INDUSTRIAL PROJECT MANAGEMENT
Concepts, Tools, and Techniques
Industrial Innovation Series
Adedeji B. Badiru
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Dedication

Dedicated to the memory of Omolade Badiru
The bud that never got to bloom, but whose spirit lives on
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Preface

Industry represents the pulse of economic development of any nation. Successful industrial project management thus holds a key position in advancing regional and national development. Project management is the process of managing, allocating, and timing resources to achieve a given goal in an efficient and expeditious manner. The objectives that constitute the specified goal may be in terms of time, costs, or technical results. Projects can range from the very simple to the very complex. Owing to its expanding utility and relevance, project management has emerged as a separate body of knowledge that is embraced by various disciplines ranging from engineering and business to social services. Project management techniques are widely used in many endeavors, including construction management, banking, manufacturing, engineering management, marketing, health care delivery systems, transportation, research and development, defense, and public services. The application of project management is particularly of high value in industrial enterprises. In today’s fast-changing and highly competitive global market, every industrial enterprise is constantly striving to get ahead. Integrative project management offers one avenue to achieve that goal.

Project management represents an excellent basis for integrating various management techniques such as statistics, operations research, Six Sigma, computer simulation, and so on. The purpose of this book is to present an integrated approach to project management for industrial applications. The integrated approach covers the concepts, tools, and techniques (both new and tested) of project management. The elements of the project management body of knowledge provide a unifying platform for the topics covered in the book. The book also contains a project-oriented chapter on Lean Six Sigma. The chapters of the book are

- **Chapter 1**: Characteristics of Industrial Projects
- **Chapter 2**: Principles of Project Management
- **Chapter 3**: Time and Schedule Management
- **Chapter 4**: Project Duration Diagnostics
- **Chapter 5**: Schedule Compression Techniques
- **Chapter 6**: Resource Analysis and Management
- **Chapter 7**: Techniques for Project Forecasting
- **Chapter 8**: Six Sigma and Lean Project Management
- **Chapter 9**: Project Risk Analysis
- **Chapter 10**: Project Economic Analysis
- **Chapter 11**: Industrial Project Management Case Studies

Appendix A of the book presents project terms and definitions, and Appendix B presents project acronyms. The premise of the book is that both simple and complex industrial projects can be managed better if an integrated approach is utilized. The integrated approach in the book covers managerial principles and analytical techniques. The book presents tools and techniques for mitigating the adverse effects of the typical constraints of time, cost, and performance in any project.
This book is intended to serve as a reference for project planners, designers, and managers; as a guidebook for industrial consultants; as a textbook resource for students and teachers; as a supplementary reading for practicing engineers; and as a handbook for project operators. It will appeal a great deal to practitioners and consultants because of its practical orientation.

Adedeji Badiru
Abi Badiru
Ade Badiru
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**Abi Badiru:** I extend my thanks to my extended circle of friends from different parts of the world. I extend appreciation to my present and former colleagues from Kraft Foods and ConAgra Foods.

**Ade Badiru:** Many thanks and love to my wife, Deanna Badiru, whose continual love and support inspire me in all my professional endeavors.
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1 Characteristics of Industrial Projects

Importance of Industrial Projects

Industry represents the pulse of economic development of any nation. The goods and services provided by industry directly influence the social, political, economic, and cultural structures of any population. Thus, successful industrial project management holds a key position in advancing local, regional, and national development. A community that cannot institute and sustain industrial vitality will eventually become politically delinquent and economically retarded. Project management is the process of managing, allocating, and timing resources to achieve a given goal in an efficient and expeditious manner. The intrinsic benefits of this definition are even more pronounced in fast-paced and globally influenced industrial projects.

Time–Cost–Result Goals of Industry

The objectives that constitute industrial project goals may be in terms of time, costs, or technical results. Projects can range from the very simple to the very complex. Owing to its expanding utility and relevance, project management has emerged as a separate body of knowledge that is embraced by various disciplines ranging from engineering and business to social services. Project management techniques are widely used in many endeavors, including construction management, banking, manufacturing, engineering management, marketing, health care delivery systems, transportation, research and development, defense, and public services. The application of project management is particularly of high value in industrial enterprises. In today’s fast-changing and highly competitive global market, every industrial enterprise is constantly striving to get ahead. Integrative project management offers one avenue to achieve that goal.

Lasting Legacy of Project Management

Project management has had more direct impacts on human development than any other single discipline of study in the history of the world. From the time of ancient history and Mesopotamia’s early development to the modern times, acts of project management have brought to bear on human accomplishments. Early examples include the construction of Stonehenge in England, the erection of the Pyramids, and the development of the notable Wonders of the World. The ancient projects using gears and pulleys required extreme preparation, labor coordination, and cooperation. Although there was no formal discipline of project management in those ancient times, the processes of planning, organizing, scheduling, and control, no doubt, were...
used in accomplishing those feats. In spite of its long-standing benefits, it was only in the past few years that project management has emerged as a formal discipline; and it is now being globally recognized. The Project Management Institute has an envisioned goal that states, “Worldwide, organizations will embrace, value, and utilize project management and attribute their success to it.” This vision is already being broadly realized. This is evidenced by the rapid growth in project management professional memberships around the world. Interest in the discipline is growing rapidly around the world—in Europe, Asia, North America, South America, the Far East, the Caribbean, Africa, and so on. There is no single country that can claim not to be touched daily by the impact of project management processes.

**Elements of Industrial Operations**

Industrial development is one primary path to achieving national economic development. So, industry is very vital to the development of any nation. Historical accounts abound on how the industrial revolution had a profound effect on world development. A sustainable industrial development can positively impact the political, economic, cultural, and social balance in a community. In order to achieve and sustain industrial development, both the technical and managerial aspects of industrial projects must come into play. This book focuses on the integration of managerial approaches and analytical techniques to improve the planning, scheduling, and execution of industrial projects.

The primary goal of any industry is to plan operations ahead and allocate resources appropriately to improve industrial project efficiency, effectiveness, and productivity while reducing production waste (Lean) and improving product quality (Six Sigma). Using a formal project management approach makes it possible to achieve this goal. For projects to be effectively managed in an industrial system, managers and analysts must understand the industrial operating environment. Any high-tech industrial project is a complex undertaking that crosses diverse areas of endeavors. Both technical and organizational issues must be addressed in order to avoid system-wide project failures. This chapter covers the building blocks essential for the application of project management to industrial operations. The contents of this and the subsequent chapters will enable the project analyst to accomplish the following learning objectives:

- Understand the basic steps and components of project management.
- Learn best-practices approach to project planning, organizing, scheduling, and control.
- Use case examples as the basis for understanding “what went wrong” and how develop sustainable project solutions.
- Learn how to develop project scope and develop a project charter.
- Using planning as the roadmap toward project success.
- Create cohesive project teams using the Triple C model of communication, cooperation, and coordination.
- Develop project work breakdown structure.
- Use a mix of qualitative and quantitative techniques to enhance project management.
• Develop compromise or tradeoff strategies for cost, schedule, and performance constraints.

Manufacturing is the process of creating a product by processing raw materials from an initial point through to the end product. It encompasses several functions that must be strategically planned, organized, scheduled, controlled, and terminated. A manufacturing cycle includes such functions as forecasting, inventory control, process planning, machine sequencing, quality control, decision analysis, production planning, cost analysis, process control, facility layout, work analysis, and a host of others. All of these are functions that fall within the process of planning, organizing, scheduling, and control cycles of project management. Industrial projects can be characterized by a combination of the following attributes:

• Large external stakeholders, customers, owners
• Internal stakeholders
• Short product life cycle (in high-tech industries)
• Variable investment sources
• Narrow margins for success.

As with all projects, industrial projects are subject to three basic constraints of time, cost, and performance as illustrated in Figure 1.1. Any other constraint in the project environment will somehow fall under one of these three constraints. Several factors lurk behind the screen of the triple constraints. Issues such as workforce capability, operating tools, and process structure impinge on the project’s ability to be delivered on time, within budget, and in line with performance expectations.

Industrial operations are predicated on strategic operations, which utilize high-tech tools, knowledge workers, and complex processes. Consequently, project management in an industrial operation implies the management of people, process, and technology, as shown in Figure 1.2, to satisfy the triple constraints.

While the proliferation of technology in industry has led to a loss of jobs, it has also led to the creation of new types of jobs, and so the coupling of technology and manufacturing has spawned a need for retraining of workers and realignment of functions. Even though high technology is sometimes blamed for stifling creativity and restricting traditional personal workmanship, it has also been credited with fostering industrial innovation.
This requires new management approaches. Effectively managing industrial technology requires project management skills on the part of management, employees, and clients in order to ensure the successful design, development, production, transfer, introduction, and implementation of various forms of technology to generate products and or services. Innovative applications of new and existing management techniques are needed to address the rapidly changing nature of industrial operations. Project management approaches are at the forefront of such applications.

**Dependency on Human Capital**

In spite of the increasing proliferation of automation in industry, human capital still holds a major role in accomplishing industrial output. Investment in human resource assets should be a primary focus of any organization’s project efforts. The success of the Toyota production system is not due to any magical properties of the approach, but rather due to the consistency, persistence, and dedication of the humans who apply the Toyota approach to all their industrial projects. This cannot be achieved without giving something (e.g., operator training, technology tools, and doable process) to obtain desired outputs. Recalling the cliché of “nothing from nothing is nothing,” as illustrated graphically in the following figure, industrial organizations should invest in their human capital in order to maximize project output. Figure 1.3 shows the central role of people in the various aspects of an industrial system.

![Figure 1.3](image)

**Global Industrial Competition**

Many North American manufacturers cannot compete globally on the basis of labor cost, where improvement efforts are often directed. The competitive advantage for
many manufacturers will come from appropriate infusion of technology into the manufacturing enterprise. Strategic research, development, and implementation of technological innovations will give manufacturers the edge needed to successfully compete globally. In spite of the many decades of lamenting about the future of manufacturing, very little has been accomplished in terms of global competitiveness. Part of the problem is the absence of a unified project management approach. Managing global and distributed production teams requires a fundamental project approach. One valid industrial proposition is the need to pursue more integrative linkages of technical issues of production and the operational platforms available in industry. Many concepts have been advanced on how to bridge the existing gaps. But what is missing appears to be a pragmatic project-oriented road map that will create a unified goal that adequately, mutually, and concurrently addresses the profit-oriented focus of practitioners in industry and the knowledge-oriented pursuits of researchers in academia. The problems embody both scientific and management issues. Many researchers have not spent adequate time in industry to fully appreciate the operational constraints of industry. Hence, there is often a disconnection between what research dictates and what industry practice requires. An essential need is the development of an industrial project road map. Two aspects that are frequently ignored in industrial project implementations involve human factors and ergonomics parameters of the work environment. A project management approach facilitates an appreciation of this crucial component of industrial projects.
**System’s View of Industrial Projects**

An industrial system is a collection of interrelated elements brought together to achieve a specific objective of meeting product or service goals. In a management context, the purposes of a system are to develop and manage operational procedures and to facilitate an effective decision-making process. A systems approach is particularly essential for contemporary manufacturing because of the various factors that interact. Four of the major desired characteristics of an industrial project system include:

1. Possession of a definite objective
2. Ability to interact with the environment
3. Ability to self-regulate
4. Ability to carry out self-adjustment.

The various elements (or subsystems) of a system act concurrently, in a separate but interrelated fashion, to achieve the common goal. This synergism helps to expedite the decision process and to enhance the effectiveness of decisions. The supporting commitments from other subsystems of the organization serve to counterbalance the weaknesses of a given subsystem. Thus, the overall effectiveness of the system will be greater than the sum of the individual efforts of the subsystems. The increasing complexity and globalization of industrial operations make the systems approach essential. The classic approach to the decision-making process follows rigid lines of organizational charts. By contrast, the systems approach considers all the information interactions necessary between the various elements of an organization. The industrial system has shifted considerably over the past decades as illustrated in Figure 1.4. The primary focus in the 1960s was on industrial efficiency. Today, we are concerned not only with globality, but also with nanoscale industrial production; and cyber-space consciousness is already making dominant inroads into every level of project operations.

**Industrial Project System Integration**

Any project can be viewed as a system of operations and activities. There are several major steps for successfully initiating, implementing, and managing a project system. Some of the steps are summarized as follows:

1. **Definition of Problem:** Define the problem using keywords that signify the importance of the problem to the overall organization. Prepare and announce the project scope and plan.
2. **Assignment of Personnel:** The project group and the respective tasks and responsibilities should be explicitly established.
3. **Initiation of the Project:** Arrange organizational meetings and project kickoff, during which a general approach to the project is announced.
4. **Development of System Prototype:** If applicable, develop a prototype system, test it, and learn more about the problem from the test results.
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5. **Full-System Development**: Expand the prototype to a full system, evaluate the user interface, and incorporate user training facilities and documentation.

6. **System Verification**: Get experts and potential users involved, ensure that the system performs as designed, and debug the system as needed.

7. **System Validation**: Ensure that the system yields expected outputs. Validate the system by evaluating performance level.

8. **System Integration**: Implement the full system as planned, ensure the system can coexist with systems already in operation, and arrange for technology transfer to other projects.

9. **System Maintenance**: Arrange for continuing maintenance of the system. Update project system procedures as new information becomes available.

10. **Documentation**: Prepare disseminate documentation of system.

With increasing shortages of resources, more emphasis is placed on the sharing of resources, both physical and intellectual. It is through the integration of industrial systems that resource sharing may be most efficiently achieved. Systems integration may involve the physical integration of technical components, the objective integration of operations, the conceptual integration of management processes, or a combination of these. Systems integration involves the linking of components to form subsystems and the linking of subsystems to form composite systems within a single organization or across several organizations. Such integration facilitates the coordination of diverse technical and managerial efforts to enhance organizational
functions, reduce cost, save energy, improve productivity, and maximize the utilization of resources. Because information and other resources are shared, it helps to ensure that components and subsystems operate synergistically to optimize the performance of the total system. Some important benefits of systems integration are as follows:

1. **Multiuser Integration**: This involves the use of a single component by separate subsystems to reduce both the initial cost and the operating cost during project life cycle.
2. **Resource Coordination**: This involves integrating the resource flows of two normally separate subsystems so that the flow of resources from one subsystem to the other minimizes the total resource requirements.
3. **Functional Integration**: This involves the restructuring of functions and the reintegration of subsystems to optimize costs when a new subsystem is introduced.

### Resource Sharing for Systems Integration

Systems integration should cover both machines and people. Just as with physical systems, the supporting cooperative actions of personnel subsystems serve to counterbalance the weaknesses at certain points in the organization. The following is a representative list of possible subsystems. Figure 1.5 shows resource sharing plays a central role in project systems.

- Management
- Manufacturing
- Quality information
- Financial information
- Marketing information
- Inventory information
- Personnel information
- Production information
- Design and engineering
- Research and development
- Management information.

![Figure 1.5 Resource-sharing linkages in project system.](image-url)
Business Process Reengineering

Business process reengineering (BPR) is the redesign of business work processes and the implementation of the new design. This has emerged in recent years as a way to manage manufacturing functions. BPR calls for changes at three levels of the organization:

1. Enterprise-wide changes (driven by management initiatives)
2. Process-level improvement changes (driven by project teams)
3. Task-level changes (driven by individual workers).

Improvement in personnel skills and functions, technology, and in the process itself all contribute to the achievement of business process improvement. The factors that drive BPR are the needs for efficiency, quality, flexibility, and competitiveness.

Traditional industrial processes operate in “blobs” (blurb) as depicted in Figure 1.6, whereby tasks are executed along fuzzy lines of responsibility. Although inputs and outputs may be lineated, within-the-box operations are often not easily tractable.

An alternative is to use a project system point-to-point lines of operations control as shown in Figure 1.7. Process inputs are clearly identifiable, the integrated outputs are observable, and the internal operations are clearly traceable. This has the advantage of the ability to trace points and sources of project problems.

Continuous Paths of Improvement

If a traditional approach to industrial process improvement is followed, as shown in Figure 1.8, then alternate cycles of process improvement and degradation occur. This impedes overall potential to achieve the target. As an alternative, it is recommended

![Figure 1.6](image1.png)  
**FIGURE 1.6** Traditional blobs of operation.

![Figure 1.7](image2.png)  
**FIGURE 1.7** Point-to-point network of industrial tasks.
that industrial process improvement be pursued through incremental steps as depicted in Figure 1.9, whereby a continuous path is charted from the starting point to the target point. This has the advantage of lower cost, smoother operations, and greater potential to achieve production goals.

**INDUSTRIAL PRODUCTION PLANNING**

Production planning is the process of coordinating activities to get raw material stage to the finished-goods stage. It is the function of making sure that new designs are added as new products while old products are modified or discontinued. It involves
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setting up production objectives, allocating resources, and establishing standards and procedures to govern the production environment. The production-planning function is an iterative process that is reviewed and revised based on the state of the system. Some of the production tasks that may need to be coordinated as project activities include:

1. **Materials and Supplies**: Generation of reports showing materials and supplies assigned to and used by each production center.
2. **Labor Requirements**: Analysis of labor hours required for production operations.
3. **Overhead Allocation**: The distribution of overhead to production centers. An analysis is made of overhead allocated and overhead actually incurred for specific jobs.
4. **Job Control**: Tracking of job status and milestones.
5. **Job Transfer**: Routing of a job from one production center to another.
6. **Supply and Demand Trending**: Seasonality of certain products.
7. **Inventory Management**: Tracking of physical assets and resources of the organization.

**PROJECT MODEL OF INDUSTRIAL PRODUCTION**

The manufacturing enterprise is a project consisting of distinct production activities. In a large organization, the industrial system may be configured as a multiproject endeavor, and the components of the project may be managed as any conventional project. Figure 1.10 shows the typical components of an industrial enterprise organized as a project network of industrial.

![Manufacturing project network](image)

**FIGURE 1.10** Manufacturing project network.
The industrial network starts with the conceptualization of a product. Some of the distinct tasks required for getting the product from the idea stage to the market include the following:

1. **Feasibility Study**: A study conducted to ascertain the practicality of the proposed product. The practicality is considered in terms of available technology, cost constraints, production process, labor skills availability, organizational goals, and market structure.

2. **Market Survey**: An analysis of what the market wants in terms of cost, product functionality, and comparative manufacturer reliability.

3. **Cost Estimation**: Development of cost figures for the various physical and qualitative components that go into obtaining the final product. These may include machines, inventory space, training, raw materials, transportation, advertising, design, customer service, labor wages, and so on.

4. **Technology Assessment**: An assessment of the current technological capabilities. This may involve questions such as: Is the technology proven and stable enough to sustain production operations? Is the technology affordable? What will be the impact of technology changes on production?

5. **Product Design and Development**: The development of a full-fledged design of the product based on the outcomes of the preceding tasks. Adaptability should be incorporated into the design so that future product changes can easily be accomplished as the technology changes.

6. **Financing**: The process of obtaining funds to complete the manufacturing project. Sources of funds may include top management (internal funding), external sponsors (e.g., government-backed projects), or contract awards (e.g., client-sponsored products). If the preceding tasks of feasibility study, market survey, cost estimation, and technology assessment are done with proper attention to details, the task of obtaining funds will be simplified.

7. **Process Planning**: The development of a plan for the manufacturing process, taking into consideration machines, tools, layouts, and raw materials. The level of process sophistication depends on the designed product configuration and availability of funds.

8. **Quality Specification**: The development of product quality specifications based on product functions and process capability. A process capability analysis may be very helpful in this task because a process capability analysis will determine the tolerance that a process can handle if it is statistically in control. The process, in this case, is a unique combination of machines, tools, methods, materials, and labor skills.

9. **Personnel Assignment and Training**: At this stage, the required personnel are acquired, either through new hires or the transfer of employees, who may be able to bring previous experience to the new product setup. Training is conducted in accordance with process requirements.

10. **Operations Planning**: The development of operational flow charts, raw-material requirements, production rates, maintenance schedules, input/output flows, operating costs, overhead allocation, job routing forms, capacity plans, shift schedules, operations sequences, labor classifications, space requirements, deadlines, and production standards.
11. **Facilities Layout**: Setup of the physical structure or the production line. It may involve the relay out of the existing facility, the installation of new equipment, or the construction of new structures.

12. **System Integration**: Coordinating the new production line to coexist with other lines within the manufacturing system. It may require schedule adjustments to satisfy shared-resource requirements, the development of policies to accommodate product integration, or a realignment of managerial responsibilities.

13. **Production Scheduling**: The generation of schedules of the various activities in the production process. This covers machine assignments, labor assignments, work releases, material supply, in-process storage, and time standards.

14. **Production Run**: The actual implementation of the production schedule. Production control functions may be incorporated into this task. Inspection should be included in the task definitions under “production run” or may be treated as a separate function.

15. **Product Shipment**: This is the final task to complete the project.

The tasks presented in the example may be treated in detail as a subproject of the overall industrial project. In specific situations, some tasks may be added, combined, eliminated, or defined in alternate terms.

**Industrial Project Interfaces**

The interface between project management functions and the industrial enterprise is easily observable throughout any organization. Many functions that directly or indirectly support the industrial effort can best be managed using project management concepts. Figure 1.11 shows a typical interface of project management in an industrial organization.

Some of the specific tasks and issues to be addressed when managing industrial projects are

- Project selection and prioritizing
- Resource requirements planning
- Cost estimation
- Team formation
- Facility design and management
- Project inventory analysis
- Project forecasting
- Activity modeling
- Human resource management
- Multiproject coordination
- Management of global interfaces
- Project economics
- Contract procurement.

All of these fall within the purview of a formal project management approach.
Quality is a measure of customer satisfaction and a product’s “fit-for-use” status. To perform its intended functions, a product must provide a balanced level of satisfaction to both the producer and the customer. For that purpose, we present the following comprehensive definition of quality:

Quality refers to an equilibrium level of functionality possessed by a product or service based on the producer’s capability and the customer’s needs.

Based on this definition, quality refers to the combination of characteristics of a product, process, or service that determines the product’s ability to satisfy specific needs. Quality is a product’s ability to conform to specifications, where specifications represent the customer’s needs or government regulations. The attainment of quality in a product is the responsibility of every employee in an organization, and the production and preservation of quality should be a commitment that extends all the way from the producer to the customer. Products that are designed to have high quality cannot maintain the inherent quality at the user’s end of the spectrum if they are not used properly.

The functional usage of a product should match the functional specifications for the product within the prevailing usage environment. The ultimate judge for the quality of a product, however, is the perception of the user, and differing circumstances may alter that perception. A product that is perceived as being of high quality for one purpose at a given time may not be seen as having acceptable quality for another.
Characteristics of Industrial Projects

purpose in another time frame. Industrial quality standards provide a common basis for
global commerce. Customer satisfaction or production efficiency cannot be achieved
without product standards. Regulatory, consensus, and contractual requirements should
be taken into account when developing product standards. These are described as
follows:

**Regulatory Standards**

This refers to standards that are imposed by a governing body, such as a government
agency. All firms within the jurisdiction of the agency are required to comply with
the prevailing regulatory standards.

**Consensus Standards**

This refers to a general and mutual agreement between companies to abide by a set
of self-imposed standards.

**Contractual Standards**

Contractual standards are imposed by the customer based on case-by-case or order-
by-order needs. Most international standards will fall into the category of consensus
standards, simply because a lack of an international agreement often leads to trade
barriers.

**INDUSTRIAL PRODUCT DESIGN**

The initial step in any manufacturing effort is the development of a manufactur-
able and marketable product. An analysis of what is required for a design and what
is available for the design should be conducted in the planning phase of a design
project. The development process must cover analyses of the product configuration,
the raw materials required, production costs, and potential profits. Design engineers
must select appropriate materials, the product must be expected to operate efficiently
for a reasonable length of time (reliability and durability), and it must be possible to
manufacture the product at a competitive cost. The design process will be influenced
by the required labor skills, production technology, and raw materials. Product plan-
ning is substantially influenced by the level of customer sophistication, enhanced
technology, and competition pressures. These are all project-related issues that can
be enhanced by project management. The designer must recognize changes in all
these factors and incorporate them into the design process. Figure 1.12 shows the
wide spectrum of what goes into a product design project.

Design in project management provides a guideline for the initiation, implementa-
tion, and termination of a design effort. It sets guidelines for specific design objec-
tives, structure, tasks, milestones, personnel, cost, equipment, performance, and
problem resolutions. The steps involved include planning, organizing, scheduling,
and control. Figure 1.13 shows the various constraints, internal and external, that
may affect the design environment.

The availability of technical expertise within an organization and outside of it
should be reviewed. The primary question of whether or not a design is needed at
all should be addressed. The “make” or “buy,” “lease” or “rent,” and “do nothing” alternatives to a proposed design should be among the considerations.

In the initial stage of design planning, the internal and external factors that may influence the design should be determined and given relative weights according to priority. Examples of such influential factors include organizational goals, labor situations, market profile, expected return on design investment, technical manpower availability, time constraints, state of the technology, and design liabilities. The desired components of a design plan include summary of the design plan, design objectives, design approach, implementation requirements, design schedule, required resources, available resources, design performance measures, and contingency plans.

**Design Feasibility**

The feasibility of a proposed design can be ascertained in terms of technical factors, economic factors, or both. A feasibility study is documented with a report showing...
all the ramifications of the design. A report of the design’s feasibility should cover
statements about the need, the design process, the cost feasibility, and the design
effectiveness. The need for a design may originate from within the organization,
from another organization, from the public, or from the customer. Pertinent questions
for design feasibility review include: Is the need significant enough to warrant the
proposed design? Will the need still exist by the time the design is finished? What
are alternate means of satisfying the need? What technical interfaces are required for
the design? What is the economic impact of the need? What is the return, financially,
on the design change?

A design breakdown structure (DBS) is a flowchart of design tasks required to
accomplish design objectives. Tasks that are contained in the DBS collectively describe
the overall design. The tasks may involve hardware products, software products, ser-
vices, and information. The DBS helps to describe the link between the end objec-
tive and its components. It shows design elements in the conceptual framework for the
purposes of planning and control. The objective of developing a DBS is to study the
elemental components of a design project in detail, thus permitting a “divide and con-
quer” approach. Overall design planning and control can be significantly improved by
using DBS. A large design may be decomposed into smaller subdesigns, which may,
in turn, be decomposed into task groups. Definable subgoals of a design problem may
be used to determine appropriate points at which to decompose the design.

Individual components in a DBS are referred to as DBS elements and the hierar-
chy of each is designated by a level identifier. Elements at the same level of subdivi-
sion are said to be of the same DBS level. Descending levels provide increasingly
detailed definition of design tasks. The complexity of a design and the degree of
control desired are used to determine the number of levels in a DBS. Level I of a DBS
contains only the final design purpose. This item should be identifiable directly as an
organizational goal. Level II contains the major subsections of the design. These sub-
sections are usually identified by their contiguous location or by their related purpose.
Level III contains definable components of the level II subsections. Subsequent lev-
els are constructed in more specific details depending on the level of control desired.
If a complete DBS becomes too crowded, separate DBSs may be drawn for the
level II components for example. A specification of design (SOD) should accompany
the DBS. A statement of design is a narrative of the design to be generated. It should
include the objectives of the design, its nature, the resource requirements, and a ten-
tative schedule. Each DBS element is assigned a code (usually numeric) that is used
for the element’s identification throughout the design life cycle.

**Design Stages**

The guidelines for the various stages in the life cycle of a design can be summarized
in the following way:

1. **Definition of Design Problem**: Define the problem and specify its impor-
tance, emphasize the need for a focused design problem, identify design-
ers willing to contribute expertise to the design process, and disseminate
the design plan.
2. **Personnel Assignment**: The design group and the respective tasks should be announced and a design manager should be appointed to oversee the design effort.

3. **Design Initiation**: Arrange organizational meeting, discuss general approach to the design problem, announce specific design plan, and arrange for the use of required hardware and tools.

4. **Design Prototype**: Develop a prototype design, test an initial implementation, and learn more about the design problem from test results.

5. **Full-Design Development**: Expand the prototype design and incorporate user requirements.

6. **Design Verification**: Get designers and potential users involved, ensure that the design performs as designed, and modify the design as needed.

7. **Design Validation**: Ensure that the design yields the expected outputs. Validation can address design performance level, deviation from expected outputs, and the effectiveness of the solution to the problem.

8. **Design Integration**: Implement the full design, ensure the design is compatible with existing designs and manufacturing processes, and arrange for design transfer to other processes.

9. **Design Feedback Analysis**: What are the key lessons from the design effort? Were enough resources assigned? Was the design completed on time? Why, or Why not?

10. **Design Maintenance**: Arrange for continuing technical support of the design and update design as new information or technology becomes available.

11. **Design Documentation**: Prepare full documentation of the design and document the administrative process used in generating the design.

**Industrial Outsourcing**

Economic pressures on manufacturers have necessitated searching internationally for areas of competitive operations, particularly in terms of labor cost. The availability of specialized skills around the world drives companies to seek skilled personnel at the lowest possible cost from wherever possible. Meanwhile, communication and information technologies have extended the reach and speed of overseas outsourcing, even without sufficient evolution of cultural adaptation. For overseas industrial outsourcing to be successful, both the "source" and "sink" of two cultures must be amenable to cultural integration. Changes to one culture as a result of influences from another culture have historically been very gradual, spanning generations. But in the modern information age, we observe a leap of cultures from one base to another. Cultures of the world evolved along geometrically unique lines over thousands of years. These cultures have been instrumental in defining who, what, how, when, and where of societal endeavors. In recent times, modern information tools and practices have allowed different cultures of the world to interact with one another in ways not previously possible. Education, travel, commerce, industry, and warfare are some of the developments that have facilitated intercultural exposures. Increasing interests in industrial outsourcing to overseas locations have created opportunities for additional cultural interfaces, which can either lead to enmeshing of cultures or creation of conflicts of cultures. This may respectively enhance or impede industrial projects.