Introduction to Project Management

CEE 1.040 – Project Management

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Portfolio
A group of programs and projects
**Aim:** to meet a strategic business objective
**Focus:** Prioritization of resource allocation among programs and projects; Alignment of portfolio with organizational strategies

Program
A group of projects
**Aim:** to manage related projects in a coordinated way to obtain benefits and control not available otherwise.
**Focus:** Resolving resource conflicts among projects; Alignment of strategic directions that affect program and project goals; Change Management within shared governance.

Project
**Aim:** to achieve goal of the project
**Focus:** To strike a balance between cost, quality and time; Satisfaction of Stakeholders

Hierarchy of Portfolios, Programs, and Projects

Text Source: PMBOK
Relationship between Environmental Portfolio, Program, and Project

**Portfolio**
Environmental Site Assessments, Green Design, Energy Audits, Composting, Waste-to-Energy

**Program**
Environmental Site Assessments (e.g. LUSTs, RCRA facilities, and Superfund sites) across the United States

**Project**
Assessment of a discrete Federal Superfund site in Crosby, Texas
**Project Phases**

The project life cycle is generally a suite of sequential and/or overlapping project phases

- Starting the project
- Organizing and preparing
- Carrying out the project work
- Closing the project

Project phases describe a project activities as a function of time

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**Process Groups**

The project management process groups include the following activities

- Initiating
- Planning
- Executing
- Monitoring
- Closing

Process groups describe project management process activities
Project Phase

Project Phases are divisions within a project where extra control is needed to effectively manage the completion of a major deliverable.

Project phases are typically sequential, but can overlap in some project cases. Usually all the project phases in the project possess similar characteristics and hence, can be treated as a small project within a project.

All the project management process groups are executed as per requirement, in every project phase.

Example of a Single Phase Project (e.g. Organizing & Preparing)

Source: PMBOK
Multi-Phase Projects: Projects within Projects

Example of a sequential three Phase Project: Demining of a Land Area

- Marking and Searching the Area
- Removing of Land Mines
- Restoring the Land and Re-checking

Example of an overlapping three Phase Project: Development of an Integrated Circuit (IC)

- Circuit Design
- Circuit Programming
- Parallel Prototyping and Testing

Text Source: PMBOK
Project Phase Boundaries

The 5 different process groups have clear dependencies and are typically performed in the same sequence on each project. Process groups are not project phases and are independent of the area of application or the industry.

The processes within the process group may be iterated in order to achieve the desired project objective.

For example: project phases could be market survey, design phase, production phase, testing phase etc. All the 5 process groups are performed within each phase and could also be iterated may the need arise.
Each project phase happens only once in every project. A process group, however, can appear multiple times during a project and each project phase can be looked at as a sub-project within a project within which all process groups occur.
Initiating Process Group

Planning Process Group

Monitoring and Controlling Process Group

Executing Process Group

Closing Process Group

Level of Activity in a Process Group

Start

1 2 3

End

Source: PMBOK
# PMI Approach to Management of Projects

## Knowledge Areas

- Integration
- Scope
- Time
- Cost
- Quality
- Human Resources
- Communication
- Risk
- Procurement

## Process Group

- Initiating
- Planning
- Executing
- Monitoring and Controlling
- Closing

**Project Management Processes**

*Source: PMBOK*
Conceptualizing the Project Life-Cycle
Phases, Groups, Effort, Deliverables, Kill Points
Project Life-Cycle: $f(\text{effort/phase})$

- Initiation
- Conceptual Goals
- Growth
- Organizational Definition
- Production
- Operational Acquisition
- Shut Down
- Divestment

Project Life-Cycle: $f(\% \text{ complete})$

- Feasibility
- Project Formulation
- Strategy Design
- Project Approval
- Planning & Design
- Detailed Cost
- Detailed Schedule
- Contract
- Production
- Manufacturing
- Construction
- Delivery/Installation
- Final Testing
- Turnover
- Startup
- Maintenance

Project Life-Cycle: $f(\% \text{ complete})$

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- Startup
- Maintenance


Kill points
Project Life-Cycle: $f(\%\text{effort/phase})$

Initiating (Defining Needs)  Planning (Creating Baseline)  Performing (Tracking and Managing)  Closing

After Gido & Clements, Successful Project Management, South-Western, 2012
Outline

Product design

Engineering design process

Project design
Product Design
Waterfall Product Development
(Royce, 1970)

“...risky and invites failure”
Why?
Waterfall Product Development
(Royce, 1970)

“…hopefully iteration is confined to successive steps”
Waterfall Product Development
(Royce, 1970)

“...unfortunately, for the process illustrated, the design iterations are never confined to the successive steps.”
Spiral Product Development (Boehm 1988, (2000))
WinWin Spiral Development Model
(Boehm, 1994, (2000))

1. Determine objectives
2. Determine constraints
3. Identify/Evaluate alternatives
4. Commit
5. Cycle through spiral →
WinWin Spiral Development Model
(Boehm, 1994, (2000))

1. Identify (primary →) stakeholders
2. Find out what features they want
3. Get them to agree to less
4. Develop and evaluate a design
5. Ask how design can be improved
6. Reality check on improvement ideas
7. Accept design and proceed to next level stakeholders
Defining Design

Design is the scientific study of the artificial as opposed to the natural. Using ideas and natural resources, design seeks to create for human ends that which does not exist in nature, although designs must then perform in a natural context. **Design means understanding and predicting the behavior of artificial phenomena as opposed to natural phenomena.** Like science, design is empirical, predictive, uses testable hypotheses, and seeks **elegant covering laws.** However, “We speak of engineering as concerned with “synthesis,” while science is concerned with analysis.” [It is better to state engineering design is both synthesis and analysis.] Design also differs from science because it is normative (ethical). “Artificial things can be characterized in terms of functions, goals, adaptation.”

Outline

Product design

Engineering design process

Project design
Engineering Design Process

1. Identify the Problem
2. Identify Criteria and Constraints
3. Brainstorm Possible Solutions
4. Generate Ideas
5. Explore Possibilities
6. Select an Approach
7. Build a Model or Prototype
8. Refine the Design


1. Identify needs
2. Identify what exists
3. Identify what’s wanted and who wants it
4. Identify limits
5. Identify hazards
6. Identify what’s required
7. Creative design
8. Conceptual design
9. Prototype design
10. Design verification

ESD.051 / 6.902
Engineering Design Process

Problem Development

Define Problem
Empathic engagement of customer, user, sponsor

Solution Development

Design-Formulate Solution
Benchmark existing solutions, ideate new ones

Test-Validate Solution

Implement Solution
Iterative Design

Figure SD4.44 With the iterative approach, less work is done and the project finishes sooner.
Axiomatic Design

WHAT IS AXIOMATIC DESIGN?
The Axiomatic Design process was developed in 1988 by Dr. Nam P. Suh at MIT. It was created as a general conceptual framework within which engineering design occurs. Instead of using a quantitative algorithmic approach, the Axiomatic Design approach considers design needs of the customer and how to weave those needs into the final design of the product.

HOW DOES AXIOMATIC DESIGN WORK?
Axiomatic design is an iterative process that crosses over four domains: customer, functional, physical and process. The process starts at the customer domain, where a problem is identified and the market addressed. Next is the functional domain, where desired parameters of the solution are set. The physical domain integrates the customer’s wants with the design parameters into a design of a possible solution. Finally, the process domain determines logistics for manufacturing such a solution. At each step along the way, “What?” and “How?” are asked in a circular pattern. Although the four domains are linearly related, constant revision is required between domains to design and implement better solution parameters.
Engineering Design Process
Engineering Design Process
Triple Bottom Line
People
Planet
Profits

Bruntland Commission, Our Common Future (1987)
“…the “environment” is where we live; and “development” is what we all do in attempting to improve our lot within that abode. The two are inseparable.”

“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

Sustainable Engineering Design
Figure 3 Main managerial and product development client activities at the design front-end

Clients' activities at the design front-end

Patricia Toutouzas, Research Institute for the Built and Human Environment, The University of Salford, 4th Floor Maxwell Building, Salford M5 4WT, UK
Rachel Cooper, Adelaide Research Institute for Creative Arts and Sciences, The University of Salford, Centenary Building, Pero Street, Salford M3 6LG, UK
Jean Child, School of the Built Environment, Northumbria University, Ellison Building, Ellison Place, Newcastle Upon Tyne, NE1 8ST, UK
Mike Kapogiannis, Research Institute for the Built and Human Environment, The University of Salford, 4th Floor Maxwell Building, Salford, M5 4WT, UK

Design Studies Vol 27 No. 6 November 2006
>50% of new products fail – why?
The design is technically sound and revolutionary!

But the product defines a new category and consumers can’t quickly grasp how to use it…

or…

The design meets no customer/user needs…

Remember the Customer (Sponsor)!

Understanding customer (sponsor) needs and preferences is critical for new product development – it is also the most important piece of information necessary before initiating a project.

Kano Analysis

Delighted
Neutral
Dissatisfied

Customer Satisfaction

Presence of Characteristics

Absent
Present

Delighters
Heated seat
Electric antenna
Rain sensor

Satisfiers
Fuel efficient
Looks nice

Requirements
Tires
Seat Belts
Brakes

Delighted
Neutral
Dissatisfied
Defining Customer/User Needs

**Traditional Market Research:** Talk to the wrong customers, ask them the wrong questions, have the wrong people interpret data, then make the wrong decision

*Four Ways Traditional Market Research Can Kill Innovation, S. Anthony, HBR, June 3, 2008*

**Empathic Design:** Observe customer/user interactions

*Spark Innovation Through Empathic Design, D. Leonard, J.F. Rayport, HBR, November 1997*

**Customer Innovators:** Make customers part of the innovation process providing new product concepts, the most popular of which are pursued

FEED

FEED became popular in the mid-1990s as a tool for structured project development.

(Change management during FEED: an owner’s case study, Jambhekar, V.S.; Weeks, S.D., 2008 AACE International Transactions - 52nd Annual Meeting of AACE International and the 6th World Congress of ICEC on cost Engineering, Project Management, and Quantity Surveying)

The success of any engineering design is predicated on the depth of effort placed on defining the design objectives. So too is the success of any engineering project.

The interpersonal dynamics between client, designer and builder are the most important feature of good design and subsequent project success.

(Cooper and Jones, 1995; Barrett and Stanley, 1999, Better construction briefing, Blackwell Science, UK).

In large scale construction projects the importance of relationships is even more critical as ~80% of project costs are defined and agreed upon at this formative time.

(Clients’ activities at the design front-end, P. Tzortzopoulosa, R. Cooper, P. Chan, M. Kagioglou, Design Studies, Volume 27, Issue 6, November 2006, Pages 657-683)

Read stakeholder RFls, RFPs – get to know them from afar
Look at what else they are buying – understand their needs and desires
Go to lunch with them
Play golf with them
In today’s global engineering marketplace, estimating and bidding multi-billion dollar mega-projects require a coordinated team effort. It is necessary for the engineering leader to assemble this team, define the positions, and assign specific roles and responsibilities, as well as requirements and timetables that are clear and understood by all.

(Estimating today's mega projects, Lofton, Waymon, Fluor Corporation, Sugar Land, TX, United States, AACE International Transactions, 53rd AACE International Annual Meeting 2009)
Outline

Work Breakdown Structure (WBS)
Graphical Project Planning Methods
Defining Work
Representing Task Relationships

1. Define Work to do and decompose into discrete Tasks
2. Define interrelationships between Tasks
3. Determine Critical Path amidst Tasks
4. Communicate Work to do through Gantt Chart
Defining Work

Work Breakdown Structure (WBS)

“WBS includes 100% of the work defined by the project scope and captures ALL deliverables – internal, external, interim – in terms of the work to be completed, including project management.”

Work Breakdown Structure (WBS)

Used to create the task (job) list
The key starting point for project planning
Required by contracts as part of the SOW
Can be activity-oriented or deliverable-oriented
Can prototype with “post-it-notes” method

WBS Guidelines

Carve off “manageable chunks”
Identify tasks of “similar” size and complexity
Refine to “granularity” of “bitmap” picture
Stop decomposition at:
  - defined cost/schedule work packages;
  - 40-hour tasks;
  - tasks representing 4% of project
WBS Guidelines

Can be up to 3-4 Levels deep
Not more than 5-9 tasks at one level

- Human cognitive “bandwidth” only 3 bits=$2^3=8$
- Short term memory for most people 5-9 items
- The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information, The Psychological Review, 1956, vol. 63, pp. 81-97
- If “too fine grained” then attention is diluted (unable to see the forest for the trees)

The more tasks there are, the more intricate dependencies there will be to keep track of

No more than 100-200 terminal elements
  if more then use subprojects
Why is it difficult to come up with a good WBS (task list, task structure) in a complex project?
Functional WBS

Main Functions of Plant
- Gas
- Steam
- Interfaces

Items
- Turbine
- Generator
- Compression Station

Units
- Compressors
- Gas Treatment
- Enclosure

Sub-units
- Compressor 1
- Compressor 2
- Foundations

Work Packages
- Design
- Procurement
- Installation
Example WBS

Conduct site visits to two former dry cleaning facilities. Collect soil samples. Return to laboratory, decontaminate equipment, and analyze samples using GC/MS. Generate Report.
Example WBS

Conduct site visits to two former dry cleaning facilities. Collect soil samples. Analyze in laboratory using GC/MS. Generate Report.

Level 1
- Generate Environmental Assessment Report

Level 2
- Analyze Samples A&B
- Decontaminate Equipment

Level 3
- Collect Sample A
- Collect Sample B
Task List

Convert WBS into a table indicating specific tasks and precedence between tasks.
## Example Task List

Two Environmental Samples A and B: Collect, Analyze, Report

<table>
<thead>
<tr>
<th>Task #</th>
<th>Description</th>
<th>Immediate Predecessors</th>
<th>Time [hours]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Start</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>Collect Sample A</td>
<td>A</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>Collect Sample B</td>
<td>A</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>Analyze Samples on GC/MS</td>
<td>B, C</td>
<td>4</td>
</tr>
<tr>
<td>E</td>
<td>Decontaminate Equipment</td>
<td>C</td>
<td>1</td>
</tr>
<tr>
<td>F</td>
<td>Generate Analysis Report</td>
<td>D</td>
<td>2</td>
</tr>
<tr>
<td>G</td>
<td>Finish</td>
<td>F</td>
<td>0</td>
</tr>
</tbody>
</table>