ECE298 System Design and Technical Communication

Textbook Notes [1]

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[1]Compiled by LaTeX

Contents

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Acknowledgement

I took ECE298 System Design and Technical Communication in Fall, 2004. I found this course very useful, with experienced professors as well as an excellent textbook, *Design For Electrical and Computer Engineers, J. Eric Salt & Robert Rothery, John Wiley & Sons, 2001*. Under the exposure to vivid examples and principles in system design, I had got familiar with the theory of system design. Moreover, with the practical experiences from two course projects, I had practiced these principles and obtained a better understanding in design.

One important fact I realized during the course is that system design is a complex process with not a few stages and various factors. And it seems to be human nature(at least myself) to forget or neglect some factors. So it is essential for me to refer to some guidelines during the system design process for instructions, hints or references. However, the textbook is still too thick for this role with about one hundred and seventy pages. So I used my leisure time to excerpt the textbook and try to make a guideline for my design process and revision for the exam. As a result, this *Textbook Notes* comes!

One thing I would like to emphasize is that these notes cannot replace the textbook at all! It acts **only** as a reminder with instructions but little explanations, not to mention examples. It is **important and essential** for you to read through the textbook first, otherwise this notes may seem to be a nonsense collection of principles.

I have try my best to make this document correct but mistakes are unavoidable. I welcome your advices, but, I will NOT take responsibility for these mistakes. I guess the copyright still belongs to the authors of the textbook because most of the words and all the figures are originally excerpted from the textbook. This document can only use in educational purpose.

Last, but not the least, enjoy your journey in system design!

Chapter 1

INTRODUCTION

1.1 THE ENGINEERING PROFESSION

1.2 THE ROLE OF THE DESIGN ENGINEER

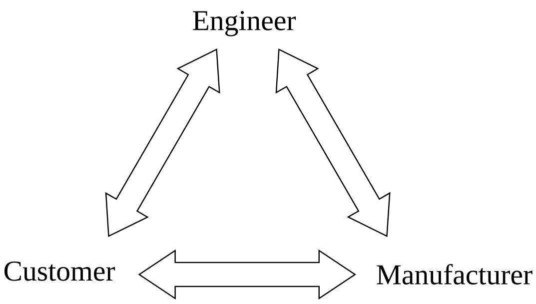

Figure 1.1: Relationship among the Design Stakeholders

Two trends reinforcing the triangle relationship of the engineer's role:

1. concurrent engineering
2. outsourcing of manufacturing

1.3 OBJECTIVE OF THIS BOOK

This book explicates the science of the design, a science that strongly suggests following a well-defined design process.

Chapter 2

THE DESIGN PROCESS

Engineering = Problem Solving

2.1 GENERAL ENGINEERING PROCESS

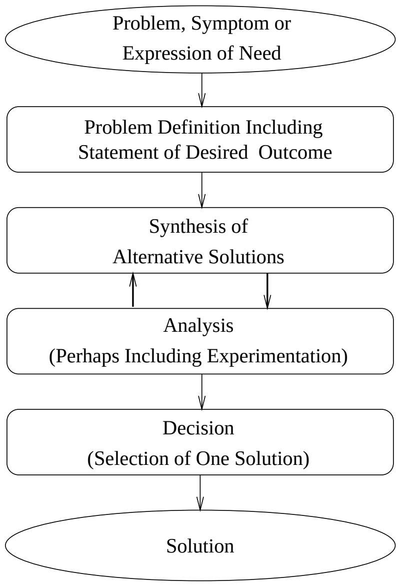

Figure 2.1: The General Engineering Design Process

Analysis: performed on existing system or a system that does not exist but has been conceived and described in detail.
Synthesis: associate with new systems
Iteration: the anlysis / design process need repetition
Decision: how many solutions to obtain? *"tradeoff"!* Forethought, expertise and experience needed!

2.2 APPLYING THE GENERAL ENGINEERING PROCESS

Steps:

1. Define the problem
2. Synthesize a solution, analyze it, refine the solution, analyze it again, etc.
3. Obtain more solutions
4. Choose one under certain criteria

2.3 EVALUATION OF ALTERNATIVE SOLUTIONS

Yardstick: the problem definition

Main factors: cost and performance
Additional factors: reliability, maintainability, flexibility, extensibility, ...
Complicate point: overlap of the various criteria
Equal choices: *simply flip a coin!*

2.4 DESIGN METHODOLOGIES

Definition Different approaches in the basic engineering process

Factors	the complexity of the design	size of the design team
	experience	personal style and preferences

Objectives To obtain the best possible solution, with the least engineering cost, and in as short a time as possible.

Two Different Approach

Method A	Straight forward top-down method	high-volume consumer products
Method B	Block level design	low-volume industrial products

2.5 A METHODOLOGY FOR HIGH QUALITY

Consumer: Cost First! Indu
Two most important topics:r

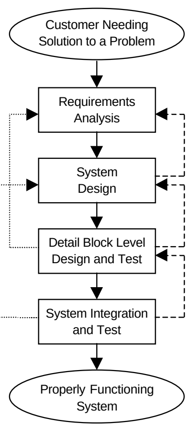

Figure 2.2: A Practical Design Methodology that Allows the Engineer to Revisit Earlier Stages of the Design as Work Progress

Chapter 3

REQUIREMENTS ANALYSIS

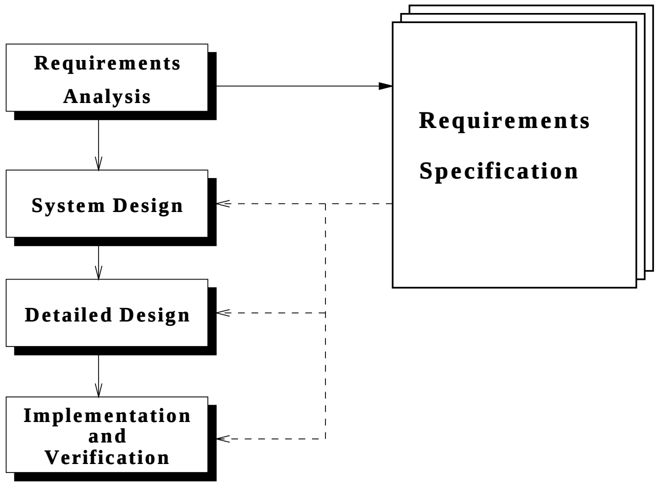

Figure 3.1: Requirement Analysis — First Stage in the Design Methodology

3.1 THE IMPORTANCE OF THE REQUIREMENT SPECIFICATION

Requirement Specification answers following important questions:

- What is the problem that the design to solve?
- How will everyone with a stake in the design know *when it is done?*

In addition, it also acts as an early filter to weed out design that are *overly ambitious, have conflicting objectives, address intractable problems or otherwise headed for failure.*

Require time, money, expertise and the most seasoned engineering judgement.

3.2 DEVELOPING THE REQUIREMENT SPECIFICATION

Focus a customer who needs a solution to a problem.

Concern understand what the problem is! So we need clarify, define and quantify the design objectives and to state these in the requirement specification.

Note 3.2.1 *Need collaboration with the customer, which can take different forms such as client, marketing department, etc.*

3.2.1 Two Scenarios

3.2.1.1 the informed customer

The customers have full knowledge of the application of the design.

3.2.1.2 frontier customer

The requirement specification must explore previously unexplored territory.

Table 3.1: Attributes Comparison

	Informed Customer Scenario	Frontier Customer Scenario
Customer's knowledge of the problem	High	Low
Availability of information	Readily available	Limited Availability
Ease of doing Requirement Analysis	Relatively easy	Relatively difficult
Probability of proceeding to next stage in design process of the problem	Relatively high	Low

The frequent case will be a mix of both "informed customer" and "frontier customer". The key is to identify those that fall into the later category! It is these that require the greatest effort and incur the highest cost.

3.2.2 A Two-Stage Approach to Developing the Requirement Specification

Note 3.2.2 *In this step, a search for solution must be avoided!*

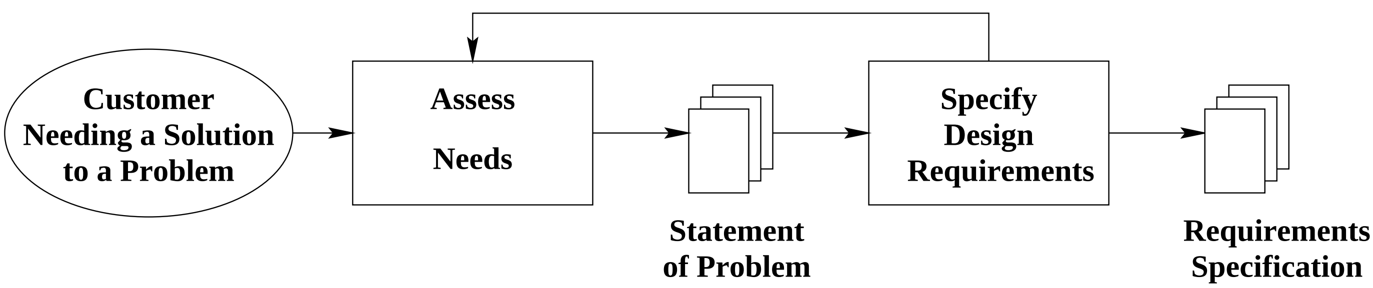

Figure 3.2: Two Stage Approach for Developing a Requirement Specification

Statement of problem: Straight forward, nontechnical, and disqualifiable.
Specify design requirements: turns the problem statement into a technical, quantifiable specification and establish criteria for judging the acceptability of the design.
Key Characteristic: NEED FOR ITERATION!

Final document: Answers "What, exactly, is the design team do?" and "How will everyone know when the design is done?"

Note 3.2.3 *Whatever formality is involved, it is important that the requirement specification have the combined approval of the customer and the designer.*

3.2.3 Real-World Considerations

In the real-world of engineering, several factors will guide and constrain the design process.

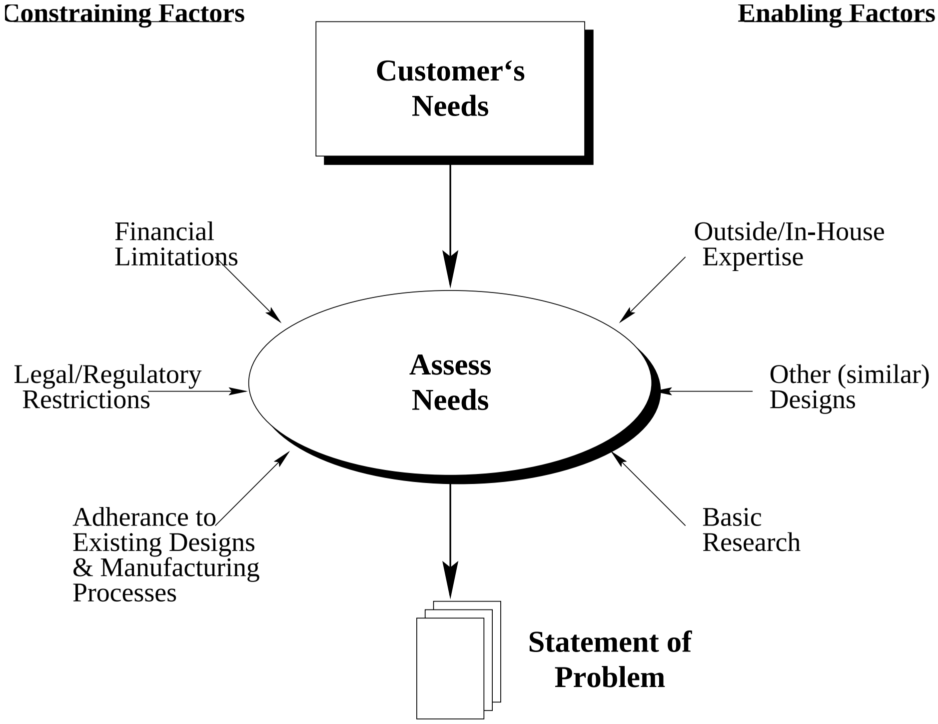

Figure 3.3: Real-world Inputs to the Design Process

3.3 NEEDS ASSESSMENT—STATING THE PROBLEM

Assessing the customer's needs leads to a nontechinical statement of the problem that the design will attempt to solve. The problem statement should have the following attributes:

Nontechnical Should be state in the language of customer.
Nonquantifiable No numerical terms!
Complete Should cover all aspects involving in the design.
Specifiable Should be possible to take a stated need and turn it into a specification.

3.3.1 Question the Customer

Tips Indirect and targeted questions are often more productive than direct and open-ended questions.

Questions:

to define the problem	to determine budget and schedule constraints
on reliability and maintenance	of contract

3.3.2 Differentiate Needs and Wants

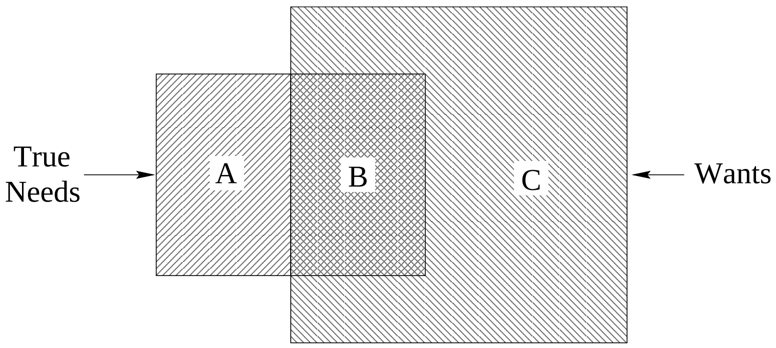

Figure 3.4: Design that Fulfill Wants Instead of True Needs

Aftermath

- Some needs would not be met, resulting in design deficiency
- Unneeded features would be provided, resulting extra cost.

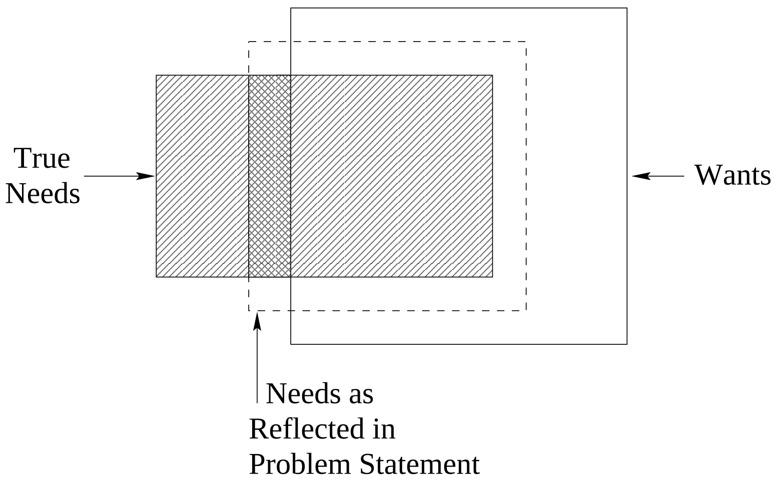

Figure 3.5: Matching the Problem Statement to True Needs Will Yield a Design that is Closer to Optimum

3.3.3 Explore Design Boundaries

Knowing the what a design cannot be is an indirect means of determining what it should be.

In many instances the boundaries are imposed by the need to fit within existing operation, standards, methods, or procedures.

Finally, there are legal boundaries to contend with.

3.3.4 Input/Output Analysis

Stating the design problem is often assisted by conceptualizing the design as a functional block that receives inputs and deliver outputs.

Input/Output Diagram Useful for identifying the needs for function.

3.3.5 Preview the User Interface

A requirements specification must include a *complete* and *thorough* definition of the user interface.

Note 3.3.1 *User may not be a human being.*

3.3.6 Survey Design Attributes

Categorizing design attributes into functional(What a design must do) and non-functional(What a design must be).

Functional Attributes Standard ones and advanced ones.
Nonfunctional Attributes User Interface, Packaging, Battery, Production, Reliability, Service, etc.

Note 3.3.2 *Some attributes such as manufacturability, reliability and serviceability,go beyond the direct needs of the design. They are likely assessed in collaboration with other departments and other engineers in the company.*

3.3.7 Identify Conflicting Needs

Classical Conflicts cost, performance and time

Method develop a matrix of overlapping needs and attempt to assess their correlation

Note 3.3.3 *It is important to let customer know that some needs overlap!*

3.3.8 Prepare a Draft Operations Manual

It helps to raise several questions about design needs.

3.4 PREPARE THE REQUIREMENT SPECIFICATIONS

3.4.1 Translating Needs to Specifications

A good statement Complete and consistent. Demand experience and expertise.

Methods for translating the statement of problem into the requirement specification:

—**Search out expert source** individual experts, industry standards, and engineering reference material.
—**Analyze similar design** Reverse Engineering
—**Conduct tests or experiments**

3.4.2 Specification of Interface Points

Have to be complete and **NOT** only human interfaces.

3.4.3 Excessive Requirement

Note 3.4.1 *Try to meet the customer's need as close as possible.*

Inexperienced engineers produces excessive specification in two ways:

- By specifying needles features or functionality
- By making specification too stringent

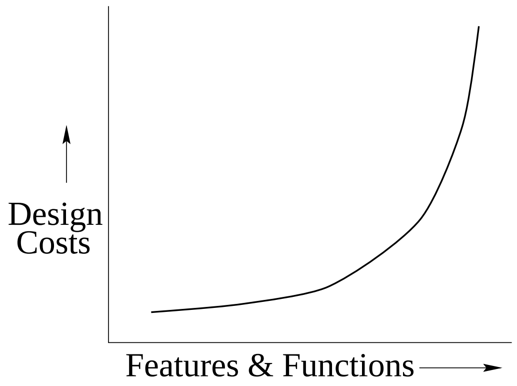

Figure 3.6: Cost of Design Vs. Product Features

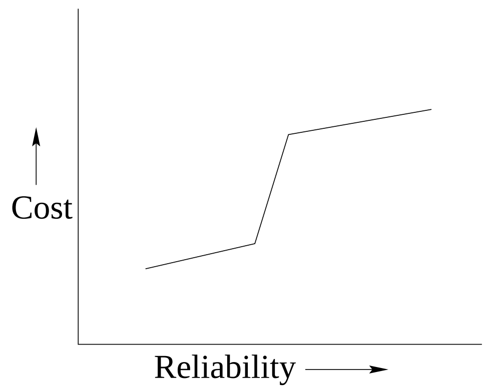

Figure 3.7: Cost-Reliability trade-off

3.4.4 Verification

Note 3.4.2 *Must be considered at this time and it is beneficial to develop a preliminary test plan along with the requirement specification.*

Rule 3.4.1 *If a design requirement cannot be verified, it should not be specified! Keep it in mind!*

3.4.5 Documenting the Requirement Specification

A typical outline for a requirement specification:

1. Overview / Executive Summary
2. Statement of the Problem
3. Operation description(draft user's manual)
4. Requirement specification
5. Design Deliverable
6. Preliminary System Test Plan
7. Implementation Consideration
    - Service and Maintainance
    - Manufacture

Attachment

- Studies(technical reports or marketing studies)
- Relevant codes and standards

3.5 SUMMARY

In this chapter we have investigated the ways in which engineers ascertains a customer's needs and turns into a statement of requirements.

Note 3.5.1 *In theory, what is included in the requirement specification will end up in the final design.*

Some comments to remember about Requirements Specifications:

- It should be an agreement between the engineer and the end user of the design — the customer
- It should be the engineer's guide as he or she moves through the design process, defining the functionality of the design and describing the limitation and constrains imposed upon it.
- It should be the yardstick by which the completed design will be judged for its conformance to the initial objectives.
- It should be provide a historical record of how the idea for the design came to be.
- It should be the engineer's contributing to manufacturers, operators, maintainers, and future designers — a reference document to help them in their work.

Chapter 4

SYSTEM DESIGN

Address the problem: How will the problem be solved?

System Design: a creative process that involves conceptualizing, analyzing, refining, and finally determining the solution.

4.1 THE IMPORTANCE OF SYSTEM DESIGN

Demand: innovation, novelty

Performance Measures: economy, maintainability, durability, etc.

Note 4.1.1 *Proficiency at system-level design is, for the most part, what distinguishes senior from junior students. Hence, it is very important that junior engineer exploit every opportunity to get experience in this area.*

Reasons for System Design

- To decide whether or not the problem is tractable.
- To determine the performance limits of the design and whether not these limits are acceptable.
- To get good estimates of the costs early in the project before investing too heavily in the design of the product. The two most important costs are:
  1. Cost of finishing the design
  2. Cost to manufacture the product
- To reduce the risk of the design not functioning properly
- To increase the reliability of the product
- To reduce the overall cost of developing the product
- To provide a framework for the organization and coordination of a team of engineers to work on the design.

4.2 SYSTEM BLOCK DIAGRAMS

Essence of Engineering: Dissect a complex problem into smaller, more manageable problems.

Definition 4.2.1 *The process of dividing one major problems into a system of smaller, more manageable problems is called* ***system engineering****.*

Definition 4.2.2 *The diagram that shows exactly how the subsystem are connected together is called* ***a block diagram****.*

A block diagram can provide a concise description of the design as a well-defined set of interconnected function.It is often used to communicate the structure of the solution.

- a big help in organizing thoughts
- a big help in estimating the cost of development and the cost of the finished product

However, a block diagram cannot fully describe a system by labels, so some additional information is needed:

- a written description of each function
- specifications of input/output
- meaningful names
- describe signal in writing along with the block diagram
- some important waveforms

4.3 THE SYSTEM DESIGN PROCESS

Input the requirements specification: defines what problem the design is to solve and specifies the design outputs.

Output the system specification: a description of each block , a description of how the blocks work together to function as a system, and an analysis showing how the system described by the clock diagram will meet the requirement specification.

A preliminary step: to determine if the design is even necessary.

Note 4.3.1 *Learn from others!*

The process of system engineering

Conceptualization

— **Objective** To develop a hazy perception of a solution.
— Look for a notion or idea that holds promise of becoming a solution(thinking, reasoning, experience, and knowledge)
— **framework** Scientific principles

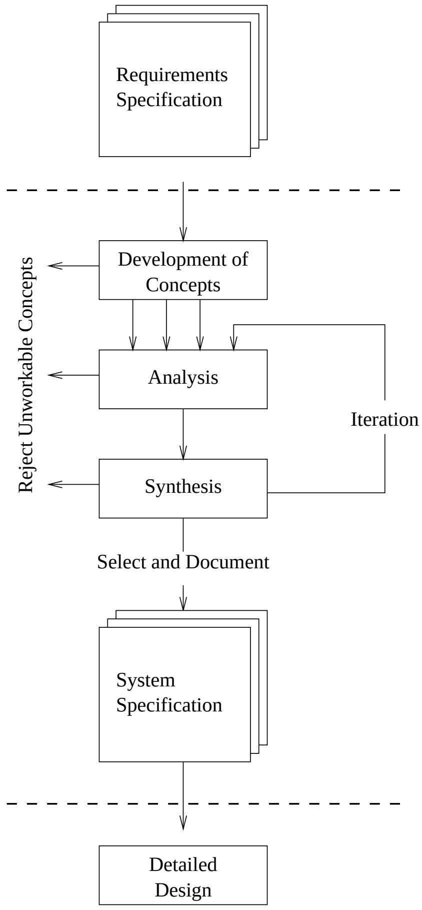

Figure 4.1: System Design Process

Synthesis

— **Objective** To create a well-defined structure for the concept.
— Should have sufficient details to support analysis on cost, performance, and risk.
— **Structure** Block Diagram

Analysis

— **Objective** To determine if the synthesized system will meet the performance and cost objectives laid out in the requirement specification.
— **Second Objective** To determine the risk involved in carrying the design through the detailed design and implementation stages.
— Based largely on past experience
— **Scientific Methods** often use their combinations

1. Develop a mathematical model for each of the blocks and analyze the system mathematically.
2. Simulate the system on a computer.
3. Lash together a lab version of the system using as many off-the-shelf components as possible, then verify the performance through lab measurements.

Refinement

— **Objective** To modify the synthesized concept based on the information gained through the analysis.
— synthesize a new structure to improve performance and correct the deficiencies revealed in the analysis
— May require several iterations

Documentation

— **Objective** To document the functions of each block in the block diagram and explain how the block work together as a system.

- function of each block
- inputs and outputs of each block in the system
- an important part for analysis and refinement

Note 4.3.2 *Through the design process, concepts will be discarded.*

Core of System Design Conceptualization, synthesis, and analysis
— require a creative, nonlinear mode of thinking
—experience

4.3.1 Conceptualization

Key to get a high-quality, economical solution To consider several different concepts and then choose the best.

Source for concepts external vs. internal

Base on proven concepts	Thinking an original concept
Easy, safe and fast	Difficult, time consuming, risky
Few advantages and low profit	Sometimes high-performance and high profit

Note 4.3.3 *The major impediment to creative process is the concern that there may not be a solution to the problem and that the search for a concept may be a waste of time. So we MUST take a positive approach to developing a concept!*

4.3.2 Synthesis

Two conflicting forces that driving the design process:

- The need to have the design complete quickly
- The need for a novel solution that offers either a cost or performance advantage over the competition.

Note 4.3.4 *The trade-off between linear thinking and original thinking*

4.3.3 Analysis

Tools Matlab^{TM}, SIMULINK^{TM}

4.3.4 The Synthesis/Analysis Cycle

First few iterations: reveal major deficiencies.
Last few iterations: to determine the performance limits.

After every failure, an engineer must consider whether *to spend time synthesizing a new structure for the same concept* or *to move to a new concept*.

After every cycle of synthesis / analysis cycle, the engineer must decide whether *to continue refining the structure* or *to stop*. There are two reasons to stop:

1. The current structure meets the cost and performance objectives, in which case the job is done.
2. The engineer cannot think of a change that will improve cost and / or performance.

Three ways to proceed:

1. Go back to the structure and modify
2. Synthesize a new structure from the same concept
3. Use creative thinking to conceive a new concept and then synthesize a structure based on this concept.

The iterative nature: a search for global optimum

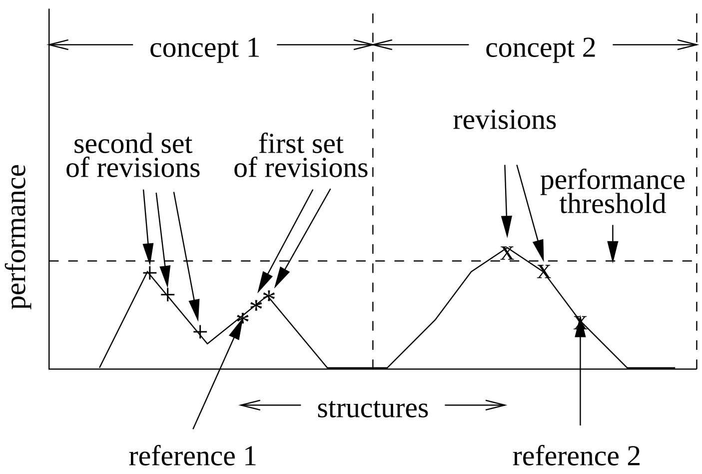

Figure 4.2: Synthesis / Analysis Iterations from Concept to Best Possible Design

4.4 BLOCK DIAGRAM BASICS

— Expresses thoughts, communicates ideas, and ultimately captures the collective creation that is the design

The quality of block diagram affects:

- time to complete the paper design
- time to debug the prototype
- the reliability of the finished product

Good block diagrams:

- each block with a single purpose

- easily described but not necessarily simple
- simple, straightforward interfaces
- meaningful labels and notations

Keep in Mind: Blocks should be specified in such a way that the detailed design of a block can be completed by an individual engineer.

Suggestions

- The function of a block should be implementable with a single technology
- Common functions should be grounded into one block
- Blocks should be defined so as to simplify the interfaces between them
- If possible, avoid feedback loops in the block diagram
- Choose and specify the standards or notations used
- For analog design, interface parameters such as impedance, loss, or some other indicator of matching are often included.
- For RF design, signals between blocks are commonly specified in terms of frequency and related parameters such as bandwidth and spectral purity.
- For digital design, specification of timing and sequencing signals is a common requirement.

Note 4.4.1 *The importance of thoroughly annotating the block diagram cannot be overstated.*

4.5 DOCUMENTATION

The document produced in the system design stage are often referred to as the **System Specifications**. It serves several purposes:

1. It is the specification used to complete the detailed design and implementation of the blocks in the block diagram.
2. It stores the details of the system-engineering effort so that the design can be modified in response to bugs or problems uncovered later. Perhaps as late as when the product reaches the marketplace.
3. It may be used as a reference for the design of future generation of the product.
4. It is a source of information for the engineers designing fixtures to test the final product. These are usually designed to probe the points that correspond to the inputs and outputs of each block. The integrity of the circuitry that implements each block can then be checked separately, simplifying the process of isolating faulty components.
5. It is a source of information to help marketing engineers develop manuals, brochures, and other literature for advertising and technical support.

Requirement for System Specification: succinct and factual. Should meet the needs of various readers such as other system engineers, a bottom block design engineer, a test engineer, and a marketing engineer.

A system specification might be organized into five sections:

The Concept This section will explain the principle of operation. It will also include background information and origin of the concept.

The Block Diagram This section comprises a well-annotated block diagram along with a specifications of the inputs and outputs of the system.

Function Description of the Blocks This section would logically be divided into subsections, with a subsection devoted to each of the blocks. Each of these subsections can be further divided into two sub-subsections: functional description of the block and specification of the outputs of the block.

Description of the System This section describes how the block in the block diagram interact with one another to make the system work.

System Analysis This section consists mainly of the results of mathematical analysis and simulation, but may also include the result of laboratory measurements.

Please refer to page 60 to 67 of the textbook for examples.

4.6 SUMMARY

Conceptualization, synthesis, and analysis create an orderly sequence of structures(block diagrams) that end in a solution. A comparison between linear thinking and creative thinking.

Chapter 5

MANAGING THE DESIGN PROCESS

Work on time and on budget!

Definition of Project 1 *A project is a quantifiable piece of work, with a defined start and end, and with expectations of specific outputs or deliverables.*

Other attributes of associated with a project are:

- The output is low volume, a unique product/service.
- There are measurable objectives.
- It uses a limited set of resources(people, material, equipment)
- The work is often complex, uncertain, and/or urgent.

5.1 THE PROJECT MANAGEMENT

Factors in a project: complexity, uncertainty, and urgency. The organization of a project usually consists of a project manager, project teams or design teams, ad some other service and facilities.

5.1.1 Project Organization

5.1.2 Elements of Project Management

Responsibilities for a project manager: make sure the design meets functional requirements, performance specifications, meeting budget, and meeting schedule.

Note 5.1.1 *By* focusing the design team on the tasks at hand *and* minimizing the tendency to follow one's individual interest, *the result is often a design that meets the objectives no less and no more.*

Three main elements in project management:

Planning Define to work to be done, the schedule to complete the work, a budget , and a description of the required resources.

Monitoring Monitor the funds expended,the resource utilized, and whether or not the work is being completed on the schedule dates.

Control Shift resources, reallocate tasks,...

NOTE: CHOOSE RIGHT PEOPLE THAT YOU TRUST!

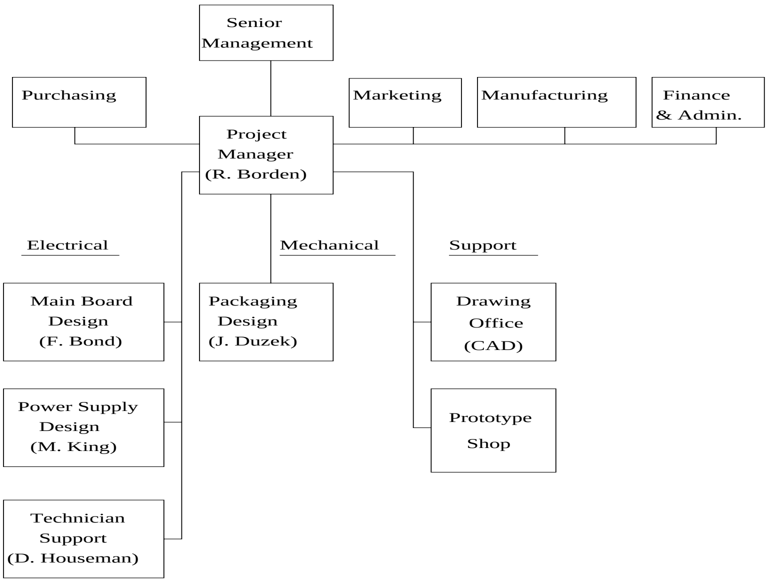

Figure 5.1: A Typical Organization Chart for Electronic Design Project

5.2 PROJECT PLAN

Project plan: answers *what it will cost, when it will be completed, and what resources will be needed.*

General Structure of a Project Plan

1. **Definition of the work:** A detailed breakdown of the various tasks and work assignments to complete the design project.
2. **Schedule:** Dates and times for completing the various tasks that make up the project.
3. **Resource Requirement:** Estimate of the individuals, materials, equipment, and support services required to complete the work.
4. **Cost Estimate:** An estimate of the costs of doing the project, also referred to as the project budget.

How does the planning process fit with the design process:

Note 5.2.1 *It is only after the system design is complete that the project requirements are known well enough to develop a plan, yet one must have thorough plan before starting the work. Thus there is normally a break in the design process following system design to take stock of the requirements and to assess what it will take and how much it will cost to implement the design.*

Note 5.2.2 *Planning is an iterative process and it is common to review the system design when developing the plan.*

5.3 DEFINING THE WORK

The first step in the planning process: to develop a clear definition of the work required to complete the design project.

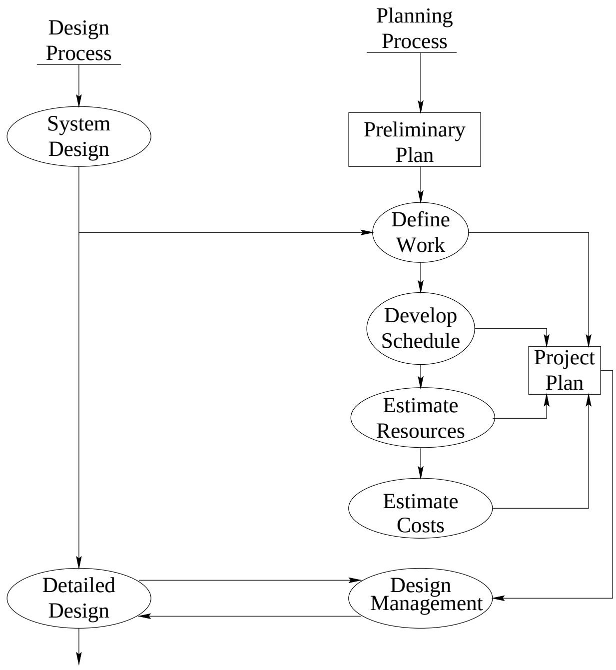

Figure 5.2: Planning Process

Elements of a work definition:

Schedule
Personnel
Budget
Task description expected outputs or deliverables
Dates milestones and the effort of a task
Resources people and facilities
Precedence The interrelatedness of tasks.

Guidelines for deciding tasks:

- Top-down approach & bottom-up approach
- One block in the system diagram should be considered as a task
- A piece of work undertaken by an individual member of the design team, independent of others, should be considered as a task.
- Work leading up to an important milestone should be considered as a task.
- A task should be independent of additional outputs.
- Consider the trade-offs between simplicity and details. Generally, it is better to err on the side of too much details and simplifying later if necessary.

5.4 SCHEDULING

5.4.1 Network Diagram

Examples:

- CPM (Critical Path Method) diagram

- PERT (Program Evaluation and Review Technique) charts
- AOA (Activity-On-Arrow) method

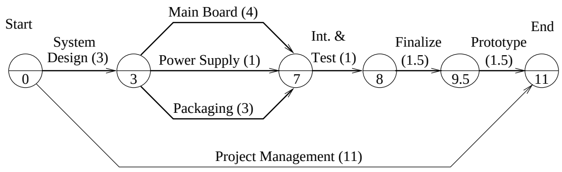

Figure 5.3: AOA Example

- AON (Activity-On-Node) method

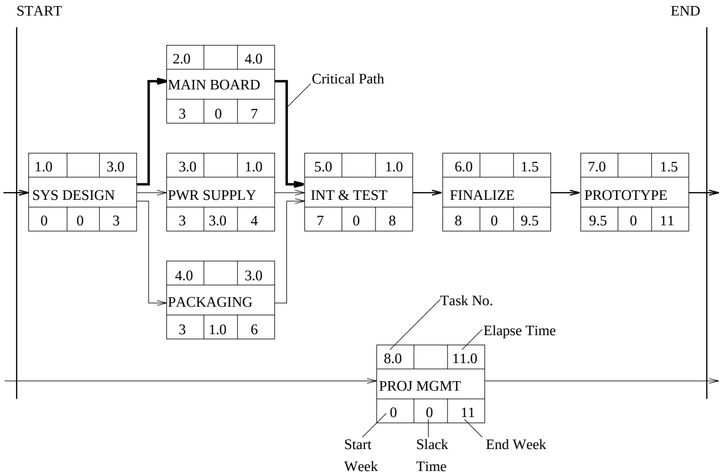

Figure 5.4: AOA Example

Key Elements of Network Diagrams: Precedence, Critical Path, and Slack Time.

5.4.2 Reviewing the Work Definition

There may exist some opportunities for improving the schedule:

- Observe the critical path and try to make it shorter by adding parallel tasks.
- Review to precedence to get better results.(Sometimes may introduce risk)

Trade-offs adding effort, adding personnel, and adding risk...

5.4.3 Bar Charts

Bar charts, such as *Time-Line Diagrams, Gantt charts, and milestone charts*, present a project tasks as horizontal lines or bars along a time axis.

Bar charts are derived from network diagrams. They are better to presentation but network diagram is better for developing the schedule.

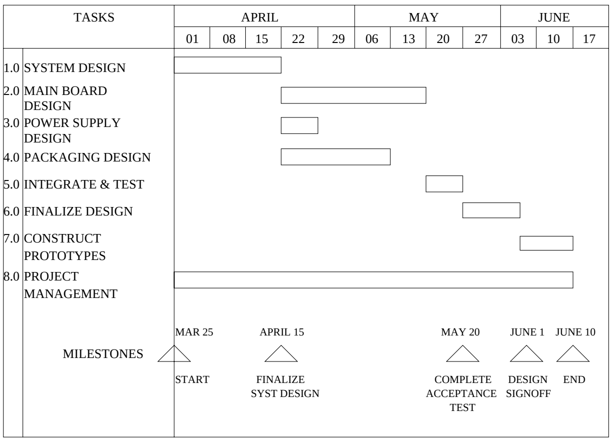

Figure 5.5: Bar Chart

5.4.4 Additional Comment on Scheduling

A common reasons to iterate the plan is to improve the presentation to sell our design. Problem of presentations include:

- Too many tasks make schedule confusing
- Too few tasks results in a loss of necessary detail
- Imbalance in tasks
- Not clearly shows each individual's tasks and responsibilities.

Note 5.4.1 *The project management system must serve the project.*

Note 5.4.2 *The sophistication of the system has no bearing on the accuracy of the information it presents.*

5.5 PLANNING RESOURCES AND ESTIMATING COSTS

5.5.1 Costing Practice

Note 5.5.1 *Usually the most significant cost of a engineering design is the costs of personnel.*

Note 5.5.2 *Be aware of* Overhead Costs.

Some cost sources:

- Personnel
- Lab, shop and other internal facilities
- Outside services and facilities
- Supplies and materials

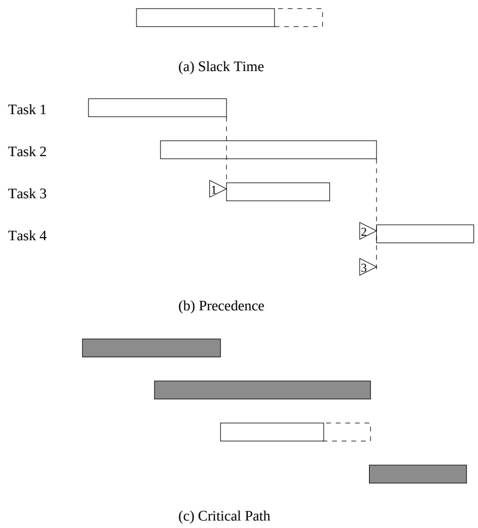

Figure 5.6: Bar Chart Practices(a)Slack Time (b) Precedence (c) Critical Path

5.5.2 Estimating Personnel Requirements

Two different ways to approach toward personnel requirements:

1. Take the work definition and schedule and simply determine how many people are required to get the job done.
2. Look around at who is available to do the work and then figure out how to organize them to complete the project, revising the schedule to meet their availability.

Usually, a *Middle-of-the-road* method is preferred— take a look at what is required to meet the schedule and then temper this with staffing limitations.

A useful tool is Personnel Histogram with following benefits:

- Provide the distribution of personnel
- Show personnel requirements

Note 5.5.3 *Avoid the use of overtime — any available overtime will be needed later when the unforseen problems arise.*

Note 5.5.4 *Never plan for a person's availability of more than 80 percent.*

5.5.3 Budget Preparation

Some elements: total expenditure, cash flow, cost distribution, and review of the work description and the schedule.

5.5.4 Putting the Plan Together

The typical outline for a project plan is shown as follows:

1. Background
2. Project Overview
3. Organizational and Management

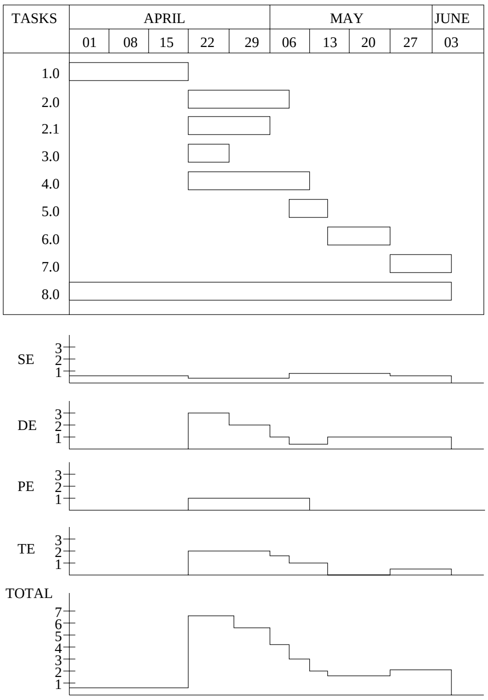

Figure 5.7: Bar Chart and Personnel Histogram

(a) Personnel
(b) Organizational and Responsibilities
(c) Monitoring and Reporting

4. Description of Work
5. Schedule
6. Budget
7. Attachments

A Requirements Specification
B System Specification

Consider each section of the plan outline:

Background Provide history, work has been done so far, constraints, key decisions, market forecasts, feasibility studies, etc.

Project Overview Summarize the entire plan, emphasizing deliverables, dates, and costs. To provide the basic understanding of the project

Organizing and Management List personnel's skills, responsibilities, assigned tasks, and expected deliverables. Show the organization structure. Describe the frequency and content of project progress reports and methods using in budget and schedule control.

Description of Work details about the work

Schedule A bar-chart-type schedule with accompanying description of key dates, area of risks, and additional information that supports scheduling decisions.

Budget Provide a cost breakdown. Show the *cash flow or schedule expenditures.*

Attachments Supporting documents

5.6 MANAGING THE PROJECT

Three functions: monitoring, reporting and problem resolution.

5.6.1 Performance Monitoring

Performance monitoring evaluates the performance of each block plus any interface anomalies that may arise. It is accomplished through informal communication with team members as well as through formal mechanisms such as design reviews and acceptance tests.

5.6.2 Task Progress

Primary measure: percent complete

5.6.3 Schedule Status

Note 5.6.1 *It is important to distinguish the most serious task.*

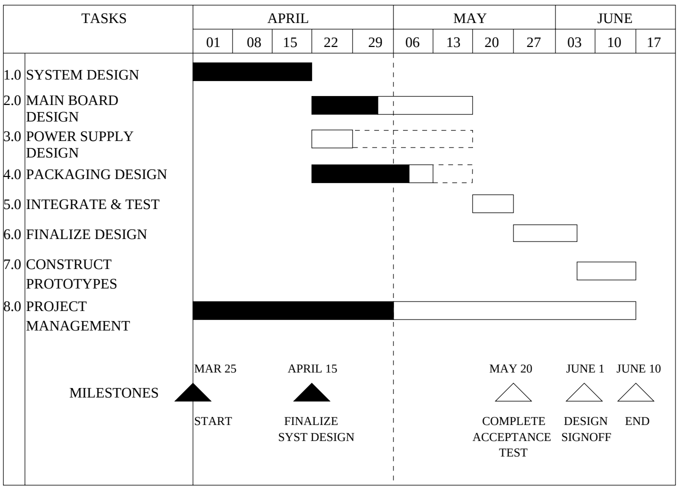

Figure 5.8: Schedule Status

5.6.4 Budget Status

Key questions:

- Are expenditures occurring in the amount planned?
- Are expenditures occurring when they were planned?
- Will the project cost end up the same as was estimated by the plan?

Additional information on how the funds have been spent, how much for personnel, how much for materials, how much on certain tasks, etc., is often provided. Usually three periods are included: Current Period, To date, and At completion.

Elements

- expenditures breakdown (personnel cost and other costs)
- project total
- comparison between estimated cost and actual cost

An *S-Curve* helps to visualize the budget tracking.

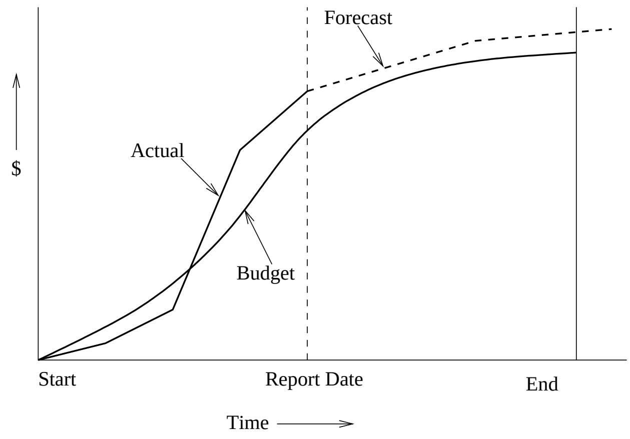

Figure 5.9: S Curve

A bar chart may help to combine budget and schedule reporting.

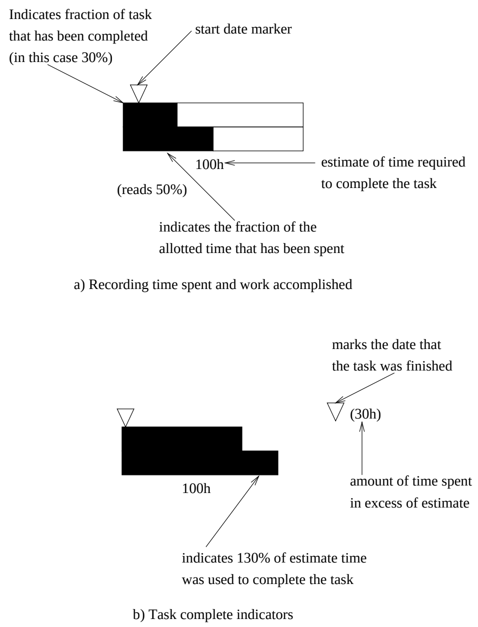

Figure 5.10: Bar Chart Reporting Practice (a) Time Spent and Work Accomplished (b) Task-Complete Indicators

5.6.5 Reporting

Usually a monthly report will suffice but we have to note that the progress report has many audiences. A typical structure is shown:

1. Summary of work completed
2. Problem areas
3. Plans for next period
4. Schedule and budget
5. Attachments

   A Project schedule
   B Project Summary

5.6.6 Problem Resolution

Three typical types of problems:

- Longer time
- Cost more
- Technically infeasible

Solutions are categorized below:

1. Accept the delay but stay within the budget
2. Add resources and increase project cost
3. Change the deliverables
4. Reorganize the project to utilize resources more effectively.

Note 5.6.2 *The last two solutions require an amendment to the plan. This should be done with the concurrence and approval of all parties who originally agreed to the plan.*

Note 5.6.3 *If a project encounters problems that extend the schedule or add cost, it is better to acknowledge these overruns, estimate the impacts, and track them through the progress reports.*

5.7 SUMMARY

Central to the management process is *plan*. Through its elements—the description of work, the schedule, and the budget—it describes for us how the project is to be conducted, when it will be completed, and how much it will cost.

Chapter 6

DETAILED DESIGN, TESTING, AND DESIGN MANAGEMENT

6.1 BLOCK DESIGN

Figure 6.1 illustrates the activities that are required to take the output of the system engineering work and turn it into a working prototype.

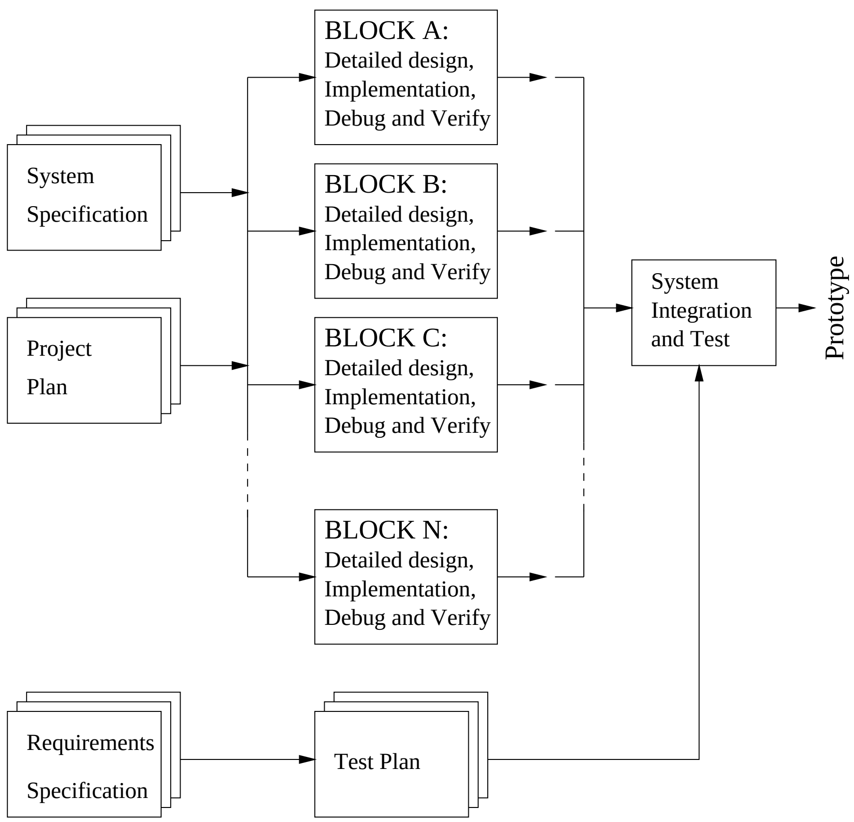

Figure 6.1: Activity Map Showing where Detailed Design and System Integration Fit into the Design Process

The figure shows:

- The detailed design, implementation and debugging of all the individual blocks must be completed before these blocks can be combined into an integrated system and tested.

- Any one block can be designed independently of the others using information from the system specification, a document that was generated with this in mind.
- The project plan contains other nontechnical but still important information relating to schedules and responsibility assignments.

The prototype is tested against the performance requirements listed in the requirement specification. These tests will determine:

- Whether or not the design is acceptable
- In the case of contracted design, whether or not the customer will pay

Because of the importance of these tests, a detailed test plan is prepared **in advance**. To catch any incorrect interpretation of the requirement specification, the test plan is commonly prepared by an engineer who has had no prior involvement on the design or an impartial third party such as an independent consultant. The test plan will normally indicate:

- When the test is to be prepared
- Who is responsible for preparing it
- Who will conduct the tests

Block design and implementation can be broken into four activities:

Detailed Design The design is first synthesized, then analyzed, and then refined with synthesis / analysis cycle.

Implementation

Debug and Verification **Debug**: An activity that removes errors in the design and mistakes in implementation. Verification Tests done to assure the circuit or program performs within the tolerance specified in the system specification.

Documentation Detailed design documentation is an extensive package including schematic diagrams, PCB wiring artwork, silk-screen artwork, solder-mark artwork, drilling plan, parts lists, etc.. It is a main deliverable of the design effort.

The relationship of these activities among themselves and with the overall design process is shown in Fig 6.2.

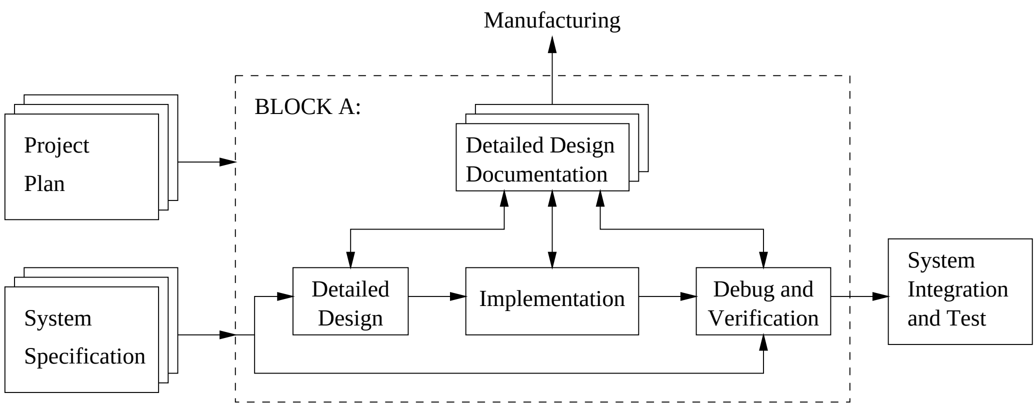

Figure 6.2: Activities Involved in Block Design Process

Note 6.1.1 *There are fuzzy lines between design, documentation and debugging. But all of them are important. It is suggested to spend equal time on each of them.*

6.2 DESIGN MANAGEMENT

Main factors associated with managing a design project.

6.2.1 Communication

Although minimizing interaction, especially distracting is important, sometimes, interaction between designers and project manager is necessary.

As the design processes, the designer will interact more frequently with people from marketing and manufacturing. ”Over-the wall engineering” is not a good approach.

Taking and making notes during meetings, telephone conversations are easy and effective way of increasing concentration and producing well-formulated thoughts.

6.2.2 Documentation Control

Note 6.2.1 *From the development of the requirements specification through he system specification and on to the detail design documentation, the need to put all relevant design information in one place cannot be overemphasized.*

A typical title block found on most design documents:

<table>
<tr><th colspan="5">Revisions</th></tr>
<tr><td></td><td>Date</td><td>Description</td><td>Drwn</td><td>App</td></tr>
<tr><td>1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td></td><td></td><td></td><td></td></tr>
<tr><td>5</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Drawn:</td><td colspan="2">Approved:</td><td>6/4/03</td></tr>
<tr><td colspan="5">RPM Monitor - Pulse Shaper</td></tr>
<tr><td colspan="2">SC/08-03514-PS.7</td><td>A</td><td colspan="2">Page 1 of 3</td></tr>
</table>

Figure 6.3: Documentation Issue Control

During the design process, there may occur two levels of document changes:

- Changes directly made to the document as handwritten notations or alterations. They are described in the revision table and a revision number is assigned.
- Accumulate all the changes and redraw , redraft or otherwise reissue the document. The document is given a new issue number and revision number.

Note 6.2.2 *Both revisions and reissues must be approved by the designer in charge and by someone with overall responsibility for the design, usually the project manager.*

Note 6.2.3 *The detailed design documentation is the key document. Every change must be reviewed by all affected designers, agreed to, and adequately documented.*

Rule 6.2.1 *As a general rule, design sketches and revisions should be formalized when other stakeholders in the design require such information.*

6.2.3 Design Reviews

The design review are another important tool for managing the design process:

- It aids in keeping all members of the design team up to date on the overall stage of design and on how other fellow members of the design team are progressing.
- It aids in keeping other stakeholders up to date and of obtaining their input on critical design decisions.

Design reviews will typically be conducted at every important milestone, including the completion of requirement specification, system specification, detailed design, and system test.

6.3 PRINCIPLES OF TESTING

Note 6.3.1 *Considerations of testing must begin with the needs analysis and continue through all stages of the design process.*

6.3.1 Stages of Testing

It is important to differentiate between **testing of the design** and **testing of the construction of the product and system** that is the output of the design. The former is to make sure the design meets its **design objectives** and the latter is to make sure the design meets **requirements specifications**.

As illustrated in Fig 6.4, if design flaws are not found and corrected during system test, finding them later can be very expensive.(Note: Even this figure is conservative!!)

6.3.2 Test Practice

Complex systems may present challenging testing requirements. A common testing problem relates to infrequent events. Another is how to verify specifications that cannot be directly tested. Long-term specifications are a third difficult area.

Test setups, also called testbeds, often are a design exercises in themselves and product design and test design should be done concurrently for the following reasons:

- To allow parallel design and construction of the testing facilities, speeding the time to market.
- To ensure that “hooks” for testing are incorporated in the design of the product.

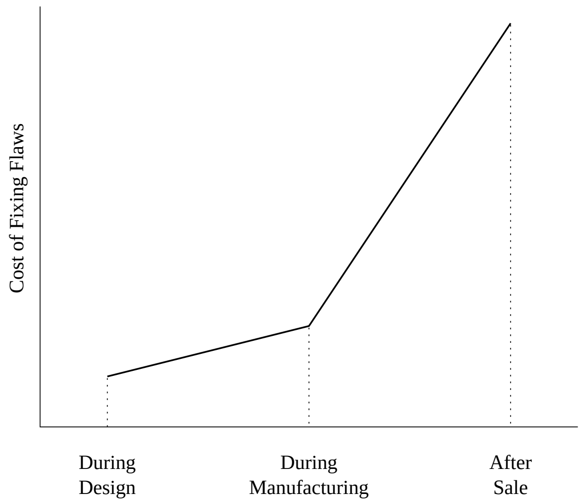

Figure 6.4: Cost of Fixing Design Flaws When Found During Design, During Manufacture, or After Sale

6.3.3 The System Test

In most instances the system test is a formal event.

Main points to be included in any formal test plan:

1. Provide adequate references to documentation, standards, test and measurement procedures, and computational methods.
2. Define the instrumentation required to undertake the tests and describe how it is to be configured.
3. Describe the conduct of the tests, including the sequence of steps to be followed and recording of the results.

Note 6.3.2 *Each individual test will include a formal signoff, where all concerned parties agree they have witnessed a successful test.*

6.4 CONCLUSION

If the design process has been properly structured, well managed and thoroughly executed, there will be few surprises during the system testing. Certainly, overlooked problems will surface and flaws will be exposed. These will require a review of earlier decisions, perhaps as far back as the need analysis. A structured approach will allow the deficiencies to be redressed and a successful design delivered. If the design process, including testing, has been methodically carried out, it is unlikely that the design will fail completely in its final test, that it will be determined to have completely missed the mark and will not satisfy the needs it was intended to.

The system test answers the question that "How will everyone with a take in the design know then it is done". It verifies if the design is completed — if it meets the objectives originally agreed to and will satisfy the needs of the customer.