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# ENGR 110 / 112 – Design I

# Design Process

## Final Design Stages and Project Management

Instructor: Dr. Flavio Firmani

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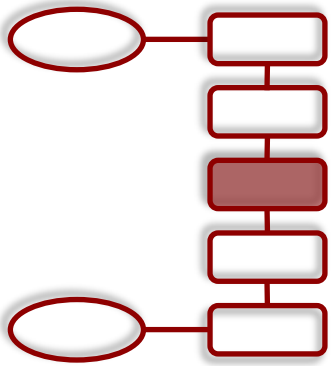
# Preliminary Design



Here we identify the principal attributes of the design concepts to make a selection.

Input: *Alternative conceptual designs*

*Design and Functional Requirements (specs)*

Tasks: *viii) Metrics for final criteria*

*ix) Select a design alternative*

*x) Analyze chosen design*

*xi) Test and evaluate chosen design*

Outputs: *Selected design*

*Test and evaluation results*

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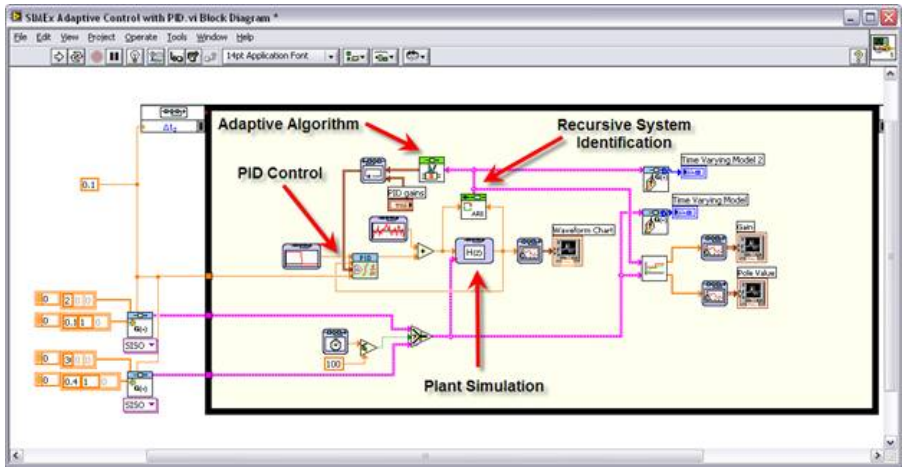
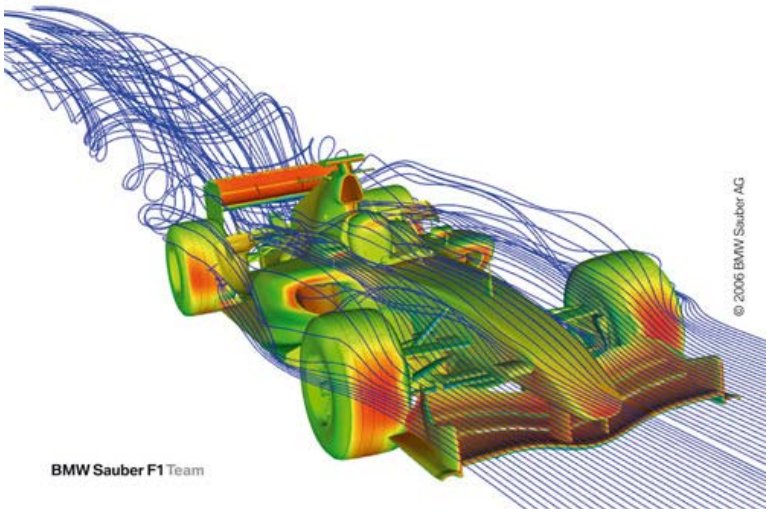
# Preliminary Design

## Analysis of Chosen Design

Geometric Modeling (CAD)
Mathematical Modeling
Computer Simulations

NATIONAL INSTRUMENTS LabVIEW™



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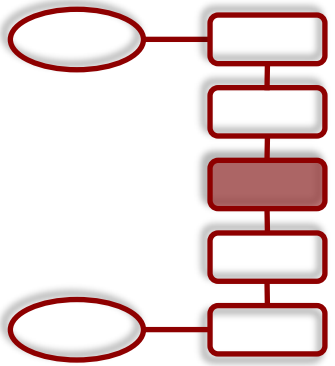
# Preliminary Design



Modeling and Simulation is the process of creating and analyzing the response of a digital prototype.

It is inexpensive and easy to modify. For example, in a mathematical model, we can either add or remove components, or we can change the characteristics of a particular element, *e.g.*, change the material.

With the results obtained from the simulation, designers and engineers understand under what conditions and in which ways a part could fail and what loads it can withstand.

However, these models are not perfect as they do not contain all the factors of a real system.

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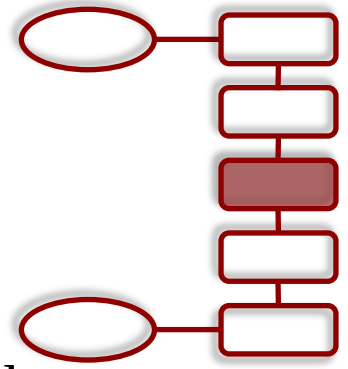
# Preliminary Design



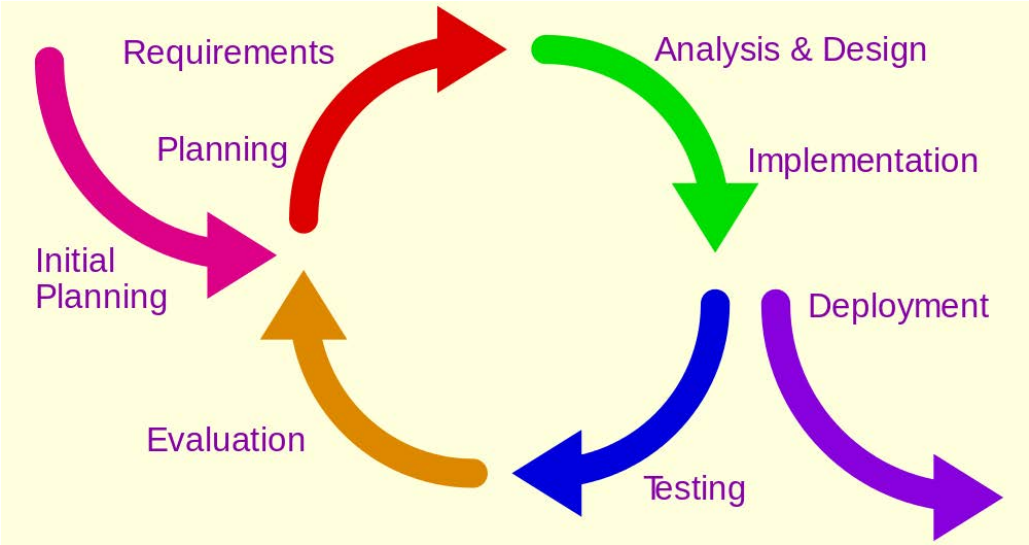
## Testing

- *Prototype*. A prototype is a full-scale working model of the designed artifact. It is tested in the same operating conditions where the product should function.
- *Physical Model*. A model is generally smaller and made of a different material than the original artifact. They are tested in controlled environments to validate their expected behavior.
- *Proof of Concept*. It refers to a model that is used specifically to test whether a particular concept will actually work as proposed.
- *Alpha Testing*. In computer science, alpha testing is employed for off-the-shelf software as a form of internal acceptance testing, before the software goes to beta testing.

# Preliminary Design

## Evaluation

- Are the objectives met?
- The results of these tests are fed back into the previous stages to *verify* that the design performs as intended.




Cycle of the Design Process. Courtesy of Interaction Design Foundation

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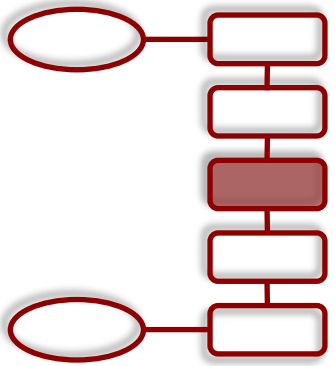
# Preliminary Design



## Iterative Process

Even though, the design process has been presented as a sequential process, it is important to revisit early stages.

Determining the need to iterate is important to improve the design process on feasibility, cost, time, and quality.

Iterating continues even after the product has already been launched into the market, as you may be looking into making improvements to the product.

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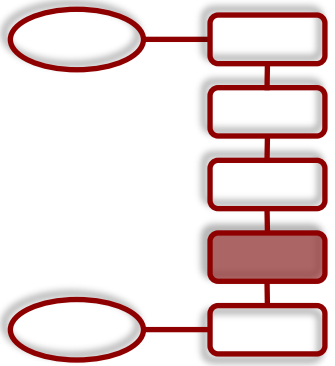
# Detailed Design



Here we refine and fix the design details.

Input: *Selected design*

*Test and evaluation results*

Tasks: *xii) Refine and optimize the chosen design*

Outputs: *Proposed fabrication specifications*

*Final design review for client*

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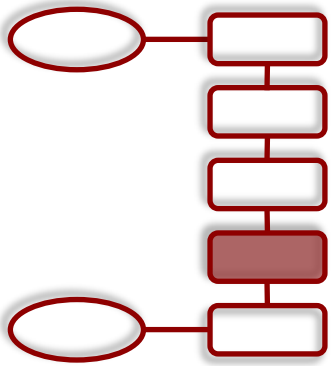
# Detailed Design



## Regulations

- Design Codes
- Handbooks
- Local laws and regulations

## Detailed Design

- Design optimization
- Refine design

## General Review

- Formal review
- Public hearings (if applicable)
- Beta testing

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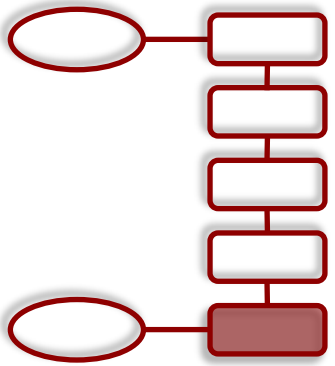
# Design Communication



Here we document the fabrication specifications and their justification.

Input: *Proposed fabrication specifications*

Tasks: *xiii) Document the final design*

Outputs: *Description of design process*

*Drawings and design details*

*Fabrication specifications*

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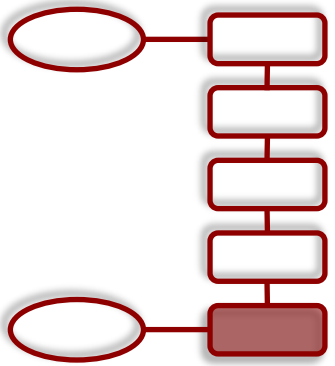
# Design Communication



## Documentation

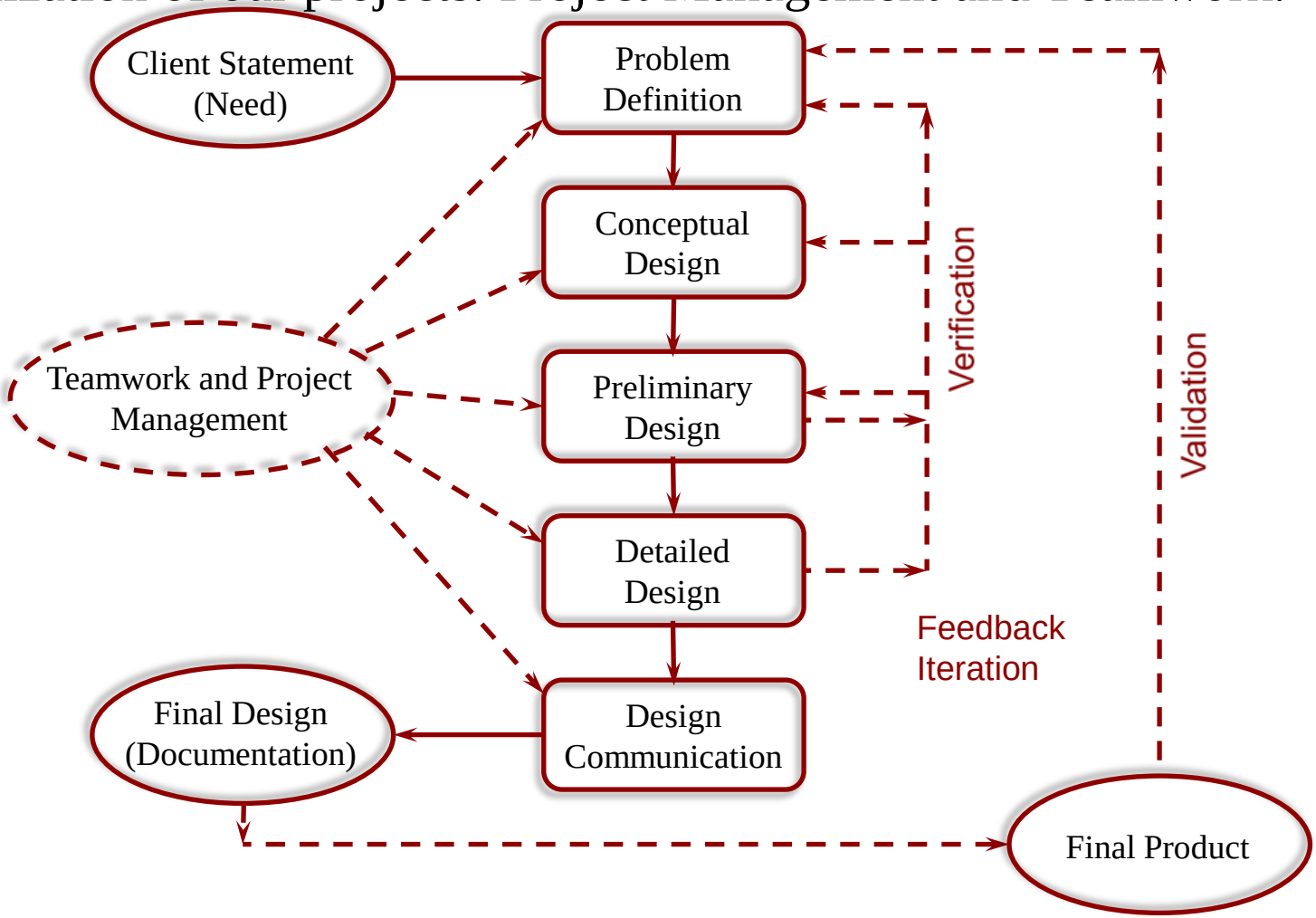
- Design Drawings (blueprints)
- Geometric Dimensioning and Tolerancing (GD&T)
- Fabrication Costs
- Justification of design requirements

## Oral Presentation

## Final Report

# Engineering Design

In engineering design, there are two aspects that critically affect the realization of our projects: Project Management and Teamwork.



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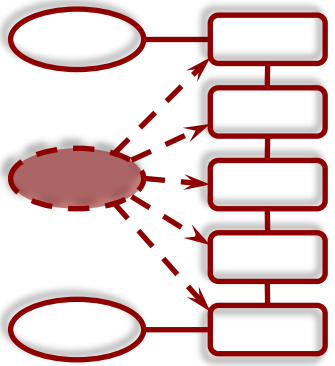
# Project Management



## Overview of Project Management

- Design Management Definition
- Functions of Management
  - Organizing
  - Scheduling
  - Leading
  - Controlling

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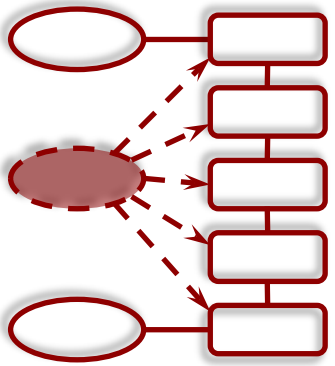
# Design Management



## Design Management Definition

As designers, we have to make decisions that will affect the outcome of our design.

There are three elements that are required to *manage* for a successful design project ($S^3$):

*Scope*
*Spending*
*Schedule*

The project must accomplish the goals (a successful design), it must be completed within the financial resources available, and it must be done "on time".

Limitations in any of the $S^3$ would require a trade off, *e.g.*, tight budget would result in smaller scope or longer schedule.

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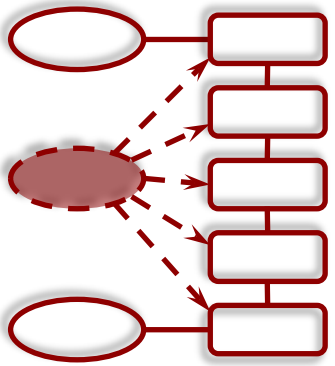
# Functions of Management



## Organizing:

It consists in identifying the tasks to be completed and defining who is responsible to complete each task.

***Work Breakdown Structures (WBS)*** – WBS is a listing of all the tasks needed to complete the project, organized in a way that helps the design team understand how all the tasks fit into the overall design project.

- Determine the top-level tasks and breakdown into smaller (mutually exclusive) tasks.
- No task should be long (80hr rule, 80min ENGR 110)
- WBS should include every task or activity
- Tasks should add up to 100% of the work (time).

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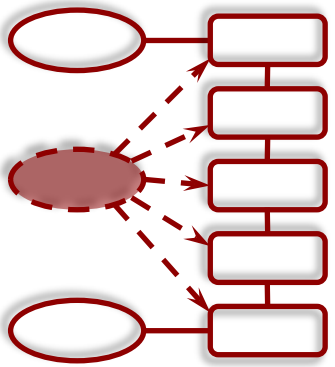
# Work Breakdown Structures



## Example

| Design Project | 0 |
|---|---|
| | 100.0 |

| Problem Definition | 1.0 |
|---|---|
| | 8.5 |

| Clarify Project | 1.1 |
|---|---|
| | 2.0 |

| Conduct Research | 1.2 |
|---|---|
| | 3.0 |

| Consumer Needs | 1.2.1 |
|---|---|
| | 0.5 |

| Prior Designs | 1.2.2 |
|---|---|
| | 1.5 |

| Norms & Regulations | 1.2.3 |
|---|---|
| | 1 |

| Design Objectives | 1.3 |
|---|---|
| | 3.5 |

| Objective Tree | 1.3.1 |
|---|---|
| | 2.0 |

| Review w/ Stakeholder | 1.3.2 |
|---|---|
| | 1.5 |

| Project Management | 2.0 |
|---|---|
| | 4.0 |

| Weekly Meetings | 2.1 |
|---|---|
| | 2.0 |

| Meet Client | 2.2 |
|---|---|
| | 2.0 |

| Function Analysis | 3.0 |
|---|---|
| | 5.0 |

| Conceptual Design | 4.0 |
|---|---|
| | 15.0 |

| Detailed Design | 5.0 |
|---|---|
| | 10.0 |

| Prototype Fabrication | 6.0 |
|---|---|
| | 30.0 |

| Testing / Validation | 7.0 |
|---|---|
| | 17.5 |

| Proof-of-Concept | 7.1 |
|---|---|
| | 0.5 |

| System Tests | 7.2 |
|---|---|
| | 12.0 |

| Electrical Subsystem | 7.2.1 |
|---|---|
| | 5.0 |

| Mechanical Subsystem | 7.2.2 |
|---|---|
| | 5.0 |

| Software Subsystem | 7.2.3 |
|---|---|
| | 2.0 |

| System Integration | 7.3 |
|---|---|
| | 3.0 |

| Evaluation | 7.4 |
|---|---|
| | 2.0 |

| Documentation | 8.0 |
|---|---|
| | 10.0 |

Top-Level Task Number

Percentage of Work (Time)

Subtask Number

Percentage of work of 2nd level tasks should add the percentage of work of top-level task.

Percentage of work of 3rd level tasks should add the percentage of work of the 2nd level tasks.

Incomplete WBS

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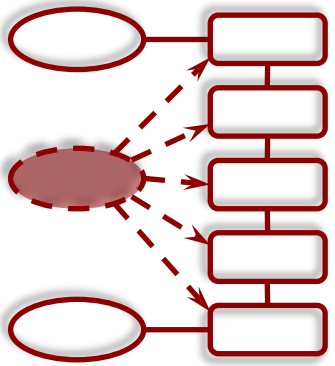
# Organizing



***Linear Responsibility Charts (LRC)*** – LRC lists all the tasks to be managed and matches them with the people who will be assigned to participate in the completion of this task.

- Assign responsibilities for each task
- List all the members of the team as well as the supervisor, client, or anyone involved in the design.
- List all tasks and lower level tasks and assign the role that each participant takes in each one of them (primary role, secondary role, etc.)
- Use the WBS to form the list of tasks and the different levels of subtasks.

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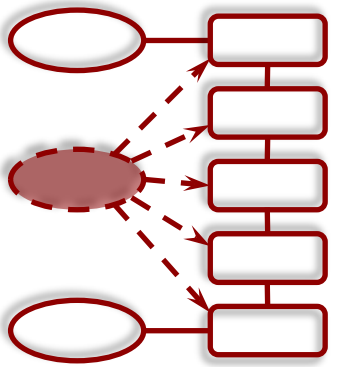
# Linear Responsibility Charts



## Example

| Linear Responsibility Chart | Team Member #1 | Team Member #2 | Team Member #3 | Team Member #4 | Team Member #5 | Director of Design | Client Liaison | Client Research Director | Outside Consultant |
|---|---|---|---|---|---|---|---|---|---|
| 1.0 Understand Customer Requirements | 1 | | | | | | | | |
| 1.1 Clarify Problem Statement | 1 | 2 | 2 | 2 | 2 | | 3 | 4 | |
| 1.2 Conduct Research | 1 | 2 | | 2 | 2 | | 4 | 4 | 4 |
| 1.3 Develop Objectives Tree | 1 | | | | | | | | 4 |
| 1.3.1 Draft Objectives Tree | | | 2 | 2 | | 5 | 5 | 3 | 4 |
| 1.3.2 Review w/ Client | 1 | | 2 | | | 5 | 5 | 3 | 4 |
| 1.3.3 Revise Objectives Tree | 1 | | 2 | 2 | | 6 | | 4 | |
| 2.0 Analyze Function Requirements | 2 | 2 | 1 | 2 | 2 | 5 | 4 | 3 | 3 |
| 3.0 Generate Alternatives | | | | 1 | | | | | |
| 4.0 Evaluate Alternatives | 5 | 1 | 2 | 2 | 2 | | | | |
| 4.1 Weigh Objectives | 1 | 2 | | | | 5 | 6 | | |
| 4.2 Develop Test Protocol | 5 | 1 | | | 2 | 5 | 4 | 3 | 3 |
| 4.3 Conduct Tests | | 1 | 2 | | 2 | | | 5 | 3 |
| 4.4 Report Test Results | 5 | 2 | 2 | | 1 | 5 | 5 | 5 | 5 |
| 5.0 Select Preferred Design | 1 | 2 | | | 2 | 5 | 6 | 4 | 4 |
| 6.0 Document Design Results | | 1 | | | | | | | |
| 6.1 Design Specifications | 1 | | | 2 | | 6 | | | |
| 6.2 Draft Final Report | 5 | 1 | | 2 | | 5 | 5 | | 4 |
| 6.3 Design Review w/ Client | 1 | 2 | | 2 | | 5 | 3 | 4 | 3 |
| 6.4 Final Report | 5 | 1 | | 2 | 2 | 5 | 6 | 4 | 4 |
| 7.0 Project Management | 1 | | | | | | | | |
| 7.1 Weekly Meetings | 1 | 2 | 2 | 2 | 2 | | | | |
| 7.2 Develop Project Plan | 1 | 2 | 2 | 2 | | | | | |
| 7.3 Track Progress | 1 | | | | | 5 | | | |
| 7.4 Progress Reports | 1 | | | | | | 5 | | |

| Key: |
|---|
| 1 = *Primary responsibility* |
| 2 = *Support/work* |
| 3 = *Must be consulted* |
| 4 = *May be consulted* |
| 5 = *Review* |
| 6 = *Final Approval* |

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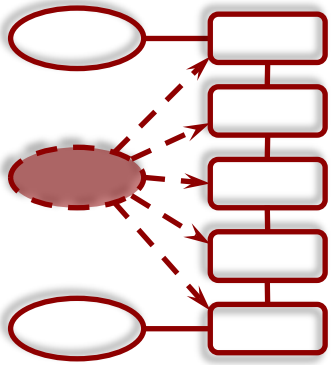
# Functions of Management



## Scheduling:

Scheduling and similar time management tools help us identify in advance those things that can affect our project if we are unable to complete them.

There are three primary scheduling tools that are frequently used in project management:

- Calendar
- Project Network
- Gantt Chart

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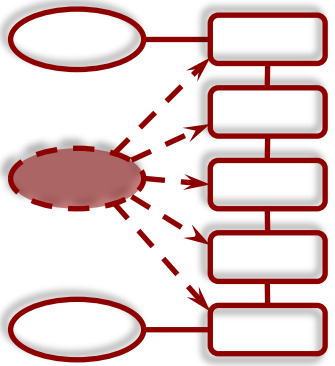
# Calendar



A Calendar is simply a mapping of the deadlines onto a conventional calendar.

**Design Team**

**April**

March

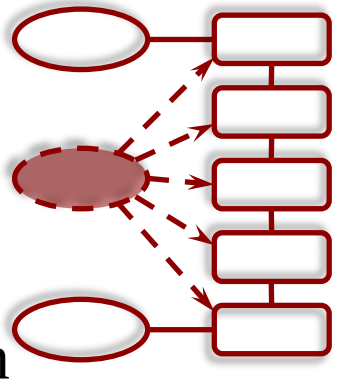
| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | 31 | | | |

May

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | | | 1 |
| 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 3 | 14 | 15 |
| 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| 30 | 31 | | | | | |

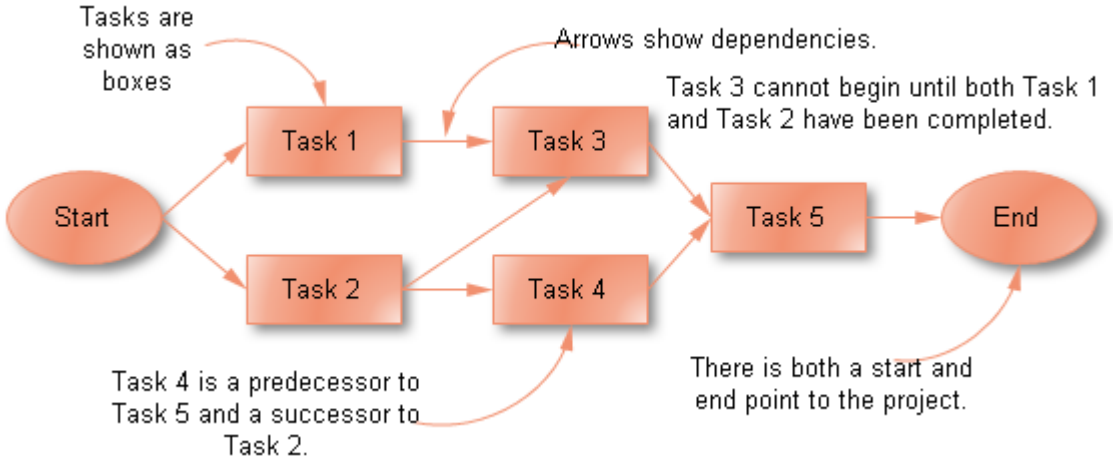
| Sun | Mon | Tue | Wed | Thu | Fri | Sat |
|---|---|---|---|---|---|---|
| | | | | 1 | 2 5:00PM Prototype Built | 3 |
| 4 | 5 | 6 7:00–8:15PM Team Meeting | 7 | 8 | 9 11:00AM Proof of Concept Due | 10 |
| 11 | 12 11:00AM Rough Outline Due | 13 7:00–8:15PM Team Meeting | 14 | 15 | 16 5:00PM Topic Stce Outline Due | 17 |
| 18 | 19 11:00AM Prsntion Outline Due | 20 7:00–8:15PM Team Meeting | 21 11:00AM Slides Due | 22 | 23 5:00PM Draft Final Report Due | 24 |
| 25 | 26 10:00–11:00AM Present Results | 27 7:00–8:15PM Team Meeting | 28 | 29 | 30 5:00PM Final Report Due | |

# Project Network



A Project Network (Activity Network) is a flow chart of the activities and events associated with the project and shows the logical ordering in which they must be performed.

It is always drawn from left to right to reflect the chronology of the events during the project. The chart shows the sequence in which the project's terminal elements (tasks and subtasks) are to be completed and their **dependencies**.



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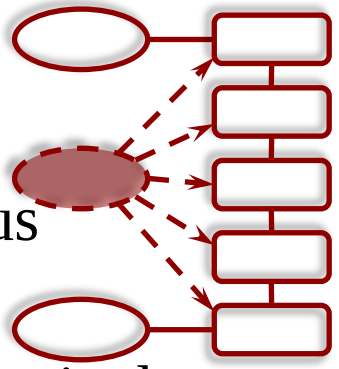
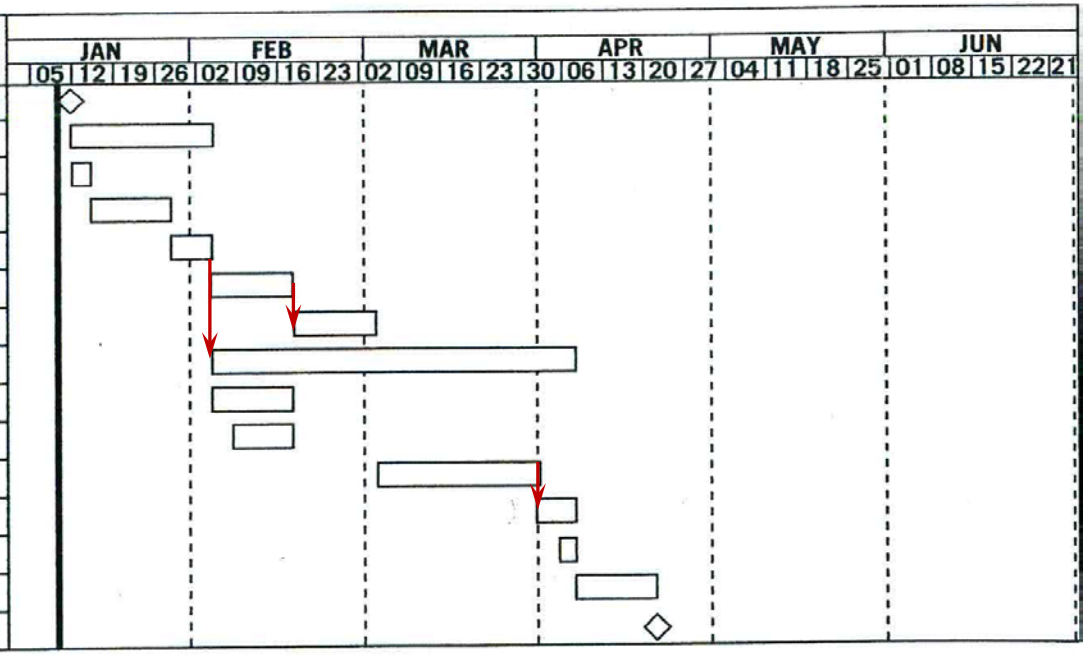
# Gantt Charts



Gantt Charts are a horizontal bar graph that maps various design activities against time (you can use MS Excel).

Gantt charts illustrate the start and finish dates of the terminal elements and summary elements of a project. Specialized software has the capability to show dependencies.

| Description | Rem Dur |
|---|---|
| Start Project | 0 |
| Understand Customer Requirements | 18* |
| Clarify Problem Statement | 3 |
| Conduct Research | 10 |
| Develop Objectives Tree | 5 |
| Analyze Function Requirements | 10 |
| Generate Alternatives | 10 |
| Evaluate Alternatives | 45* |
| Develop Weighted Objectives | 10 |
| Develop Test Protocol | 8 |
| Conduct Tests | 20 |
| Report Test Results | 5 |
| Select Among Alternatives | 3 |
| Document Design Process | 10 |
| End Project | 0 |



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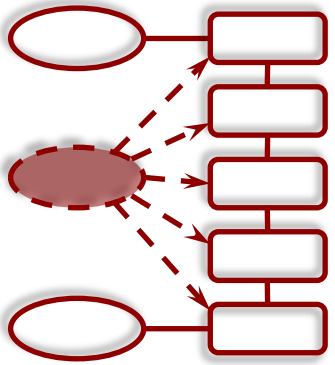
# Functions of Management



## Leading:

It is the process of influencing others to engage in behaviors necessary to reach the desired goals.

Team Roles: It is important to define the roles of each member in the beginning. (Team Leader, Team Member, Treasurer, etc.)

Fair Work: To avoid destructive conflict it is important to distribute the workload equitably.

Team Leader: Tracks team's goals and achievements, communicates progress to team members, removes barriers in team progression, coordinates and runs meetings, helps to resolve conflict.

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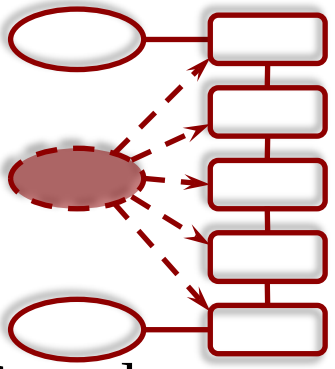
# Functions of Management



## Controlling:

It is the process of *monitoring* and regulating the process toward achieving the desired goals. Percent Complete Matrix is a tool that determines the overall status of the project.

**Percent Complete Matrix**

| Task | Planned Duration (days) | Percent of Total | Status (see key) | Credit (days) |
|---|---|---|---|---|
| Start Project | 0 | 0% | 2 | 0.0 |
| Clarify Problem Statement | 3 | 3% | 2 | 3.0 |
| Conduct Research | 10 | 11% | 2 | 10.0 |
| Draft Objectives Tree | 2 | 2% | 2 | 2.0 |
| Review OT | 1 | 1% | 2 | 1.0 |
| Revise OT | 2 | 2% | 2 | 2.0 |
| Analyze Functions | 10 | 11% | 1 | 3.3 |
| Generate Alternatives | 10 | 11% | 1 | 3.3 |
| Develop Weighted Objectives | 10 | 11% | 2 | 10.0 |
| Develop Test Protocol | 8 | 9% | 1 | 2.6 |
| Conduct Tests | 20 | 21% | 0 | 0.0 |
| Report Test Results | 5 | 5% | 0 | 0.0 |
| Select Among Alternatives | 3 | 3% | 0 | 0.0 |
| Document Design Process | 10 | 11% | 0 | 0.0 |
| End Project | 0 | 0% | 0 | 0.0 |
| | | | | |
| Total Days Budgeted | 94 | 100% | | 39.6% |
| | | | | |
| Key: 0 = Not Started, No Credit, 1 = In Process 1/3 Credit, 2 = Completed, Full Credit | | | | |