1.040/1.401 - Project Management

Nathaniel Osgood
Outline

- Class Objective
- Course Information
- Context
- Lecture Outlines
- Mission
Objective

Inform professionals in the art and science of directing and coordinating human, equipment, material, and financial resources to develop a project in a way that they could give maximum attention to project details in the most cost-effective way possible while maintaining a broad perspective of the project.

Enhance the following attributes of these outstanding professionals:

- Technical skills.
- Communication skills.
- Decision-making skills.
- Problem-solving skills.
- Interpersonal skills.
- Leadership skills.
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Handouts

- Syllabus Handout:
  - Course Description
  - Course Organization
  - Academic Honesty

- Survey (Problem set 1)

- Term Project Part I (TP1)c
Class Schedule

- **Monday & Wednesday (Osgood)**
  - Lecture
  - 1:00 PM – 2:30 PM

- **Friday (Grimaldi)**
  - Focused on
    - Contractor practices
    - Interactive discussion
  - Recitation
  - 3:00 PM – 4:00 PM

- **Office Hours: TF, 12-1pm (Osgood)**
Guest Lectures

- Dr. Oddmund Granli
  - Megaproject organization
  - Megaproject control
- Bill Fitzgerald (Behavioral components)
- Dr. Roberto Pietroforte (Façade scheduling)
- Victoria Siriani
  - MIT Capital Planning Office
- David Myers
  - MIT Facilities Management
- Prof. Fred Moavenzadeh
Analytic & Qualitative Components

- **Analytic:** Lectures, readings, problem sets
  - Tools for managing complexity, uncertainty
  - Presented so
    - Understand assumptions
    - Understand shortcomings
    - Anticipate future directions in construction

- **Qualitative:** Recitations, readings, problem sets
  - Empirical components
  - Understanding of current state of practice
Reference Textbooks

- **Primary Readers:**
    - General introduction

- **Construction Project Management.**
  Hendrickson & Au.
  - [http://www.ce.cmu.edu/pmbook/](http://www.ce.cmu.edu/pmbook/)
  - Quantitative components

- **Construction Nightmares.**
  - Vignettes illustrating principles from course.
Grading

- Individual Participation 15%

- Term Project / Individual Grading 50%

- Assignments / Individual Grading 35%
Grading Details

- **Late Assignments:** Reduced 10%/day (compounded) up to 7 Days

- **Group Term Project Evaluated Individually**

- **For Individual Assignments:** Share with others ONLY Concepts and Problems

- **Academic Honesty Statement**
Collaboration

- Large Group
- Group Dynamics
- Task Assignment
Academic Honesty

- Individual Work Only Allows for Group Discussion of Concepts and Problems
- Do Not Copy Previous Year Work
- Reference Any Source
- When Confused Ask Instructor
Term Project

- TP 1: Project Selection or Assignment
- TP 2: Estimating, Bidding, Mobilization Plan and Project Organization
- TP 3: Project Planning, Monitoring and Control
- TP 4: Claim, Close-Out, and Project Learning

Deliverable: A Full Report and Presentation

Iterative Process
Software Packages

- Primavera P3
  for deterministic time and resource scheduling

- Primavera Monte Carlo
  for probabilistic time and resource scheduling

- TreeAge
  for decision and risk analysis

- Vensim
  for system dynamics analysis
Outline

✓ Class Objective

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➤ Context

■ Lecture Outlines

■ Mission
Project Management: An Iterative Process

Evaluate

Organize

Plan

Monitor

Control

Learn
Project Scope

- Time /Schedule
- Cost/Budget
- Natural environment
- Political/social environment
- Quality
Industry Context 1

- Multiple Disciplines
- Unique and Evolving Project Team
- Generally One-of-a-kind Projects
- High Social/Political/Env. Implications
- Increasing sophistication of designs

- High
  - Time pressure
  - Cost and cost pressure (low profit)
  - Complexity
  - Uncertainty/Risk (cost, schedule, quality)
  - Turnover
  - Conflict & Litigation (claims 1% of cost)
Industry Context II

Important industry
- Construction value >$850B
- Roughly 8% of US GDP
- 700K construction firms
  - 90% < 10 employees
  - 215K GC/Building, 442K trade contractors
- Buildings are 70-80% of market

Sectors
- Residential const
- Commercial
- Industrial contractors
- Infrastructure and heavy construction

Affiliated institutions
- Professional services
- Suppliers
- Financial Services
Uncertainty in Construction

Uncertainty in Final Project Cost

A century of cost overrun in 111 projects (constant prices)
Uncertainty in Final Project Cost II

Conceptual Estimates

Deviation in Conceptual Estimate

-1.500
-1.000
-0.500
0.000
0.500
1.000
1.500
2.000
2.500
3.000

Project Type

- Wastewater Treatment Plant
- Building
- Transportation
- Drainage
A calamitous history of cost overrun

**Spectacular Projects with Spectacular Cost Overruns**

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>COST OVERRUN (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suez Canal</td>
<td>1,900</td>
</tr>
<tr>
<td>Sydney Opera House</td>
<td>1,400</td>
</tr>
<tr>
<td>Concorde Supersonic Aeroplane</td>
<td>1,100</td>
</tr>
<tr>
<td>Panama Canal</td>
<td>200</td>
</tr>
<tr>
<td>Brooklyn Bridge</td>
<td>100</td>
</tr>
</tbody>
</table>

Growing Expenditures, Declining Control

Recurrent Themes

- Complexity
- Performance ($, time, quality)
- Uncertainty and Risk
- Flexibility
- Incentive
- Conflict
- Crucial role of qualitative and quantitative factors
Parties – Diverse Motivations

- **Owner**
  - Role: Commissions project, arranges financing
  - Common Motives: Good design, save $, finish quickly

- **Designer (Architects & Engineers)**
  - Role: Designs facility (typically w/owner)
  - Frequently oversees construction
  - Common Motives: Recognition, happy client

- **Contractor(s)**
  - Role: Builds facility (often w/design assistance)
  - Common Motives: Make $, finish quickly, happy client
Survey of Construction Phases & Class Topics

- System and Project Management
  - Managing the Product Development Process
  - Feasibility Analysis
  - Design
  - Development
  - Closeout
  - Operations
  - Divestment
Survey of Construction Phases & Class Topics

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Managing the Product Development Process
Feasibility Studies and Preliminaries

- **Understanding project finance and evaluation**
  - Helps understand economic challenges faced by owner and contractor

- **Understanding and managing risk**
  - Insight into risk premiums, incentives, making choices under uncertainty, management

- **Deciding on fundamentals of contract**
  - Delivery type (organizational method)
  - Award method (how decide who hired?)
  - Contract type (how pay?)
  - Conditions
Project Evaluation and Financing

- Financing mechanisms
  - Public, private and hybrid funding
- Time value of money, present value, discounted cash flow analysis
- Evaluation measures (NPV, IRR, Cost-benefit and cost-effectiveness analysis)
- MARR and WACC
Risk Analysis

- Risk Management
  - Identification, Classification, Mitigation

- Basics of Decision Analysis
  - Decision Trees

- Risk attitude

- Essential concepts of preferences

- Sources of risk in construction
  - Particular emphasis: Changes and Claims
Example Decision Tree

- **BidPrice**
  - **6.75M**
    - **Accepted**
      - 6750000 < LowestCompetingBid
    - **Rejected**
      - 6750000 ≥ LowestCompetingBid
  - **7M**
    - **Accepted**
      - 7000000 < LowestCompetingBid
    - **Rejected**
      - 7000000 ≥ LowestCompetingBid
  - **7.25M**
    - **Accepted**
      - 7250000 < LowestCompetingBid
    - **Rejected**
      - 7250000 ≥ LowestCompetingBid
  - **7.5M**
    - **Accepted**
      - 7500000 < LowestCompetingBid
    - **Rejected**
      - 7500000 ≥ LowestCompetingBid

- **Costs**
  - 6750000
  - 7000000
  - 7250000
  - 7500000

Delivery, Award, Contract Method

- Delivery Methods – How to organize?
  - DBB, DB, Turnkey, BOT, Mult. Primes, ...

- Award Mechanism – How to pick?
  - Lowest cost, Multiparameter, Negotiated

- Contract Type – How to Pay?
  - Lump sum, Cost plus %, GMP, etc.

- Contract Design
  - Scope definition
  - Risk sharing
  - Dispute resolution
  - Pointers to avoid claims, defend contract
Survey of Construction Phases & Class Topics

- SYSTEM AND PROJECT MANAGEMENT
  - FEASIBILITY ANALYSIS
  - DESIGN
  - DEVELOPMENT
  - CLOSEOUT
  - OPERATIONS
  - DIVESTMENT

- MANAGING THE PRODUCT DEVELOPMENT PROCESS
Design Phase

- A/E and owner Define scope, budget, time of project
- Estimation
  - Successive estimates produced
- Initial Planning
  - Deterministic
  - Probabilistic
  - Resource
- Possible roles for contractor
  - Value Engineering (Flexibility considerations)
  - Constructibility Analysis
Project Estimating

- Project Budgeting
- Life-Cycle Costing
- Successive estimates
  - Preliminary (financing) model
  - Schematic, development, contract
- Methodologies
  - Parametric
  - Quantity Takeoff
- Deterministic and Probabilistic Estimation
Deterministic Planning I

- Critical for
  - Careful examination of approach
  - Juggling diverse activities, resources
  - Reasoning on cost, time at completion
  - Monitoring & Control
  - Use in litigation

- Phased and fast-tracked construction

- Gantt (Bar) Chart

- Network Techniques
  - CPM
    - Criticality Index
  - PDM
    - Criticality
    - Splitting
    - Warnings
  - Tips to watch out for
Probabilistic Planning

- PERT
- Monte Carlo Simulation
- GERT
- Q-GERT
- Dynamic Planning Methodology
Resource Planning

- Budget Management
- Resource Scheduling
  - People, Space, Equipment, Materials,…
- Resource-Cost Tradeoffs I
- Line-of-Balance Method
- Quality assurance
Survey of Construction Phases & Class Topics
Project Monitoring

- Performance Categories
- Earned Value Approach
- Progress Reporting
- Learning effects
- Cost and Schedule Monitoring
- Reviews and audits
Project Control

- Cost/time tradeoffs
- Acceleration
  - Resource shifting
  - Project crashing
- Feedbacks complicating control
- Managing changes and risks

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Claims and Changes Control

- Principles to limit damage
- Conflict escalation
- Dispute resolution
- On-call contractors
- Delay claims
- Dynamics of claims and claim resolution
Project Control Feedbacks

- Dynamics of Changes, Rework
  - Quality
  - Cost
  - Time

- Counter-intuitive effects of acceleration
  - Overtime lowers quality, productivity
  - Fast track increases sensitivity & vulnerability
Example Feedbacks

Uncertainties + Assumptions in Design

+ Owner's Requests on Changes

+ Potential Design Change Impact on Construction

Overlapping Between Design and Construction

Construction Process Overlapping

+ Increase in Workforce

R2

Construction Work Done Before Upstream Completed

R1

Estimated Project Duration

+ Productivity

R3

Construction Changes

Design Changes

+ Delay

- Oversizing

Project Costs + Project Duration

+ Time Pressure

+ Increase in Workforce

R2

Construction Work Done Before Upstream Completed

R1

Estimated Project Duration

+ Productivity

R3

Construction Changes

Design Changes

+ Delay
Survey of Construction Phases & Class Topics

- Feasibility Analysis
- Design
- Development
- Closeout
- Operations
- Divestment

System and Project Management

Managing the Product Development Process
Project Close Out

- Substantial and final completion
- Termination
- Close Out
- Warrantees
Outline

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➢ Mission
Mission Statement

“The mission is to help organizations achieve their project objectives and objectives of scope, quality, budget, and schedule within the context of the natural, social and political environment in which the project is being developed.”