS-IS" Human and Organizational

8.1 *Introduction*

Development of the proposed enterprise integration program to be documented by the Master Plan requires the establishment of a detailed benchmark of the current status of any existing manufacturing plant and its operational policies. It also requires documentation of any computer-based or other control system presently installed, as well as the existing human organization and human-relations policies of the Enterprise Business Entity. These are necessary for several reasons. First, to be able to determine exactly what has to be done to achieve the desired system requires knowing from where you start. Second, determining the economic, quality and productivity gains achieved by the new system requires knowing these factors for the plant prior to its modification.

The first important area of concern in relation to the documentation of the situation existing in the plant being considered for a enterprise integration program prior to the initiation of the program (the AS-IS) is that of the human factors (people and organization) involved. This combines with the material in the next two chapters to cover all of the important aspects here of (1) the human component of the plant: the human resources and organization; (2) the current plant itself: the physical plant resources available, the operations carried out and the manufacturing policies in place and, (3) the information system currently installed: the information resources available.

Just as with the next two chapters there is a need to document the situation as it existed prior to the development of the proposed enterprise integration program. We will use this to:

1. Document known problems and concerns for input into Chapters 5 and 12 (the TO-BE Human and Organizational Architecture and the Transition Plan).

2. Document the AS-IS condition of the plant to allow the post-project evaluation of results obtained such as:
    a. Determine to what degree the expected monetary, quality, and productivity benefits were actually obtained.
    b. Verify that costs were within predicted bounds or be able to determine where and why they were different.
    c. Show that the plant staff received adequate preliminary information concerning the expected changes; were properly trained for their new responsibilities; and responded in the ways expected to these changes. If they are not, it is important, be able to establish the cause of any variance from the expected results.

In the case of the human resources factors it is necessary to document these for the following reasons:

1. To be able to outline specifically the proposed differences between the current situation (prior to the program) and that at the end of the program in order to be able to detail:
   a. The costs expected to be involved in actually making the changes noted.
   b. The amount, degree, and costs of the training of new and current staff personnel expected to be necessary for assuring successful implementation of the proposed system.

2. Again for comparison purposes it is necessary to record the existing cultural and organizational factors at play in the current system, in order to be able to document the differences achieved in the new system in comparison to the old.

3. To provide a picture of the current staffing of the Enterprise Business Entity, the personnel policies in effect, and the organizational structure involved in order that a reader of the Enterprise Integration Program Master Plan can readily understand the basis of the new, or TO-BE, staffing, policies, and organizational structure proposed in that document.

It is noted once again that we must not attempt to document the current system completely, the desire here is only to consider those factors which will be affected by the proposed system. On the other hand, it is important to be sure that the documentation of these latter factors is complete.

Figure 8-1 shows the activities to be covered by the material of this chapter in relation to those factors considered and the information to be developed from this work. Figure 8-2 shows the place of this activity in relation to the Purdue Enterprise Reference Architecture.

8.2 *Importance of the Personnel Equation*

It has been repeatedly shown that personnel considerations are very often the most important aspect of any proposed enterprise integration program.

If the personnel involved give only token acceptance and cooperation to a new enterprise integration system its results may be only marginal at best. In particular, if there is downright opposition to the new procedures the system is usually sure to fail.

Thus it is extremely important that the current human relations situation be assessed as completely as possible in relation to how it may affect the proposed system. Only then can the proper measures be proposed to alleviate any potential problems and to secure, if possible, the wholehearted acceptance of and cooperation with the new system by those personnel who are directly involved.

Table 8-I lists a series of questions which must be answered in evaluating the AS-IS human relations situation in the Enterprise Business Entity. Table 8-II asks a series of further questions to probe the general management and operational personnel's attitudes, conceptions, and actions

as they will affect the acceptance of the proposed new enterprise integration system for the Enterprise Business Entity. Also involved are the types of planning necessary to help smooth the acceptance of the proposed new system.

Table 8-III and 8-IV list a group of documents which should be on-hand or developed especially for the Master Plan development effort in terms of human relations. Table 8-III lists those documents usually available for any operational organization. Those of Table 8-IV are not likely to be readily available and may need to be especially developed. Some such as the Informal Decision Matrix and the list of Major Stakeholders are distinctly political in nature and will be difficult to formulate. These should be foregone if their pursuit should in any way endanger the overall project. In other words, this is important information to have on hand, but is not worth the risk of further alienating individuals who are already negative in their acceptance of the proposed enterprise integration program.

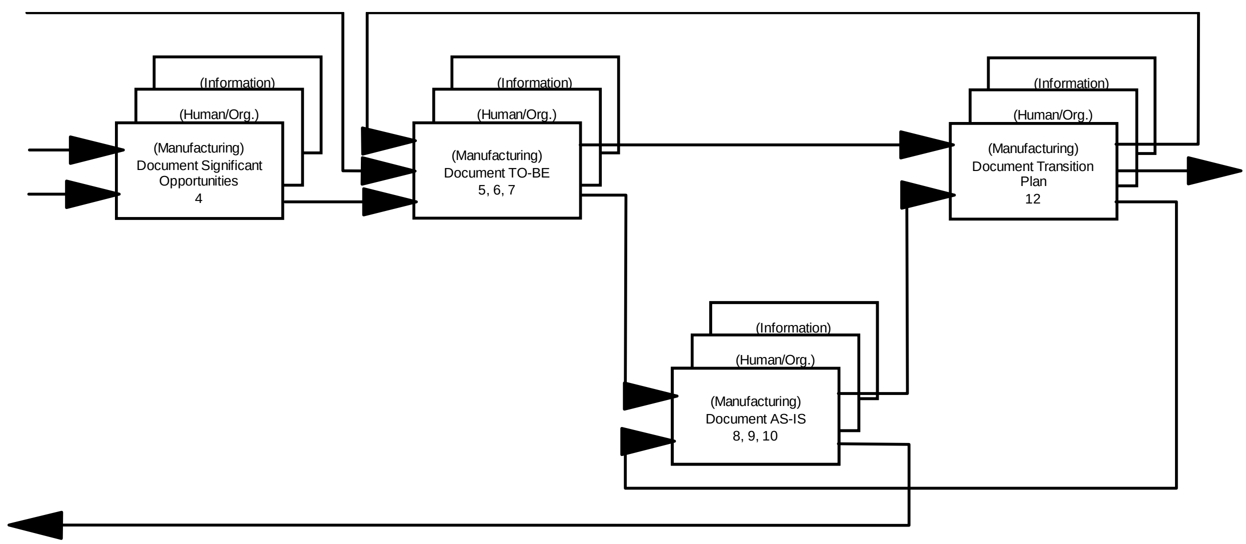

FIGURE 8-1 RELATIONSHIP AND DEPENDENCIES OF THE AS-IS TO THE OVERALL PLANNING PROCESS

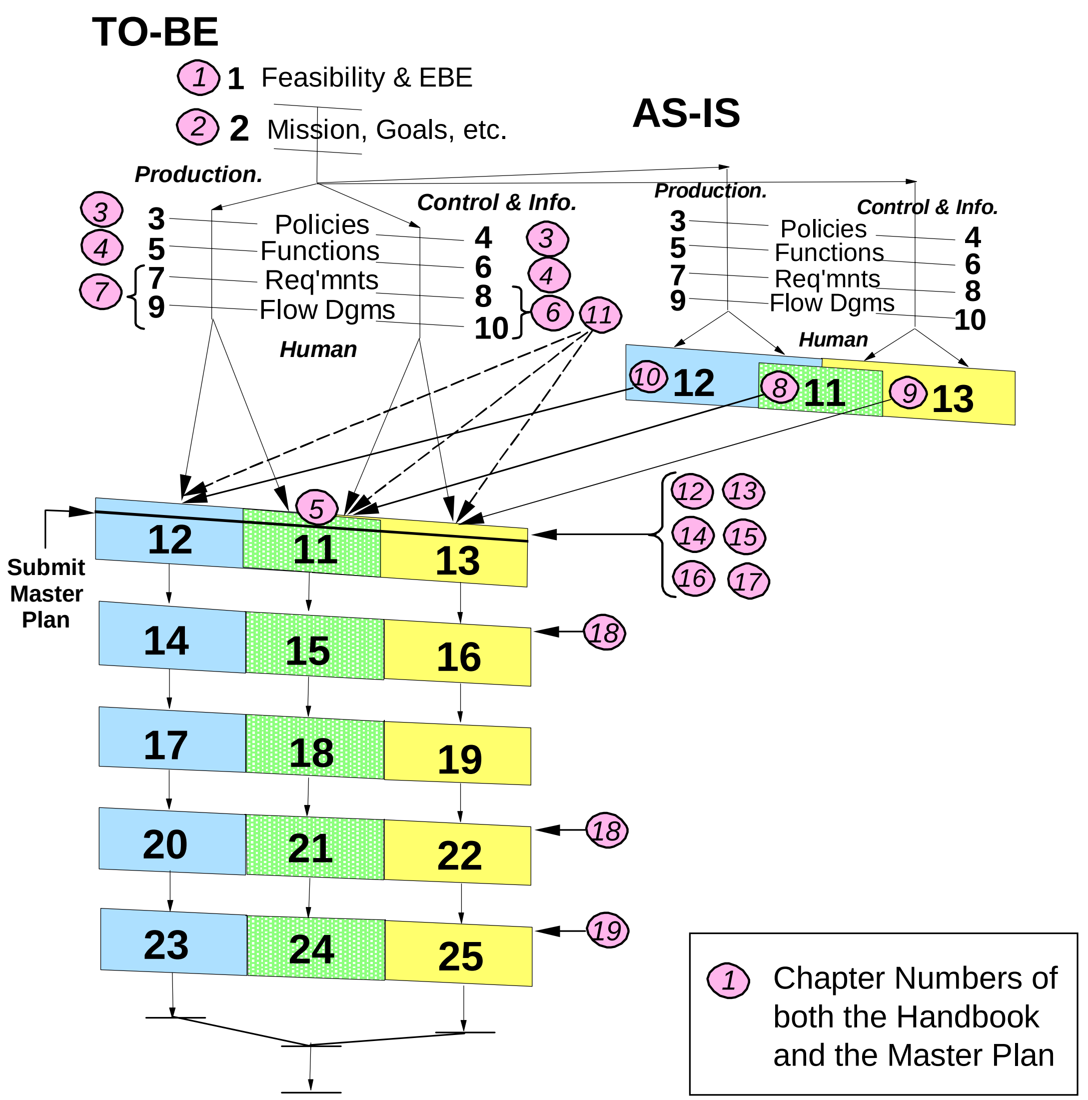

FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

8.3 *Summary*

In contrast to previous chapters, the types of questions usually asked in our checklist are here included in Table 8-1. However, Figure 8-3 summarizes the transformation task involved here along with Attachment 8-I.

TABLE 8-I

QUESTIONS CONCERNING HUMAN RELATIONS IN THE CURRENT AS-IS PLANT

1. What is the current management/operational personnel attitude? Is it cooperative, neutral or antagonistic? What is the cause of any perceived difficulty?

2. Do operational personnel have any major problems or disagreements with the current human relations policies in general:
   a. Work practice rules
   b. Compensation and reward system
   c. Promotion policy and opportunities
   d. Safety practices and policy
   e. Work hours, overtime, union line of progression
   f. Training opportunities?

3. In the view of management what are the current major human relations and personnel problems of the company in relation to:
   a. Personnel availability
   b. Skills and training
   c. Union relations
   d. Salary, compensation and rewards system
   e. Employee attitudes
   f. Safety practices and policy?

   How do these compare to those expressed by the members of the work force?

4. Are operational personnel represented by a union? What is the attitude of union executives toward the company and the management? What is the union attitude toward automation in general? How will they affect any proposed new system?

5. What is the current attitude of both management and the operational staff toward change, per se?

6. Is a total quality management program in place? How has it been received?

7. Does the Enterprise Business Entity employ any of the recently developed human relations policies, such as:
   a. Self-managed work teams
   b. All skills on shift
   c. Others?

TABLE 8-I (Continued)

8. What is the current status of skill levels in the Enterprise Business Entity? Are they satisfactory or is more training vitally necessary at present even without an enterprise integration program?

9. What is the degree of acceptance of automation by the operational staff as evidenced by their response to current automated systems at this location or others?

TABLE 8-II
IMPORTANT QUESTIONS REGARDING THE HUMAN RELATIONS ASPECTS OF THE AS-IS ENTERPRISE BUSINESS ENTITY IN RESPECT TO THE PROPOSED NEW SYSTEM

1. How well will plant operational personnel be informed of the details of the proposed enterprise integration program prior to its initiation?

2. Are major changes expected in the staffing of the plant as a result of the enterprise integration program - in terms of numbers of personnel involved - in terms of actual tasks carried out by these personnel - in terms of their organizational relationships - in terms of skills required? How are these changes expected to be accepted by plant operational personnel? What can be done to mollify negative attitudes and actions?

3. Do unions represent plant operational personnel? If so, what are the expected union attitudes toward the proposed enterprise integration program, particularly in terms of personnel changes noted in item 2 above?

4. Are changes contemplated in personnel policies such as:
   a. Compensation and reward system
   b. Working hours
   c. Shift staffing policies
   d. Promotion policies
   e. Work rules
   f. Performance measures and ratings?

   Are any difficulties expected in the acceptance of these changes by the personnel involved?

5. How will the plant supervisory structure be affected by the proposed enterprise integration system? Will they be adequately informed? Are any difficulties expected in acceptance of the system by these personnel?

6. What is the expected attitude of all affected upper management to the proposed system? Are there any negative feelings concerning it? What steps are being taken to counter these feelings?

TABLE 8-III
SPECIFIC FORMAL DOCUMENTATION REQUIRED OR HIGHLY DESIRABLE

1. Current organization charts of the enterprise integration business entity including operations, maintenance and support groups and including worker reporting structures as well as supervisory and management positions.
2. A written description of currently available training programs, including in-house programs and those at local schools and training organizations which are company funded or compensated. Include company published policies in reference to selection for attendance, credit for completion, early effect on career path, etc.
3. Current promotion and progression policies for both management and hourly personnel including skill and experience requirements.
4. A written description of the total quality management program.
5. The current compensation and reward system of the Enterprise Business Entity.
6. Document the current automation policy of the company particularly as it may relate to the organizational and human relations policies currently in existence.

TABLE 8-IV

HIGHLY DESIRABLE INFORMAL DOCUMENTATION OF THE AS-IS PLANT AND ITS HUMAN RELATIONS ASPECTS

1. Document the informal decision matrix for the Enterprise Business Entity. Where are major decisions made in plant operations? Point out major variances with the formal organizational structure.

2. Document the employment demographics of the current management structure and operational personnel staffing. Note each position in regard to:
   a. Age of the incumbent,
   b. Skills mix of the incumbents of the positions,
   c. Potential retirement age,
   d. Attrition history of the position, if significant,
   e. How is overtime welcomed?
   f. Absenteeism.

3. Written description of current work practices as actually employed including communications across shifts, across departments, etc.

4. A flow chart of material flow through the plant, identifying departments and work groups who handle the intermediate and finished products and byproducts.

5. Identify those individuals and groups who have the greatest stake in the current human relations system, particularly those who will be most affected by the proposed change and therefore most likely to oppose the necessary changes.

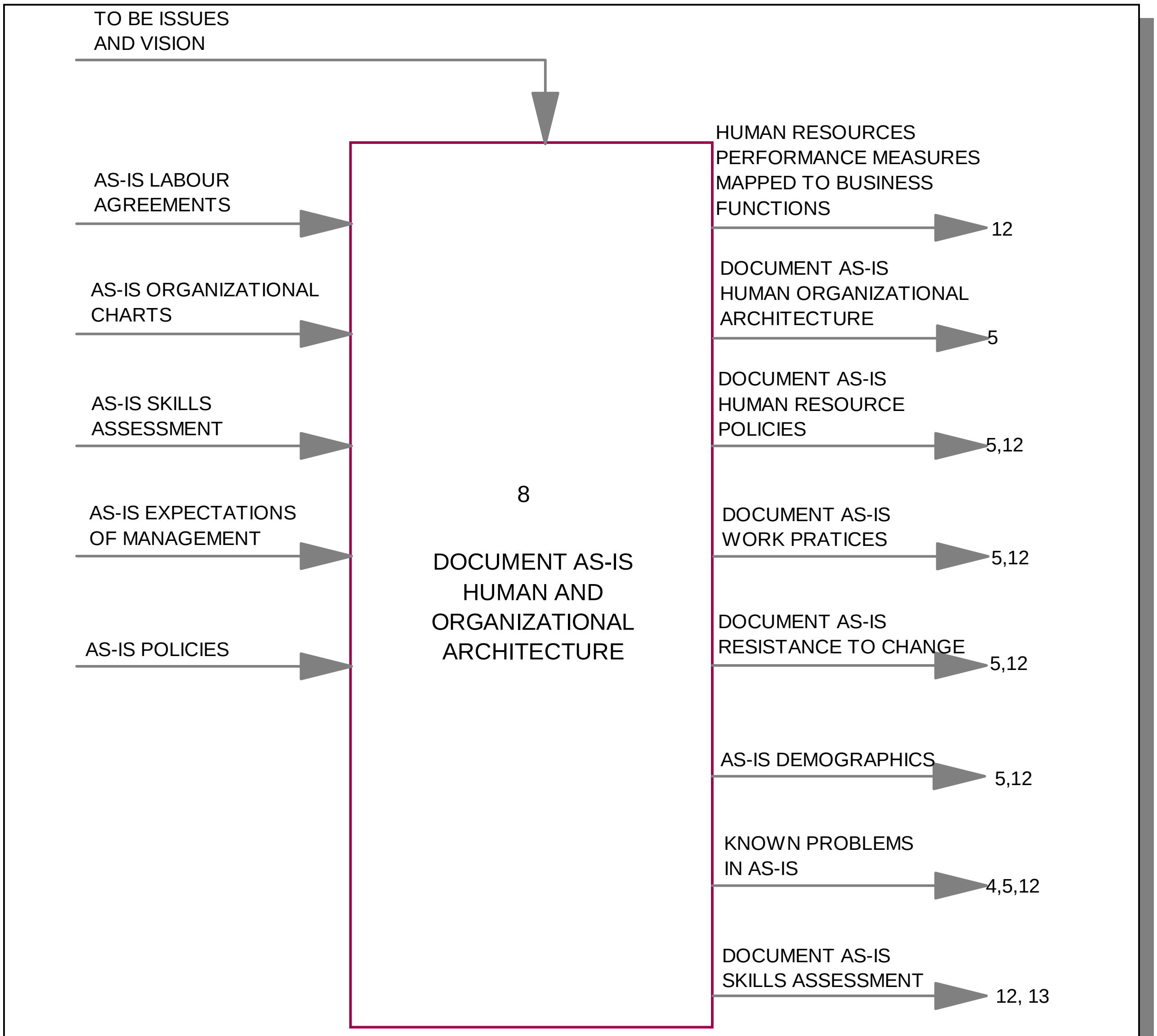

FIGURE 8-3 THE TRANSFORMATION TASK OF CHAPTER 8 -- DOCUMENT AS-IS HUMAN AND ORGANIZATIONAL ARCHITECTURE

ATTACHMENT 8-I

SUMMARY OF PLANNING STEP 8
"AS-IS" HUMAN & ORGANIZATIONAL ARCHITECTURE

Identify and Document:

- Human Resources Performance Measures Mapped to Business Functions
- Human Organizational Architecture
- Human Resource Policies
- Work Practices
- Resistance to Change
- Demographics
- Known Problems
- Skills Assessment

9. "AS-IS" Manufacturing Equipment Architecture

9.1 *Introduction*

The task of the members of the Enterprise Integration Planning Team who will be carrying out the work detailed in this chapter is to secure all appropriate data concerning the design, construction and operation of the current or AS-IS plant that will be helpful in developing the TO-BE plant requirements and organizing a viable plan for the transition between the AS-IS and TO-BE states. As pointed out below great care must be taken to bound and control the types and amounts of data and information collected to avoid unnecessary and excessive expenditures of manpower in the activity. At the same time the data must be organized and presented in that format which will be most helpful to those members working in the TO-BE and transition areas.

This chapter will treat only the physical manufacturing equipment (the Manufacturing Equipment Architecture) of the Enterprise Business Entity as involved in the proposed enterprise integration program. Chapter 10 will treat the AS-IS status of the plant's Information System Architecture, and Chapter 8 has discussed the AS-IS status of the Human and Organizational Architecture.

A major source of the information noted above will be the documentation (project proposals and recommendations, economic and technical justification analyses, plant flow sheets, piping and instrumentation drawings, construction drawings, etc.) used for the original installation of an existing Enterprise Business Entity. However, one must be very cautious in using this information and compare it thoroughly with the existing plant as now operated. Most manufacturing plants face a period of modification and adjustment of equipment and operational techniques immediately after commissioning to correct design errors and eliminate unforeseen bottlenecks. Some or all of these changes may not have been documented in updated versions of the original plant documentation. In addition, most manufacturing plants also undergo a continuing program of updating and improvement during their operating life, based upon plant optimization studies or improvement ideas developed by operational or research personnel. Again, care must be taken to be sure any such changes that might not have been documented are considered.

Thus there can be major differences for the Enterprise Business Entity between its AS-SPECIFIED characteristics developed during initial project definitions, and its AS-DESIGNED and AS-BUILT state, since financial, personnel availability, and schedule consideration have modified the original AS-SPECIFIED proposal. Further, the after construction changes just noted result in still a third condition, the AS-OPERATED state of the Enterprise Business Entity. It must also be kept in mind that these changes can apply to the company's operational policies for the manufacturing plant as well as in its manufacturing and information system physical equipment.

Since the plant is undergoing essentially continuous change, there may be projects already approved and under development which will be finished ahead of the enterprise integration program itself. These must be documented, if applicable, to present the true AS-OPERATED condition facing the enterprise integration program upon its initiation. Additional proposals already under study, but not yet approved for installation may also be prime candidates for inclusion in the enterprise integration program itself. These latter would be considered in the Master Plan under Chapter 14, "Identify Enterprise Integration Projects."

It should also be kept in mind that previously proposed components of the AS-SPECIFIED and AS-DEFINED cases which might have been earlier eliminated for economic or schedule reasons at the time of actual plant construction may be viable candidates for inclusion in the current enterprise integration program and should be evaluated as such.

Current plant operational and engineering personnel may have additional ideas for manufacturing equipment or operational practices, modifications or improvements beyond those already implemented or in the pipeline for implementation. All of these should be seriously considered by the Enterprise Integration Planning Team both for their real value and also for the goodwill which it will generate for the enterprise integration program among Enterprise Business Entity personnel.

An excellent way of obtaining the ideas of current operating personnel who may be wary of exposing their ideas to their peers or immediate supervisory manager is through the media of a confidential "suggestion box" used by the planning team with anonymity guaranteed if desired by the suggestor. This method has proven very valuable as part of the Japanese "continuous improvement" process in their plants [48].

9.2 *Data Collection Formats and Requirements*

In documenting the AS-IS physical plant and its operational policies and procedures, we wish to consider only those parts of the Enterprise Business Entity actually included in the proposed enterprise integration program. We would only supply the detail necessary to provide a benchmark for the development of the program transition plan and for the evaluation of the TO-BE potential and actual benefits.

Thus the work of the team carrying out the work encompassed in this Chapter 9 must depend to a great extent on the needs and desires of those developing Chapter 6, "TO-BE Manufacturing Equipment Architecture," Chapter 3, "TO-BE Process Manufacturing Policies," and Chapter 12, "Transition Path From AS-IS to TO-BE." These latter individuals must therefore specify what information they desire concerning the AS-IS manufacturing equipment and related manufacturing policies to complete their own work. Since this work is itself in development these requirements may change, necessitating an iterative procedure to complete all necessary work and an ever deeper degree of detail may be necessary as the work proceeds. However, this is considered preferable to over specifying the necessary detail at the start and wasting the Team's effort on what will probably become useless effort.

The Teams undertaking the later chapters, particularly Chapter 12 must specify the format required for the needed data, since they must establish a common basis for developing their proposed transition path for carrying out the TO-BE proposed enterprise integration program from the current AS-IS state to the desired TO-BE state. There are three different scenarios that the TO-BE team may present to the AS-IS team. These cases need to be understood by the AS-IS team to allow them to collect the proper data to the degree needed without excessive effort and detail.

Case I If the AS-IS and TO-BE physical visions for a part of the plant are identical then no analysis is necessary under this Chapter.

Case II If a part of the plant exists in the AS-IS but not in the TO-BE, then no AS-IS data collection activity is required here.

Case III If a difference exists for a particular plant unit between the TO-BE and the AS-IS plant then data collection activity and analysis as outlined here is required.

An early joint analysis and agreement between all three teams as to which case applies to each major segment of the plant is a necessary strategy for the joint team for determining the required breath of AS-IS analysis.

Figure 9-l outlines the procedures involved in completing the program of work described in this chapter. Figure 9-2 shows the mapping of this material on the Purdue Enterprise Reference Architecture.

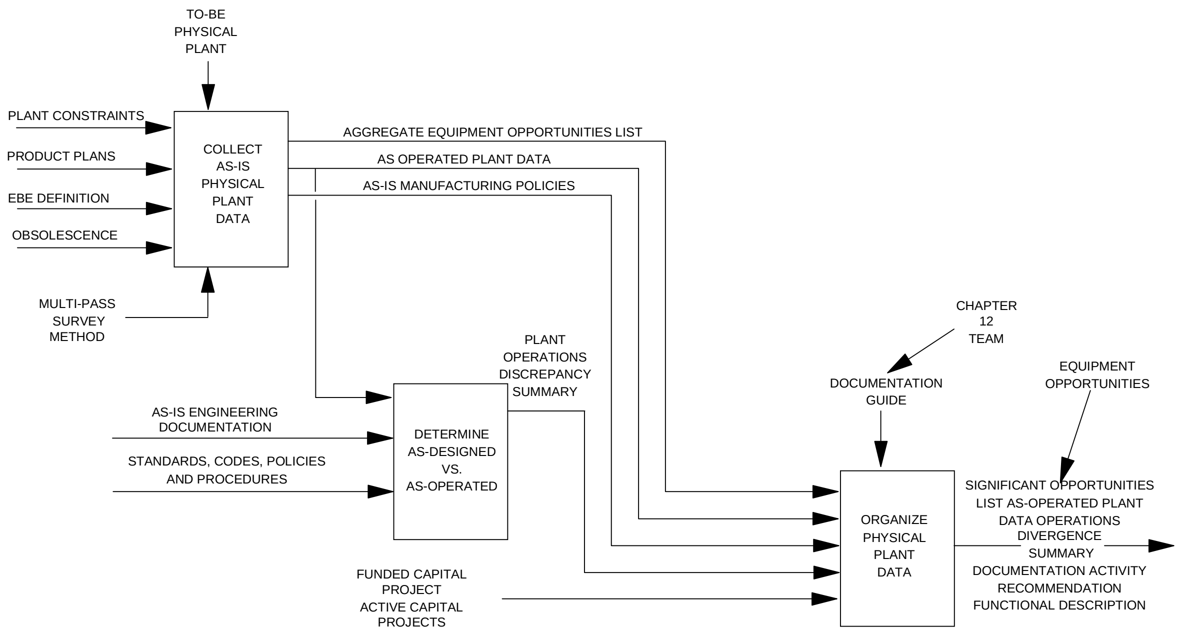

FIGURE 9-1 FLOW DIAGRAM OF DATA COLLECTION ON AS-IS PHYSICAL RESOURCES, OPERATIONS AND POLICIES

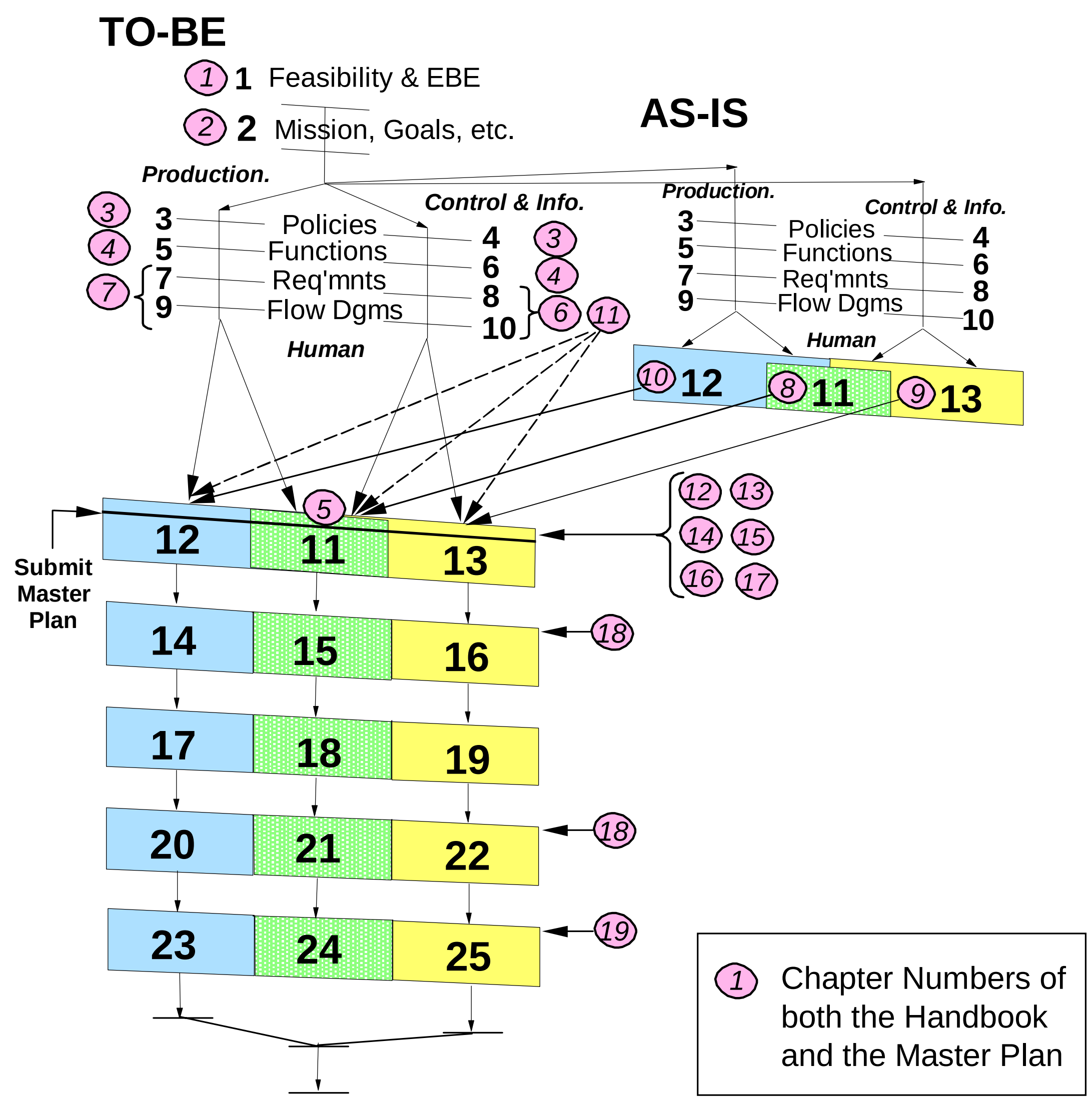

FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

9.3 *Examples of the Type of Data*

Although the later Chapter Teams will be specifying the actual data to be collected in this task there are many examples of the types of information to be included that are useful as information for planners or as check lists to be considered when checking the completeness of the task undertaken.

Important among these sources are the steel and paper industry example master plans developed some years ago by personnel of the Purdue Laboratory for Applied Industrial Control in the then current research program to study steel mill and paper mill, plant wide automation. References [24,79-81] present this material. Table 9-I presents an outline of the types of data that may be required.

9.4 *Suggested Method of Procedure*

The tasks of collecting the AS-IS physical resources, operations and policy data can be organized in a top-down fashion in terms of decomposition and detail as noted in the Purdue Reference Architecture as follows:

1. Present production entity identification
2. Physical production requirements
3. Unit operations functions
4. Unit operations flows and networks
5. Manufacturing equipment architecture
    a. Functional
    b. Specific

The data collection may take place over an extended period of time because of the way these data are used by the Enterprise Integration Planning Team. The length of time involved and the degree of detail necessary will thus depend upon the extent of requests from the TO-BE physical plant planning activity and transition requirements. The format to be used in reporting this data should also be specified by its recipients.

Much of the data to be collected will focus on the problem of the identification of "controllable deviations" in the operation of the plant. That is, what are the measurements that can be made that will serve to provide the basis for a control system which will counteract plant deviations and keep it operating at the highest possible efficiency.

The data collection task discussed here will likely be organized into three phases or passes, i.e., the plant will be visited three times to collect ever more detailed and specialized data as requested by the recipient groups. These passes can be described as in Table 9-II.

Figure 9-3 presents the comparable IDEF-like diagram that outlines the work of this chapter similar to the others.

TABLE 9-I
A LISTING OF POTENTIAL VALUABLE DATA FROM THE AS-IS ENTERPRISE BUSINESS ENTITY NECESSARY FOR TO-BE AND TRANSITION STUDIES

I. Details of current operational policies

1. Identify and document existing codes, standards and operational manuals which impact plant operations, included pending but not yet implemented changes in the above.
2. Document existing company operational policies for this facility. Note modifications of these policies as employed in current plant operations.

II. Details of plant operational constraints, proposed obsolescence or closing and other operational limitations

1. Identify and document current plans for on-going plant unit obsolescence or transition.
2. Identify and document physical plant constraints, boundaries and barriers to future development in terms of geography, operations, environment or physical capacities.
3. Identify known operational problems occurring in the plant's physical equipment.
4. Identify status of specific plant operational equipment as a class, and indicate present plans for future utilization and correction of deficiencies.

III. Details of on-going and proposed improvement projects

1. Details of currently funded equipment modification or improvement projects not included in currently available plant documentation.
2. Details of equipment modification or improvement projects being studied for possible later implementation outside of the planned enterprise integration program.
3. Details of major equipment modification or improvement projects that were proposed but not funded by management because of lack of funds or of difficulty in justification under then-current procedures.

IV. Additional opportunities not presently being considered by the Enterprise Integration Planning Team.

1. Details of existing Enterprise Business Entity growth or improvement visions prior to current enterprise integration vision development.
2. List of opportunities for current plant improvement as voiced by plant operational, management and engineering personnel currently outside of the present enterprise integration program planning effort.
3. Potential additional opportunities for plant improvement noted by Enterprise Integration Planning Team members in their analysis of the current plant (AS-IS).
4. Items included in past suggestion box proposals of plant personnel or developed from new suggestion box effort (Reference [48]).

TABLE 9-I (continued).

V. Physical plant data

1. Geographical layout of the Enterprise Business Entity.
2. Manufacturing process flow diagrams.
3. Interfaces to other enterprise entities.
4. Descriptions of unit operations processes carried out by the Enterprise Business Entity.
5. Descriptions of unit operations equipment.
6. Product flow diagrams within each unit operations.
7. Support material on physical equipment operation (instructional manuals, etc. are examples).
8. Descriptive data on the physical plant.
9. Name plate capacities of process unit.
10. Details of physical plant changes currently in progress.
11. Information sources and references needed.
12. Figure 9-4 shows a block diagram of the relationship of the manufacturing system to the enterprise integration Information System and Human and Organization Architecture in terms of the interfaces involved.

VI. AS-IS capital expenditures and procedures

1. Identify the current policies and procedures for capital project justification.
2. Document current, active projects and planned projects that are on a shorter time horizon than the Master Plan. Those projects that are in the same time horizon as the Master Plan will be addressed in the transition planning activity.

VII. AS-IS physical plant strategic plan

1. Identify and document the current strategic plan for the plant, if it exists. The plan can be used as a starting point for the transition planning activity.
2. Collection of physical data may require department heads to be added or polled for their plans for an area that may not be documented yet. Their plans are an input to the "identify significant opportunities of this chapter."

VIII. AS-IS physical plant constraints.

1. Identify and document physical plant constraints and boundaries in terms of the physical plant's:
   a. Geography,
   b. Operations,
   c. Environment, or,
   d. Capacities
2. Identify and document existing codes, standards and manuals used for operating the plant.
3. Identify pending but not implemented and proposed or pending codes, standards or manual revisions that may impact the plant operation.

TABLE 9-II

THE THREE PASSES REQUIRED FOR AS-IS DATA COLLECTION

I. First pass:

Identification of known problems.

Identification of current capital project activity.

II. Second pass:

Physical plant data of the material transformation or energy conversion type.

The manufacturing side of the Purdue Enterprise Reference Architecture requires:

- Physical layout
- Listing of units
- Flow diagrams
- Layout of equipment
- Connectivity drawings for:
  - Utilities
  - Product
  - Energy
  - Material transformations
  - Information sources

III. Third pass:

Physical plant data of the purely information type. The information side of the Purdue Enterprise Reference Architecture requires:

- Operating policies
- Operating manpower
- Environmental regulations

TABLE 9-II (continued).

Physical plant data that supports the Data Flow Model
- Procurement
- Raw materials and energy
- Manage production
- Processing orders
- Schedule production
- Manage costs
- Product shipping
- Product inventory
- Assure quality

IV. At each pass organize the information into these classes:
- Plant
- Processes
- Equipment
- Utilities
- Networks and communications

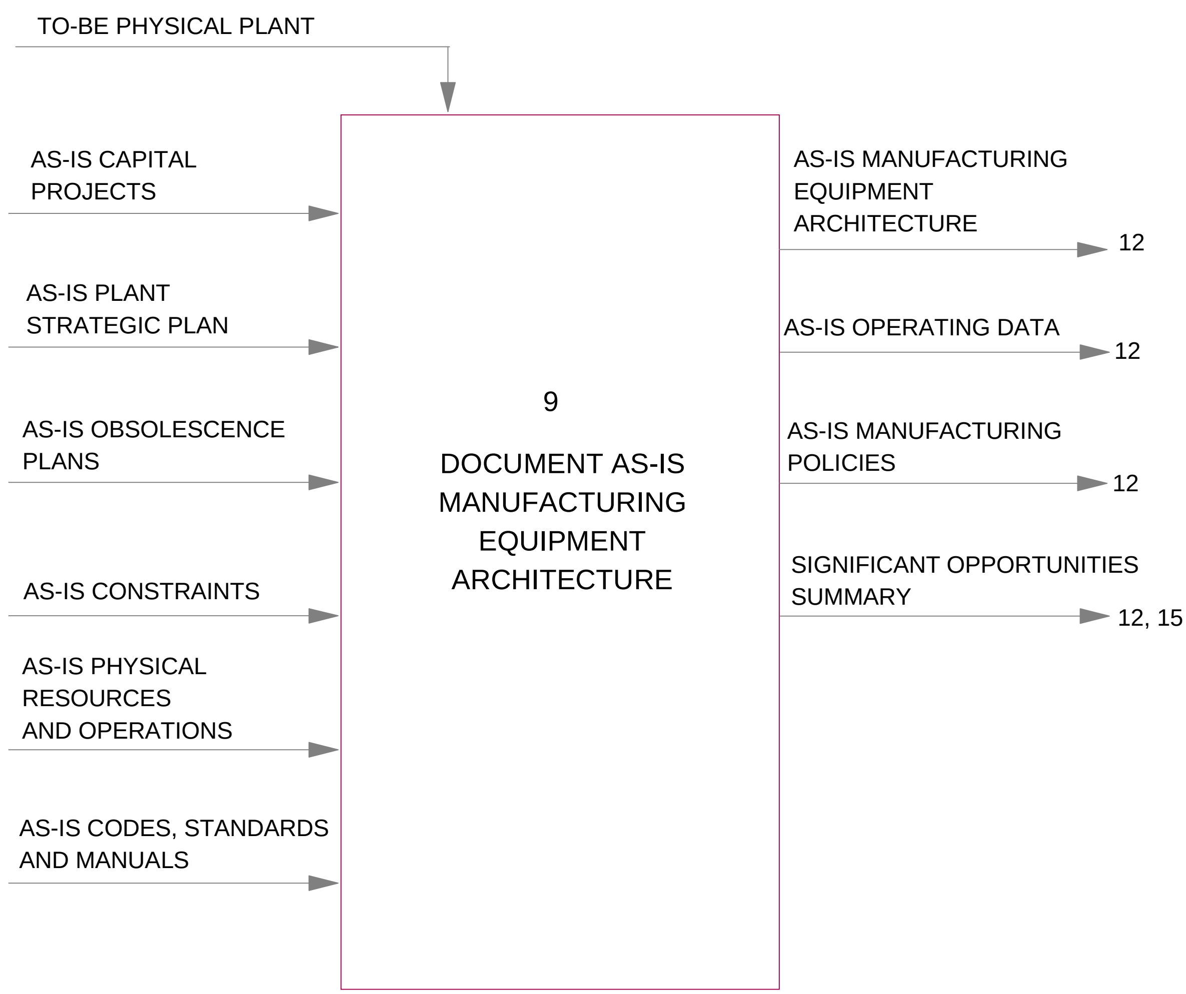

FIGURE 9-3 THE TRANSFORMATION TASK OF CHAPTER 9 – DOCUMENT AS-IS MANUFACTURING EQUIPMENT

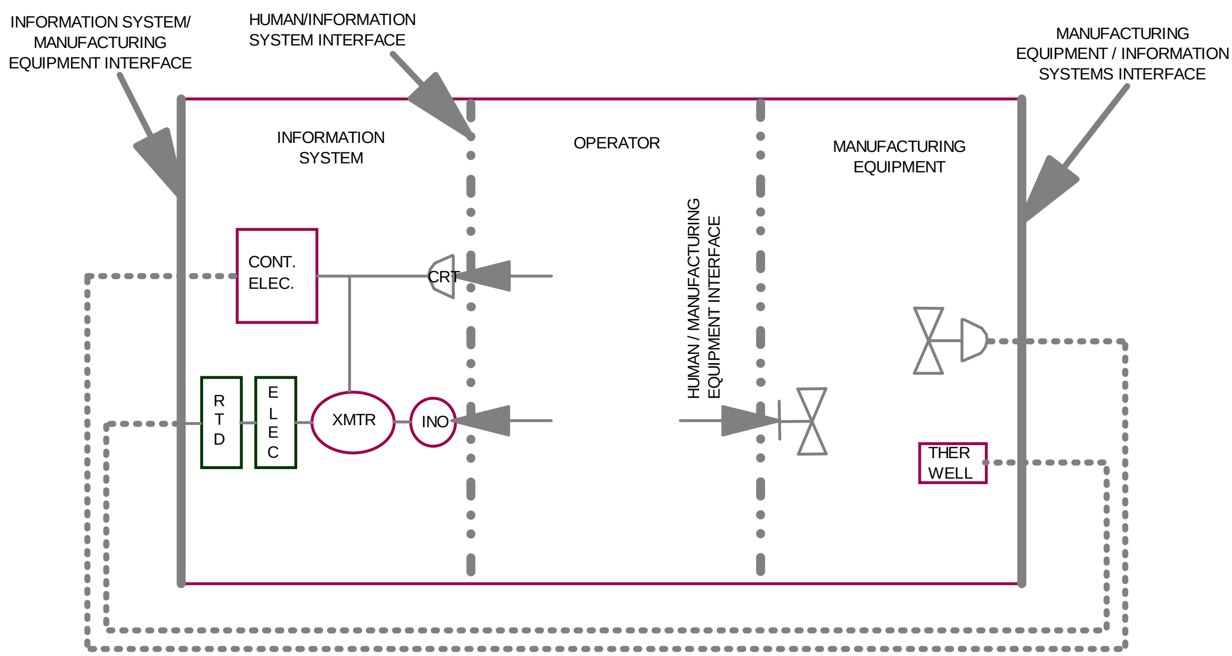

FIGURE 9-4 INTERFACES IN THE OVERALL ENTERPRISE INTEGRATION SYSTEM

9.5 *Summary*

Attachment 9-I summarizes the work of this chapter.

ATTACHMENT 9-I

SUMMARY OF PLANNING STEP 9
"AS-IS" MANUFACTURING EQUIPMENT ARCHITECTURE

Identify and Define:

- Manufacturing Equipment Architecture
- Operational Data
- "AS-IS" Manufacturing Policy
- Significant Opportunities Study

Resources:

- On-going Capital Project Plans
- On-going Plant Strategic Plans
- Obsolescence Plans
- Plant Models
- Regulatory and Plant Codes, Standards and Manuals

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10. "AS-IS" Information System Architecture

10.1 *Introduction*

Purpose

The purpose of the activity discussed in this chapter is to model, at a high functional level, the AS-IS Information System Architecture. This will be accomplished through using an appropriate methodology (the methodology should conform to the one used to document the TO-BE Information System Architecture, Chapter 7 and that needed by Chapter 12). The level of detail is to be held to only that which is required to support the Transition Plan development process of Chapter 12. This level of detail is to be specified in each request of the TO-BE and Transition Plan activities for AS-IS definition data. This should be expected to result in an iterative cycle whereby specific information is initially requested and then further details are later required until the necessary pertinent information is documented.

In no way should the purpose of this process be misunderstood. It is not:

1. To justify existing systems,
2. To justify previous investment, or
3. To justify replacing existing systems.

Instead, its sole purpose is to help in the process of deciding what the future direction of the Information and Control System of the Enterprise Business Entity should be from now onwards and the best path in terms of effort, time and cost for progressing toward the TO-BE vision. This message should be clearly given to all involved in this process, otherwise, it can seem to be a threat to existing systems and the information provided may be distorted. Figure 10-1 outlines the overall task involved while Figure 10-2 maps the information involved here onto the Purdue Enterprise Reference Architecture.

Sources and Data Required

In order to properly supply the data on the AS-IS Information Functional Architecture of the existing plant that is needed by the functions developing the TO-BE Information Functional Architecture (Chapter 6) and the Transition Plan (Chapter 12), the Enterprise Integration Planning Team members will need the following information available:

1. The existing documentation describing the information systems of the currently operating plant. Where this documentation is inadequate to supply the requested information or is not up-to-date, a direct survey of the existing physical system and its operation will be necessary.

2. Almost all plants and their constituent systems are under relatively continuous change. This is probably true of the subject plant as well and there are changes to it already approved which will be completed before the Enterprise Integration Program Proposal items or coincident with them. Since what is desired is a snap-shot of the plant as it will exist at the time program installation will take place, these expected improvements must be included in the team's analysis. Thus documentation of these expected changes must be available to the team.

3. Since the data developed here is for the use by others, the team must be supplied with information on the format, and degree of detail and accuracy required in the requested documentation as well as the identity of the particular items of information needed.

10.2 *Task Involved*

The development of the requested information on the AS-IS Information Functional Architecture of the Enterprise Business Entity must be a team effort requiring that the team members have:

1. Familiarization with the methodologies and tools selected for the collection and presentation of the requested data and information.
2. Receipt of a clear definition of the nature of the requested data and information and the format, etc., of the requested deliverables.
3. An agreed upon schedule to maintain.
4. A business awareness of the Enterprise Business Entity and of all of its existing systems.
5. Support of management and of the current personnel of the Enterprise Business Entity.

The level of effort involved with this task must be determined directly by the size and complexity of the Enterprise Business Entity and the degree of completeness and level of data about the plant that is requested by expected users of the resulting information. Additionally the level of sophistication in the existing systems may require considerable increases in the overall knowledge, effort and skills required to successfully accomplish this task.

10.3 *Expected Documentation Required*

While the actual documentation requested by the TO-BE and Transition Path investigators cannot be completely foreseen, the following are expected types and amounts of data and information which might be needed:

1. An overview of the AS-IS information model describing its top level functional structure and approach to addressing the critical success factors and the business objectives or portions thereof.
2. An information flow diagram which documents at a high level:
    a. Functional modules including a list of respective capabilities
    b. Identification of reports and related information views
    c. Data descriptions, flows, sources, timing, accuracy, and usage relationships to respective functional modules, reports, and views.
3. A hardware configuration layout with a correlating functional overlay map.

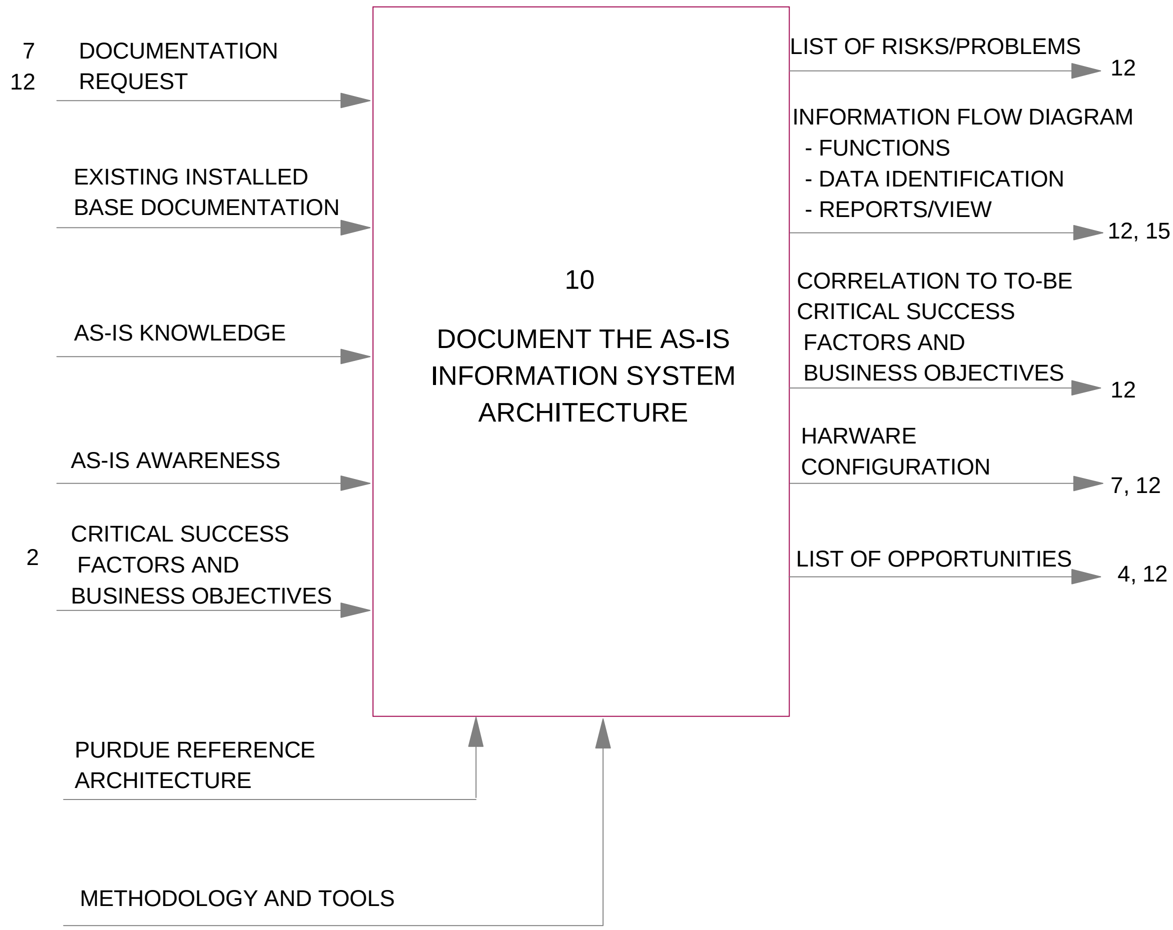


FIGURE 10-1 THE TRANSFORMATION TASK OF CHAPTER 10 –
DOCUMENT THE AS-IS INFORMATION SYSTEM ARCHITECTURE

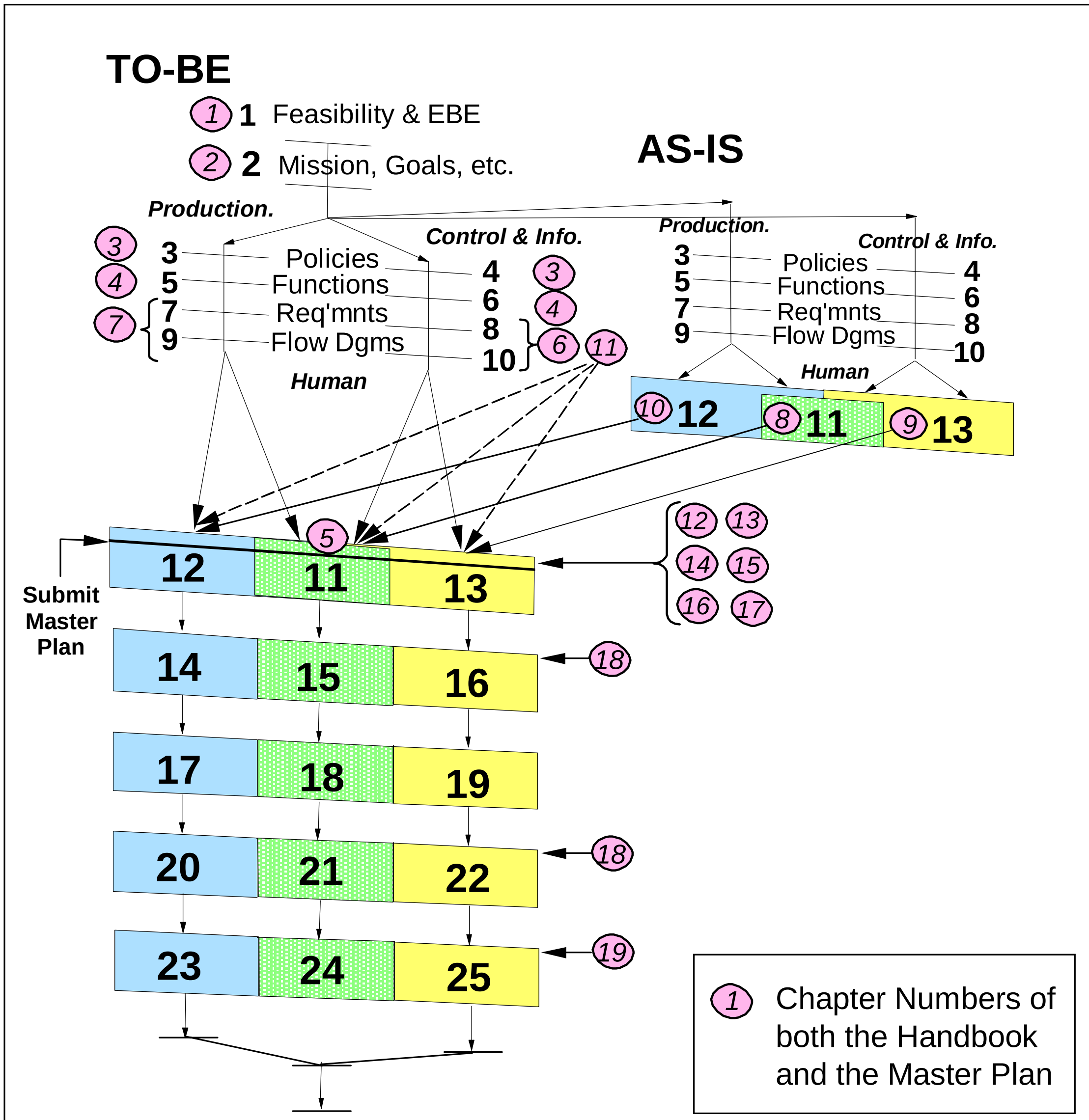


FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

4. A descriptive list of all high risk areas (which may include the life expectancy of the existing system(s)) and any other problem, restriction, and/or limitation areas.

5. A list of opportunity areas (like redundancy or simplification for example).

6. Lists of sensor and actuator identities, functions, specifications, current limitations or problems with them, etc.

It will be important that this data and information collection process be signed-off by the appropriate section or department which is considered the "owner" of the existing system being documented. This sign-off is to achieve a concurrence that the documentation is balanced and accurate. This should allow for the owners to add comments or notes of their own to the respective document(s) if necessary to obtain their sign-off.

The quality of the information and/or data so obtained may be assured by attention to the following points:

1. Maintaining the appropriate functional level

2. Participation by qualified personnel in the team

3. Access to knowledgeable personnel in the organization

4. Access to the existing documentation

   a. A clear definition of what is to be provided and to what level the information needs to be documented

5. A check list of the information to be addressed

6. Determination that the necessary sign-off has been obtained

7. The integration and sophistication of the modeling tools

8. Project leadership and guidance

9. Management support

ATTACHMENT 10-I

SUMMARY OF PLANNING STEP 10
AS-IS INFORMATION SYSTEMS ARCHITECTURE

Identify and Define:

1 List of Risks & Problems
2 Information Flow Diagram
  - Functions
  - Data Identification
  - Reports/Views
3 Critical Success Factors and Business Objectives
4 Existing Network Architecture

Resources

1 Existing Drawings and Archives
2 Folklore Knowledge/Interviews
3 Software Listing and Data Models

11. Required Standards Selection Process

11.1 *Introduction*

There are two types of standards, voluntary and regulatory. Only the voluntary standards are covered in this chapter. Standards are a very important part of the enterprise integration picture as well as for manufacturing in general. They permit solutions to industrial problems at one location to be used in other similar systems in other locations or even other companies and industries. They provide the specifications for the interfaces and other components for connectivity that can allow equipment produced by different vendors to work together. They permit software programs to operate on different makes and models of computers. They prescribe the use of common symbols for concepts and functions across an industry and often across all industries to permit the easy transfer of information in drawings and publications. Standards can also apply to personnel selection (i.e., minimum standards), operating methods and procedures, safety standards, hazardous material handling procedures, physical equipment and dimensions, etc. These and many other aids to facilitate the concept, promotion, design, specification, development, construction, check-out and operation of enterprise integration systems are made possible and enforced by standards.

Standards may be developed by a company for their own internal use, or for that of their customers or by committees of technical societies for the benefit of their members or for the industry they represent. They may also be developed by the appropriate committees of national and international bodies devoted to standards development and promulgation for country-wide or world-wide application.

National and international standards have the force of law (i.e., they must be used) in many countries of the world (but not in the United States).

In an integrated environment, standards become important in establishing ease of integrating in multi-vendor solutions. In this case, adoption of standards can create value to the enterprise.

Figure 11-1 represents the task to be carried out here in terms of the information to be used and the outputs expected from the study. Figure 11-2 shows the place of this work in the overall program.

TABLE 11-1
THE EVOLUTION OF A NEW TECHNOLOGY OR PRODUCT

TECHNOLOGY STAGE	RISK	PRODUCTS	VENDORS	SUPPORT
R&D	Very High	Immature	Entrepreneur	Little / None
Business Specific	Medium	Stable	Stable	Limited
Utility	Low	Mature	Established	Full

11.2 *Objective*

Therefore, standards, particularly a list of those that are expected to be used in the implementation of the projects of the Enterprise Integration Program Proposal, must be a major topic of the Master Plan. This chapter will detail the what and the how of standards as they should be considered in the Master Plan and aid the Enterprise Integration Planning Team to select the standards appropriate to the Enterprise Business Entity.

11.3 *Background*

How Standards are Prepared or Developed
The development of any new technology can be modeled by the Technology Model shown in Figure 11-3. The usual route and the degree of acceptance and utilization of the resulting product and/or technique is shown in Table 11-I. As can be seen, low risk, mature products; established vendors and broad support cannot be obtained until new technology evolves to the utility stage.

Standards are often initiated to develop and regularize the use of a new technology or product. However, standards can only come when that new technology or products reach the utility stage. Like the technology life cycle, that of standards development can also be shown by the same model which would now be labeled as the Standards Process Model (Figure 11-4). The model as used for Standards is expanded and explained in Table 11-II.

There are many different application areas for standards. However, this chapter is primarily concerned with technology standards. There are also two types of standards, regulatory and voluntary. Those established in conjunction with regulatory laws such as for the environment are, of course, regulatory standards. Those established to facilitate commerce and industry are voluntary in America. Both types of standards follow the Standards Process Model in their development and application to use.

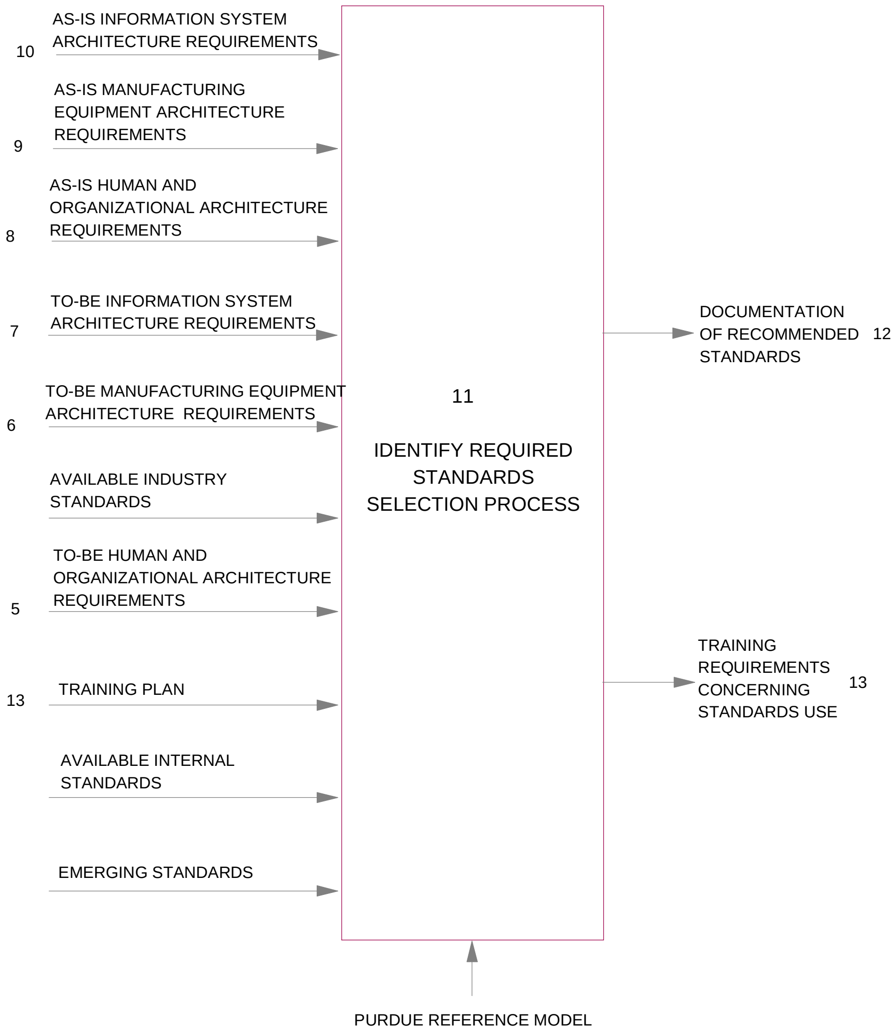


FIGURE 11-1 THE TRANSFORMATION TASK OF CHAPTER 11 – IDENTIFY REQUIRED STANDARDS SELECTION PROCESS

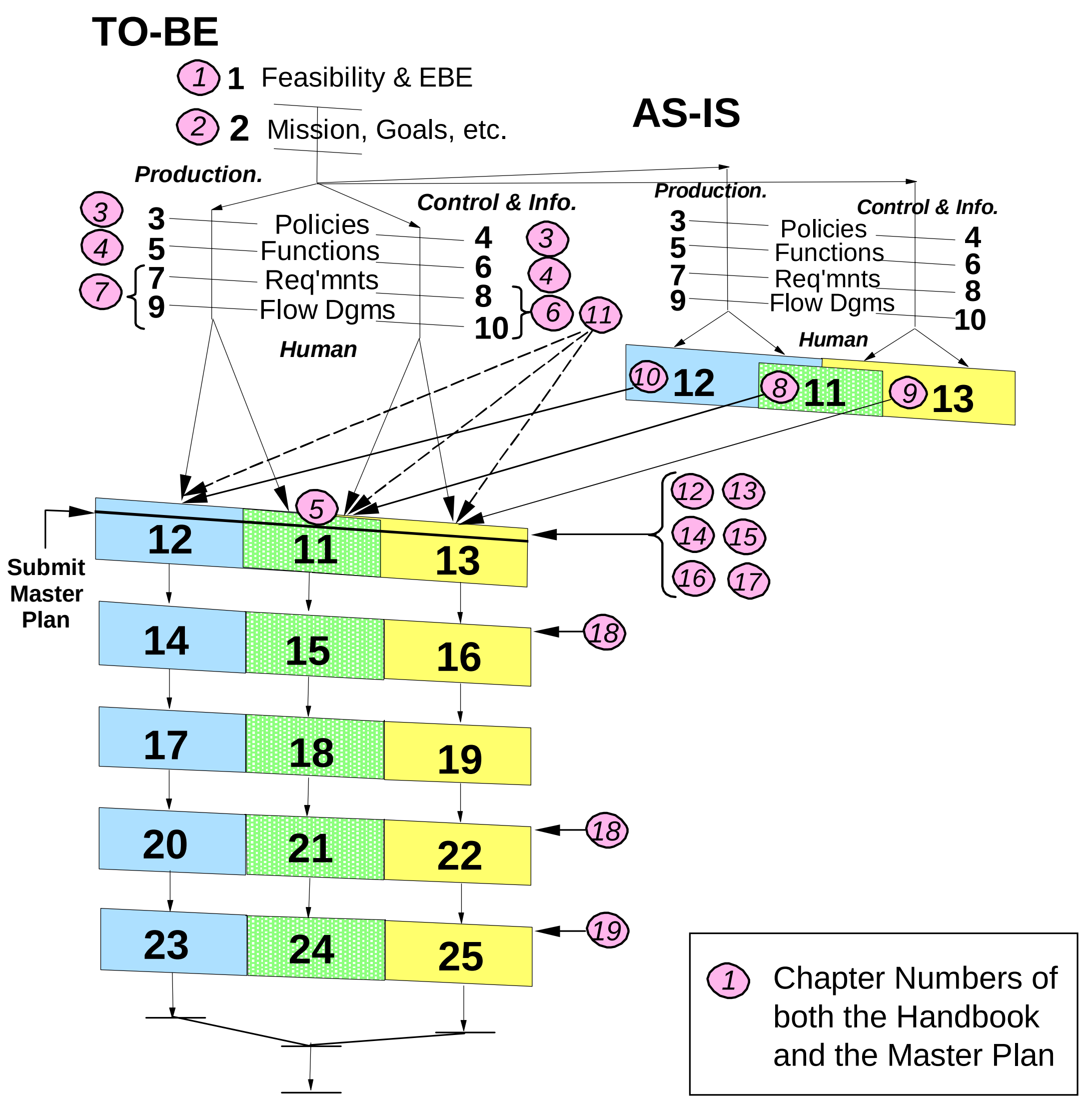


FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

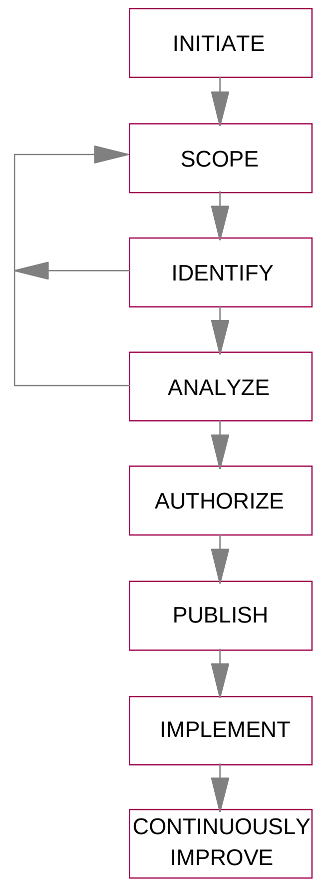


FIGURE 11-3 TECHNOLOGY PROCESS MODEL

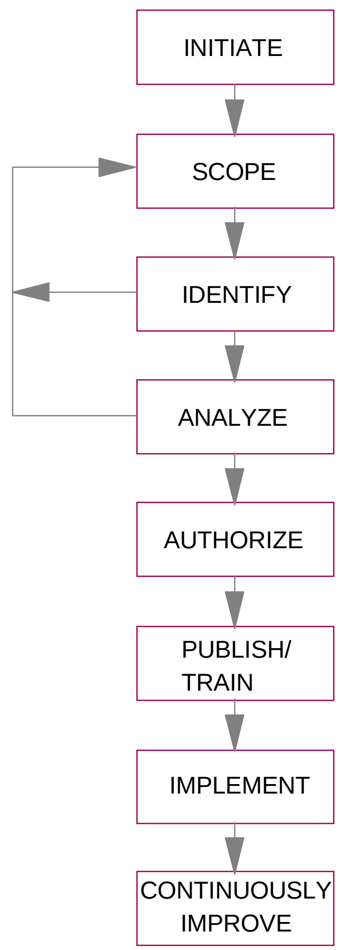


FIGURE 11-4 STANDARDS PROCESS MODEL

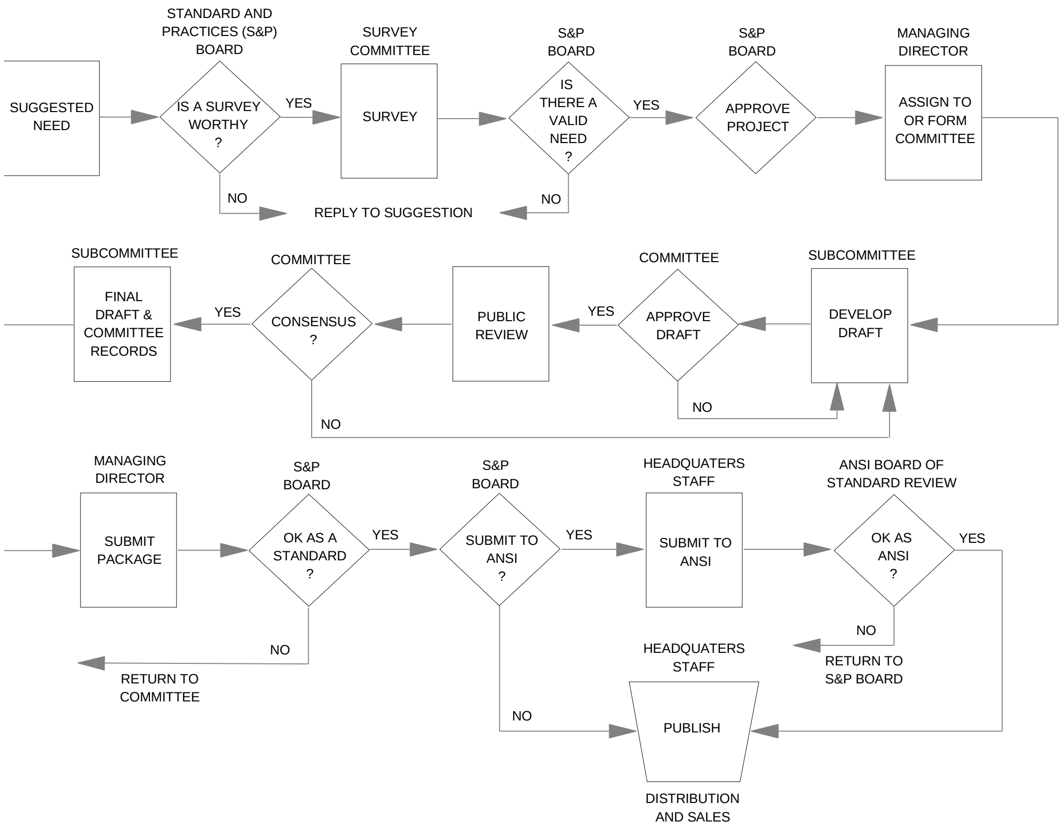


FIGURE 11-5 DEVELOPMENT OF AN ISA STANDARD

TABLE 11-II
OUTLINE OF THE STANDARDS PROCESS MODEL
(EXAMPLE FOR INFORMATION TECHNOLOGY)

A. Initiate the standards process - caused by one of the following:
   1. Regulatory response
   2. Resolve a business problem
   3. Provide a benefit
   4. Apply enterprise value to an existing standard

B. Scope the effort
   1. Further definition
   2. Expansion to enterprise/industry level
   3. Assign the effort to the responsible group
   4. Establish minimum level specification
   5. Does the enterprise agree with the proposed standard?

C. Identify the standard
   1. Is it quantifiable ?
   2. Is there an existing standard or an alternative to the current proposal?
   3. Assure that the proposed standard addresses a government mandate, an enterprise integration business entity value, or a critical success factor

D. Select/develop the standard
   1. Consensus process
   2. Equality and fairness
   3. Technical wording and content
      a. Usability
      b. Completeness
      c. Applicability
   4. Develop the documentation and guides
      a. Description of the standard
      b. IG - instruction guide. How to use and implement the standard
      c. GEN - general document to explain the philosophy behind the standard
      d. Recommended practice. This includes products that are to be used and if published requires acknowledgment if the standard is not used as directed

TABLE 11-II (continued)

E. Authorize

   1. Validate the process

      a. Is there consensus?

      b. Does the standard answer the original question?

      c. Is there technical merit?

      d. Cost vs. benefit

   2. Publish and communicate the standard

TABLE 11-III

A SUGGESTED SET OF PROGRAMMING AND COMMUNICATIONS INTERFACE STANDARDS

I. Programming Interfaces (Refer to Chapter 6 of the CIM Reference Model [Reference 81]). See also Figure V-51 there.

Level 1 - All work at this level should be carried out by "configuration" using the available configuration aids developed by the control system vendors. These programs tend to be proprietary and restricted to one model of control system. They are subject to change by the manufacturers as competition dictates. They comprise a set of menus of possible functions from which the user chooses those desired for the case at hand.

Level 2 - Some configuration tools are available at this level but more actual programming is required of the users. All necessary programming should be carried out using high level languages as discussed in Chapter 6 [81]. The minimum possible number of such languages should be specified to minimize the learning required for system developers and to promote the transportability of the resulting programs between the computer nodes of the overall system.

Levels 3 and 4 -As one progresses higher in the hierarchy menu type programming aids become less available and more direct programming is necessary. In many cases, however, preprogrammed packages are available from vendors to carry out single tasks or groups of tasks at these levels. Compatibility of these "packages" with each other and with the overall system becomes the overriding factor in their selection. The selection of languages may be somewhat modified for these levels compared to Level 2 because of the differing tasks and the different backgrounds of the personnel involved. Again, the overall list of languages involved should be kept to minimum.

II. Communications Interfaces (Refer to Chapter 10 of the CIM Reference Model [Ref. 81])

Levels 1 and 2 - The distributed, microprocessor-based, control system now comprising the major offerings of the control system vendors usually incorporate a proprietary communications system unique to that vendor's offering and often to the particular models involved. These are usually bit serial systems closely resembling the IEEE 802 systems discussed in Chapter 10 of Reference [81]. Efforts are underway to make them completely compatible with the standards being developed by the OPC, Fieldbus and Profibus groups. In any case, the CIM program developer must assure himself that the chosen Level 1 system is or can be made readily adaptable to the other computers and communications systems with which it must communicate either by adherence to accepted standards or through "gateways' which achieve the same purpose. Chapter 10 of Reference [81] outlines the standards and interfaces involved.

Levels 3 and 4 - The ISA S95 standards handle these levels as well as those discussed above. Here we are generally discussing computer-to-computer interfaces because of the types of tasks involved. Again the enterprise integration program developer must assure himself that the chosen computer communications systems follow the proposed and accepted standards discussed in Chapter 10 or that suitable "gateways" are made available by the respective manufacturers to assure the same compatibility of communications promised by the standards themselves.

As noted in the Programming Interfaces section above, these standards, or alternate gateway solutions, should be specifically stated in an enterprise integration specification as part of the Master Plan and agreed to by all vendors involved.

Since they are expected to be widely used, it is extremely important that they be carefully drafted so that no one is unduly injured by their application and no biases are shown against any company, industry or group. Therefore, standards are almost always initiated by a committee, reviewed by still another independent group or committee and finally approved by still a third totally separate group or committee. One or more of these committees must be representative of those companies or individuals who are most affected by the standard.

Standards may and often are developed by a single company for use within the company and/or with its customers. However, most standards are developed by groups representing national technical societies such as the American Society of Mechanical Engineers (ASME), Institute of Electrical and Electronic Engineers (IEEE), Instrumentation Systems and Automation Society (ISA), and the Society of Manufacturing Engineers (SME) as well as many, many others. They are also developed by companies or laboratories sponsored by insurance companies such as Fire Underwriters, Underwriters Electrical Code (UEC), Boiler Safety Code, etc. There are also governmental bodies such as the National Institute of Standards and Technology (NIST) formerly the National Bureau of Standards (NBS).

Overall standards work in America is coordinated by the American National Standards Institute (ANSI). All so-called "national standards" must be reviewed and approved by them. In some areas ANSI has delegated its responsibility here to one of the national societies such as ISA for industrial process controls. Every other major nation has an organization similar to ANSI.

Internationally there are two major standards groups: first, the International Standards Organization (ISO) along with its International Consulting Committee on Telephone and Telegraph (CCITT) and second, the International Electro-technical Commission (IEC). Both groups produce standards with international acceptance. They have effectively split the several fields of technology between them but there still is some overlap particularly in the newer fields such as computers.

Every major nation is represented in both groups. The United States is represented by ANSI in the ISO. However, IEC works directly with several of the American engineering societies such as ISA for instrumentation.

To show how all of these groups: technical society, national or international safeguard the general applicability and non-bias of all standards, Figure 11-4 presents an outline of the process used by the Instrument Society of America.

11.4 *Interface Standards*

It was long the policy of the International Purdue Workshop on Industrial Computer Systems that the establishment of a set of interface standards (communications and programming) would be the easiest and best way of assuring the interconnectivity of the elements of an Enterprise Integration scheduling and control hierarchical computer system and the transportability of all computer programs between the several computer nodes of the system.

There is a decided trend in industrial control at this time to develop the concept of "configuration" rather than direct computer programming for many of the vendors' products in the industrial control field, particularly microprocessor-based systems for use at Level 1. While these latter systems are very easy to use, they do generally prevent the user from directly programming the system, i.e., altering the available menu of possible functions. They also tend to be less standard than the languages from which they have been developed.

The developer of a Master Plan for a proposed enterprise integration program should therefore prepare a specification for the communications interface between system units and a companion specification for the programming interface between the systems developer and the implementation of the system itself. An example of some of the important points in such a dual specification is presented in Table 11-III. This specification becomes part of the Master Plan and should be agreed to by all vendors involved.

11.5 *System Capability*

Once the Master Plan has been completed and accepted by company management the Program can proceed as finances, personnel availability and equipment procurement permit. It should be noted that, as long as all communications and programming interfaces are religiously observed system (sub) projects can be completed in any order appropriate to company desires and needs since overall operability of the final system is insured by the established interface rules and provisions.

Further, should potential system technology change during the implementation period, equipment following the new technology can be readily submitted for that previously specified so long as the above mentioned communications and programming (or software) interfaces rules and provisions continue to be observed.

11.6 *Implementation of Standards*

Most large companies have a standards evaluation group whose task it is to review all available standards from whatever source and pick those which should be used by the company. Where standards for particular applications do not exist, this group can institute an internal procedure as outlined above to establish such a standard.

The Enterprise Integration Planning Team in carrying out the work of this chapter for the Master Plan and the Enterprise Integration Program Proposal should review the established company standards list and be sure that all company established standards (regardless of source) which are applicable are recorded and made known to all connected with the Enterprise Integration Program through a listing in the Master Plan or other applicable means.

Where appropriate and valuable external standards (including de facto) important for the enterprise integration program exist but have not yet been considered by the company standards group, the Enterprise Integration Planning Team with Steering Committee approval, should initiate a request for such action.

The promised checklist for these procedures is given in Attachment 11-I. Attachment 11-II provides the summary for the work of this chapter as with previous chapters.

ATTACHMENT 11-I

CHECKLIST

Below is a checklist of areas to consider for standards (international, national or internal to the company).

1. Computer Operating Systems.
2. Computer (Enabling) Application Software.
3. Suppliers (and Maybe Even Specifically by Model) of Computers, Distributed Control Systems, Programmable Logic Controllers, and Packaged Control Systems.
4. Suppliers (and Maybe Again by Model) of Transmitters, Sensors, Analyzers, etc.
5. Suppliers (and Maybe Again by Model) of Drives, Valves and Other Final Actuators.
6. Networks or Protocols (by Both Supplier and Model Number).
7. Suppliers of Strategic Planning Consulting Services.
8. Methodologies for Doing Strategic and Tactical Planning.
9. Models and Architectures as a Basis of Common Understanding.

ATTACHMENT 11-II

SUMMARY OF PLANNING STEP 11
REQUIRED STANDARDS SELECTION PROCESS

Define:

- Catalog of Program Standards
- Needed New Standards
- Training Requirements for Standards Use

Resources:

- Available Industry Standards
- Emerging Standards
- Available Internal Standards

12. Transition Path from "AS-IS" to "TO-BE

12.1 *Introduction*

The development of the Enterprise Integration Master Plan follows the pattern of producing a set of chapters outlining the proposed TO-BE conditions of each of the major subdivisions of the Enterprise Business Entity; the manufacturing equipment, information systems and human and organization architectures. These are then followed by a similar description of the AS-IS conditions for each of these same subdivisions.

The task to be outlined in this chapter follows the work just noted in that its task is that of determining the best path from the current AS-IS condition to the proposed TO-BE situation of the future. The output of the work outlined in this chapter thus proposes the best path to solve all of the existing gaps between the AS-IS and TO-BE in order to have a complete documentation of the proposed enterprise integration program of the Enterprise Business Entity. It is left to Chapter 14, "Identify Enterprise Integration Projects," to develop the actual order in which these gaps are filled.

The overall purpose of the task outlined by Chapter 12 is then to:

1. Coordinate the TO-BE's (all 3) with the overall enterprise integration plan
2. Determine the required direction of each of the needed changes based on the AS-IS status for all three architectures.
3. Define discrete change steps that will move the enterprise integration business entity in that direction allowing for any necessary prerequisites and dependencies.
4. Define the ideal sequence of steps in a manner that is supportive of the integration plan of the Enterprise Business Entity.

Figure 12-1 diagrams the task involved here. It may also be necessary to carry out this task interactively and return to the previous AS-IS and TO-BE tasks to procure additional data to complete the work as outlined below.

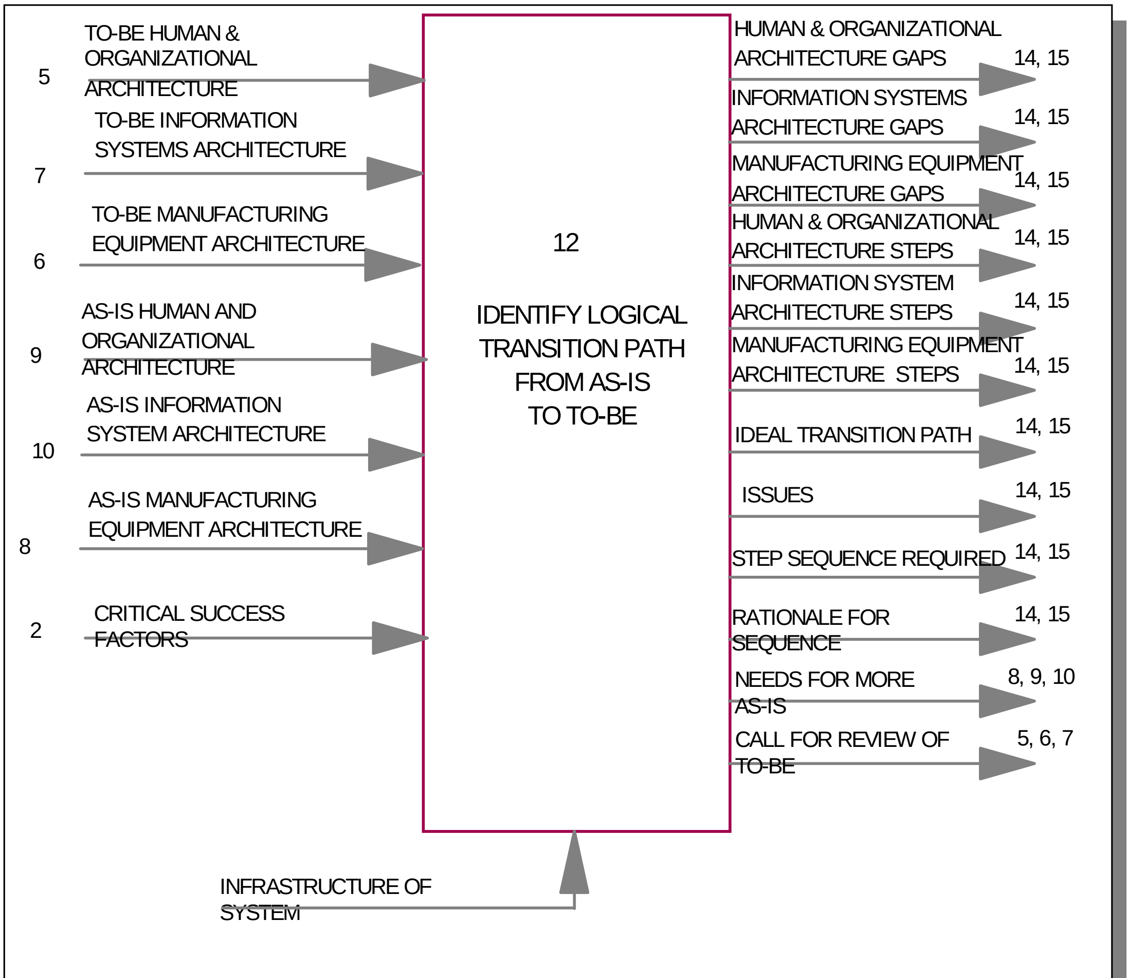


FIGURE 12-1 THE TRANSFORMATION TASK OF CHAPTER 12 – IDENTIFY TRANSITION PATH FROM AS-IS TO TO-BE

12.2 *Phased Approach for Task Completion*

It is recommended that a phased approach as discussed below be used for carrying out the tasks outlined in this chapter. One version of this method is as follows:

Proposed Phased Approach

The phases are identified as follows and each is discussed here in turn.

Phase 1 - Identify existing gaps between the AS-IS and TO-BE conditions

Phase 2 - A proposal with no constraints

Phase 3 - Modify the above proposal by restoring realistic constraints

Phase 4 - Discard all low-value steps from the analysis

Phase 5 - Determine the logical time sequence of the remaining steps.

Phase 1- Identify Gaps Between AS-IS And TO-BE

By a "gap" we mean simply that difference (whatever it may be) which separates the AS-IS state or condition or position from that of the TO-BE. Whatever word is applied, what we are seeking here is the difference between where we are now and where we intend to go in the future. See Figure 12-2. For the Information Systems Architecture, e.g., there will be a net overall gap that may be decomposed into two or more parallel gaps, and each parallel gap may consist of one or multiple serial or sequential sub-gaps.

In any case, we have in the end a number of gaps to be eliminated or reduced by means of various steps.

Phase 1 is a crucial operation. It may be tempting to separate or decompose the all-encompassing gap into its different functional or architectural parts so that experts can immediately get down to their real business and begin discovering the most effective bridges for crossing the sub-gaps. However the temptation must be resisted to let the experts have their day at once without due consideration of the real necessity to integrate these bridges so that, for instance, the information "bridge" creates an appropriate path or route for the human "bridge" designers. This integration of the functional steps into a holistic system can be the "icing on the cake" that generates the widespread feeling that the effort devoted to enterprise integration planning was "worth it".

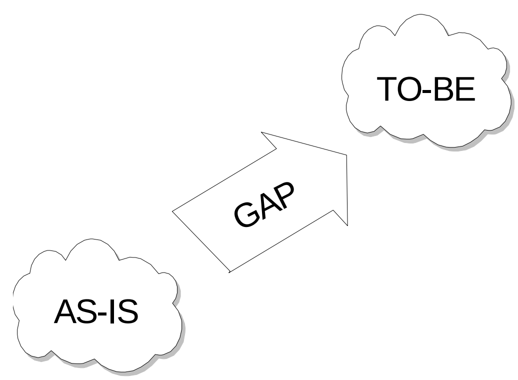


FIGURE 12-2 THE TRANSITION (RESULT OF PHASE 1)

Phase 2 - A Proposal With No Constraints

The first considerations for a transition plan should be, "free form". That is, they should consider all possibilities, and temporarily at least, not consider constraints, real or imagined, which might exist. This is to assure that all reasonable suggestions for the transition get a fair hearing.

One method of doing this is to call a meeting of those personnel involved in this task and through the use of one of the recognized techniques for generating ideas formulate an unrestricted proposal for the steps necessary to take the Enterprise Business Entity from the AS-IS to the TO-BE. In carrying out this meeting it will be necessary to develop an approach that will not only bring forth these steps that are generally known to be necessary, or even overdue, but will also be one that encourages the spontaneous generation of fresh ideas which may never have been "publicly" aired before, ideas which may indeed appear to be so "far out" that their author(s) might otherwise have kept them under wraps. It is imperative that the participants have complete confidence in the meeting discipline adopted. Otherwise some may fear turning off fellow participants to the point that the latter will refuse to make their new ideas known so that these new ideas can be considered along with the others.

Whatever meeting conduct technique is used, planners should be encouraged to throw out ideas for moving toward the TO-BE's. Meanwhile others present should refrain from criticizing or even evaluating any suggestions. Questions should be allowed only for clarification purposes. Other points to keep in mind are:

1. Do not consider the availability of resources
2. Do not consider the availability of funding
3. Do not consider the availability of time
4. Do not consider the constraints of standards

See Figure 12-3.

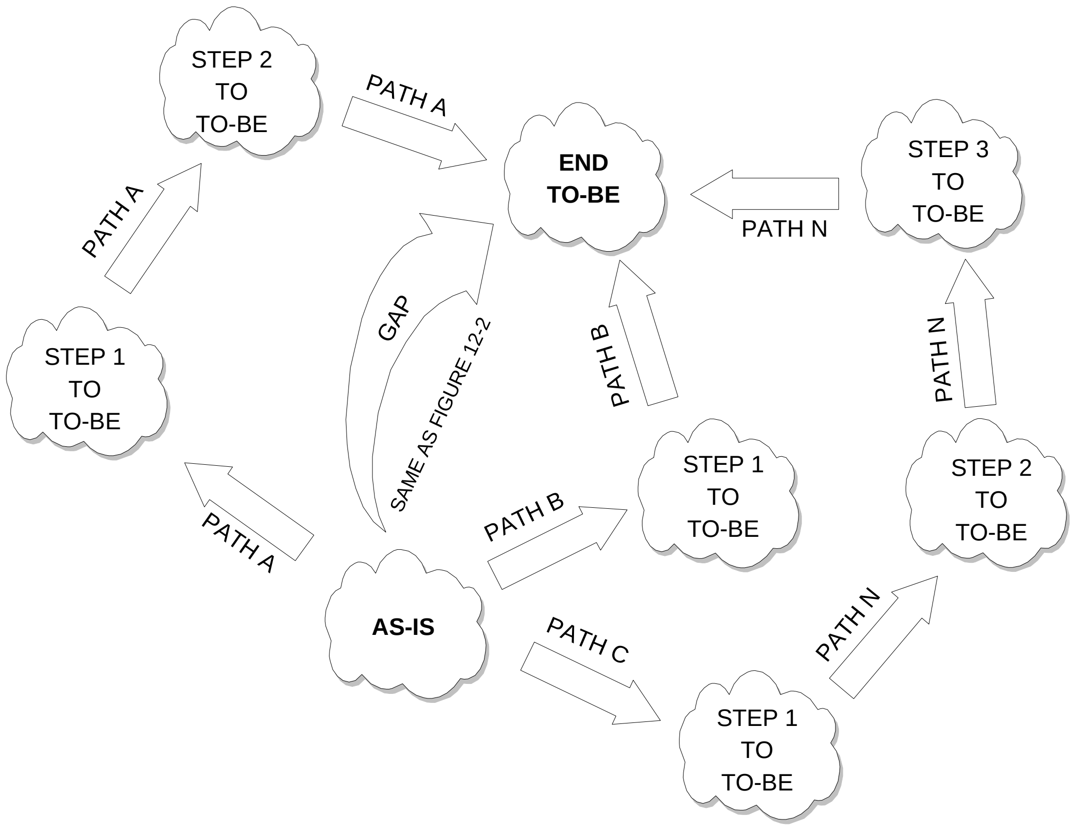


FIGURE 12-3 MULTIPLE POTENTIAL TRANSITION PATHS (RESULT OF PHASE 2)

Phase 3 - Modify the Above Proposal by Restoring Constraints

Up to now the group has been diverging and discovering more and more ways to overcome the gaps. The next step is to begin to turn the thinking into convergent ways. The group should now stop the generation of new potential steps, and should select certain of those already suggested, thereby eliminating those not offering sufficient value or help at this time.

Without being overly restrictive of ideas (if possible, err on the side of too few constraints) re-impose constraints which are either known or anticipated as limiting or confining certain of the "gap-reducing" steps. This results in the following:

Once again, any of various analytical techniques may be used. Any one of these should involve:

1 Open discussion for full understanding of proposed steps

2 Some method of weighting or ranking of the proposed steps by all participants

3 A prioritized listing of all proposed steps

Phase 4 - Discard All Low-Value Steps From the Analysis

By further ranking or voting, develop a pared down list of those high level or "giant" steps which survive the stress and restrictions induced by Phase 3, and which seem justifiable even with the constraints. Discard the remainder. The steps considered here should not involve any details of implementation, but rather should merely be proposed systems and functional designs. What is left now constitutes the Transition Path. See Figure 12-4. Each major step in this Path can probably be divided into three sub-steps, one for each area. In fact, the agreed upon path can be thought of as consisting of three related, integrated paths, as depicted in Figure 12-5.

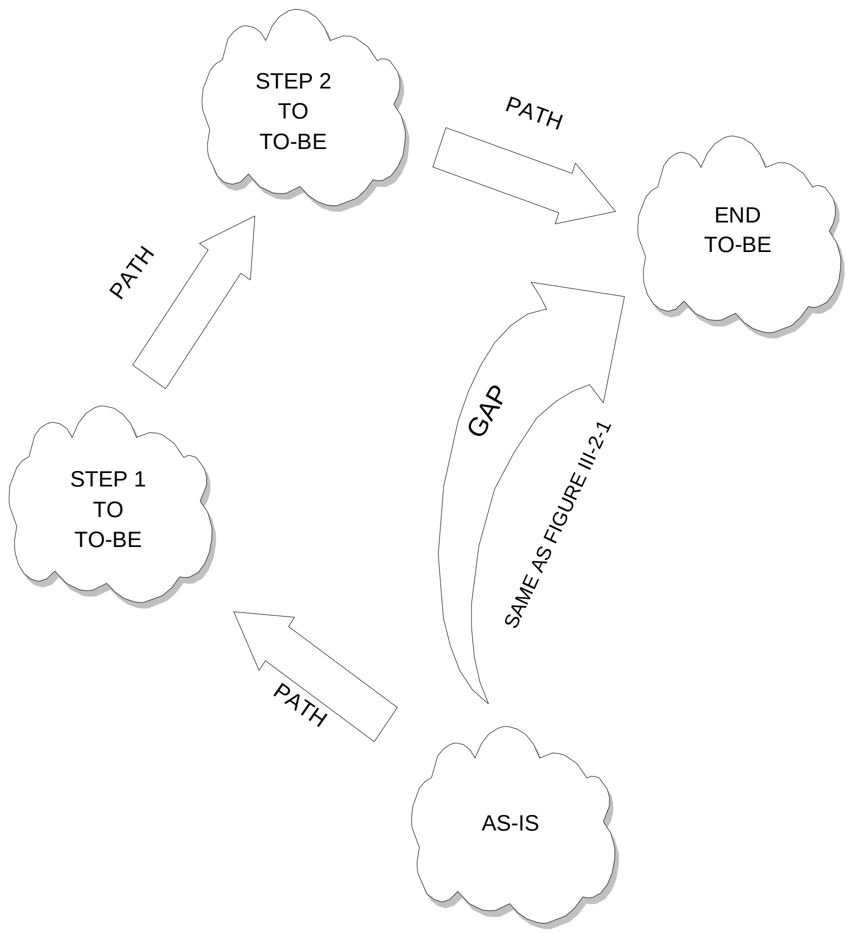


FIGURE 12-4 AGREED UPON PATH (RESULT OF PHASE 4)

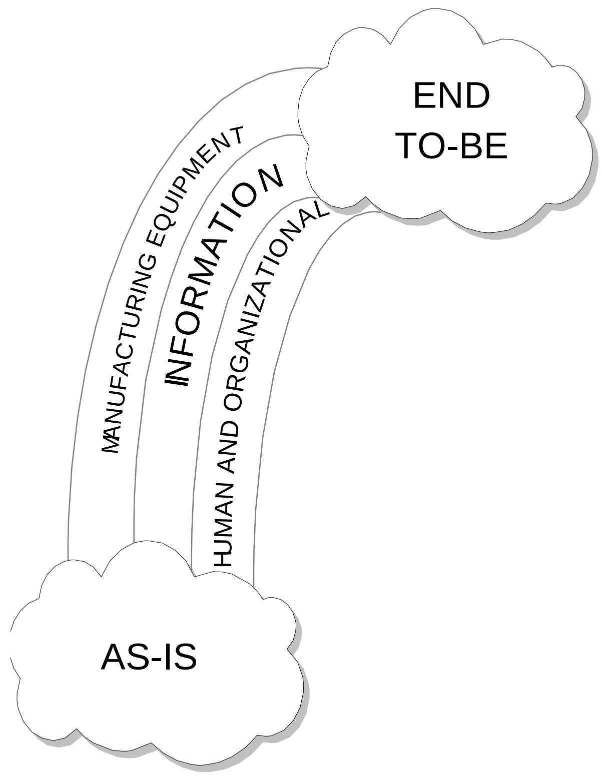


FIGURE 12-5 DECOMPOSED AGREED UPON PATH (RESULT OF PHASE 4)

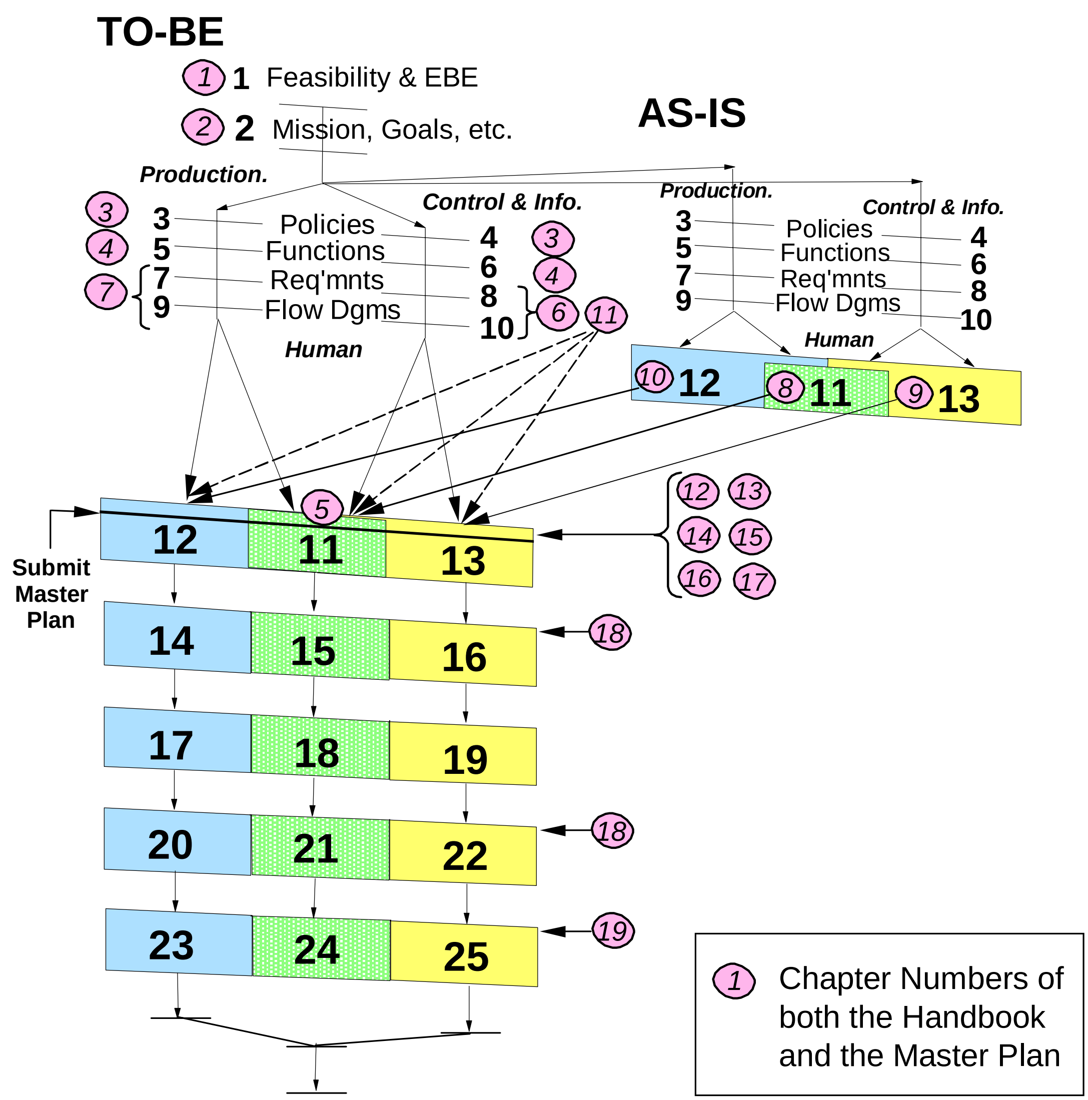


FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

Phase 5 - Determine the Logical Time Sequence of the Remaining Steps

This section is intended to affect only those steps which, for some reason, can be implemented most effectively or most economically if they precede certain other steps, and/or if they follow other different ones. An example, it might be that step (A) results in the installation of a system which is essential to the operation of a system to be installed in step (B). Certainly (A) should precede (B). Other prerequisite relationships may not be so clear. It could be that certain operator training can be accomplished best during step (C). If step (D) were done first, the operators may not be prepared to use its systems. Important criteria are the following:

1. Strategic content of the steps. This refers to the kind of situation described in the first example above.

2. Critical success factors (CSF's). Perhaps a CSF demands that workers' sense of preparedness be given uppermost consideration in any planning. Then the second example above would dictate putting (C) before (D).

12.3 *Quality Criteria to be Used*

The following are criteria to be used in judging the completion and quality achieved in developing each phase of the task outlined in this chapter:

1. Does each step achieve an identifiable, quantifiable goal along the ideal, logical transition path developed?

2. Is the transition path flexible as well as leading to a flexible TO-BE state? That is, does it lend itself to the modifications required by new directions and strategies of the Enterprise Business Entity that might be developed in the future?

3. Is it certain that no steps overlap in a wasteful manner?

4. Have all feasible integration or synergy opportunities been realized?

12.4 *Acceptance Procedure*

The proposed "ideal" logical transition plan from the AS-IS to the TO-BE should be reviewed critically by one or more experts who are skilled and experienced in the areas involved, and who have no ownership in the plan that is being proposed. That is, such experts must be chosen so they would feel completely free to report that the plan requires re-working. They should be borrowed from outside the Enterprise Business Entity, even from outside the Enterprise. Once such re-work has been accomplished, the transition plan must be judged acceptable by:

1. The Planning Team, and
2. The Steering Committee

Attachment 12-I presents a checklist for determining the completeness of this Transition Planning task, and Attachment 12-II provides a summary sheet for it. Figure 12-6 shows its place in the overall PERA model.

CHAPTER 12 – Transition from AS-IS to TO-BE

ATTACHMENT 12-I

CHECKLIST FOR TRANSITION PLANNING

1) Use the help of experts or specialists (from both within and outside the Enterprise Business Entity to judge the existence of:
   a) Incomplete knowledge of existing/future processes and technologies
   b) Inadequate access to expertise in certain areas - i.e., not knowing what you don't know
   c) Overlooked inputs from important stakeholders

2) Check for organizational constraints on organizations' abilities to manage change - to accept the transition steps proposed.

3) Consider separately each of the following possible topics that could threaten success in each of the major areas:
   a) Manufacturing equipment
      i) Leased facilities which need upgrading
      ii) Equipment which is neither efficient nor obsolete
   b) Operational policies
      i) New policies - e.g., prohibition of reworking defective product in production areas - may cause problems with workers
      ii) New policies - e.g., pushing decision making downward - may be a problem for management
   c) Information systems
      i) Incompatible networks or computers
      ii) Obsolete hardware which will not run modern software
   d) Human and Organizational
      i) Unions who refuse to "partner"
      ii) Potential union contract problems
      iii) Managers or workers who cannot change

4) Consider the effect of the following problems.
   a) Possible unforeseen effects of each step within its area:
      i) People in some areas have interfering plans
      ii) Proposed idea was discarded some time ago
   b) Area people feel step is too high-tech, too risky, too costly for anticipated goals
   c) Required skills may necessitate excessive retraining or even replacement of some people
   d) Effects of each step on other areas of the Enterprise Business Entity.
      i) Beware of cascading effects of integration
      ii) Steps that integrate two architectural parts in certain acceptable ways may themselves necessitate further integration which may not happen in a timely manner because (a) too costly, or (b) too demanding of change in people's work or responsibility or skills, or (c) will make the Enterprise Business Entity too far advanced or too out-of-step with the rest of the enterprise for the comfort of corporate management.

ATTACHMENT 12-I (continued).

5) Seek a critical review from an independent and knowledgeable person or group.

6) Does the sequence of steps proposed exhibit the best logic possible?

7) Are the steps associated with each AS-IS to TO-BE area separate? If so, is there not some synergy which might be achieved by a possible combination of steps between areas? There may be a similar function in different parts of the architecture that permits such a combination and the resulting synergy.

8) Are some steps in each area prerequisite to others? If so are these in the natural sequence for accomplishing the required transition? Identify all assumptions involved including obvious subconscious ones to assure completeness of this step.

9) Are certain of the proposed steps vital to the foreseen projects or especially visible and attractive to those who must approve or accept the final proposal? If so, effort should be expended to be sure that these items are on the proposed enterprise integration projects list.

10) Are some topics independent of a sequence, i.e., can they stand alone.? If so, they may be identified in a "pool" of steps which, though essential to the success of the enterprise integration program, permit themselves to be accomplished at the convenience of those charged with managing the program.

11) Are there any issues that have arisen concerning standards involved? If so, clear them through the procedures involved with Chapter 11, "Identify Required Standards Selection Process".

12) Is the data necessary to define all areas and sequences involved available? If not, request the necessary additional data from the AS-IS and TO-BE areas as soon as possible to avoid a bottleneck situation.

13) Is there sufficient expertise present in all working groups and sub-groups to assure the accuracy of the resulting work? If not, be sure to recruit the appropriate experts from in-house or contract organizations.

ATTACHMENT 12-II

SUMMARY OF PLANNING STEP 12
TRANSITION PATH FROM "AS-IS" TO "TO-BE"

Define:

- Human & Organizational Architecture Gaps / Steps
- Manufacturing Equipment Architecture Gaps / Steps
- Information Systems Architecture Gaps / Steps
- Ideal Transition
- Issues
- Transition Step Sequence / Rationale

Resources:

- Documentation of Previous Steps of Chapters 5 to 10

13. Develop Training Plan

13.1 *Introduction*

As has been brought out often in this Handbook, enterprise integration is not just the computerization of the current methods of operating a manufacturing facility. A whole new culture and outlook on the part of plant operational and management personnel and often a much higher technical awareness and capability will be required over earlier systems. The culture and technical performance levels of plant and management personnel must therefore be changed to match the new needs if full advantage of the new enterprise integration system is to be realized.

Companies will desire to take full advantage of the new capabilities made possible by;

1. Information availability,
2. Overall task coordination,
3. Decision support at all management levels,
4. Global optimization, and
5. Potential gains from analysis of plant data

There are many ways of accomplishing such a change ranging from a slow osmosis of absorbing the new culture and knowledge from the new system itself to hiring a whole new staff already trained for this new outlook and performance. The first of these is usually unsatisfactory because of the time required and the intermediate low results involved. The second is infeasible for social and economic reasons and also because of a lack of availability of sufficient individuals who fulfill the needed qualifications.

The most satisfactory remedy is that of the development of an internal training program to teach Enterprise Business Entity personnel at all levels all that they need to know to allow the company to reap the full benefits of the new system. Because of the wide-ranging needs of the different tasks of the people involved and differences in the individual backgrounds of these same people, a very extensive and varied program will probably be necessary. Such an endeavor needs to begin early in the implementation of the enterprise integration program, probably almost as soon as approval is obtained for the overall program itself. This allows all personnel to become familiar and comfortable with the new system as early as possible and promotes the needed "buy-in" for them to assure their acceptance of the system when it is finally installed and commissioned.

As in the transition activity of Chapter 12, the training plan also analyzes gaps between the AS-IS and the TO-BE states. Along with the others training topics to consider the training plan also focuses on the human changes necessary in the areas of culture, technical skills, and interpersonal development. Figure 13-1 shows the integration of these activities in diagram form. Figure 13-2 shows its place in the overall development of the Master Plan. This activity involves preparing the work force at all levels of the Enterprise Business Entity for the integration of the TO-BE

CHAPTER 13 – Training Plan

Human and Organizational Architecture with the TO-BE Manufacturing Equipment and Information Systems Architectures.

This activity associated with cultural change is important for setting the stage for developing a new organization capable of using new technologies. Without proper training enterprise integration will become just another technical project. In the enterprise integration environment, a switch from the old methods, procedures and mindsets is required. This requires the organization to relearn a new sense of the Enterprise Business Entity's mission, vision and values. Equally important for this Training Plan is management's continual reinforcement of the new mission, vision and values. In the end, it is this reinforcement by management's actions that will sustain the principles of the new organizational paradigm being used.

This management action takes the form of:

1. Consistently interpreting and communicating the mission, vision and values at all levels,
2. Funding projects consistent with the established goals and objectives, and
3. Consistently recognizing and rewarding people for their behavior toward these goals and objectives.

In addition to the cultural changes accompanying enterprise integration, there are technical and skill level training courses required. There are two basic activities in this area. The first is communicating the functional requirements of the Manufacturing Equipment and Information Systems Architectures and the meaning and implementation of the division of tasks between machines and humans (the Extent of Automation Line). Because enterprise integration is as much conceptual as it is technical, people need a broad understanding of the manufacturing processes in terms of the technical aspects of these processes and of the concepts of the Purdue Reference Model for CIM and the Purdue Enterprise Reference Architecture as they apply.

The second activity is that of learning the new job skills necessary. This activity takes the job descriptions and requirements developed in Chapter 5 and assesses what training is required to attain them with the existing plant staff. Assessing how to communicate with and prepare the work force for assimilating the required new knowledge is the difficult part of this activity.

There is a third dimension to the Human and Organizational Architecture as discussed in Chapter 12 that must be taught, i.e., how do people in the organization behave in the new enterprise integration environment? With a focus on broader individual job functions, a new organizational infrastructure must be taught. This infrastructure deals with the new issues involved like those of a higher degree of interdepartmental communication, team rather than individual problem solving, increased responsibility, lower level decision making, etc. These activities must begin with the introduction of enterprise integration and must continue as an on going basis as Chapter 19 suggests.

Therefore, a major component of the Master Plan and its associated Enterprise Integration Implementation Proposal will be to identify the needed training program, the timing of its presentation and the resources required.

13.2 *Objectives*

The work of this chapter should supply the following information to the Master Plan and the Enterprise Integration Implementation Proposal.

1. A set of needed training programs with justification and including proposed scope and curricula content summaries.
2. Estimates of needed resources in space, equipment, personnel and capital.
3. A "Skill Development" matrix relating all personnel and departments to the defined training and education programs. See Figure 13-3 for an example. Note that this figure lists only the personnel relations and general information type skills required.
4. An implementation schedule and course presentation schedule in relation to the proposed program implementation schedule.

Of course, these courses must also cover all the technical skills required as well and corresponding matrix diagram developed including these latter courses.

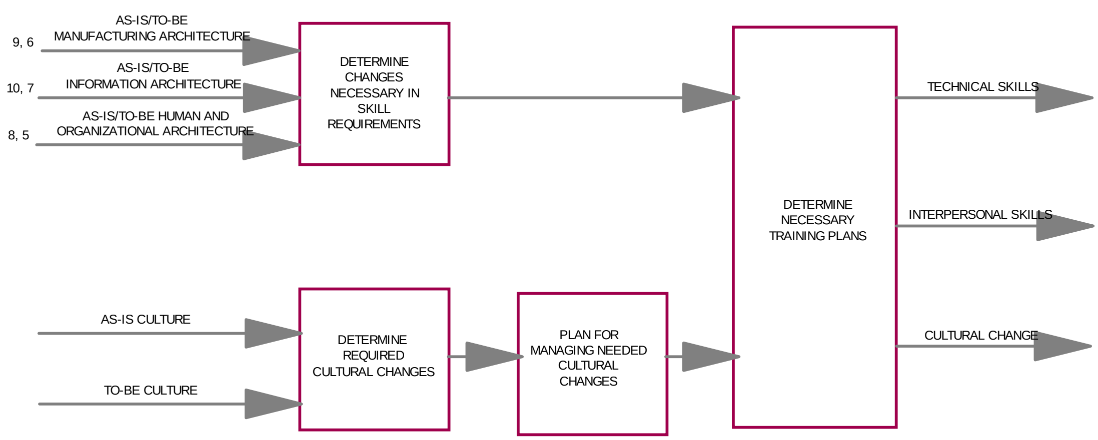
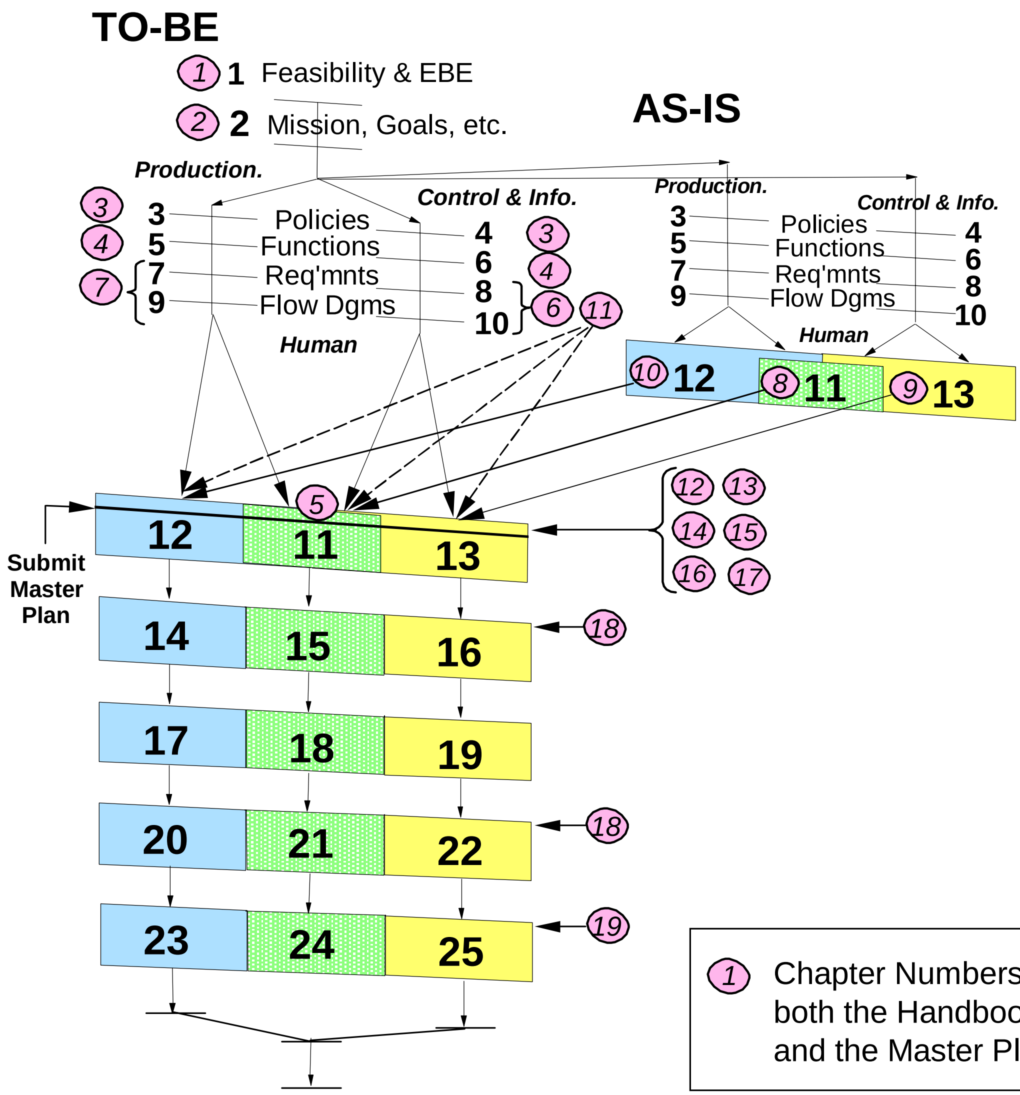


FIGURE 13-1 THE TRANSFORMATION TASK OF CHAPTER 13 – DEVELOP TRAINING PLAN



1 Chapter Numbers of both the Handbook and the Master Plan

FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

13.3 *Training Program*

Development of Needs - WHAT

The following are important components to develop when determining the needs for training programs (probably many separate courses) involved here:

1) Specify the training and educational philosophies to be used.
   a) Training in-house or extra-mural? If not wholly one or the other, what split is contemplated?
   b) Will training be on-the-job or after-hours, part of the job scope or extra duty? Will it be compensated with extra pay?
   c) Will instructors be employees, consultants, or local educational institutions?
   d) What about texts, the availability of hands-on experience, etc.

2) Assess the present culture (AS-IS) in comparison to that of the new system and methods (TO-BE).
   a) What culture change will be necessary between present operational methods and those necessary to fully exploit the new system and method.
   b) How is this culture change best achieved: by lecture courses, by operating a system simulating the proposed system, by visiting installations resembling the proposed system, etc.?
   c) Some of the skills involved with the new organizational structures present with newly implemented enterprise integration systems involve such personnel skill traits as conflict resolution, team building, decision-making, etc. How will these be taught?

3) What technical skill upgrading appears necessary in comparing the present AS-IS skill levels already available versus that necessary for the TO-BE system. As above determine the best way of imparting these new skills to the personnel needing them.

4) Develop a ball-park estimate of the resources required to accomplish the needed training:
   a) Time to be allocated, both in terms of length of the program and also its daily intensity.
   b) What equipment resources and what type and amount of space are necessary.
   c) Needs for and availability of personnel for conducting the program (Internal, External as Individuals or External Organizations to be Involved). If internal personnel are to be involved do we have to "Teach the Teachers".

5) Keep in mind that training may be involved for Management, Staff, Operations, Engineering, Maintenance, etc. Be sure all are considered, for all functional areas.

6) Develop an overall strategy for achieving all of the above.

CHAPTER 13 – Training Plan

Development of Needs - HOW

The types of individuals, in terms of their own experience and knowledge, who serve on the Enterprise Integration Planning Team will usually have the skills to determine what change is necessary between the AS-IS and TO-BE situation in the Enterprise Business Entity. However, they are probably not qualified to specify exactly what training is necessary to fill the resulting gap and how to best achieve the same. Thus they will most likely make recourse to training specialists, either those within their own company, if it is large enough, or training consultants.

Simulators offer excellent methods for training in technical skills, particularly those related to plant operations. The behavior of a plant can be simulated on a computer system that is attached to representative operator's consoles. A pilot system may be developed to allow personnel to work directly with a model system without impacting regular operations. Operational techniques such as response to emergencies can be taught and the trainees assimilation of the required knowledge can be verified. These and many other applications of simulators should be considered in planning the training program.

Development of the Needs - CAUTIONS

The following are some cautions to keep in mind when planning the Training Program:

1. Training is a fundamental tool supporting cultural change throughout the company. The culture affects people directly. Thus the program must somehow be made participative rather than dictatorial. Perhaps the potential trainees can somehow participate in its planning or organization. It must reflect the local situation. It should generate the least upset possible.
2. All training has a "Just-in-Time" component: If too early, trainees will forget, thus reducing their skill level when needed. If too late, trainees will have to implement solutions as they learn, thus reducing their effectiveness greatly.
3. Experience is not a substitute for education.
4. Training requires knowledgeable teachers, experienced workers may not be able to teach unless they possess, or develop teaching skills as well as their technical skills.
5. If in-house personnel are used for teaching, plans must be made to cover their normal tasks.
6. Involve Trainees in defining and implementing their training and development programs if at all possible. This will result in a wider acceptance of the training and the plan is more likely to fulfill the Trainees' needs.

13.4 *Management Considerations*

Risks Involved

Both the Enterprise Integration Planning Team and the Steering Committee will wish to evaluate the risks, or rather uncertainties, involved in the development and implementation of the training plan. These can be investigated with the help of training specialists, either internal or consultants. Risk areas may relate to the following:

1. Inadequate training period or content for the task and personnel involved.
2. Incompatibility of the trainees as a group for the jobs proposed.
3. Excess training costs
4. Timing of training period in relation to project schedule.
5. Inaccurate job descriptions resulting in training plan errors.
6. Potential for loss of trained personnel to competitors.
7. The adjustment period for newly-trained personnel being assigned to newly created positions?
8. Trainees being "over-trained" to compensate for potential misjudgments of needs, better too much than too little?
9. Potential risks from education rather than training, i.e., using "generic" technical institute and junior college general educational programs for high school level operators rather than specialized short courses.
10. Other risks specific to the Enterprise Business Entity and training identified during the evaluation.

13.5 *Checklist and Summary*

As in previous chapters, Attachments 13-I and 13-II present a checklist and summary of the tasks involved in completing the Master Plan work covered in this chapter.

ATTACHMENT 13-I

A CHECKLIST ON THE TASK OF DEVELOPING THE TRAINING PLAN

1. Obtain and document the AS-IS skills assessment (from Chapter 8)
2. Obtain and document the TO-BE skills requirements
3. Obtain and document the TO-BE job descriptions
4. Document the results of the "Changes Necessary in Skill Requirement" analysis
5. Document the required cultural changes
6. Document the plan for managing the needed cultural changes
7. Document the proposed training plans for:
    a. Technical and operating skills
    b. Interpersonal skills
    c. Management and coaching skills
8. Identify resource alternatives for each of the above

ATTACHMENT 13-II

SUMMARY OF PLANNING STEP 13
TRAINING AND DOCUMENTATION PLANS

Define:

- Changes Necessary in Skill Requirements
- Required Cultural Migration
- Plan for Managing Skill and Cultural Migration
- Technical Skills Training Plan
- Interpersonal Skills Training Plan
- Cultural Migration Plan
- Documentation Criteria
- Documentation Management Plan

Resources:

- Previous Step Documentation
- Human Resource Training Files

14. Identify Enterprise Integration Projects

14.1 *Introduction*

This task comprises taking the Transition Plan developed as the result of the work of Chapter 12 and evaluating each of the steps listed there. It converts these steps into feasible projects and places them in a priority list for approval for implementation as part of the Master Plan. The high priority projects will form the Enterprise Integration Implementation Proposal to accompany the Master Plan.

The work described here will iterate with the work of Chapter 15, "Analyze Costs, Benefits and Risks." The intent is to come up with the best possible ordering of the potential projects in terms of the company's project approval criteria to produce the best Enterprise Integration Implementation Proposal. The work of this chapter is responsible for the final version of that listing. Figures 14-1 and 14-2 show the relationship of this chapter to the others in the preparation of the refined project list and the preparation of the Master Plan. See also Table 14-I. In addition to taking the Transition Plan of Chapter 12 the personnel conducting this work will also wish to review the results of the investigation of:

1. TO-BE Manufacturing Equipment Architecture requirements (Chapter 6);

2. TO-BE Information System Architecture requirements (Chapter 7);

3. Training requirements (Chapter 13); and,

4. Significant Initiatives and Opportunities (Chapter 4).

TABLE 14-I

THE STEPS IN A POTENTIAL PROJECT ANALYSIS TO PRIORITIZE THE SET OF ENTERPRISE INTEGRATION PROJECTS

1. For each opportunity or potential project identified, decompose the opportunity into one or more applications.
2. For each application, determine the major system functions that the application should provide.
3. For each application determine, based on order of magnitude, the benefits available from it.
4. For each application, identify the interfaces necessary to other applications.
5. Complete the gross cost/benefit/risk analysis.
6. Complete the weighted application analysis matrix.
7. After all opportunities are completed, prioritize the projects into high, medium, or low value ratings.

CHAPTER 14 – Identify Projects

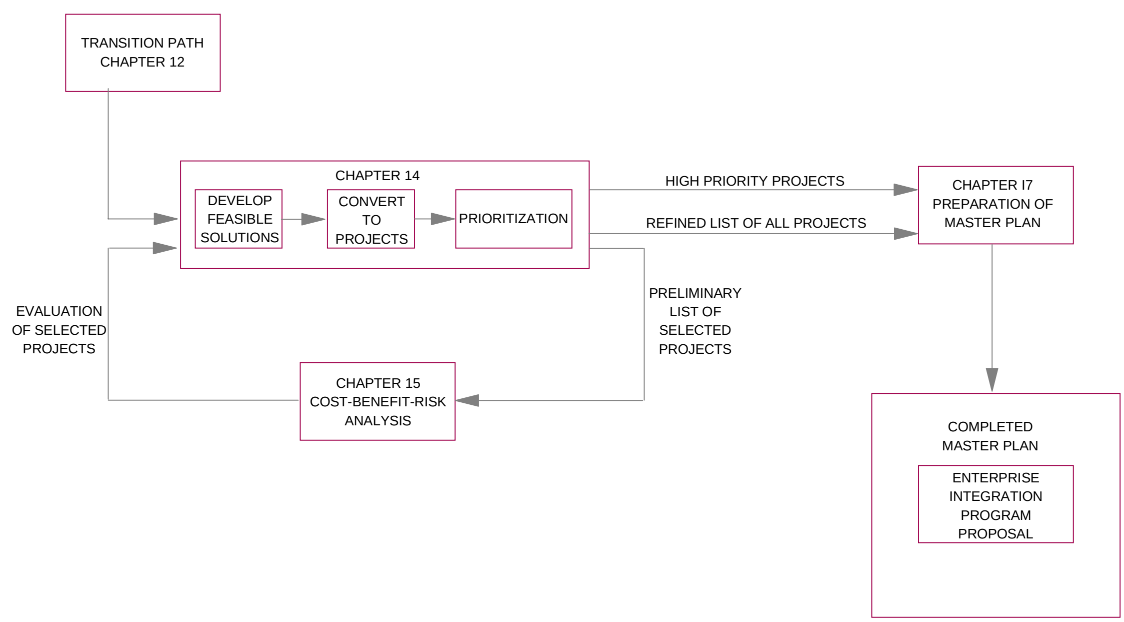


FIGURE 14-1 RELATIONSHIP OF MATERIAL OF THIS CHAPTER TO THE COMPLETION OF THE MASTER PLAN

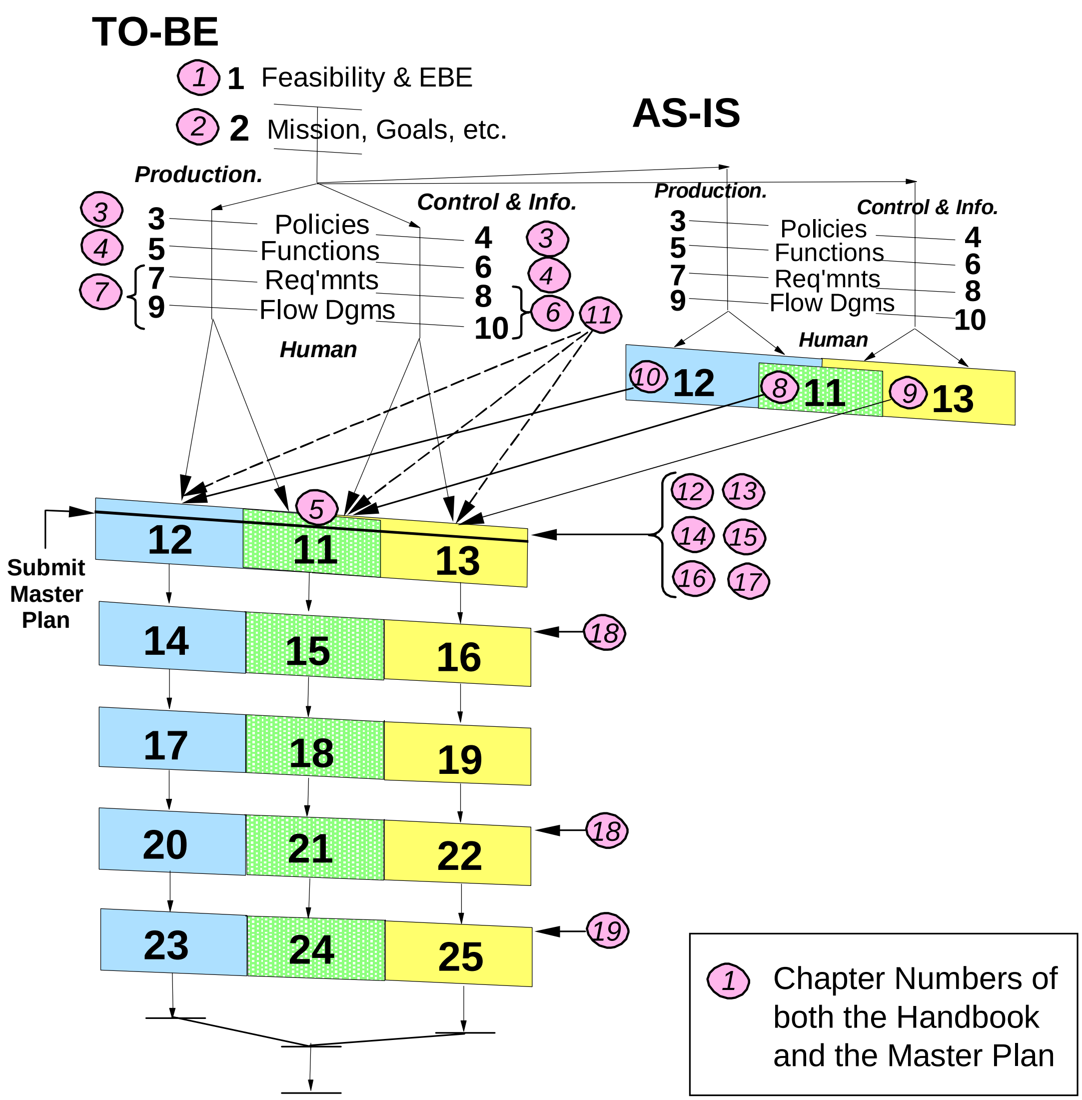


FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

While this was also done by the transition plan study group, the present group may want to review these results themselves for their own insight into the transition plan. In addition these results are helpful in making the initial cost estimates required for the preliminary positioning of the projects to be evaluated by the Chapter 15 work.

14.2 *Conduct of the Work*

In preparing the initial priority list of projects, the work group should make only an order of magnitude estimate of the economic and strategic importance of the proffered projects. This involves grading their potential for significant returns (high benefits, low risk, important strategic or tactical value, etc.) as high, medium or low for the initial ordering.

To achieve this goal it is necessary to perform seven steps for each potential project. Please see Table 14-I. Five of these steps have traditionally been performed for every project. But the last two steps may be new to the project team. The first of these new steps is the application of a weighted analysis matrix. The second of the new steps is that of prioritizing them to determine their inclusion in the Enterprise Integration Program Proposal and their place within it. In more detail the procedure proposed is as follows:

The result of this chapter will be three groups of projects arranged in one continuing priority order. The first part of the list should be "High" priority projects that will have obvious benefits and potentials. The second part of the list will be those projects of "Middle" priority that still have obvious benefits but which may have a high cost of implementation, for example, which may lower their overall desirability. The third and last part of the list will contain projects of "Low" priority. These are usually projects that need to be done sometime but for which the returns are low or because they have technology or cost barriers to their implementation. The output will use the "High" priority list for the Enterprise Integration Implementation Proposal. The second list will be the list of all the above-prioritized projects.

The Figures 14-3, 14-4, and 14-5 present:

1. A flow chart of the analysis process involved.
2. A check sheet determine a weighted evaluation of the potential worth of each project..
3. A suggested summary sheet for evaluating each project's place in the overall list.

Finally the list itself is prepared.

The matrix weighted analysis method applies factors other than straight payback to the selection and prioritization of projects. Payback is a factor, but is not the sole determinate to a project's ranking. Weighing is a way to interject intangibles into the process.

For example, a work in progress system, may rank the highest when payback alone is considered, but may require the completion of other systems prior to implementation. Without the use of a weighing scheme the project team would constantly have to defend why the highest payback project is not the first to be done. Some examples of factors that the project team might want to consider would be:

1. Will this project improve the Enterprise Business Entity competitiveness?
2. Will this project improve time to market of products?
3. Will this project reduce the organizational levels?
4. Will this project reduce paper flow within the Enterprise Business Entity?
5. Will this project improve the quality of the product?

6. Will this project assist in decentralized empowerment?
7. Is there a commercial product available?
8. Will this project require extensive training?
9. What is the business need of this project?
10. Is there an existing project?
11. Is the technology involved in this project available and commercially usable?
12. What is the payback time frame?

The factors listed above are not all-inclusive and the weightings may be different for each Enterprise Business Entity. The weightings should be what is important to the Enterprise Business Entity. A weighted analysis matrix sheet should be completed for each project (Figure 14-5).

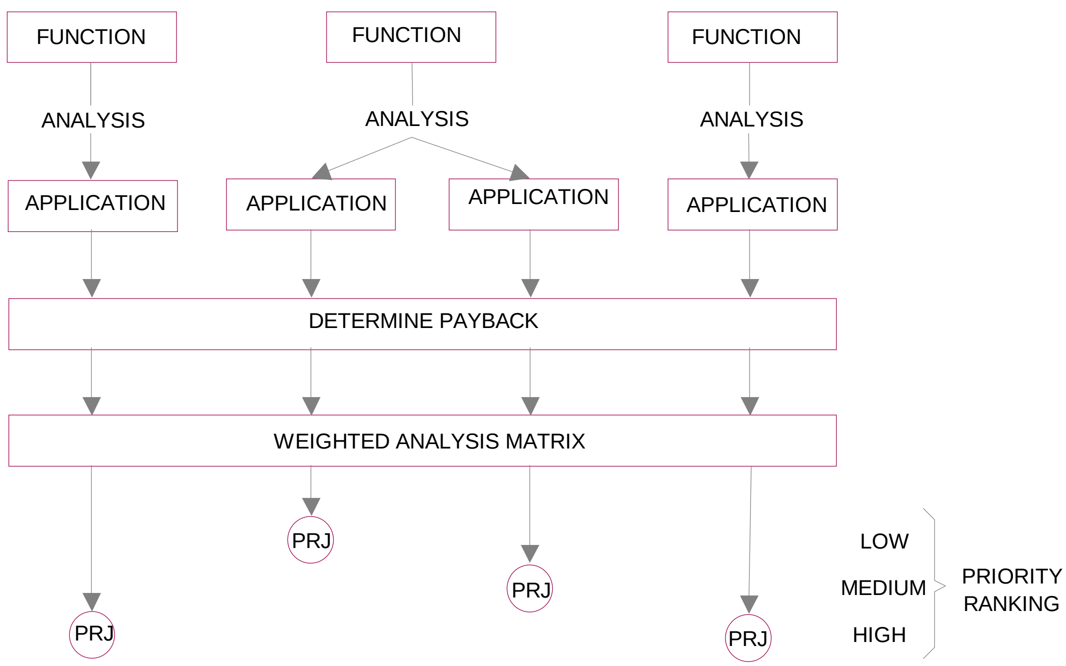


FIGURE 14-3 TRANSITION FROM FUNCTIONAL AREAS TO CIM PROJECTS

PROJECT NAME:

CRITERIA	SCORE	WEIGHT	TOTAL
TOTAL			

FIGURE 14-4 INDIVIDUAL PROJECT EVALUATION SHEET

					TOTAL	WGHTD TOTAL	ORDER	WGHTD ORDER
CRITERIA WEIGHT (1-10)								

FIGURE 14-5 OVERALL WEIGHTED ANALYSIS MATRIX

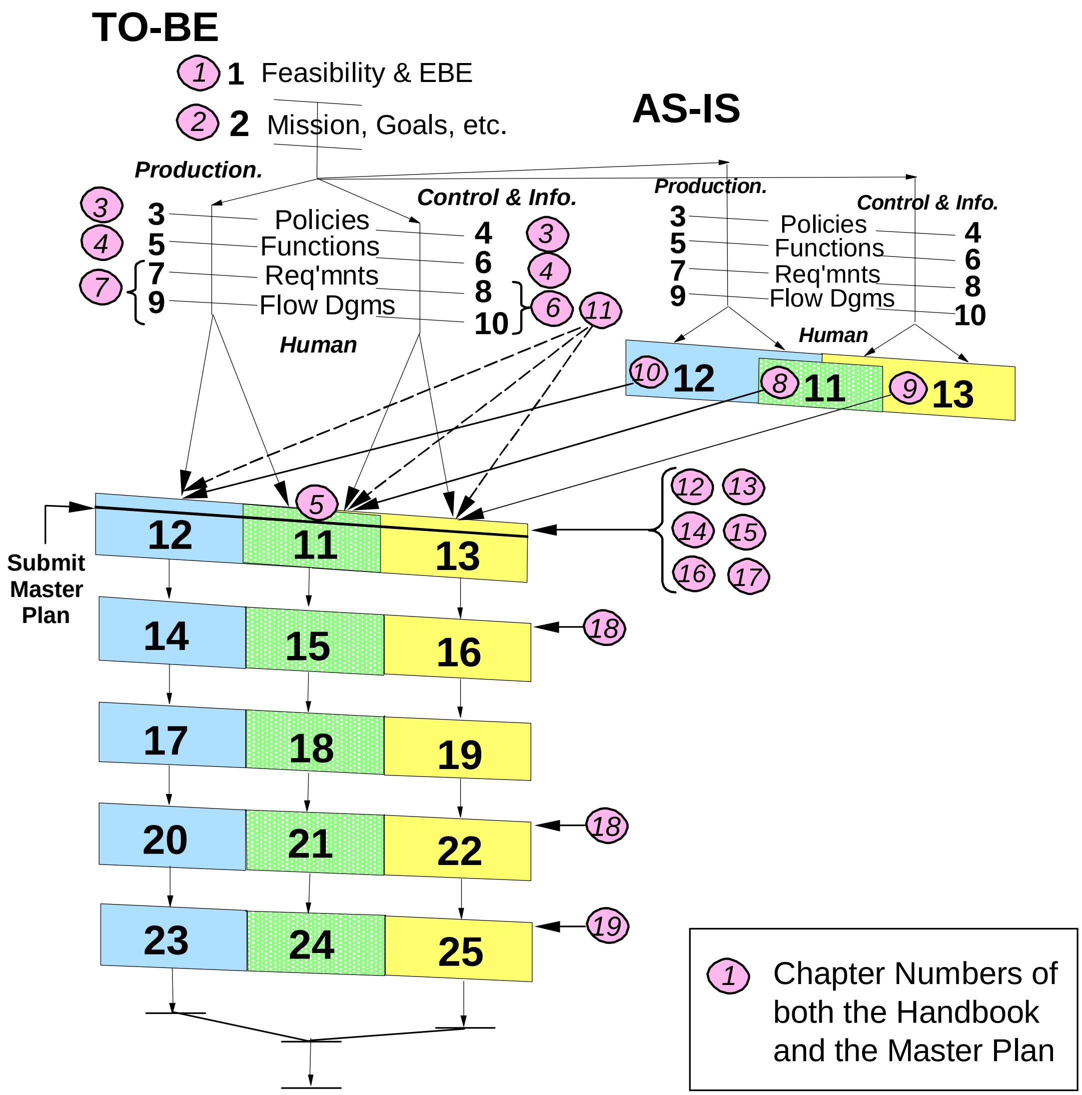


FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

14.3 *Checklist and Summary*

Attachments 14-I and 14-II provide a checklist of questions to help the Planning Team with its tasks associated with the Section of the Handbook as well as a Summary to help further.

ATTACHMENT 14-I

A CHECKLIST FOR DEVELOPING THE LIST OF ENTERPRISE INTEGRATION PROJECTS

1. Determine and document the possible solutions and alternatives for each of the steps from Chapter 12.
2. Select from the various alternatives, and document the solutions which best meet the business goals, objectives and critical success factors.
3. Develop and document the scope, cost estimate and possible benefits for each of the above solutions in the form of projects.
4. Analyze and document the various projects to determine the priority of each, based on the suggested steps from Chapter 12 and the financial analysis from Chapter 15.
5. Document the criteria used to determine project priority (high, medium, low).
6. Document the projects which were rated "high" priority as a separate listing.

The reader should note that the ordering of the projects according to value ratings very closely approximates the suggestion first raised under the section entitled, "The Detail Necessary in the Master Plan," of Appendix IV and its associated figure. Phases II and III and Summary in that figure represent a similar evaluation.

ATTACHMENT 14-II

SUMMARY OF PLANNING STEP 14
IDENTIFY ENTERPRISE INTEGRATION PROJECTS

Define:

- Feasible Solutions Summary
- Project Conversion Summary
- Prioritization Factors and Summary

Resources:

- Previous Step Documentation

15. Analyze Costs, Benefits and Risks

15.1 *Introduction*

The task described by this chapter is to take the initial list of projects of Chapter 14 and apply a traditional cost/benefits analysis for each of the important projects selected there. This information may alter the priority order of the project list and result in an iterative cooperative effort between the tasks covered by the two chapters.

This work gives another opportunity to review and verify that the tentatively selected projects will further the critical success factors of the Enterprise Business Entity in an optimal way. Finally an assessment of the technological, economic, and business risks of each project is made to further evaluate the developing Enterprise Integration Program Proposal and its suggested priority list of projects. See Figures 15-1 and 15-2.

15.2 *Team Needs for Study*

To carry out its investigation the study group from the Enterprise Integration Planning Team doing the cost/benefit/risk analysis must have the following materials called for by other chapters of this Guide or supplied by the Steering Committee or others:

1. The Transition Plan from AS-IS to TO-BE as developed under the work of Chapter 12 including both the path itself and the suggested timing.

2. The tentative priority list of projects for the Enterprise Integration Program Proposal as developed under the work of Chapter 14. As noted above this will probably be iterated between the work of Chapter 14 and Chapter 15.

3. The scopes and initial costs and benefits as determined by:
    a. The "Transition Plan" (Chapter 12),
    b. The TO-BE studies (Chapters 5, 6 and 7),
    c. The "Significant Initiatives and Opportunities" (Chapter 4), and
    d. The "Objectives, Goals and Critical Success Factors" of Chapter 2.

4 The required hurdle rate for economic return as approved by the Steering Committee.

5. The company's preferences for methodologies and tools to be used in making the cost/benefit/risk analysis of each proposed project and of the Enterprise Integration Program Proposal.

6. The Enterprise Integration Planning Team should establish the milestones for this study, the resources required, and the level of detail required. It should also monitor the progress achieved versus the milestones previously set.

7. The Steering Committee should conduct periodic reviews with the Enterprise Integration Planning Team to monitor progress and to review and solve any key internal justification issues which arise.

15.3 *Required Products of the Study*

In addition to the actual report of their analysis of the costs and risks involved, the Enterprise Integration Planning Team should generate the following additional information for the Master Plan from their investigations here:

1. An estimate of the staffing impact on the company during implementation and operation of each of the proposed projects. These changes may be positive or negative, i.e., more personnel required or personnel savings.
2. On-going support needed for each project - again both during implementation and also during the succeeding operational period.
3. An estimate of the timing required for implementation and a suggested schedule for this implementation.

15.4 *Conduct of the Tasks*

As mentioned above, the task described in this chapter involves making a more detailed and accurate assessment of costs, benefits and risks than those carried out by the investigations called for in earlier chapters. These latter include the preliminary studies under "Initiatives and Opportunities" (Chapter 4) and those of "Identify Feasible Solutions in the Form of a Set of Enterprise Integration Projects" (Chapter 14).

Figure 15-3 is a flow chart showing the progression of the work described in this chapter.

The major effort involved is determining the costs, returns and resulting economic benefits calculations. The analysis must be based on approaches that will use justification techniques which are acceptable to the overall Enterprise Integration Planning Team and the Steering Committee of the Enterprise Business Entity. Review the technical material if uncertain about analysis techniques. The company's previously selected standard set of methodologies and tools should be used if at all practical. Any change from the established standard should be reviewed and approved by the Steering Committee.

When a project is being analyzed for justification, be sure to check the resulting costs and benefits versus risks for that particular project. The project might be justifiable but carry a risk due to maturity of technologies used, or the ability of your company to implement the project in the current culture. In doing risk assessment be sure to consider the culture of your company and site and their willingness to adapt to cultural change and to the use of leading edge technologies. Can it be maintained once it is installed?

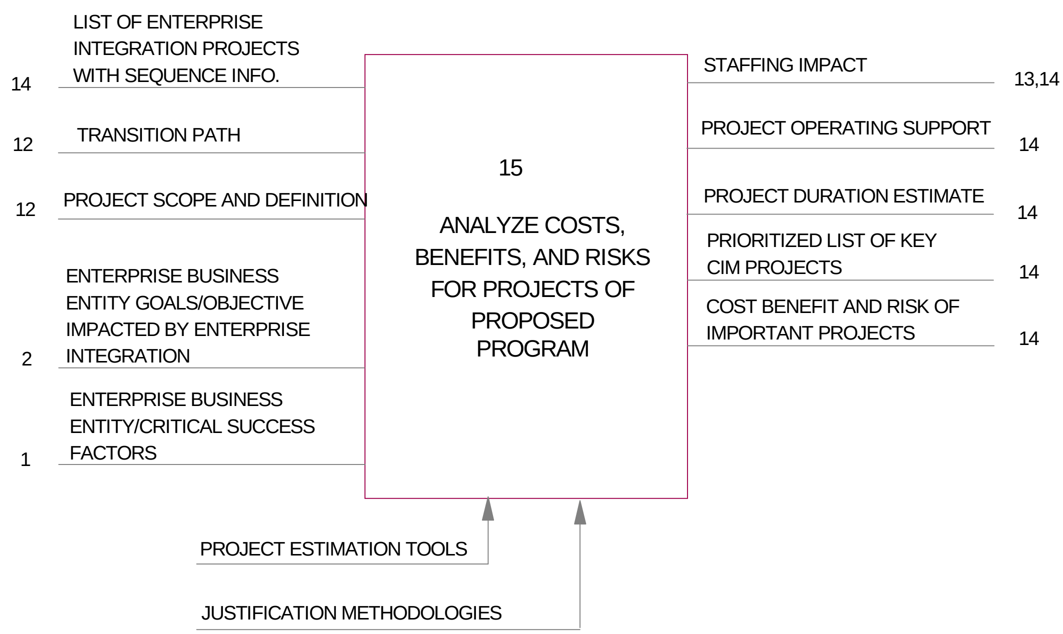


FIGURE 15-1 THE TRANSFORMATION OF CHAPTER 15 – ANALYZE COSTS, BENEFITS, AND RISKS FOR PROPOSED PROJECTS

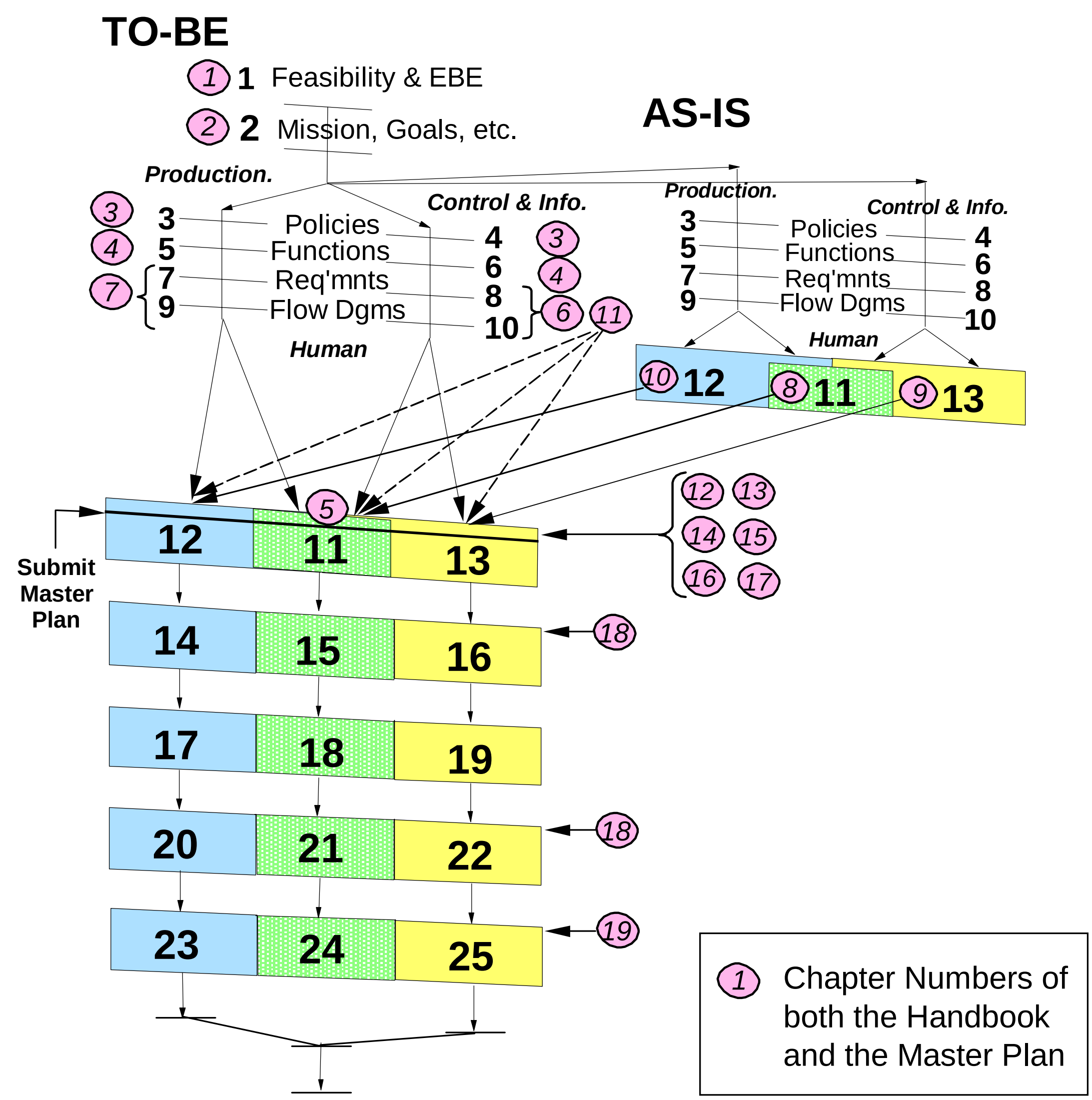


FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

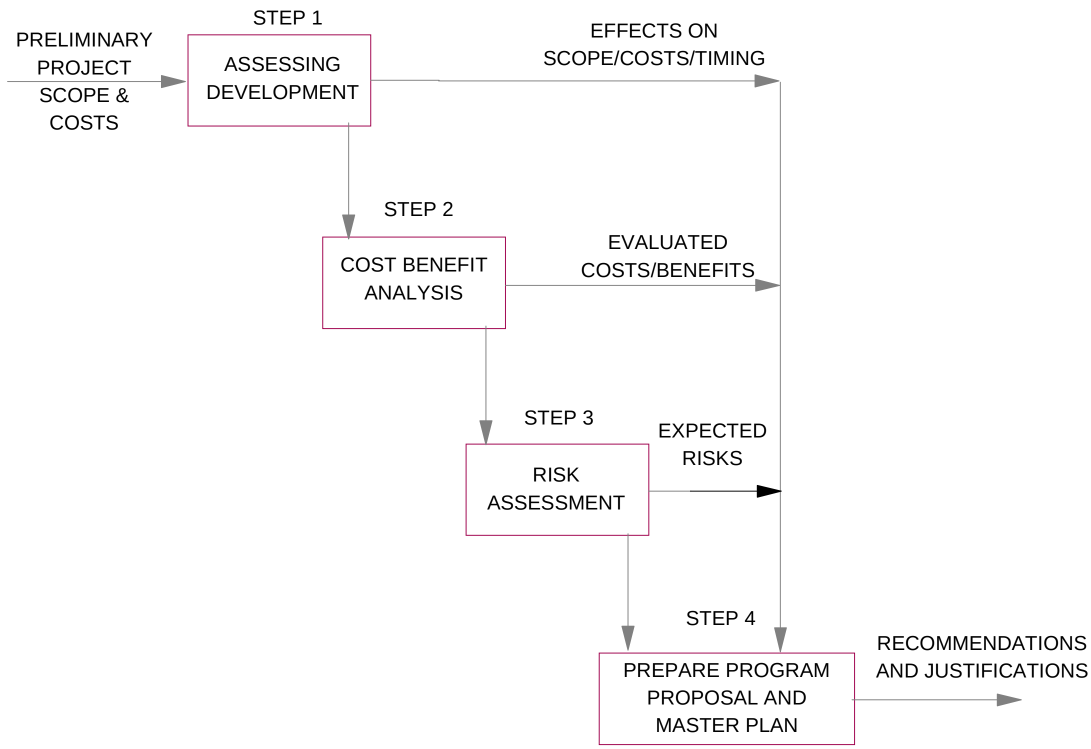


FIGURE 15-3 FLOW CHART OF THE JUSTIFICATION PROCESS

15.5 *Economic Justification*

Figure 15-4 presents a selection of common and available methods that may be used if no company standard set already exists.

The justification approaches that are usually used can generally be classified as:

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

The matrix diagrams of Figures 15-5 and 15-6 give a visual comparison of the improvement potential possible from each opportunity uncovered. There would be a set of these drawings for each such case. Note that this diagram shows the remaining potential after the action considered has taken place. Thus in Figure 15-6 the new blocks are below and to the left of those in Figure 15-5. The gain achieved by this action has removed some of the potential available earlier. This methodology was also used in Chapter 4.

The DuPont model (Figure 15-7) provides a specific algorithm in chart form for assessing the potential economic return for a potential project, here an enterprise integration opportunity. Again this analysis would be carried out for each potential opportunity uncovered by the initiatives analysis discussed here.

In many enterprise integration projects, two or all of the approaches may have to be used together. A strategic justification accompanying an economic one may assure justification of 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 yields little 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 should also be used to reveal the full impact of the investment decision on capacity, productivity, and quality, etc. The strategic justification alone is usually not enough to authorize investment. Figure 15-4 also shows the three justification approaches and what type of analysis tools and concepts need to be used for each category. Please note also the evaluation techniques given in Chapter 4.

A descriptive discussion of some of the techniques listed in Figure 15-3 follows:

Payback Period
The payback period is the length of time necessary to recoup an initial investment. This method is easy to explain and simple to calculate. It may also indicate “riskiness”. The shorter the payback period, the lower the risk.

It is easy to construct an analysis in which one investment has a shorter payback than another but is clearly less attractive in a longer term perspective. Thus this method used alone gives an incomplete analysis.

ROI - Return on Investment

Return on investment shows how effective a company is in generating income given the amount of the investment. It is calculated using the formula: ROI = net income/total investment. The result is a percentage; the higher the percentage, the more favorable the project. ROI does not take into account the time value of money.

The negative to this approach is having different patterns of cash flows that can have the same average value over a period of years although some might be clearly preferable. Again, supplemental methods may be necessary to make the best selection of options.

	JUSTIFICATION		
TYPE	ECONOMIC:	ANALYTIC:	STRATEGIC:
TOOLS USED	PAYBACK PERIOD ROI - RETURN ON INVESTMENT IRR - INTEREST RATE OF RETURN NPV - NET PRESENT VALUE DCF - DISCOUNT CASH FLOW	VALUE ANALYSIS PORTFOLIO ANALYSIS RISK ANALYSIS	COMPETITIVE ADVANTAGE BUSINESS OBJECTIVES TECHNICAL IMPORTANCE

FIGURE 15-4 JUSTIFICATION APPROACHES USED

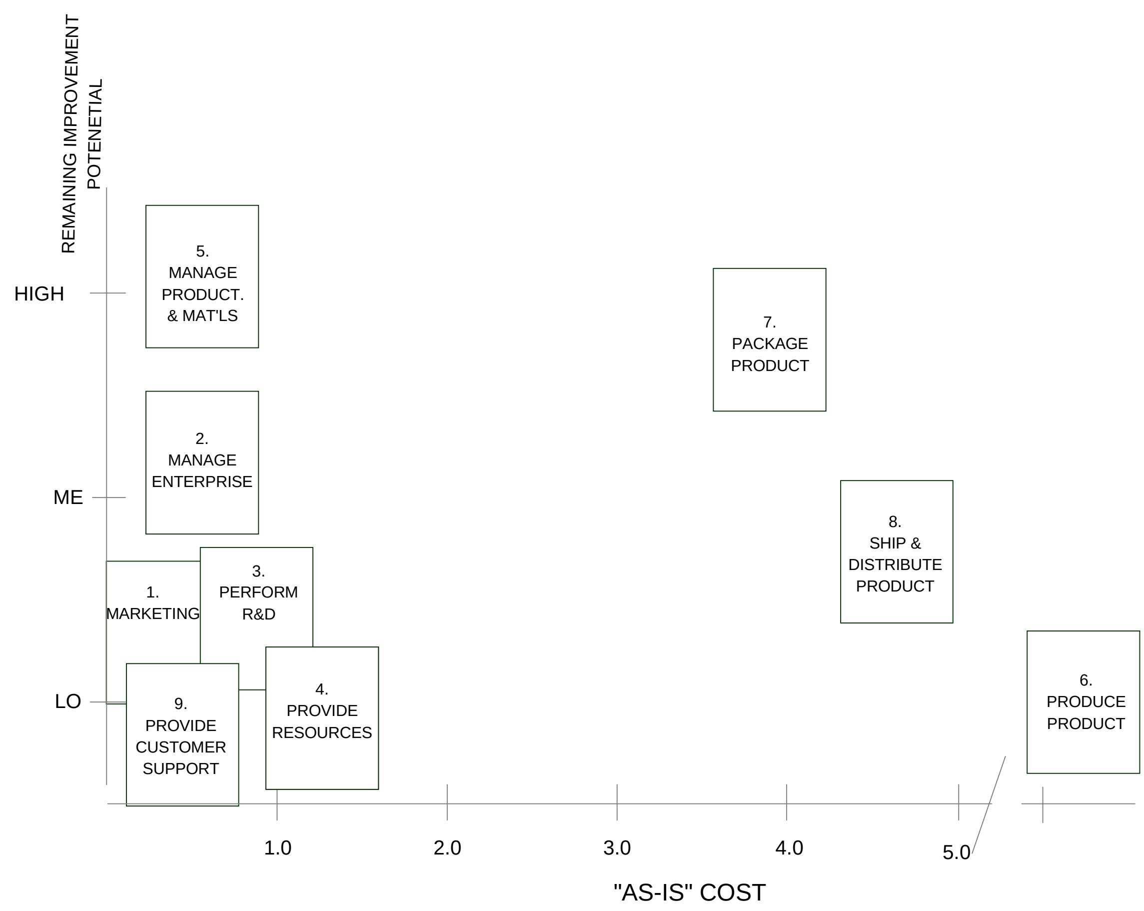


FIGURE 15-5 OPPORTUNITY MATRIX – AS-IS COST

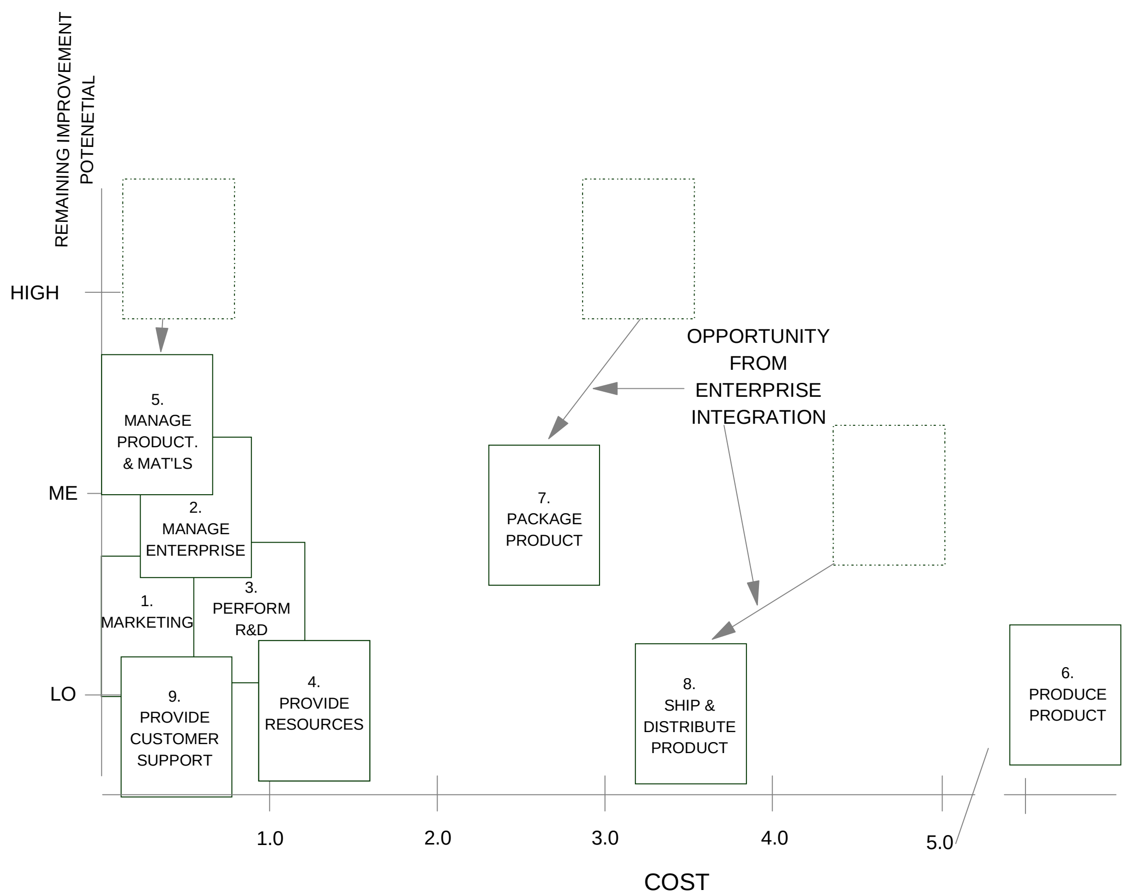


FIGURE 15-6 OPPORTUNITY MATRIX TO-BE

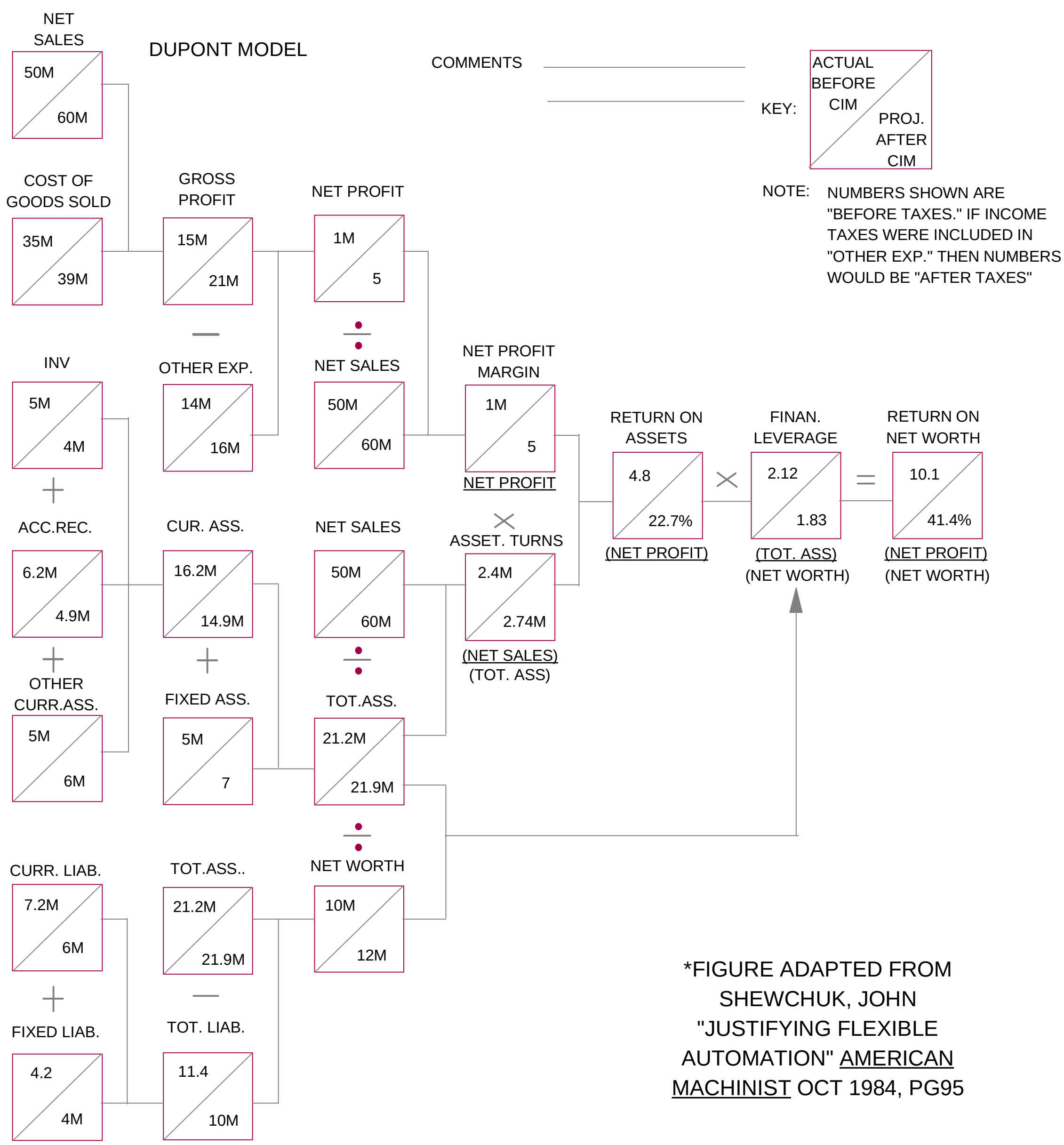


FIGURE 15-7 ENTERPRISE INTEGRATION TECHNOLOGICAL ASSESSMENT AND FINANCIAL SCOPING

IRR - Interest Rate of Return / NPV - Net Present Value
These two methods improve on the ROI technique by including the effect of interest (time value of money) in the calculation. IRR calculates the equivalent interest rate which would be necessary to make the same return from the original capital as will be generated by the project. For success, this number would have to be larger than the prevailing interest rates in the financial markets. NPV calculates that amount of capital necessary at some required interest rate to equal the worth of the project plus its earnings at the end of a certain period of time. This number must be more than the expected capital cost of the project if the project is expected to succeed.

DCF - Discounted Cash Flow
Discounted cash flow takes into account cash flows and the time value of money to evaluate projects. DCF is the present value of a project's future cash flows minus the cost of the project. This method can be confusing to understand with its present values of future sums and opportunity costs. Computations of discounts rates are involved.

The most common difficulty with DCF is choosing an appropriate discount rate and evaluating correctly all relevant investment alternatives.

Usually in using these approaches for analyzing the justification of investments separate proposals are considered on an individual basis. The individual projects may have to be approved at different levels within the organization depending on their individual total capital requirements. In each Enterprise Business Entity we are likely to find a specific capital funding limit within it because most companies budget capital by organization structure.

15.6 *Assessment of Benefits*

Benefits obtained from any project including enterprise integration can be readily characterized as tangible or intangible benefits. These are defined as follows:

Tangible Benefits

These benefits are known as hard benefits and usually consist of production volume, labor costs, and raw material costs benefits. They are always measurable and trackable by the cost accounting system so are easily visible. Table 15-I is a useful matrix diagram to highlight these areas of benefits.

Intangible Benefits

These benefits are known as soft benefits and are often ignored during justification because of the difficulty of assigning actual dollar values to them. This should not be the case. Today, accounting practices typically put a zero value on the intangible benefits. Since these numbers are based on projections into the future it is very difficult for quantification. Since many of these benefits are in the area of revenue enhancement they are unknowns with no past cost history. Examples of intangible benefits are quality, market share, customer satisfaction, etc.

15.7 *Evaluation of Individual Project Risks*

In this phase of the justification process the developmental, implementation, and operational risks that might result from new methods, policies, procedures, and additional system developments are assessed by the team. The important point here is to identify the most significant risk factors, and to develop a risk management plan that will increase the probability of success by focusing project management attention on the identified risk factors.

15.8 *Quality Assurance in the Justification Process*

The following points are vital in making sure that the results from the analysis described in this chapter are the best possible for the case at hand:

1. The team must have access to knowledgeable people concerning the project in question.
2. They must have a clear definition of each individual proposed project and how it fits into the whole Enterprise Integration Program Proposal.
3. There should be joint participation by the team members and personnel from the impacted area of the Enterprise Business Entity (related to Item 1 above).
4. The team must be sure to make a proper assessment of risk areas without bias (pro or con).

15.9 *Desired Results*

The projects proposed by the transition plan analysis of Chapter 12 will be evaluated in the work of this chapter. This is supplied to the team carrying out the work of Chapter 14 to prepare the final Enterprise Integration Implementation Proposal for inclusion in the Master Plan.

Figure 14-1 has shown the interrelationship between the work of Chapters 14, 15 and 17 in completing the work on the Master Plan.

Each of the tentative projects of the Enterprise Integration Program Proposal are labeled and their economic justification developed according to the following formula:

1. Highly desirable, feasible, projects - these will be cost estimated and scoped at about 25% accuracy in terms of expected costs and benefits.
2. Moderately desirable, preferred projects - these will be cost estimated and scoped at about 50% accuracy in terms of expected costs and benefits
3. The remaining projects will be scoped and estimated with minimal effort, within an order of magnitude in terms of expected costs and benefits.

The exact degree of accuracy required will depend upon established company policy for such work.

CHAPTER 15 – Analyze Costs Benefits and Risks

The results of the work of this chapter may well drastically revise the preliminary listing developed in the work of Chapter 14. Thus the iteration indicated on Figure 14-1. When agreement is achieved between the two chapters, the resulting Enterprise Integration Implementation Proposal including the details of the economic justification, are, after approval by the Steering Committee, transmitted to the individuals carrying out the work of Chapters 16 and 17 for inclusion in the Master Plan. Attachment 15-I summarizes the steps involved here.

TABLE 15-I
POTENTIAL ENTERPRISE INTEGRATION BENEFIT AREAS

Factors	Market Potential	Mgmt Strategy& Commit-	Research & Devel-opment	Product Definition	Product	Dist-rib-ution	Field Service	Financial Service
Product Improvements								
<u>Quality:</u>								
Value								
Consistency								
Reliability								
Maintainability and Support								
Customer acceptance								
<u>Flexibility:</u>								
New Product Introduction								
Existing Product Upgrade								
Adaptability to Special Req'mts								
<u>Introduction:</u>								
Existing Product								
<u>Upgrade:</u>								
Adaptability to Special Req'mts								
<u>Product Support:</u>								
Data Availability								
Spare Availability								
Training Availability								

TABLE 15-I (continued).

Factors	Market Potential	Mgmt Strategy & Commit-ment	Research & Developm ent	Product Definition	Product	Dist-rib-ution	Field Service	Financial Service
Product Cost Improvem'ts								
<u>Production optimization:</u> Resource Utilization Manufacturing Cycle Time Change Mgt Time Operational Flexibility <u>Labor Costs:</u> Hands-on Labor Process Yield Indirect Labor Product Definition Process Planning <u>Material Costs:</u> Acquisition Inventory Scrap and Rework Config. Control <u>Indirect Benefits:</u> Customer Satisfaction Management Visibility Strategic Planning Tactical Planning Personnel Satisfaction Training								
0 – Some Impact 00 - Significant Impact 000 - Major Impact								

15.10 *Management Considerations*

Overall Justification Risks

The following factors have been shown to be the major reasons why companies have had difficulties in their efforts to cost-justify computer integrated manufacturing:

1. **Reliance on Traditional Cost Accounting and Performance Measurement Techniques.** In particular the current popular method of focusing on direct labor and production efficiency measures, without the consideration of other major factors, often leads to the wrong conclusions and resulting decisions. People respond to whatever they are measured against. Unfortunately, many are measuring the wrong things.

2. **Bias Towards Incremental Investment and Short Term Results.** There is nothing short term about an Enterprise Integration. It is a long-term endeavor with up-front investments required to achieve long-term results. Enterprise Integration is sure to ultimately succeed because of its dedication to flexibility and its response to customer requirements. What industry must do is to ignore the financial critics and not focus on short-term profits at the expense of the company's long-term vision.

3. **Excessively High Hurdle Rates Not Tied to the Business Strategy.** It is difficult to quantify flexibility. Likewise the quantification of the ability to respond to a customer's whim is equivalently difficult. Thus hurdle rates tied to traditional discounted cash flow techniques may fall far short of tying investment decisions to modern day business realities.

4. **Failure to Quantify Important Enterprise Integration Benefits and Opportunity Returns and Costs.** The quotation, by Robert Kaplan of the Harvard Business School "Although intangible benefits may be difficult to quantify, there is no reason to value them at zero. Zero is no less arbitrary than any other numbers. Conservative accountants who assign zero values to intangible benefits prefer being precisely wrong to being vaguely right," has summed the situation here precisely.

5. **Inability to Simulate and Analyze Alternate Business Scenarios.** Managers like to play "what if" games when analyzing the alternatives in making major investment decisions. The present availability of simulation packages to model the enterprise integration process and to carry out such analyses makes this a natural desire. CAD packages are also available to readily revise proposed plant layouts, etc. Thus the enterprise integration manager must be prepared to redo his analysis repeatedly before approval is finally granted. Unfortunately, the very problems listed above all conspire to prevent the results from the simulations to be those desired by the enterprise integration manager.

Other Risks Involved
In addition to the dangers inherent to the cost, benefit, risk analysis results due to the direct business and technical reasons listed above there are other more generic overall impediments which need to be listed and avoided. Some of these are:

1. A management or team bias in the development of projects such as toward certain technologies or specific vendors. Even though not overt, such feelings can potentially greatly influence the results that are possible from the enterprise integration program proposal.
2. A lack of full understanding of the impact of the several technologies inherent in enterprise integration on physical systems, their related organizations, and their operational conduct. Thus the full potential of these technologies may not be realized when the Enterprise Integration Implementation Proposal is implemented by the company.
3. The tendency of management to short-change the allocation of resources and time to the execution of the projects involved thus imperiling the attainments of the potential possible. Even more important is the potential problem that such restriction of implementation needs will result in the projects being treated as individual, unrelated entities justified only on their own potential alone and with only short-term payouts allowed
4. Thus the final alignment of projects for the Enterprise Integration Program Proposal of the Master Plan may be fraught with errors either in their sequencing in the program or in their eventual impact on the Critical Success Factors of the Enterprise Business Entity.

Acknowledgments

Figures 15-5 and 15-6 are presented through the courtesy of Price Waterhouse Manufacturing.

Figure 15-7 is presented through the courtesy of the DuPont Company through IBM. Originally published in American Machinist, they are also reproduced in the Enterprise Integration Handbook, McGraw Hill, New York.

ATTACHMENT 15-I

SUMMARY OF PLANNING STEP 15
ANALYZE COSTS, BENEFITS AND RISKS

Define:

- Proposed Organizational Structure
- Job Descriptions and Functions
- Job Skill Requirements
- Risks and Obstacles
- Review of Established Extent of Automation

Resources:

- Previous Step Documentation
- Project Estimation Software
- Justification Methodologies

16. Final Critical Evaluation

At this stage in the preparation of the Master Plan it is important to "step back and review the effort to date" to assure that it is complete, accurate and reflective of the viewpoints of all concerned. Some particularly important points to review at this time are:

1. Are there any issues brought up in earlier chapters which have not been resolved or which require further work before finalizing the Master Plan?

2. Give a critical review of the whole document and in particular of each chapter in turn.

3. Assess the thoroughness, completeness, accuracy and believability of each point in turn.

4. Is the basic proposal covered by the Master Plan practical for implementation in this company? Is it implementable under present circumstances? If not, what additional work must be done to satisfy these two requirements?

5. Is there a broad based understanding and support of the proposed program within the Enterprise Business Entity and in upper company management.

16.1 *Desired Results*

In making the above review of the draft Master Plan at this time, the Enterprise Integration Planning Team should achieve the following results:

1. Identification of all issues requiring additional work or rework.

2. Development of a plan of action and a schedule and assignment of personnel to accomplish the needed tasks.

3. This may require a step process to secure the completion and acceptance in final form of each point to be corrected. Once the above has been accomplished to the satisfaction of the Enterprise Integration Planning Team they should proceed to:

4. Obtain a formal "Sign-Off" by the Steering Committee and the Initiating Sponsor of the work to-date in order to be able to complete the remainder of the required tasks.

The sketch of Figure 16-1 shows those items to be considered in making the program review discussed herein and the results to be expected here. Figure 16-2 shows the place of this work in the overall development process here. Attachment 16-I presents a set of critical evaluation points to be used in making the review of the developing Master Plan.

CHAPTER 16 – Final Critical Evaluation

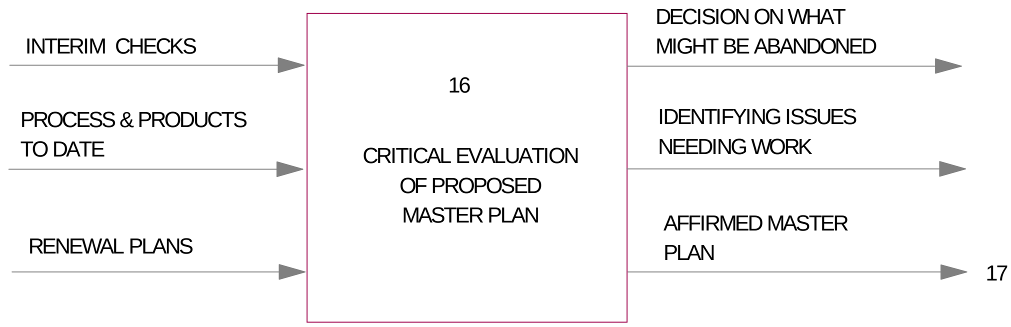


FIGURE 16-1 THE TRANSFORMATION TASK OF CHAPTER 16 – FINAL CRITICAL EVALUATION OF THE MASTER PLAN CONTENTS

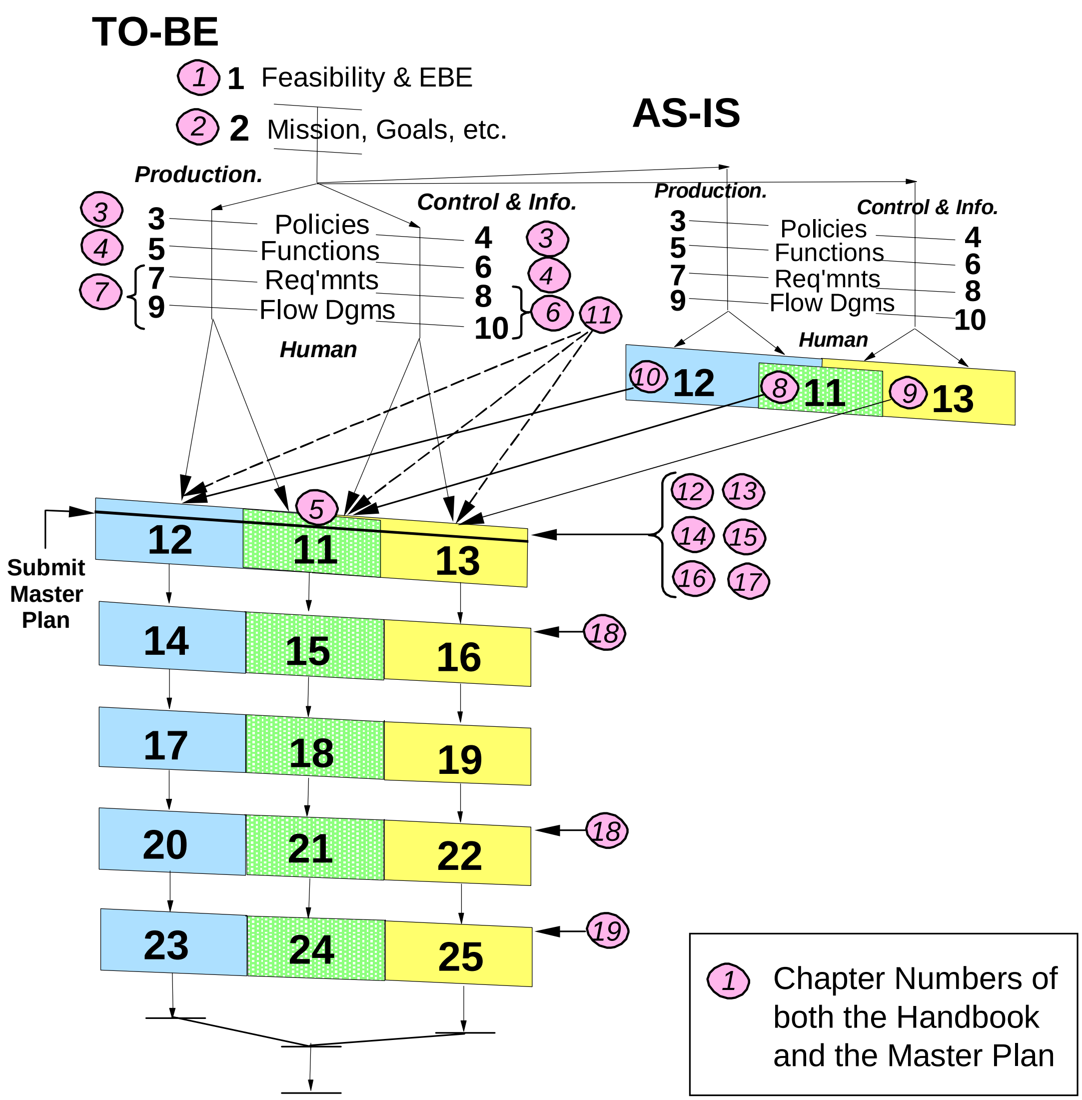


FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

16.2 *Mechanisms for Carrying Out the Required Review*

As noted above it is important that the work already included in the developing Master Plan get a thorough and unbiased review of all factors involved; technical, human relations, organizational, and business. This review must be done by a group separate from the Enterprise Integration Planning Team themselves since they are decidedly anything but unbiased at this point in time.

An ideal group to carry out the review would be the Steering Committee, since by definition they are the major stakeholders in the success of the final project and must give it their blessing. They also represent a level of management which must support the Plan and therefore must thoroughly understand it. In addition, this review would then be a test of the overall understandability of the work to date.

The Steering Committee should also be relatively unbiased at this point. They have probably not been intimately involved in the details of the work to date and therefore have no pride of authorship at this point.

Since the Enterprise Integration Planning Team was picked as the best qualified to carry out the Enterprise Integration Planning Task there is probably no other similar group in the company other than the Steering Committee to make the required appraisal. Anyone from the company, reviewing this group's work needs to be one whom the Enterprise Integration Planning Team respects. Those others of equivalent ability should have been among the candidates for the Enterprise Integration Planning Team itself. Thus there is concern about the objectivity and unbiased nature of these latter people.

Failing the assignment of the Steering Committee as the reviewing body, it would seem that the best second choice would be the hiring of a team of consultants from outside the company or at least outside the Enterprise Business Entity.

The hiring of an external group does raise the question of proprietary data of the Enterprise Business Entity since presumably nothing can be more proprietary then a company's future plans in the enterprise integration field. This question must therefore be of highest importance in the minds of those contemplating this review process.

16.3 *Caveats*

The charter of the reviewing team should be strictly limited. They should in no way attempt to redesign or rewrite the developing Master Plan. Their task should be to point out problems with the current drafts using the criteria given earlier. Their report on the plan should be written, should point out all areas which are inadequate, with specific recommendations for changes or additions. It should list all missing data, explanations, plans, etc., with specific justification for each item listed or changed. In case it is felt that certain sections are superfluous or should be eliminated for other reasons, such as political, these should be called to the attention of the Enterprise Integration Planning Team as part of the review.

The Enterprise Integration Planning Team should then respond to the Review Team giving their proposed response for each comment made. The resulting interaction should be continued until agreement is obtained or higher authority has settled any impasse.

Since the task of reviewing the Master Plan is a major undertaking it may be possible to break it up into sections, such as reviewing the Manufacturing Equipment parts (Chapters 6 and 9) the Information Systems part (Chapters 7 and 10) and the Human Relations part (Chapters 5, 8, 13, and 19) as separate but coordinated groups of chapters with different outside groups of experts reviewing each separate section.

This does help somewhat the proprietary information problem since no one outside group would have the full picture of the company's enterprise integration plans. This might also ease the task of an internal group such as the Steering Committee doing the overall review since they could be assured that a qualified technical group had already reviewed the technical details of the individual technical sections.

16.4 *A Final Note*

At this point management must demonstrate its understanding of and commitment to the proposed project. An assessment of the state of management's position will be an important part of the review process. Perhaps examples of the commitment evident up to this point in time could be provided as part of the assessment.

Any unwillingness of management to listen to, support and act on the recommendations of the Master Plan can lead to costs and risks to the program which become rapidly much greater from this point on in the program. Costs of hardware, software and the associated implementation are obvious and can begin to accumulate from this point on.

Costs for human resources are not so obvious but can also accumulate. Besides the direct costs, there are the costs associated with personnel "reading" management's position with the resulting morale and performance losses.

16.5 *Summary*

As before, Attachment 16-I summarizes this chapter and its work for the team.

ATTACHMENT 16-I

A CRITICAL EVALUATION CHECKLIST

1. The review should include ALL outputs (products) from each chapter.
2. The review should include a review of the process used for each chapter.
3. Is there confidence in the long term viability of the Enterprise Business Entity?
4. Does the proposed Master Plan and its associated recommendations support the goals, objectives and critical success factors of the Enterprise Business Entity and the Business Unit?
5. Are the recommendations consistent? Have "Authorship" and "group-think" biases been removed from the proposal?
6. Does the proposal have the consensus of the Steering Committee and the Initiating Sponsor?
   a. Is it really "do-able"?
   b. Is the technology available? Software, hardware, integrators
   c. Are the financial and human resources available/accessible to execute the proposal?
   d. Does any part of the recommendation challenge a "Sacred Cow," something which management and/or the organization is unwilling to change?
7. Are the human resources plans consistent with the documented organizational resistance to the proposed plan and the required changes?
   a. Does the proposal require organizational changes? If so, are the plans in place and are the resources available to make the change in concert with the execution of the proposal?
   b. How are the roles of managers and supervisors going to change? Are the new roles clearly defined, are people available, is training and development available? Are there new positions or options available for any displaced positions?
   c. How are the roles of operators, maintenance, and support personnel going to change: Are the training plans in place? Are there new positions or options available for any displaced positions?
8. Are the early projects "positioned for success?" Are there significant obstacles that will be difficult to manage or overcome? Are there subsequent projects that hold the key to significant benefits of the earlier projects?

ATTACHMENT 16-II

SUMMARY OF PLANNING STEP 16
FINAL CRITICAL EVALUATION(S)

Formulate and Select Decisions to:

- Terminate Projects (Desk Kill)
- Identify Issues Requiring Further Work
- Affirm Master Plan

Resources:

- Previous Step Documentation
- Renewal Plans
- Interim Checks and Reports

17. Author Master Plan

17.1 *Introduction*

At this point in time the work on planning, information collection, recommended project list preparation, etc., has been completed and most back-up text has been prepared. The final major activities of the Enterprise Integration Planning Team are then those of authoring/publishing the Master Plan and presenting it for implementation to management and other decision making bodies. This chapter describes the work of preparation of the completed Master Plan and the associated management presentation documents.

Data Readiness Check

Usually, the materials described in the earlier chapters have not all been prepared by the same individuals. The first task is to collect all the authors, their representatives, and their product reports or information together in order to judge the overall completeness of the work and to arrange for the rapid development of any missing information, documents, plans, etc.

When the Enterprise Integration Planning Team believes the data collection and preparation tasks and initial recommendations for action are complete, it is essential to review them with the Steering Committee before final text preparation begins. The Steering Committee will be of major help in determining how to present the Master Plan materials to higher management in terms of media style, salability of concepts and proposals, and the current climate for acceptance of the concepts and proposals.

Master Plan Structure/Format

The Master Plan will probably be prepared and presented in several different forms. These will usually include the following:

1a. A Management Summary of only a few pages presenting the minimal highlights of the study and of its recommendations. Use graphics to deliver condensed images of ideas and goals.

1b. The Enterprise Integration Implementation Proposal outlining the prioritized list of high-priority projects describing the scope, costs, justification, proposed schedule, and benefits of each. This should probably be included in the same document as the Management Summary above.

2. A series of management presentation scenarios aimed at gaining acceptance of the Enterprise Integration Implementation Proposal. These will vary in detail and length (i.e., time allowed for presentation) dependent upon the level of management involved. These may involve video, slides, computer-based displays, and presentation folders of several degrees of sophistication. Pay strict attention to the use of possibly different documentation/presentation standards required or preferred by each organization contacted.

3. The Master Plan itself. Again it may include material in several different forms dependent upon the audience to be addressed, e.g.:

    a. A management summary in more detail than that mentioned above in Item 1a, but still less than 20 pages but preferably under 10.

    b. The Master Plan itself with full descriptions of; all projects in the Enterprise Integration Program Proposal, the AS-IS and TO-BE information for all three architectural areas, the transition plan, the major findings in all investigative areas, summaries of all benefits, costs, etc. In short a full description of the enterprise integration planning effort and its results, but omitting much of the fine detail developed in the TO-BE; cost, benefits, and risks; initiatives and opportunities; and the feasible solutions chapters.

    c. A series of separate reports documenting the necessary detail resulting from the findings under the chapter headings listed just above.

A major early critical decision to be made, again with Steering Committee input, is to determine who will actually write and edit the documents listed above. For something as important to the company as the Master Plan for further enterprise integration implementation, many companies employ professional technical writers. They prepare presentation materials, with the input from the actual Enterprise Integration Planning Team.

17.2 *Steps in Producing the Master Plan*

Regardless of who actually puts the words on paper there are several steps that should be carried out to establish the continuity, quality and acceptance of the Master Plan. The initial steps are listed below:

1. Review, reaffirm and verify that the original directives of the Steering Committee were used as the focal points of the study and the development of the Master Plan and its associated documents.

2. The work of the study may have discovered or developed new concepts which require the establishment of new directives or modification of the original ones. The Steering Committee must obtain or provide the new or amended directives for inclusion in the plan.

3. The importance of these directives is such that they must be included (perhaps in abbreviated form) in the Executive Summary or Introduction of the Master Plan.

4. The work called for in several of the chapters of this guide has probably developed considerable data concerning requirements and functional information on the TO-BE and AS-IS manufacturing equipment; information system; and human resources. It will also include organizational functional architectures. The policies in each of these areas; as well as the above mentioned and other data are vital to the future enterprise integration system and thus to the Master Plan. Gather and validate this information and package it in a form convenient for incorporation into the proper location in the Master Plan and/or its related documentation.

5. Conduct informal meetings of all contributors to the Master Plan including those carrying out the editorial function to assure continuity of flow between the various chapters and sections. These meetings are important to get agreement of all on the wordings of the conclusions and recommendations sections, to resolve any semantic differences and to effect a resolution of any differences of opinions between team members.

6. Test the findings and recommendations of the proposed Master Plan against all manpower availability, capital investment allowances, and practical rate of implementation constraints. Correct all such excesses or secure the necessary permission for deviation.

7. Establish a schedule for the preparation of the Master Plan and all associated documents including review periods and approval requirements.

8. Identify the professional resources required to produce the actual copy for the Master Plan documentation and presentation material. Assure that the latest computer-based editing and composition techniques are available. Sophisticated, up-to-date, computer-based, editorial methods should not be abandoned because of local unavailability. Use of combined text and graphics particularly in the executive summaries should be encouraged. Test the presentation techniques readily available against others to be sure the most impressive presentation possible is considered.

9. Whenever possible a critical editorial evaluation should be made by qualified, unbiased individuals outside the current Enterprise Integration Planning Team, its Steering Committee or Enterprise Business Entity operating and management personnel. They should check for editorial and style consistency and ready readability and comprehension of the material presented. If possible the ability of the document in its proposed final form to impress the reader should also be evaluated. All such review results should be well heeded.

Figure 17-1 is another way of illustrating the above steps and Attachment 17-I further summarizes them.

Figure 17-2 shows their place in the overall Master Planning process.

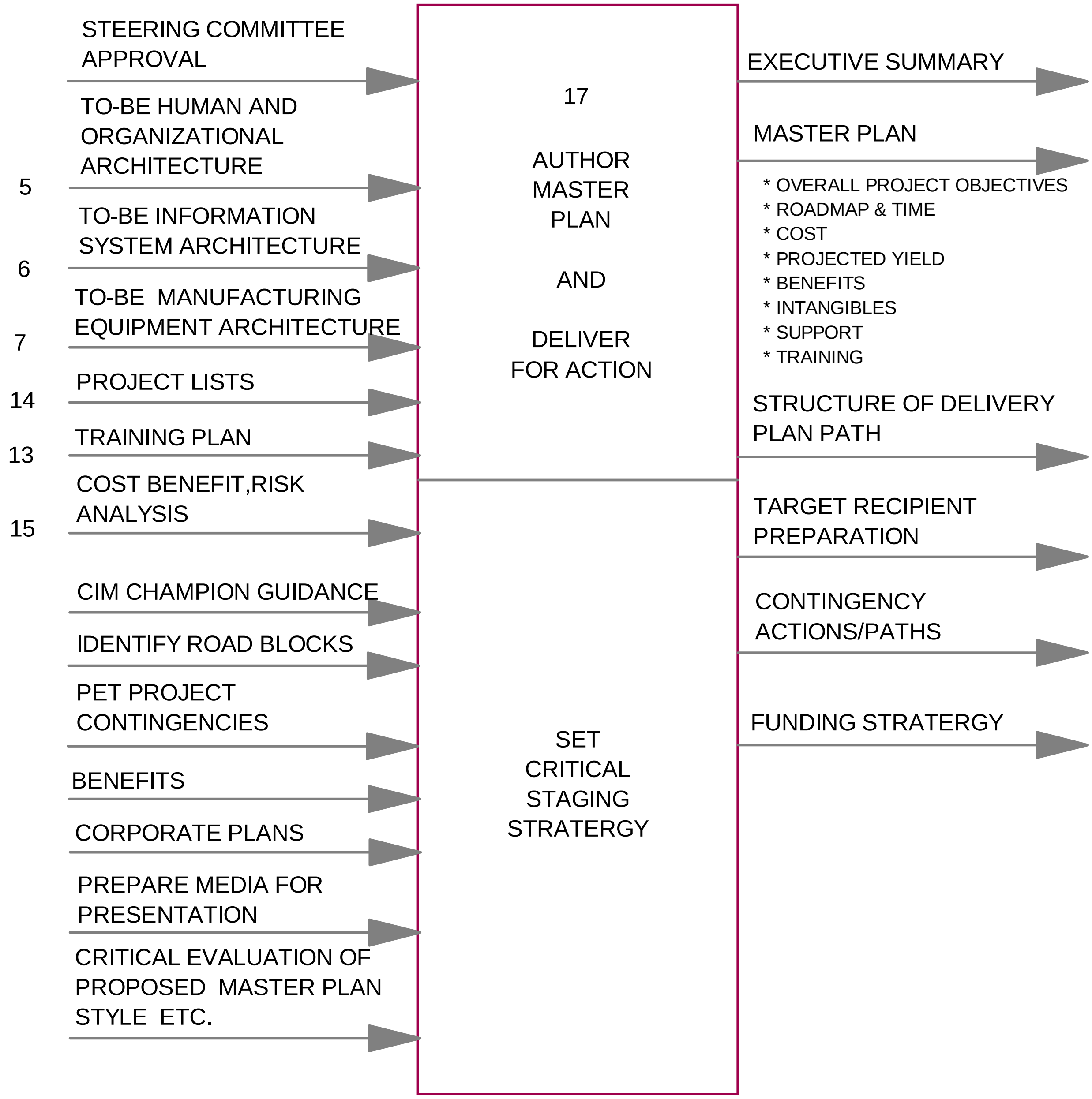


FIGURE 17-1 THE TRANSFORMATION TASK OF CHAPTER 17 – AUTHOR MASTER PLAN AND DELIVER FOR ACTION

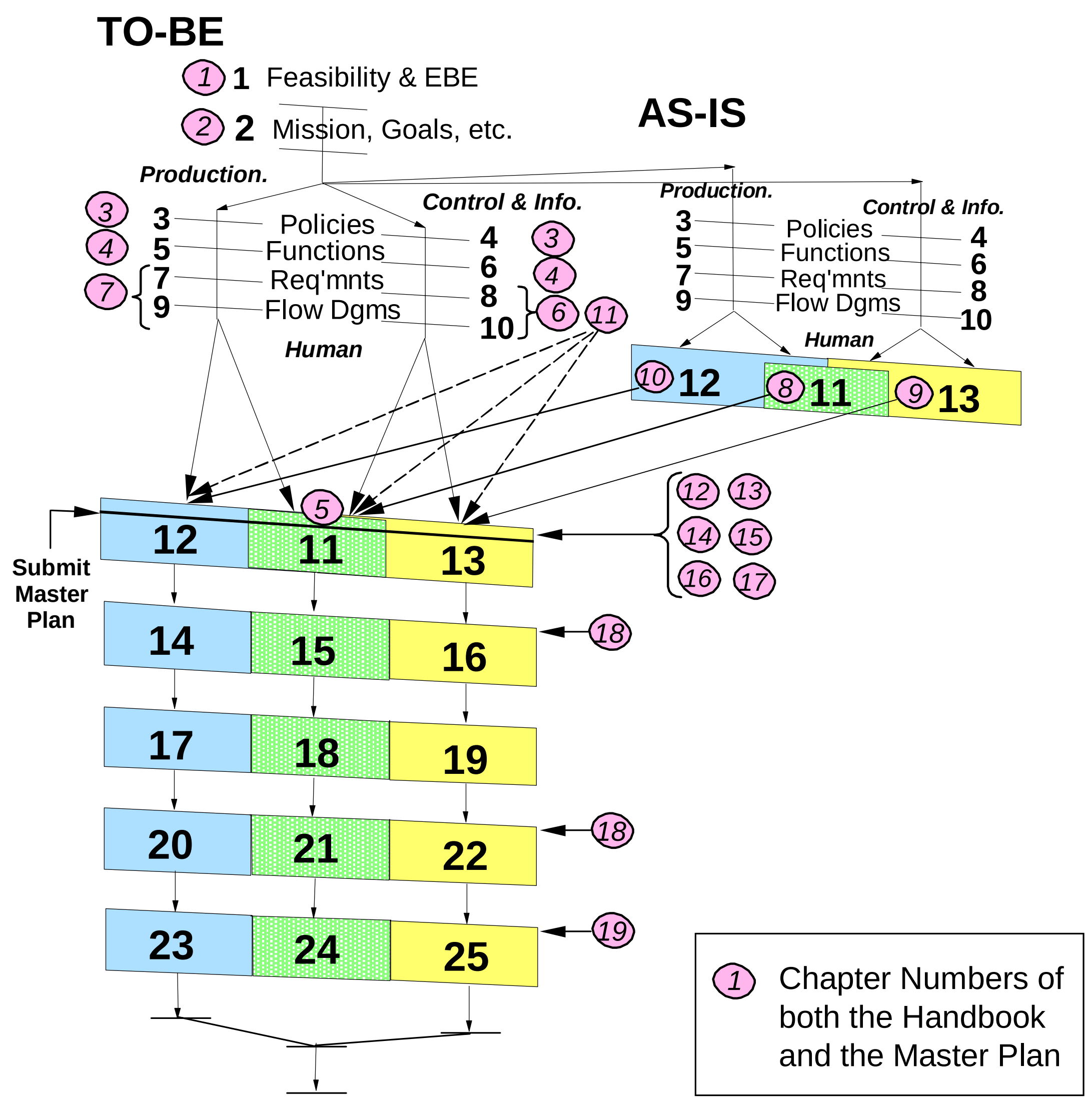


FIGURE 24 REALTIONSHIP OF CHAPTERS OF THE HANDBOOK ON MASTER PLANNING TO THE PURDUE ENTERPRISE REFERENCE ARCHITECTURE

ATTACHMENT 17-I

SUMMARY OF PLANNING STEP 17
DOCUMENT MASTER PLAN

Contents:

- Executive Summary
- Master Plan
- Overall Enterprise Integration Objectives
- Lists of Projects and Their Rationale
- Schedule
- Cost
- Project Returns
- Benefits
- Intangibles
- Support Training
- Structured Delivery Plan
- Target Recipient Preparation
- Contingency Plans/Actions
- Funding Strategy

18. Master Plan Renewal Process

18.1 *Introduction*

As has been mentioned many times in this Manual, all industrial plants are subject to continual change due to the following factors among others:

1. New technology or new applications of existing technology.
2. New enterprise integration business strategies and plans evolved by the Enterprise Business Entity.
3. New business strategies and plans developed by the business enterprise of which the Enterprise Business Entity is a part, caused by:
    a. Successful new competing sources of customers' desired products or new competitive products.
    b. Major new environmental or safety rules.
    c. Down scaling
4. Progress in completion, with coincident success, of projects from the current Enterprise Integration Master Plan.
5. Corresponding failures in the completion of these projects or inadequacies or outright failures of the results obtained as compared with earlier expectations.

As a result, the current Master Plan will eventually (rapidly or more slowly as the case may be) become obsolete. Thus it is important that a procedure be in place as part of the original plan to review and refresh the Enterprise Integration Master Plan and keep it "ever green."

This review process should be triggered by two separate mechanisms in order to assure that the above desired review and refreshing actually occurs whenever needed. These are:

1. A periodic basis or as part of a regularly planned event like the yearly business planning cycle or,

2. Whenever significant business changes such as, changes in product demand, financial environment, loss of business due to cost and/or quality, etc., occurs.

It should be noted that Scenario 2 above will require a major revision to the Master Plan and, as such, will essentially send the process back to Section 2 for a thorough re-analysis and rewrite of the current plan, i.e., probably, a new Master Plan.

The purpose of this chapter is to handle the case of Scenario 1. This covers a review of the Master Plan, a check of progress and problems that occurred during past years, and a determination of the next phase of projects. This effort should be linked to the business planning cycle so that these projects are budgeted and so that management is factoring the expected results into the near term goals, expectations and performance forecasts. Figure 18-1 shows that this involves a new project after plant obsolescence threatens.

18.2 *The Current Environment*

Assuming that no major occurrences requiring a whole new master planning effort are involved as noted above, the review effort will probably have been initiated by the annual business planning cycle of the Enterprise Business Entity or higher business enterprise unit. Several other major factors affecting the review may also have taken place during the preceding period. Each of these vitally influence the review procedure and its execution. Some examples of these are:

1) The original Enterprise Integration Planning Team was probably disbanded at the conclusion of the original study.
2) The Enterprise Integration Champion has probably also been reassigned to other work.
3) Some of the projects prioritized in the original plan have been initiated or even completed.
4) For the completed projects, an audit of the economic and technological results achieved versus those predicted by the Master Plan may be available.
5) Minor, but still important, changes have occurred in the business of the Enterprise Business Entity:
   a) Business plans, strategies and objectives
   b) Available enterprise integration and manufacturing technology and equipment
   c) Customer requirements (quantities and quality)
   d) Competitive factors (competing prices, other competing products)
   e) New, minor but still important, environmental or safety requirements
   f) Downscaling.
   g) Etc.

Hopefully the Enterprise Integration Steering Committee, the so-called "stakeholders" in the Enterprise Business Entity itself, is still in existence and can provide the source for initiation and pursuit of the needed work. Succession planning for the individuals holding this position is vital if the impetus of the Enterprise Business Entity Implementation Program is to be maintained.

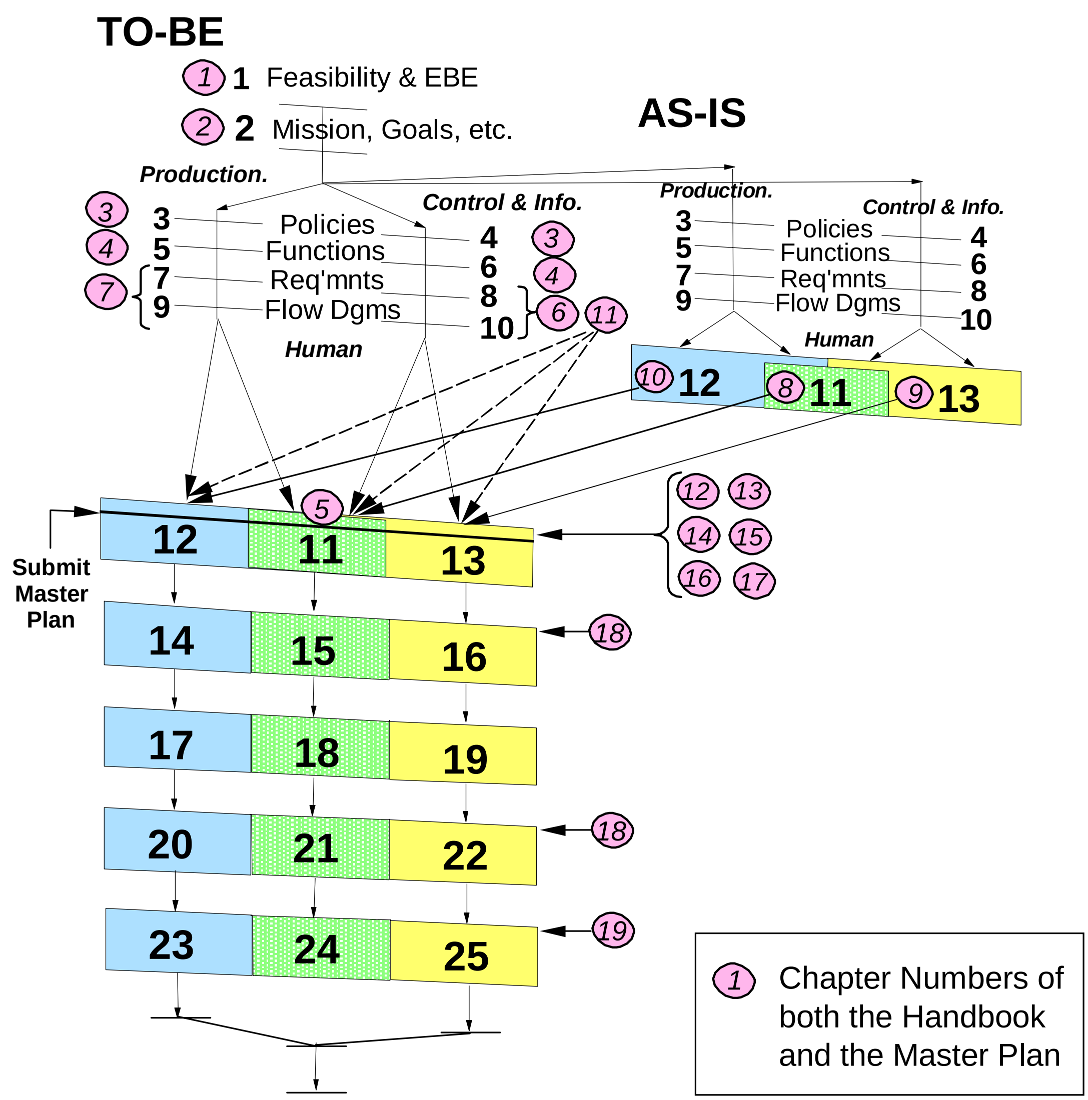


FIGURE 18-1 THE WORK OF CHAPTER 18 CARRIES OUT THE MASTER PLAN RENEWAL PROCESS AS SHOWN IN PERA

18.3 *Initiation of the Review Process*

Depending upon the degree of change occurring in each of the factors just enumerated, the Steering Committee must take the following steps to initiate the review needed:

1. Assess the degree of change just noted and estimate the degree of review of the current Master Plan this will necessitate.
2. Review the progress and successes or failures of the original plan to determine the accuracy of its proposed schedule and predicted benefits.
3. Based on Items 1 and 2 above estimate the effort to be assigned to the review process.
4. Resurrect the remnants of the original Enterprise Integration Planning Team who are still available for the task or recruit sufficient suitable replacements.
5. Monitor the progress of the planning review effort and lend guidance and support as necessary to the team to assure that it completes its work as assigned, included here are:
   a) Reviews of any new proposed business plans or objectives
   b) Review of draft Enterprise Integration Master Plan revisions
   c) Final approval of the revised Master Plan.
6. Maintain top management commitment to the enterprise integration project program for the Enterprise Business Entity as confirmed and/or modified by this on-going study.

18.4 *Planning Team and Its Work*

Even though this is admittedly a review and updating process only, the work will require the same ability and backgrounds from the review Enterprise Integration Planning Team as were required of the original Enterprise Integration Planning Team itself. They must possess the same skills, both technical, and human relations or political as before.

The product of their work must receive the same support and guidance during its preparation and as much acceptance and impetus to its implementation drive as earlier.

Before undertaking the new work, the new Enterprise Integration Planning Team should assure themselves of the following:

1. In-depth knowledge of the current Enterprise Integration Master Plan
2. The content of the Guide to Master Planning and Implementation and how it was used to develop the original Master Plan. Sections 1 and 2 here are as important as Section 3.
3. Knowledge of the critical success factors of the Business Enterprise and how they might have changed since the completion of the original Master Plan.
4. Likewise for the business strategies, goals and objectives of the Enterprise Integration Business Entities.
5. Be assured particularly that any new members of the team are adequately trained and briefed for the task.
6. Helpful also is a thorough review of the executive summary of the previous plan and of the so-called "selling tools" of Chapter 17. An analysis of the relative success of the latter would be important background information at this juncture.

18.5 *Carrying Out the Review*

It is likely that the review process will comprise several phases that can be described as discussed below:

Establish Extent and Timing

The Enterprise Integration Planning Review Team should establish with the Steering Committee the following points concerning the renewal or review effort:

1. Scope, schedule required, and resource requirements.
2. Mutual understanding of extent and depth of the study and approval of any team plans.
3. Promises of help in securing needed personnel help, access to personnel and information and needed budget.
4. Extent and frequency of request for progress reviews.

Review of Business Plans and Objectives

Review any new business plans and objectives that have appeared since the last review or since the initial preparation of the Master Plan. Contrast these with the ones included in the most recent Master Plan version. Be clear as to the extent and effects of the changes.

Review of Progress and Setbacks

Some suggestions for carrying out this phase of the current review are given below:

1. Review all three areas of the original endeavor (Human and Organizational, Manufacturing Equipment and Information Systems).
2. Assess and evaluate progress and benefits (or the lack of either) achieved to date in the Enterprise Business Entity's Enterprise Integration Project Program.
3. Interview the Project Manager of the original Enterprise Integration Planning Team. The Project Manager represents a unique viewpoint of the intent, plans and progress of the program and obviously has a deep personal interest in its ongoing well being.
4. Look for signs of different rates of progress in the implementation of the several different projects of the Enterprise Integration Project Program. Assess the reasons for such differences and their required remedy if necessary.
5. Where little or no progress has been made probe deeply and thoroughly but discretely for the reasons why. Ascertain from the Steering Committee members their willingness and ability to press for the needed progress.
6. Evaluate current technology and its impact on the proposed continuing implementation.
7. Several cycles of the TO-BE vs. AS-IS status of the plant may be required to complete the renewal process. The AS-IS should change from year to year as a result of implementation. It should be updated and checked for consistency of purpose. A look at the lower priority projects of Chapter 14 of the original Master Plan is an excellent source of ideas for the next set of projects to be recommended.

Final Approval of Revised Plan

The work required here will be much like that outlined in Chapter 17, i.e., to be sure that marketing and the resulting support of the program is broad based. Also be sure the Steering Committee is committed to support of the funding and execution of the program.

18.6 *Caveats*

The following are important concerns that the team should have in carrying out and documenting the review (renewal) study:

1. Beware of "party line," "pet project" and "me too" tendencies.
2. Note that "traditional" managers may oppose rather than lead change while appearing to give support.
3. Don't make changes for change's sake. Justification of expenditures is still very important.
4. In the early years of implementing a specific Enterprise Business Entity Master Plan, check on how the human relations acceptance is developing. Make changes to the plan as required to achieve the needed acceptance.
5. Be sure that the Master Plan review, Steering Committee plans and the business planning cycle are linked.
6. Management must demonstrate a genuine commitment to the new business strategies and objectives as well as having an understanding and commitment to the current Enterprise Integration Master Plan. Deviations from either must be seen with concern and effectively worked through and resolved.
7. The team must be sensitive to the credibility of original estimates of costs, benefits, etc., as compared to actual results, missed expectations, etc. Discrepancies must be addressed or else the whole future program is at risk.
8. Team members must be aware that participation in a large and important project such as this can enhance or endanger their career. If the planning team does not work well together, they need to be changed. Likewise for project implementation teams. Steering Committee and Project Planning Teams should be "overstaffed" so that many people can become key members and these groups can be readily refreshed. It would be an important step to plan for a scheduled turnover of both "permanent" and "long" term groups.

18.7 *Documentation*

Table 18-I presents a list of points for the team to keep in mind in presenting their report to the Steering Committee and upper management to assure easier buy-in of the recommendations contained therein.

TABLE 18-I

SOME IMPORTANT CONSIDERATIONS IN DOCUMENTATION OF THE RENEWED MASTER PLAN

1. Is there continued confidence in the long term viability of the Enterprise Business Entity? Is the effort worthwhile?
2. Do the refreshed Enterprise Integration Master Plan and associated recommendations support the goals, objectives, and critical success factors of the Enterprise Business Entity and the business unit?
3. Is the proposal time frame and project sequence logical, realistic, practical, workable, and fundable?
4. Does this renewal reflect the progress and rate of progress of the earlier plans? Is it sufficiently challenging?
5. Estimate project(s) duration - If any project's duration is much beyond one year, consider restructuring it into smaller projects whose scope can be accomplished in six to twelve months.
6. Go back into the "significant opportunities" portion of past effort(s) and mine these to assure a complete and up-to-date proposal.

19. Plan Continuing Education and Training

19.1 *Introduction*

The personnel, who work with the enterprise integration system will change over time because of promotions, retirements, new hires, etc. Therefore, it is imperative that those responsible for the planning, operation, and maintenance of the system be as well trained and capable as those who were present at its initiation. It is also important that these personnel be continually upgraded in their skill set to make them eligible for promotion and higher-level technical work with the system as opportunities for such work become available. Thus, there must be plans and actions in place to carry out the continuing education and training necessary to accomplish the above. Naturally the plans for this training will depend heavily on those developed for the initial crew. However, there will be differences as noted below.

Figure 19-1 presents a diagram outlining the situation described here and the inputs influencing it. Figure 19-2 shows its place as part of the renewal project.

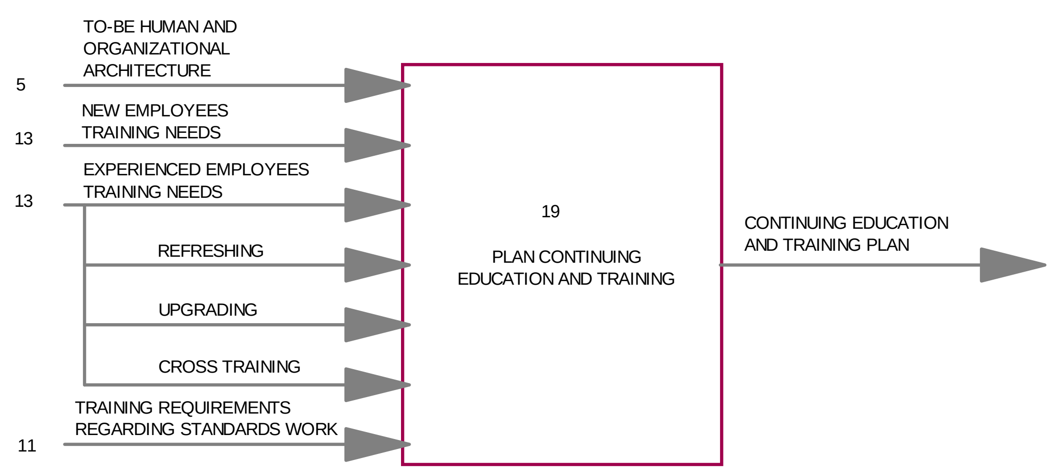


FIGURE 19-1 THE TRANSFORMATION TASK OF CHAPTER 19 – PLAN CONTINUING EDUCATION AND TRAINING

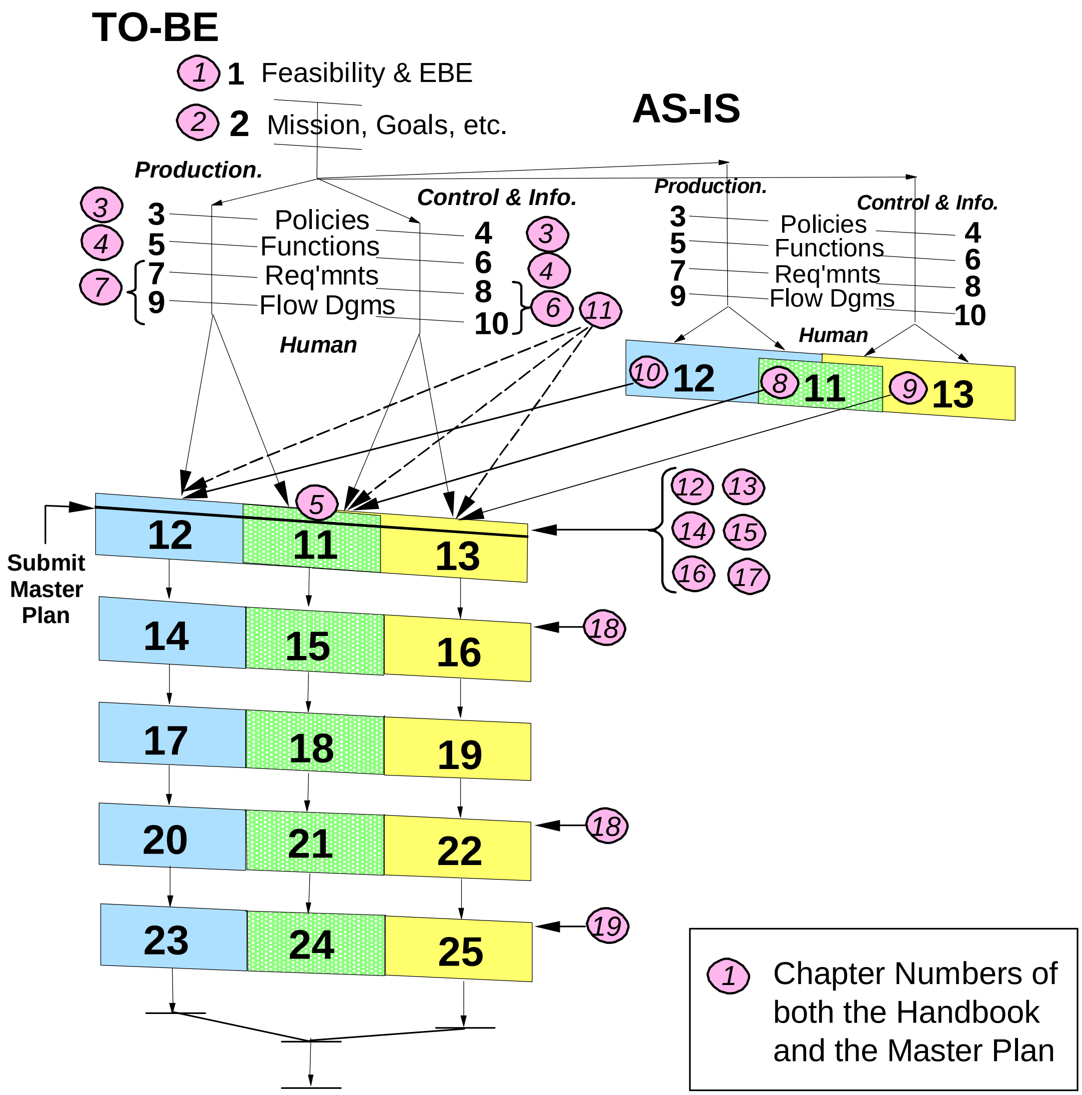


FIGURE 19-2 THE WORK OF CHAPTER 19 EXTENDS CONTINUING EDUCATION AND TRAINGING PROGRAM AS SHOWN BY PERA

19.2 *Training Requirements*

New Hires and Transferred Employees

The audit developed for identifying the needs of the original staff of the system will form the background against which the training needs of new or reassigned employees must be judged. They must be brought up to the skill and educational level (in terms of needed familiarity and operational skills with the equipment) as the current staff so that there is no diminution of system performance as personnel change. This can be accomplished by formal classroom studies, by using parts of the equipment as a simulation to gain experience in plant and control system troubleshooting, or by training on the job. The major requirements here are as follows:

1. The training needs to be thorough to assure that the new worker is totally familiar with the equipment and what is expected of him.
2. Regular short courses at the vendor's school can be particularly helpful on equipment details, operational practices, troubleshooting, and maintenance.
3. Simulator training, if applicable, is particularly valuable because of Its "presentation of 'emergencies' in a realistic atmosphere."
4. On the job training is the least satisfactory of the three listed above since situations requiring skill-developing actions may be few and far between.
5. Orientation to the company, the plant and the job in terms of training on:
6. Company policies
7. Safety requirements and practices
8. Material safety data sheets (MSDS)
9. Environmental regulatory requirements

In all cases, it must be assured that instructors are themselves fully knowledgeable on the system and are themselves skilled teachers.

Experienced Personnel

It has been shown that the efficiency of a technical facility increases with the level of technical training (beyond specific knowledge of the system) of those operating the system. This is due to an individual having better knowledge of "how" and "why" the system operates as it does and a lack of "fear of the unknown."

In addition, this familiarity increases their morale and gives them a better attitude overall in their relations to the system, the plant and the company. Further, increased knowledge increases eligibility for future promotion as opportunities permit, again further increasing morale and job satisfaction.

Such continuing education and training covers these two aspects:

1. Upgrading of skills concerning the enterprise integration system and the plant, in terms of specific studies on details of the system and its operation and of the processes and equipment of the plant.
2. General technical education, on electronics, computer operation and programming, industrial technology, maintenance practices, etc.

Just as with the new hires, this training can include each of the methods listed earlier with emphasis on participation in vendor training sessions and on simulator experiences.

The general education noted as Item 2 just above can come from a wide variety of sources:

1. General technology sessions on electronics, process control, industrial engineering, process control equipment and maintenance, etc., given by vendor companies.
2. Similar short courses presented by the technical societies such as the Instrumentation, Systems, and Automation Society, American Institute of Chemical Engineers, TAPPI, etc.
3. Similar short courses presented by universities, technical schools, etc.
4. Part-time or night school given by technical institutes.
5. For those with bachelors degrees, night school or release time graduate programs of nearby colleges and universities.
6. Where economics favors such action, in-house courses on particularly important topics presented by properly qualified company members or consultant instructors.

Refresher Training

On-shift personnel are responsible for responding to plant emergencies and to diagnosing the causes of plant and control systems outages and their remedies. As plant and control system equipment becomes more reliable, the time period between such emergencies becomes longer with a resultant drop in the skills of on-shift personnel to respond correctly and/or correctly diagnose its cause.

Thus it is important that steps be taken to assure the required skill level of on-shift personnel. Simulation of plant emergencies through use of part of the on-site equipment is one of the best methods of carrying out such training, since it can produce realistic mock emergencies, on familiar equipment, for maximum benefit to the trainee. If the on-site equipment is not capable of use as a simulator, most vendors have demonstration equipment of the same or similar types on which they can conduct training courses for emergency response. The company should take advantage of such opportunities if needed.

19.3 *Responsibility for Training*

Responsibility for analyzing the need for training, for developing the required courses and for supervising their preparation and presentation is usually the purview of a company training department. However, the unit supervisor or the work group involved should take it upon themselves to determine the effectiveness of their employees in regard to the presence or lack of sufficient training for the task at hand. They should inform the training department of their needs and assure that the necessary training is made available.

The training department should develop a plan for assuring that all new employees are properly indoctrinated and receive the necessary instructions and training to carry out their assigned task. There should also be a plan in place to supply the upgrading and refresher training noted above.

Such a plan should be part of the continual improvement program of the company.

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