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Development of a Special Topics Course on Civil Engineering Project Finance for the Zachry Department of Civil Engineering of Texas A&M University

Final Report

Ivan Damnjanovic and Zafer Aslan

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16. Abstract

Experts predict that the highway trust fund will deteriorate rapidly over the course of the next several years. This situation has led many state agencies to seek alternative financing methods that can meet both social and economic needs. One possible solution to the problem is to partner with the private sector and together, utilizing project finance methods, deliver facilities. This innovative approach has only recently found new applications in delivering transportation infrastructure. This trend is likely to increase in the near future. Because it has been widely adopted in other infrastructure sectors, mainly for delivering power plants, major pipelines, etc., many valuable cases and lessons learned can be brought to the transportation arena. Nevertheless, very few, if any, of the educational programs in the country have a project finance course integrated into the core curriculum for graduate civil engineering students. Even fewer programs treat project finance as a truly interdisciplinary topic. In fact, the topic of project finance often constitutes only a small part of the structured finance curricula. The purpose of this project was to bridge this gap by developing educational and teaching materials for an interdisciplinary course in project finance. This course communicates the implications of financial decisions on engineering choices and vice versa. The course is directed toward graduate students at the Master of Science level to better prepare them to deal with real-world transportation financing.

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Development of a Special Topics Course on Civil Engineering Project Finance for the Zachry Department of Civil Engineering of Texas A&M University

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Executive Summary

Experts predict that the highway trust fund will deteriorate rapidly over the course of the next several years. This situation has led many state agencies to seek alternative financing methods that can meet both social and economic needs. One possible solution to the problem is to partner with the private sector and together, utilizing project finance methods, deliver facilities. This innovative approach has only recently found new applications in delivering transportation infrastructure. This trend is likely to increase in the near future. Because it has been widely adopted in other infrastructure sectors, mainly for delivering power plants, major pipelines, etc., many valuable cases and lessons learned can be brought to the transportation arena.

Nevertheless, very few, if any, of the educational programs in the country have a project finance course integrated into the core curriculum for graduate civil engineering students. Even fewer programs treat project finance as a truly interdisciplinary topic. In fact, the topic of project finance often constitutes only a small part of the structured finance curricula.

The purpose of this project was to bridge this gap by developing educational and teaching materials for an interdisciplinary course in project finance. This course communicates the implications of financial decisions on engineering choices and vice versa. The course is directed toward graduate students at the Master of Science level to better prepare them to deal with real-world transportation financing.

Introduction

Traditionally, public agencies have undertaken the large infrastructure projects and funded them with taxpayers' money. This method of financing worked smoothly under the welfare state but has become inefficient as public needs and services expand. The recent deficits and budgetary constraints experienced by public agencies of both developed and developing countries demonstrate the inefficiencies with the traditional taxpayer funding method. In order to overcome the deficiency in public financing and to enable developing an ever-expanding infrastructure system, public agencies and funding authorities have begun to search for alternative financing methods. Following this trend, many public agencies have adopted direct foreign investment and different forms of private financing as an innovative alternative to traditional public-sector debt financing. The technique of project finance is one of the most preferred choices for financing capital-intensive projects in the sector today.

In most cases, the term project finance refers to a limited or non-recourse financing structure where a unique mixture of debt, equity, and credit enhancement is used to construct, operate, or refinance a capital-intensive project. These projects can include infrastructure (public and private), industrial, energy, and extractive enterprises. In this context, lenders evaluate credit appraisals based on the projected future cash flow of the project under consideration. That is, the project financing is secured solely by the project and its revenues. Throughout the project life cycle, if the project revenues are insufficient to cover the principal and interest payments of the project debt, the project sponsors do not have any obligation to guarantee the repayment. The lenders rely on the cash flow projections as collateral for the debt, in contrast to the underlying assets or the credit of the sponsor of the proposed project. Hence, the credit risk associated with the borrower (project sponsor) is not as important as in an ordinary loan transaction. However, the identification, analysis, allocation, and management of every risk associated with the proposed project are of great importance.

The use of project finance in public infrastructure development offers broad benefits to hosting nations and private investors. First and foremost, host governments/agencies can bring private capital without being obligated to make full payments of project costs. The lenders, on the other hand, benefit from the use of project finance by lending on a project-specific basis in situations where a developing country would present an otherwise unfavorable credit risk due to political unrest or other non-economic factors. Because project finance allows bringing more investors and creditors from all around the globe to the negotiation table, this financing method offers a broad variety of financial instruments and thus reduces the cost of funds.

Another important advantage of project financing for the project sponsors is the possibility of using high leveraged debt, which enables less equity commitment from project sponsors compared to the traditional corporate finance deals. This particular advantage is the main reason why project finance is used primarily in capital-intensive projects, such as energy, mining, power, and transportation.

Project finance offers an advanced risk management mechanism where the payment obligations and financing needs are shared and allocated among the project participants via

contractual agreements. This advantage attracts all of the participants because none of them need to bear the full risks of the project; this is essential for capital-intensive projects.

In summary, project finance is an attractive and viable financing technique for project sponsors and lenders as well as the hosting governments. However, the underlying structure of this unique financing technique needs to be carefully crafted to succeed. A successful project-financing implementation requires preparing the detailed financial plan (capital budgeting analysis), assessing and allocating the risks (uncertainty modeling, risk analysis, and contractual structure), designing the finance mix (debt and equity ratio), and reducing the cost of funding for participants.

This project develops a special topics course that offers both theoretical and practical training with innovative approaches for designing, managing, and engineering the project finance transactions for large-scale transportation projects. This is accomplished by developing appropriate financial tools integrated with engineering models to optimize the performance throughout the project life cycle.

Course Objectives

The main objective of the course is to provide students with the necessary theoretical and practical tools to create the link between engineering decisions and the financial implications that accompany these decisions in relation to project finance. The course emphasizes the design, development, risk management, and engineering analysis of project finance transactions, as well as understanding the different roles, needs, and interests of project participants.

This course provides the fundamentals of project finance techniques and a thorough engineering analysis of the potential performance issues. The analysis is fortified with case studies, guest speakers, and real-world examples. The teaching modality for the course incorporates core text readings, lectures, and student presentations.

The course begins with identifying the fundamentals of financial and engineering analysis, including discussions of the methodological differences and similarities between the two. The course then examines how the decisions made in one stage (e.g., engineering design) affect the decisions made in another (e.g., loan structure). The course then focuses on systems engineering and modularity to capture the dynamic relationship between engineering decisions and their financial implications. The course moves into the topics of uncertainty analysis and risk management (including risk identification, assessment, allocation, and mitigation), which constitute the foundation of project finance solutions. This is followed by a discussion of the role of contracts in mitigating risk. Next, the course focuses on project performance modeling and finally finishes with an explanation of how lenders and sponsors evaluate and price the risks in project finance transactions.

Learning Objectives

At the conclusion of this course, the students should be able to do the following:

- Define the “off-balance sheet”, “non-recourse” project financing method.
- Outline the key steps in developing projects’ financial structure.
- Analyze business opportunities for their potential to be structured for project financing.
- Define the roles and objectives of the various participants.
- Determine the project’s borrowing capacity.
- Prepare cash flow projections and use them to measure expected rates of returns, tax and accounting considerations, and analytical techniques to validate the project’s feasibility.
- Understand the differences and similarities between engineering and the financial approach to design.
- Apply basic system engineering principles and concepts to develop an understanding of functional requirements for a successful project finance implementation.
- Understand the dynamics of project decision making and the key interactions.
- Identify risk factors and how they affect the cost of capital.
- Assess the risks of the transaction from different viewpoints.
- Develop and implement optimum risk management strategies for a given project.
- Develop and understand processes and models used to evaluate engineering and financial design concepts.
- Understand how transactions are priced, and be able to price a transaction.
- Understand how to make optimal choices.
- Understand and discuss the importance of the dynamic relationship between engineering design and finance structure in relation to the decision-making process.
- Provide alternative solutions to today’s project finance problems in light of the discussions and materials covered throughout the semester.

Target Audience

The course is designed as a graduate-level course for students intending to pursue careers in engineering, consulting, investment banking, risk management, corporate or structured finance, and business development. The class is particularly beneficial to students with an interest in large-scale domestic or international projects and to those who intend to be involved in the decision-making process in relation to debt or equity investments.

Course Outline

The basic outline developed for the course is given in Table 1.

Table 1. Course Outline.

Week	Day 1 Topic	Day 2 Topic
1	Engineering Projects	Project Development Process
2	Finance Fundamentals	Financial Analysis
3	Financial Design Discussion	Engineering Design Fundamentals
4	Other Engineering Functions	Engineering Design Discussion
5	Projects as Systems	Engineering Project Finance
6	Special Purpose Vehicle	Public-Private Partnerships (PPP)
7	PPP Examples/Discussion	Project Risks
8	Project Risk Management Discussion	Midterm Examination (to be determined)
9	Modeling Project Performance	Modeling Uncertainty in Project Performance
10	Lenders' Analysis of Projects	Lenders' Analysis of Projects
11	Paper Discussion	Investors' Analysis of Projects
12	Investors' Analysis of Projects	Investors' Analysis of Projects
13	Paper Discussion	Term Project Presentations
14	Term Project Presentations	Term Project Presentations

Lecture Materials

The lecture materials were developed to provide students with the necessary knowledge to achieve the learning objectives. The lecture materials were grouped into nine modules:

- Module 1: Introduction and Overview of Civil Engineering Projects.
- Module 2: Fundamentals of Finance and Engineering Economics.
- Module 3: Fundamentals of Engineering.
- Module 4: Complex Engineering Systems and Systems Engineering.
- Module 5: Special Purpose Vehicles (SPVs) and Public-Private Partnerships (PPPs).

- Module 6: Project Risk Management.
- Module 7: Project Performance Modeling.
- Module 8: Lenders' Analysis of Projects.
- Module 9: Investors' Analysis of Projects.

A copy of the lecture materials and each module's learning objectives are contained in the appendices of this report.

Evaluation Materials

The grade breakdown used for this class is given in Table 2.

Table 2. Percentages used for evaluation.

Class Participation	15%
Assignments	30%
Midterm Examination	15%
Term Project	40%
Total	**100%**

As stated above, 40 percent of the student's final grade comes from a term project. The class is divided into teams, and each team prepares a video explaining the topic of their choice among the subjects discussed in class. A peer evaluation form is handed out to students, and they assess the relative performance of the other team members. Thus, students must actively participate in all of the team tasks.

The grade for each student is determined according to the scale in Table 3.

Table 3. Grading scale.

A	90–100
B	80–89
C	70–79
D	60–69
F	< 60

However, the minimum score needed to get a specific grade may be lowered at the discretion of the instructor; it will not be raised. The grades will not be curved.

Required Course Materials

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Appendix A: Lecture Slides for Module 1

Introduction and Overview of Civil Engineering Projects

Learning Objectives for Module 1

By the end of Module 1, students should be able to:

- Identify common characteristics of projects.
- Identify key stakeholders.
- Recognize different stages in the project life cycle.
- Learn what the system development cycle is.
- Describe project methodology.
- Have an insight into project feasibility analysis.
- Use strengths, weaknesses, opportunities, and threats (SWOT) analysis and Porter's Five Forces Model.

CVEN689: Engineering Project Finance

Introduction

Spring 2011

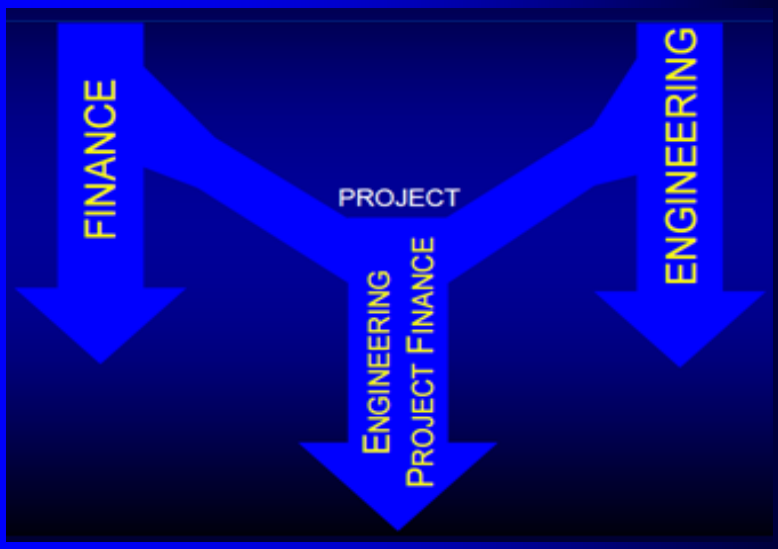
Introduction of Students

- Name
- Area of Interest
- Brief background
- Class expectations

Class Objectives

- Define *non-recourse off-balance sheet* financing method
- Understand the differences in engineering and financial approach to design
- Outline the key steps in developing project's financial structure
- Understand dynamics of project decision making and the key interactions
- Identify risk factors and how they affect cost of debt
- Understand processes and models used to evaluate engineering and financial design concepts

Engineering Project Finance



What is a Project

A project is a temporary endeavor undertaken to create a unique product or service

An undertaking that encompasses a set of task or activities having a definable starting point and well-defined objectives

Common Characteristics of a Project

- It is unique
- It is temporary (has a beginning and end)
- It has a clear goal and objectives
- It involves a series of activates
- It needs resources
- It is a joint or combined venture

Common Characteristics of a Project

- It is unique
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Different Types of Projects

Apollo Project

More Civil Engineering Projects

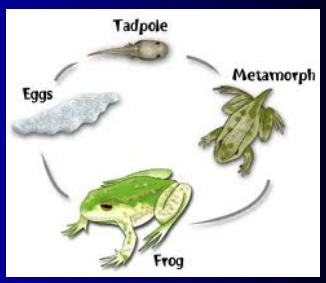
Project Life Cycle

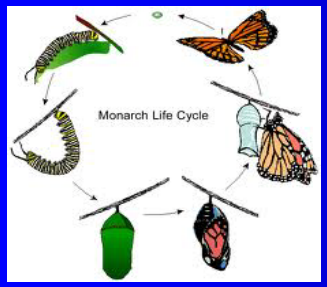
It's useful to think of a project end item as a system that moves through phases of a life cycle

Life Cycle Stages: Natural Organisms

- All living organisms follow life-cycle stages

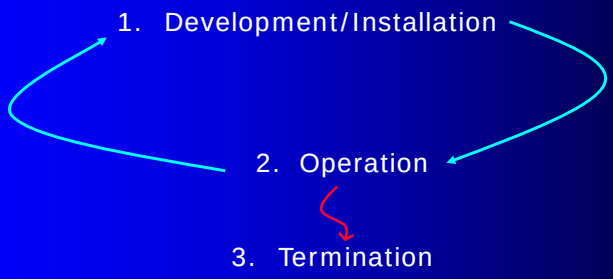
Conception → Birth → Growth → Maturity → Decline → Death



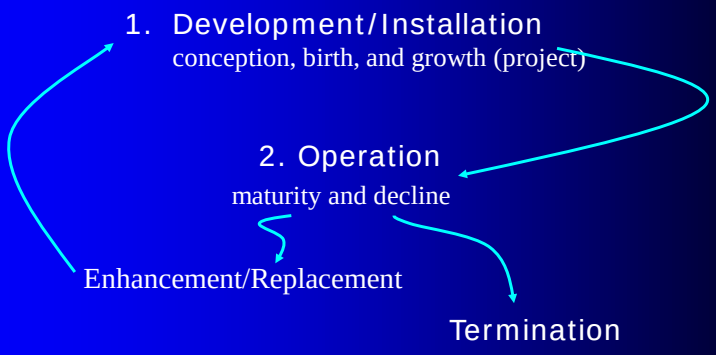


Life Cycle Stages: Human-Made Systems

All human-made systems follow this cycle

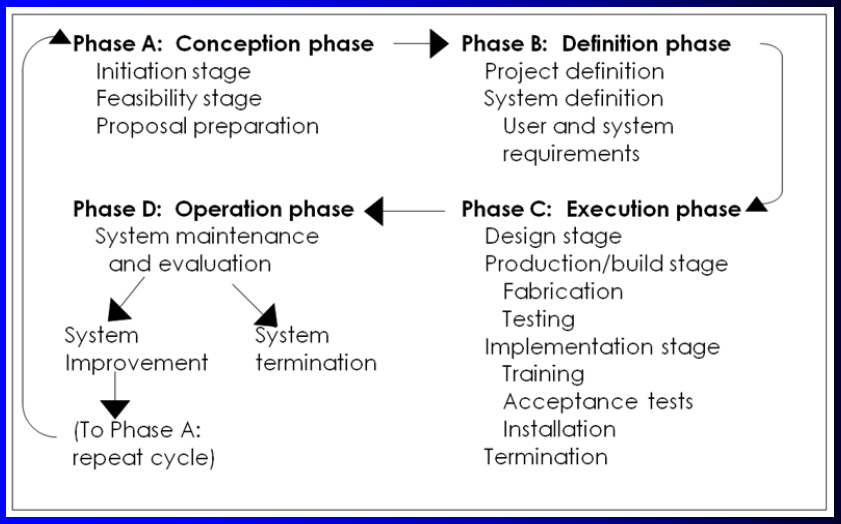


Life Cycle Stages: System Life Cycle



- For a human-made system, termination is not inevitable
- System is kept alive through enhancement/replacement
- Thus, *every* human-made system *begins* as a project and often ends with the start of a new project

Systems Development Cycle (SDC)



Key Actors (Stakeholders)

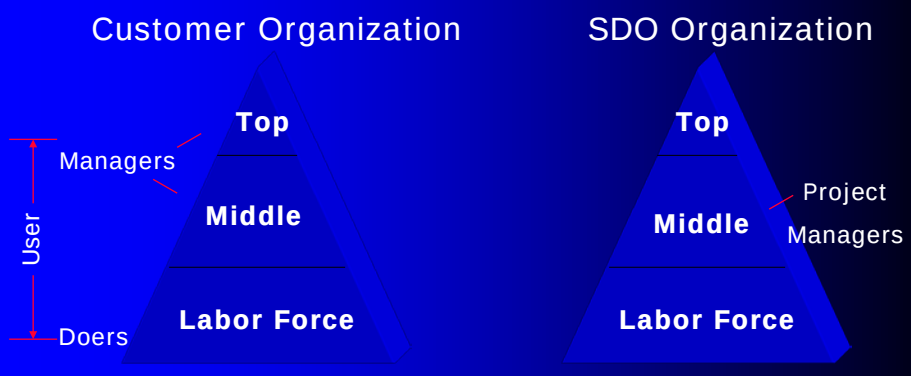
- Customer/Client
  - Party for whom project is being done
  - Pays for project
  - Has needs and requirements to be met
- User
  - Party that operates or is beneficiary of project end-item
  - Might be same as customer, might not
  - If different, important to differentiate user from customer
- System Development Organization (SDO)
  - Party that performs work for customer
  - Aka developer, contractor, consultant

Key Actors in SDC

- For most projects, customer and developer are separate organizations or separate units within same organization
- Sometimes they are the same

Key Actors in SDC (cont'd)

- Customer and contractor/developer each are organizations:



Key Actors in SDC (cont'd)

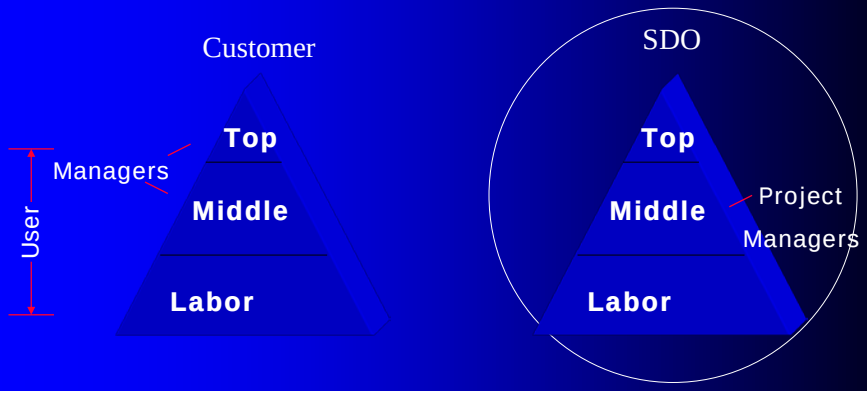
In customer organization

- User (party with need or problem) can be at any level
- Project approval/funding happens at management levels

Key Actors in SDC (cont'd)

In SDO organization

- Project approval happens at top
- Project work performed by engineers
- Project managed by project manager (PM) in middle level



SDC Phases

- Phase A: Conception
  - Perceived need or problem or opportunity
  - Initial screening or feasibility study
  - Proposal
  - Concept approval/rejection

SDC Phases (cont'd)

- Phase B: Definition (Birth)
  - Specify requirements in detail:
    - ✓User requirements
    - ✓System requirements and
    - ✓ System specifications
  - Define project to produce end item/delivery requirements:
    - ✓Project master plan

SDC Phases (cont'd)

- Phase C: Execution (Growth)
  - Design/development
  - Procurement/fabrication
  - Production/building
  - Installation

SDC Phases (cont'd)

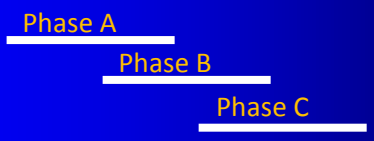
- Phase D: Operation (Maturity)
  - Customer gains control
  - System developer might remain involved with system/customer through:
    - Maintenance
    - Evaluation
    - Enhancement
    - Replacement

Project Life Span, Variations

- Phased project/program planning
  - In very large projects, phases A, B, and C are treated somewhat *independently*, almost like separate projects
  - Each phase requires justification and approval. Project can be cancelled in each phase. Different contractors can be involved in each phase. Examples: phase/gate methodology and development/production contracting

Project Life Span, Variations (cont'd)

- Fast-tracking or Concurrency
  - Phases (and stages within phases) ***overlap*** so work in successive phases (stages) happens simultaneously

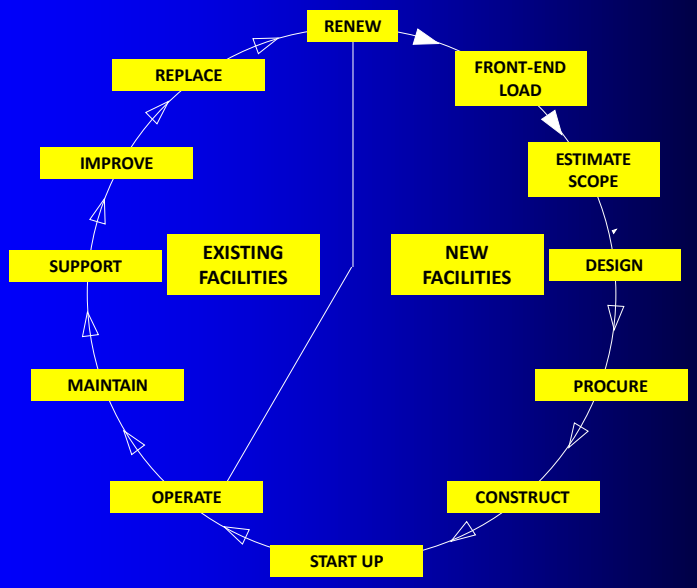


  - Pro: shorten project life span
  - Con: Increase risk of mistakes/changes/rework

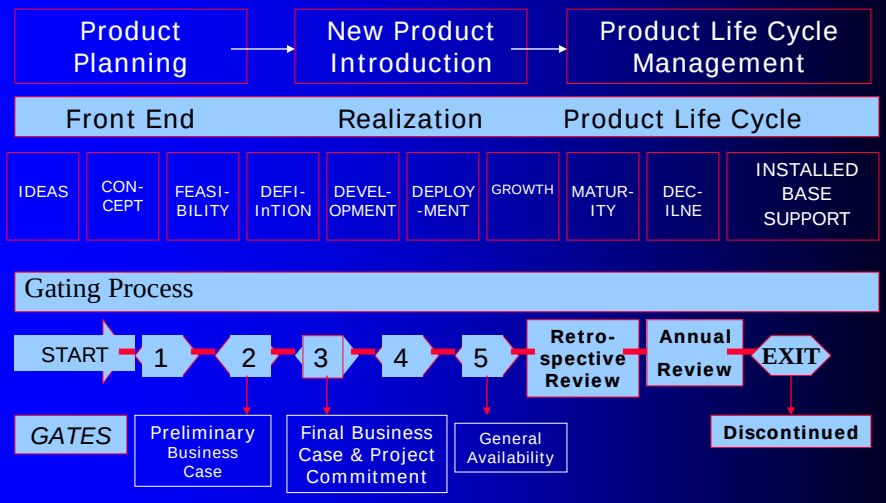
Project Methodology

- Companies follow own versions of project life span
  - Create their own project methodology
- Example….

Engineering's Value-Adding Cycle



Project Methodology



Phase A: Conception

- Project Conception involves:
  - Initiation
  - Request for proposals (RFPs)
  - Feasibility
  - Needs analysis
  - Proposal preparation
  - Proposal evaluation/project selection
  - Contracting

Initiation

- Every project starts in somebody's mind as a need or problem, or as a solution to somebody else's need or problem
- An idea develops based on perceived problem, opportunity, or need
- Idea can originate anywhere in customer or contractor organizations

Initiation (cont'd)

- To determine if idea has merit, instigate an initial (usually brief) investigation
  - Data sources
    - ✓Interviews
    - ✓Background research
    - ✓Documentation

Usually owner does this

Initiation (cont'd)

- Focus of initial investigation:
  - Symptoms, problems, needs
  - Objectives
  - Preliminary alternatives; estimated costs, benefits, strengths, weaknesses
  - People and groups affected

Initiation (cont'd)

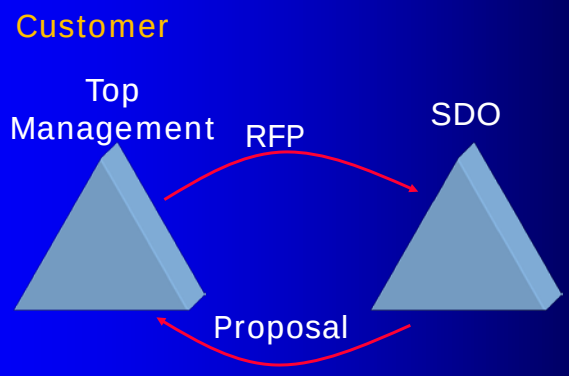
- Owner's decision-to-proceed criteria:
  - The needs are real and funding is available
  - Project is consistent with goals and resources of organization
  - Project has priority with respect to other needs
  - Project has value in terms of new technology, organizational reputation, market share, profits, etc.

RFP

- If owner decides to proceed with an idea, the next step is to contact an SDO (developer or contractor) to
  - investigate idea further, or
  - do the work and deliver the solution/end item

RFP (cont'd)

- Contact between customer and SDO initiated with the RFP



RFP (cont'd)

- Purposes
  - Describe customer's needs, problems, or idea
  - Solicit suggestions/solutions from SDO
  - Inform SDO *how* to respond to RFP (where to send proposal, to whom, and what to include in proposal)

RFP

- Contents
  1) Statement of work (SOW)
  2) Proposal requirements
  3) Contractual provisions
  4) Additional information or data

RFP Contents

1) SOW
   - ➢ Description/background of problem, need, or general type of solutions to be investigated
   - ➢ *Scope* of work to be performed
     - ✓ work/deliverables to be *included*
     - ✓ work/deliverables to be *excluded*
     - ✓ work restrictions
     - ✓ Criteria of acceptance for deliverables, results or end items
   - ➢ *Requirements* for results or end item; e.g.,
     - ✓ technical specifications and standards
     - ✓ how results and work will be measured
     - ✓ expected relationship between user and contractor
     - ✓ expected completion date
     - ✓ constraints on cost of work to be performed

RFP Contents (cont'd)

2) Proposal Requirements
   - ➢ Conditions placed on proposal
     - ✓ proposal contents and format
     - ✓ data requirements
     - ✓ sample forms to include
     - ✓ submission location and deadline
   - ➢ All proposals should look the same

RFP Contents (cont'd)

3) Contractual Provisions

- Type of contract to be awarded and contractual provisions
  - ✓Fixed-price
  - ✓Cost-plus
  - ✓Incentives
  - ✓Special considerations

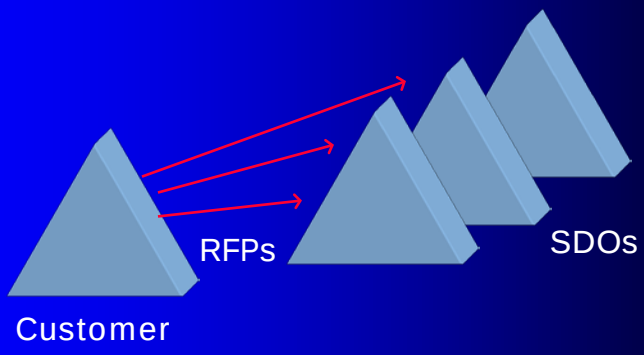
RFP Contents (cont'd)

4) Additional Information or Data

- Name of contact person for requesting additional data—as necessary to enable SDO develop solution and prepare proposal or price quote
- Technical information to support the SOW

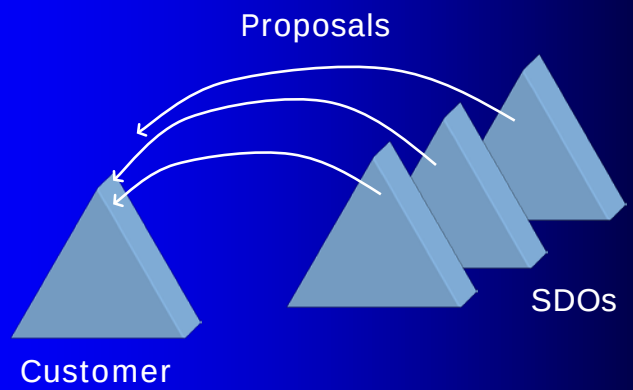
RFP

- Send RFPs to multiple SDOs in expectation of receiving multiple proposals



RFP (cont'd)

- Send RFPs to multiple SDOs in expectation of receiving multiple proposals



Why is this process important?

- Clarification of user requirements
- Selection of best contractor
- Determine market price for project
- Set tone for project: systematic, organized, well defined

Question: Where to send RFPs?

Where to send RFPs?

- Customer sends RFPs to
  - SDOs on qualified bidders' list
  - SDOs recommended by other customers
  - SDOs requesting an RFP (as advertised in Commerce Business Daily or trade newsletters)
  - Qualified SDOs based upon requests for information (RFIs)

Feasibility Study

- Most projects are preceded by detailed study/analysis to compare costs with benefits/outcomes
- Study considers feasibility of idea or proposed work given proposed benefits and constrained resources
- Feasibility study might be done by customer during initial investigation

Feasibility Study (cont'd)

- Alternatively, might be done by SDO
- Regardless, somewhere in the conception phase a feasibility study is performed to justify the idea or proposed solution

Feasibility Study (cont'd)

- Steps in Feasibility Study
  - Gain full understanding of user's problem, need, and current situation
  - Perform *needs analysis* to fullest extent possible

Feasibility Study (cont'd)

- Articulating user needs
  - Ask user to define the need clearly
  - Ask user a complete set of questions about need
  - Do necessary research to understand the need better
  - Reformulate need as best you can
  - Ask user to respond to reformulation, and revise accordingly
  - Resulting actual needs are often different from the original stated needs

Feasibility Study (cont'd)

Example

- Stated need:

  "We need a ledger system"

But…A ledger system can be purchased at OfficeMax for $99. Will that system enable your organization (say, 18,000 employees with offices in 23 states and 9 countries) to close its books in three days?

Most likely not!

Feasibility Study (cont'd)

Actual need:

"We need a system that will enable our organization to close the books in three days"

Feasibility Study (cont'd)

- Pitfalls in defining and addressing needs
  - Some needs are ever changing
  - Some needs are only vaguely perceived
  - Solutions are identified prematurely
  - Needs identified are for wrong users
  - Multiple users exist, each with differing needs
  - User's needs are distorted by expert
    - ✓Gold-plating of needs
    - ✓Filtering of needs
    - ✓Father-knows-best approach

Steps in Feasibility Study

1) Gain full understanding of user's problem, need, and current situation
2) Document current system
   - Use schematic diagrams showing inputs, outputs, elements, attributes, flows, etc.
   - Summarize all information collected (or note where it can be found)
3) Devise alternative solutions
4) Analyze the alternatives
   - Use models to assess alternatives' ability to meet objectives as specified by user criteria
5) Include solution in proposal, technical section
6) In some cases, feasibility involves analysis of environmental impacts (next slide)

Environmental Impact (EI)

Typical contents of an EI Statement include

- Summary of proposed development and management plans
- Alternative sites and technologies to the proposed project
- Description of project's existing site and surrounding area
- Potential project impacts, such as on
  - Quality of air, soil, watersheds, wetlands, flood plains
  - Fisheries; sensitive plants; sensitive, endangered, or threatened species
  - Scenic resources: societal and aesthetic experiences
  - Heritage resources (sites, structures, buildings, districts, objects)
  - Historical resources (logging, ranching, grazing, mining, recreation)
- Adverse impacts that cannot be avoided

Project Charter

For *internal* projects, the charter describes the project to stakeholders

- Sometimes it is used to generate interest in a proposed project
- Often it is used to announce authorization of an approved project. in the organization and establish the project manager's authority to gather and make use resources
- It provides a good overview of the project and may include
  - the project objectives and scope
  - stakeholders and their stakes
  - estimated budget and schedule
  - risks
  - assumptions and constraints
  - resources
- Sometimes it is used as the project plan; more commonly it is somewhat brief

Customer Review of Proposal

- Customer evaluates:
  - Cost
  - Benefits
  - Likelihood of Success
  - Contractor Reputation
- Often a handful of good proposals remain after many others have been discarded
  - These go to negotiation

Negotiation

- Customer and SDO meet to
  - clarify terms (ensure common understanding)
  - reach Agreement on requirements, schedule, or price

Negotiation (cont'd)

- Ideally, the would-be PM is involved
- The proposed PM must know:
  - Terms of contract and areas open to negotiation (what's Fixed, what's flexible?)
  - Customer's situation (how much does customer need project?)
  - Competition (who are competitors, and what are they saying to customer?)

Contracting

- Every project involves contracting
  - an agreement for one party (SDO) to do something (project) for another (customer)
- Most people think of project contract only between customer and SDO
  - in many projects the SDO is also a customer that contracts its work to many other organizations

Project as Business

How to Develop a Project?

- The vision or the idea
- Defining the concept
- Market research and analysis
- Business structure

The Vision: A Marketable Need or Service

- Vision source
  - Work experience
  - Educational experience
  - Business colleagues and friends
  - Observed business trends and opportunities
  - Advanced education and training
  - Media coverage

Note: *Without an identifiable customer segment willing to pay for a product or service, its value is dubious no matter how clever it seems*

Who comes up with the vision?

Who are project developers, sponsors or promoters?

- Contractors
- Vendors
- Operating companies
- Investment banks
- Venture capital funds
- Other investors

Defining/Redefining the Vision

- If an invention, build a prototype or prepare design drawings and specifications
- If a process, clearly define its purpose and advantage
- If it is proprietary intellectual knowledge, define how it can produce clear competitive advantage
- If a new market, define the market and why it will use the product or service
- If a niche market, define why the product has an advantage over existing participants

Market Research

- Market information: Investigating the supply and the demand for the considered or substitute products
- Market segmentation: Dividing the market or population into subgroups with similar motivations
- Market trend: Predicting and analyzing upward or downward movements of a market during a period of time

Market Research

- Costumers or buyers
- Vendors
- Barriers to entry and exit
- Substitute products
- Competitors
- Current industry trends
- Apparent factors for success
- Societal factors

Strategic Approach to Market Analysis

- Strengths, weaknesses, opportunities, and threats (SWOT) analysis
- Porter's five forces model
- Other techniques (context analysis, six forces model, etc.)

SWOT Analysis

Strategic planning tool to evaluate a project's:

- Strengths, attributes of the organization that are helpful to achieving the objective
- Weaknesses, attributes of the organization that are harmful to achieving the objective
- Opportunities, external conditions that are helpful to achieving the objective
- Threats, external conditions that are harmful to achieving the objective

SWOT Analysis

Strategic planning tool to evaluate a project's:

- Strengths, attributes of the organization that are helpful to achieving the objective
- Weaknesses, attributes of the organization that are harmful to achieving the objective
- Opportunities, external conditions that are helpful to achieving the objective
- Threats, external conditions that are harmful to achieving the objective

Factors

- Internal factors: The strengths and weaknesses internal to the organization
- External factors: The opportunities and threats presented by the external environment

Strengths

- Consider this from an internal perspective, and from the point of view of your customers and people in your market
  - What advantages does your company have?
  - What do you do better than anyone else?
  - What unique or lowest-cost resources do you have access to?
  - What do people in your market see as your strengths

Note: *If all your competitors provide high quality products, then a high quality production process is not a strength in the market, it is a necessity*

Weaknesses

- What could you improve?
- What should you avoid?
- What are people in your market likely to see as weaknesses?

Opportunities

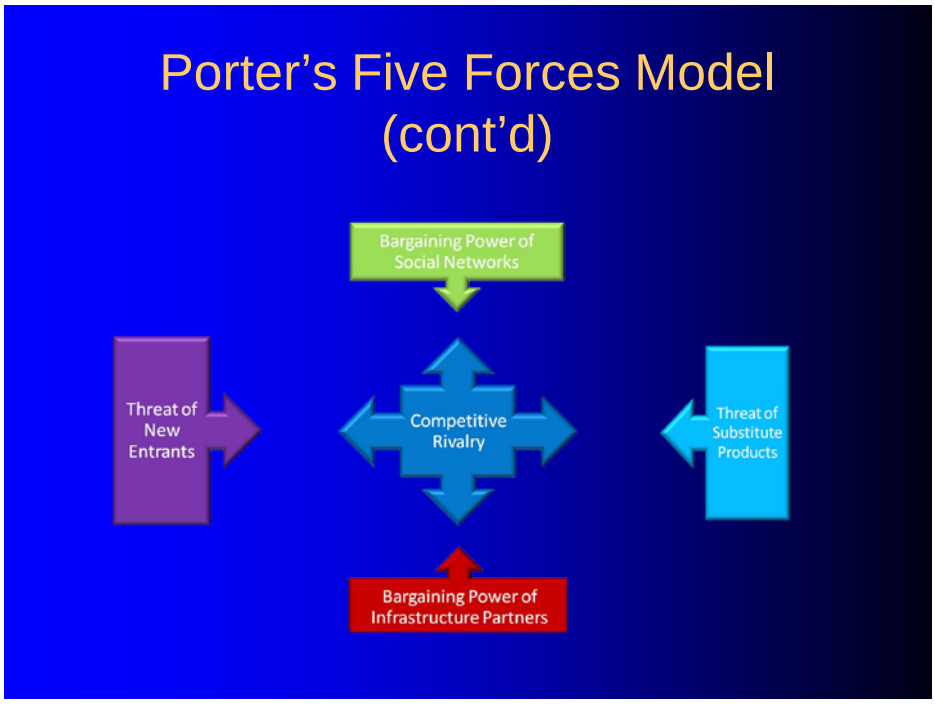
- Where are the good opportunities?
- What are the interesting trends?
- Useful opportunities can come from such things as:
  - Changes in technology and markets on both a broad and narrow scale
  - Changes in government policy related to your field
  - Changes in social patterns, population profiles, lifestyle changes, etc.
  - Local events

Threats

- What obstacles do you face?
- What is your competitor doing?
- Is changing technology or policy threatening your position?
- Do you have debt or cash flow problems?
- Carrying out this analysis will often be illuminating-both in terms of pointing out what needs to be done, and in putting problems into perspective

Porter's Five Forces Model

- Developed by Michael Porter in his book "Competitive Strategy: Techniques for Analyzing Industries and Competitors" (1980)
- Five forces determine the attractiveness of a market:
  - Bargaining power of customers
  - Bargaining power of suppliers
  - The threat of new entrants
  - Threat of substitute products
  - The level of competition in an industry


Porter's Five Forces Model (cont'd)
Bargaining Power of Social Networks
Threat of New Entrants
Competitive Rivalry
Threat of Substitute Products
Bargaining Power of Infrastructure Partners

Appendix B: Lecture Slides for Module 2

Fundamentals of Finance and Engineering Economics

Learning Objectives for Module 2

By the end of Module 2, students should be able to:

- Describe the basic corporate finance functions and their role in business.
- Describe the primary stakeholders in a typical revenue-generating project, financial institutions, markets, and how they interact with each other.
- Develop skills in the evaluation of alternative capital investments.
- Learn problem-solving techniques involving economic evaluation methods such as cash flow and time value of money analysis, and understand the major capabilities and limitations of each method.
- Understand the impact of depreciation, taxation, and uncertainty over the decision-making process.
- Recognize, formulate, and analyze evaluation models in practical situations.
- Understand the assumptions underlying these models and the effects on the modeling process when these assumptions do not hold.
- Distinguish financing options (debt vs. equity) and become familiar with different debt instruments.

Communicate the results of the modeling process to management and other non-specialist users of engineering analysis.

Fundamentals of Finance

What is Finance?

- The science and art of determining if the funds of an organization are being used properly
- Every business is a process of acquiring and disposing of assets such as:
  - Real assets–tangible and intangible
  - Financial assets
- The two main objectives of business are:
  - Valuation of assets
  - Management of assets

Finance Function

"An effective finance function, which includes all aspects of finance, tax, treasury, and typically risk management, makes a positive contribution to the achievement of the organization's strategic objectives and to its value creation goals"

Deloitte MCS Limited

Five Basic Corporate Finance Functions

1) *Financing function*: Raising capital to support company operations and investments
2) *Capital budgeting function*: selecting those projects based on risk and expected return that are the best use of a company's resources
3) *Financial management function*: Managing company cash flow and balancing the ratio of debt and equity financing to maximize company value
4) *Governance function*: Developing a company governance structure to encourage ethical behavior and actions that serve the best interests of its stockholders
5) *Risk management function*: Managing risk exposure to maintain optimum risk-return trade-off that maximizes shareholder value

Key Participants

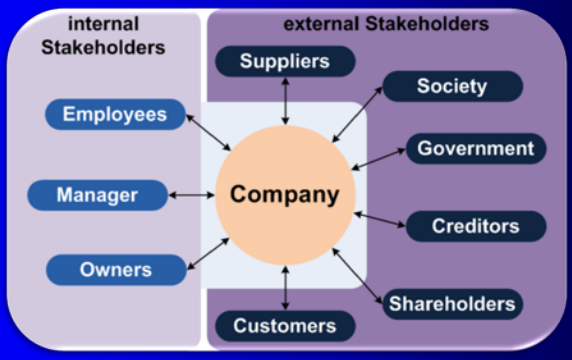
- Stakeholders

- Financial Institutions

- Markets

Stakeholders

Stakeholders are individuals or groups who will be impacted by or can influence the success or failure of the project's work and/or its deliverables



(http://en.wikipedia.org, 2009)

Financial Institutions

Financial institutions provide service as intermediaries of the capital and debt markets

There are three major types of financial institutions:

1) Deposit–taking institutions (banks, building societies, credit unions, trust companies, and mortgage loan companies)
2) Insurance companies and pension funds
3) Brokers, underwriters, and investment funds

Markets

A market is a public place where products or services are sold, either directly or through intermediaries

1) Trading of goods or services
2) Enabling for competition for the best price
3) Providing liquidity

Classification of Markets

❖Based on the *length of time* for which the funds are lent

1) Capital Markets: Long-term securities trade in the capital markets
   - ➢ Subject to significant price risk, default risk, purchasing power risk, etc. due to their longer maturities (e.g., certificates of deposits)
2) Money Markets: Short-term, high-quality debt securities are traded here
   - ➢ Carry little or no default risk and have very little price risk due to their short maturities (e.g., treasury bills and money market mutual funds)

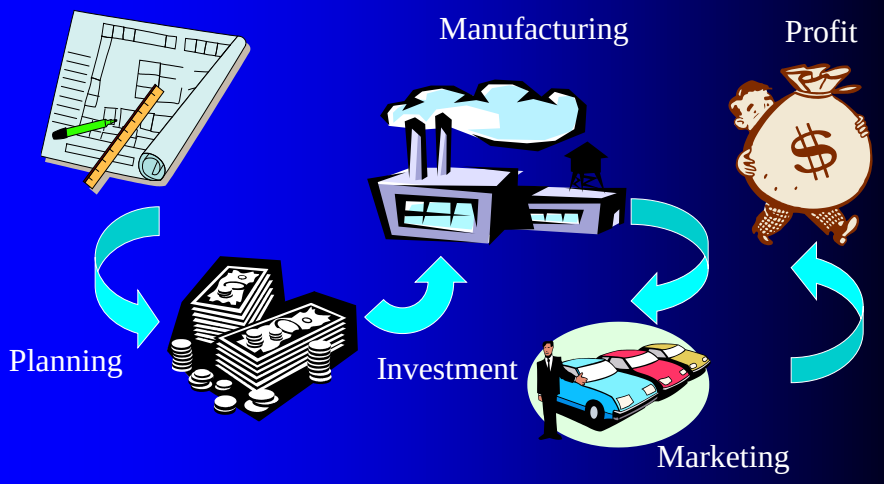
Classification of Markets (cont'd)

- Whether or not assets can be *resold* to other buyers

1) Primary Markets: These are the markets where securities are initially sold
   - The issuer receives the proceeds from the sale (e.g., saving bonds)
2) Secondary Markets: In a secondary market, financial assets can be resold, which provides liquidity to investors
   - The seller of the securities receives the proceeds, not the issuer

Financial Analysis

Financial Analysis Scheme

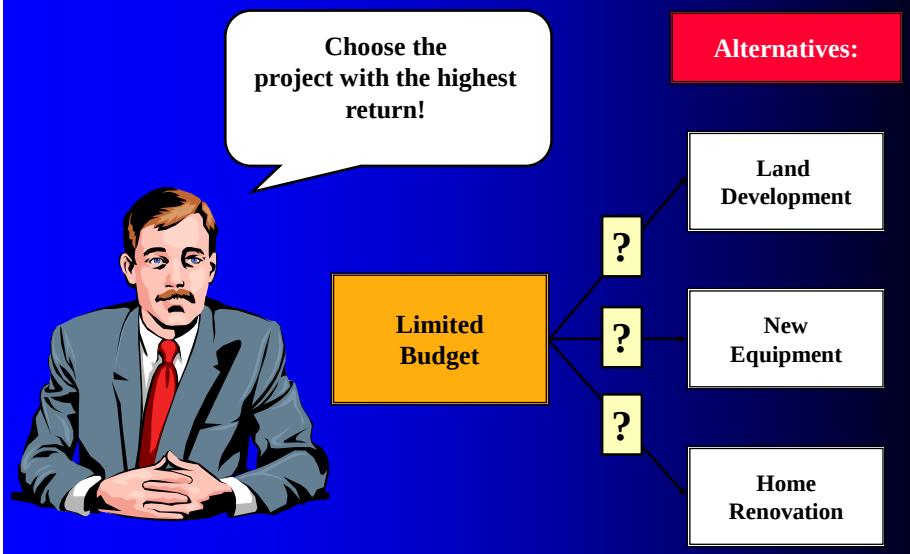


Decision Making

Capital Budgeting is the process of considering alternative capital projects and selecting those alternatives that provide the most profitable return on available funds

- Examples of capital projects include:
  - land
  - buildings
  - equipment
  - other major fixed-asset items

Capital Budgeting



Value Creation

Value is created either financially or socially

- *Financially* by creating net cash flow
- *Socially* by creating social benefit

The private sector's main objective is value creation for their owners (stockholders)

The public sector attempts to maximize social benefit

Any project must be able to create value!

Project Selection Methods

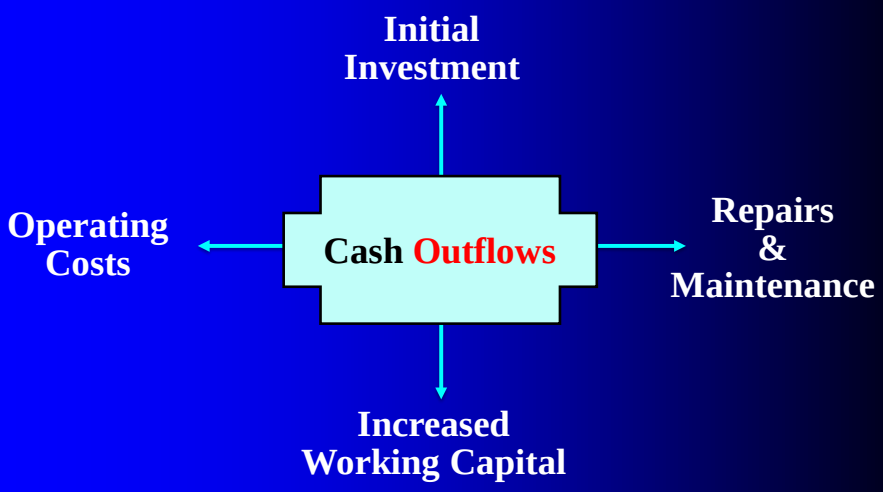
Cash Flow Analysis

- The movement of **cash** into or out of a business, project, or financial product

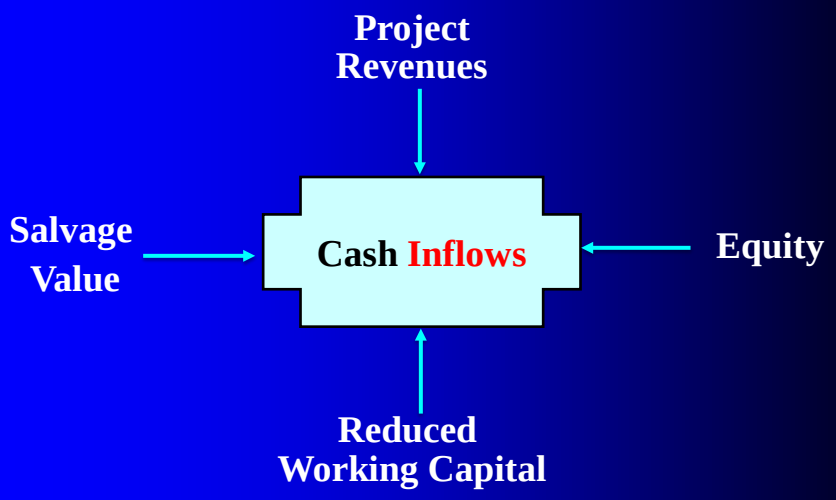
Time Value of Money Analysis

- A **dollar today is worth more** than a dollar tomorrow!

Cash Flow Analysis



Cash Flow Analysis



Evaluating Opportunities

- Simplified Approach:
  - Payback Period Method
- Time Value of Money Approaches:
  - Net Present Value (NPV) Method
  - Internal Rate of Return (IRR) Method

Payback Period

Payback period is the amount of time required for the firm to recover its initial investment

- If the project's payback period is less than the maximum acceptable payback period, **accept** the project.
- If the project's payback period is greater than the maximum acceptable payback period, **reject** the project.

- Computation:
  - Estimate the cash flows
  - Subtract the future cash flows from the initial cost until the initial investment has been recovered

Payback Period (cont'd)

Advantages of Payback Method:

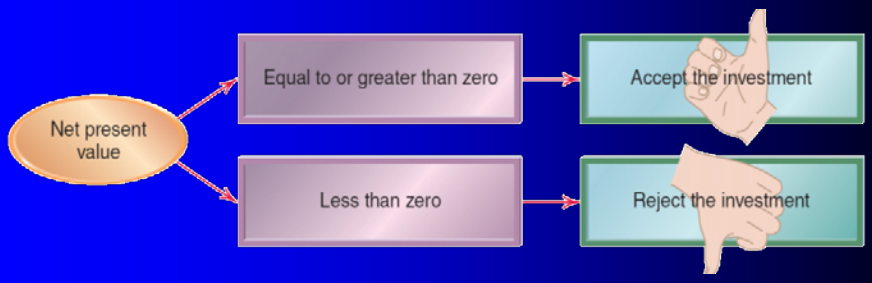
- Easy to compute
- Uncertainty is adjusted for future cash flows
- Biased towards liquidity

Disadvantages of Payback Method:

- Time value of money is *ignored*
- Assumes an arbitrary endpoint
- Ignores cash flows beyond the endpoint date
- Biased against long-term projects

Net Present Value (NPV) Method

Under the net present value method, the present value of all cash inflows from the project is compared against the initial investment



Net Present Value Method (cont'd)

Advantages of NPV Method:

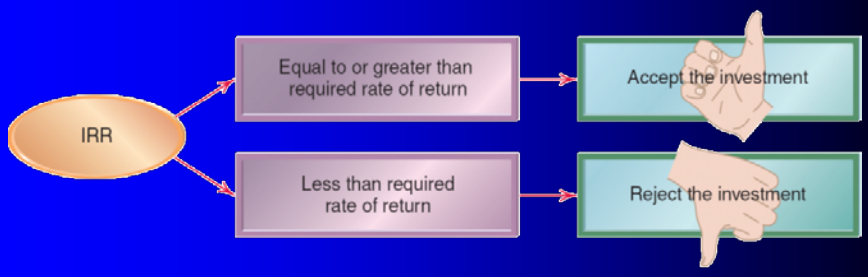
- Focuses on cash flows
- Accounts for time value of money
- Accounts for risk differences between projects

Disadvantages of NPV Method:

- Lacks the simplicity of payback method
- Fails to capture managerial flexibility
  - Does not account for option value

The Internal Rate of Return (IRR) Method

IRR is the discount rate that makes the net present value of all cash flows from a particular project equal to zero



The Internal Rate of Return Method (cont'd)

Advantages of IRR Method:

- Properly adjusts for time value of money
- Uses cash flows rather than earnings
- Project IRR is an easily understood/appealing number

Disadvantages of IRR Method:

- Possible to have multiple answers
- Can be misleading (incorrect decisions)
- Difficult to calculate (compared to Payback and NPV)

Required Rate of Return (ROR)

- At what rate should we discount the cash flows of the project?
  - Cash flows need to be discounted at the required rate of return
  - In general, ROR equals the ***cost of capital*** for the project/firm

Cost of Capital

Cost of capital is the weighted average of the **costs of debt** and **equity financing** used to generate the capital for investments

- **Cost of Debt:**
  - Interest paid to individuals, banks, or other companies that lend money to the project/firm
- **Cost of Equity:**
  - Return demanded by shareholders

Debt vs. Equity

What is Equity Financing?

Equity financing means sharing of ownership of the business depending upon the invested amount

- Equity represents ownership in the firm
- Owners are residual claimants (profit or loss)
- No contractual commitment is required
  - to return the original amount invested

Types of Equity Securities

Two major types of equity securities are:

1) Common Stock

2) Preferred Stock

What is Debt Financing?

Debt financing is a common method used to borrow money for a specific period of time that usually must be paid back with interest. *Unlike* equity financing, the loan source does not require a piece of ownership in the business

- Debt requires contractual commitments such as:
  - Repayment of the principal
  - Payment of the interest
  - Maintaining of financial ratios

Debt vs. Equity Financing

Advantages of Debt Compared to Equity:

- Because the lender does not have a claim to equity in the business, debt does not dilute the owner's ownership interest in the company
- Principal and interest obligations are known amounts that can be forecasted and planned for
- Interest on the debt can be deducted on the company's tax return, lowering the actual cost of the debt to the company
- Raising debt capital is less complicated because the company is not required to comply with state and federal securities laws and regulations

Debt vs. Equity Financing (cont'd)

Disadvantages of Debt Compared to Equity:

- Unlike equity, debt must at some point be repaid
- Interest is a fixed cost that raises the company's break-even point
- High interest costs during difficult financial periods can increase the risk of insolvency. Companies that are too highly leveraged (that have large amounts of debt as compared to equity) often find it difficult to grow because of the high cost of servicing the debt
- The larger a company's debt-equity ratio, the more risky the company is considered by lenders and investors

Types of Debt

- **Short-term Debt**
  - Maturity of 1 year or less
  - Traditionally has a floating rate of interest (cost) to the borrower and therefore exposes the borrower to interest rate risk
  - Because of the short life, the rates of interest are often lower than long term
- **Long-term Debt**
  - Maturities greater than 1 year
  - Typically more expensive than short-term debt
  - Often borrowed at a fixed rate immunizing the borrower from interest rate risk by locking in a coupon-rate in the case of bonds/debentures

Debt Instruments

Debt instruments can be divided into two major groups as *non-marketable* and *marketable* debt instruments

1) Non-marketable
   - Certificates of Deposit
   - Money Market Deposit Accounts (MMDAs)
   - Savings Bonds
2) Marketable
   - Money Market Instruments
   - LongTerm Instruments

Bonds as Financial Assets

- Bonds are loans that represent debt that the seller must repay to the investor
- Bonds have three basic components:
  - *Coupon rate*: The interest rate that a bond issuer will pay to a bondholder
  - *Maturity*: The time at which payment to a bondholder is due
  - *Par value*: The amount to be paid to the bondholder at maturity

Different Types of Bonds

- Corporate
- Government (Treasury)
- Municipal

Characteristics of Bonds

- Bond prices are affected by the changes in the market interest rates
- Coupon payments are generally semi-annual
- The bond's full face amount is paid back to investors at maturity

What Determines Bond Prices?

- Current market interest rates: Bond prices tend to increase when interest rates fall and decrease when rates rise
- Inflation: High inflation will de-value a bond
- Liquidity: The ease and cost of trading a particular bond will affect the price
- Political risk: People tend not to invest when the governments are unstable

Bond Pricing

- Present value (PV) of the bond = Present value of interest payments + Present Value of Principal

  ⟶ PV of Annuity (PMT, i, N) + PV (FV, i, N)

$$PV = \sum_{t=1}^{N} \frac{PMT}{(1+i)^t} + \frac{FV}{(1+i)^N}$$

Where N = time to maturity
i = market interest rate
PMT = semiannual interest payment
FV = face value

The Concept of Yield to Maturity (YTM)

- So far we have valued bonds by using a given interest rate and then discounted all payments to the bond
- Prices are usually given from trade prices
  - need to infer interest rate that has been used
- *Definition:* The yield to maturity is that interest rate that equates the present discounted value of all future payments to bondholders to the market price
- YTM can be computed via trial and error

Duration Calculation

$$\text{Duration} = \frac{\sum_{t=1}^{T} \frac{t \times \text{Coupon Payment}}{(1+Yield)^t}}{\sum_{t=1}^{T} \frac{\text{Coupon Payment}_t}{(1+Yield)^t}} = \frac{\sum_{t=1}^{T} \frac{t \times \text{Coupon Payment}}{(1+Yield)^t}}{\text{Bond Price}}$$

$$\text{Modified duration} = \frac{\text{Duration}}{1+\left(\frac{\text{Yield}}{\text{Coupon Payments per Year}}\right)}$$

Direct estimate of the percentage change in bond price for each percentage point change in the market interest rate.

% change in bond price = – 1 × % Yield change × modified duration

Which Bond to Buy?

Cumulative Historic Default Rates (in percent)				
Rating categories	Moody's		S&P	
	Municipal	Corporate	Municipal	Corporate
Aaa/AAA	0.00	0.52	0.00	0.60
Aa/AA	0.06	0.52	0.00	1.50
A/A	0.03	1.29	0.23	2.91
Baa/BBB	0.13	4.64	0.32	10.29
Ba/BB	2.65	19.12	1.74	29.93
B/B	11.86	43.34	8.48	53.72
Caa-C/CCC-C	16.58	69.18	44.81	69.19
Investment Grade	0.07	2.09	0.20	4.14
Non-Invest Grade	4.29	31.37	7.37	42.35
All	0.10	9.70	0.29	12.98

Advantages & Disadvantages of Bonds

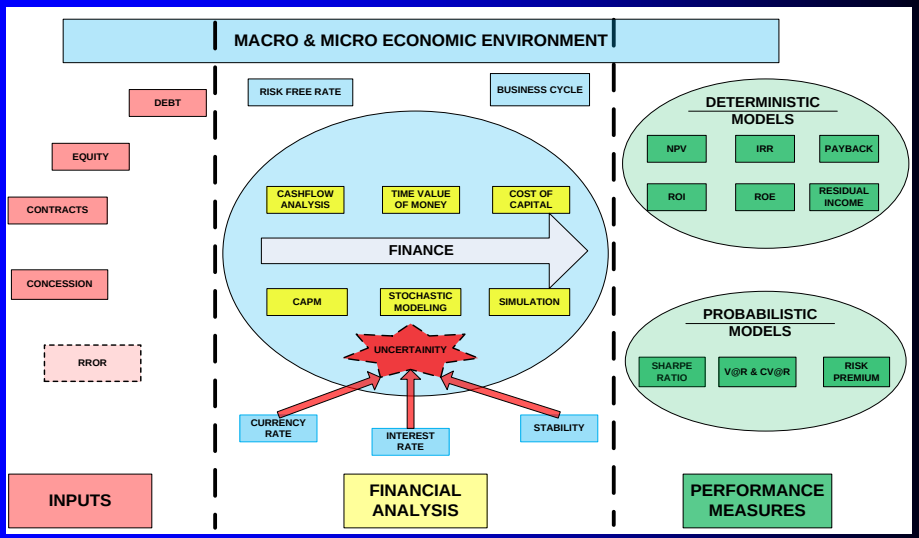
Advantages of Bonds:

- Once a bond is sold, the coupon rate remains the same
- The issuer does not have to share profits with bondholders if it is doing well

Disadvantages of Bonds:

- The issuer must make fixed interest payments and cannot change its interest payments
- An issuer's bonds may be given a low bond rating and be harder to sell when the firm is not doing well

The Big Picture



Appendix C: Lecture Slides for Module 3

Fundamentals of Engineering

Learning Objectives for Module 3

By the end of Module 3, students should be able to:

- Have a broad view of engineering analysis and describe fundamental engineering functions such as design, construction/manufacturing, and operation and maintenance.
- Learn the strategies, methods, limits, and constraints in different phases of an engineering project.
- Determine the design problems and their elements, understand the needs, and select the best alternative.
- Describe the challenges in the construction/manufacturing phase, and determine cost drivers and evaluate methods for cost reduction.
- Become familiar with design for manufacture (DFM), design for assembly (DFA), and design for reliability (DFR) concepts.
- Describe the operations and maintenance (O&M) goals and identify different O&M approaches.
- Estimate O&M costs and determine the optimum O&M approach for different scenarios.
- Describe the interaction between different engineering functions. Determine the effects of design, manufacture, and maintenance on project cost and value.

Fundamentals of Engineering

Engineering is the creative process of applying scientific and mathematical principles, experience ,and judgment/common sense to address a need (problem) that results in a new product, process, or system

The American Engineers' Council for Professional Development (ECPD, the predecessor of ABET) has defined "engineering" as:

The creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation and safety to life and property

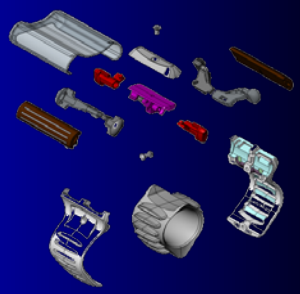
Engineering Functions

The three major functions of all engineering branches are the following:

1) Design

2) Manufacturing

3) Operation & Maintenance



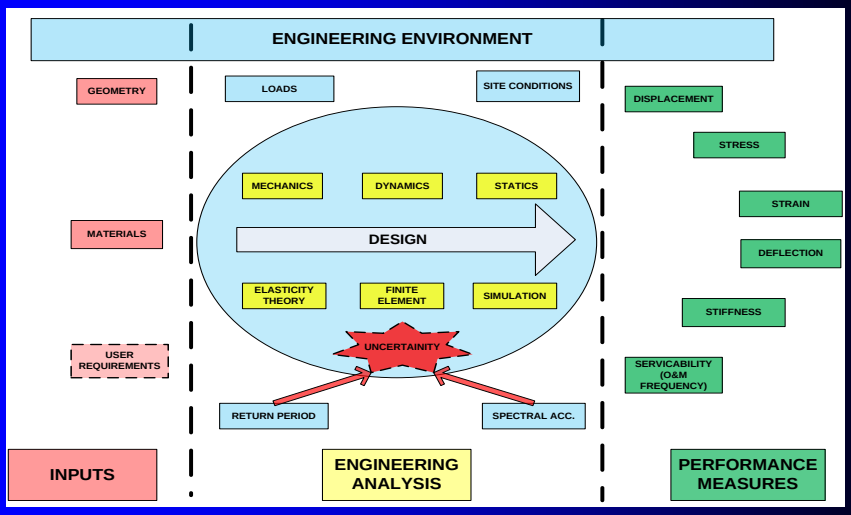
Engineering Functions (cont'd)

1) Design: In designing a structure or a product, the engineer selects methods, specifies materials, and determines shapes to satisfy technical requirements and to meet performance specification

2) Construction & Manufacturing: During this phase the engineer is responsible for preparing the site, determining procedures that will economically and safely yield the desired quality, directing the placement of materials, and organizing the personnel and equipment. He/she chooses processes and tools, integrates the flow of materials and components, and provides for testing and inspection

3) Operation & Maintenance: The engineer controls machines, plants, and organizations providing power, transportation, and communication. He/she determines procedures and supervises personnel to obtain reliable and economic operation of complex equipment

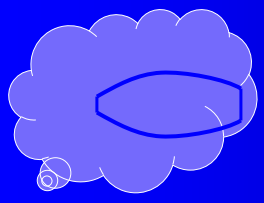
The Big Picture

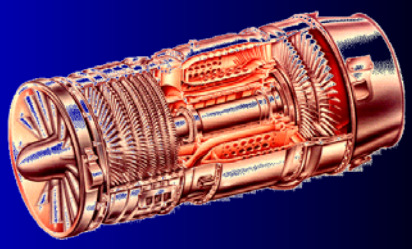


FUNCTION 1:

DESIGN

Definition





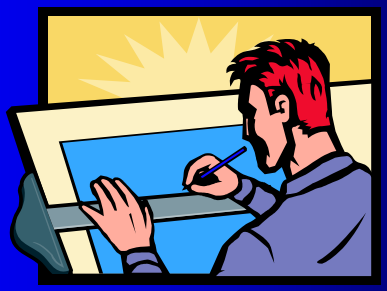
Abstract Concept

Hardware Reality

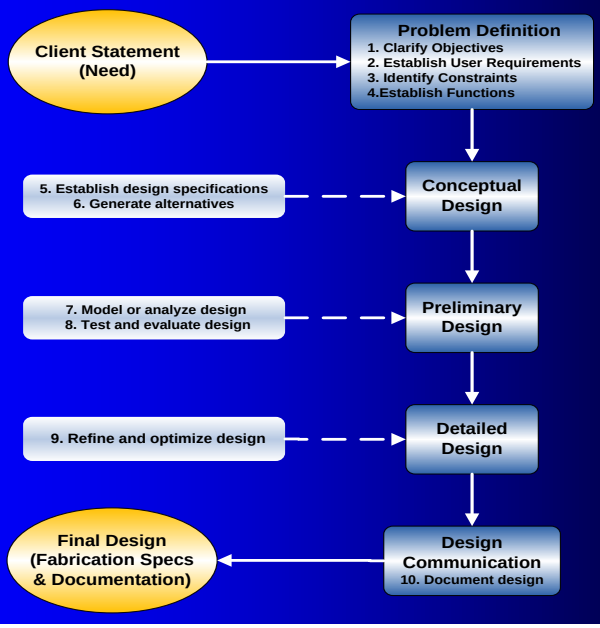
Design Process

- Engineering design is an *iterative* process.
  - Reconsider:
    - assumptions
    - decisions
    - conclusions

Design Process



Five-Step Design Process



Design Process Example

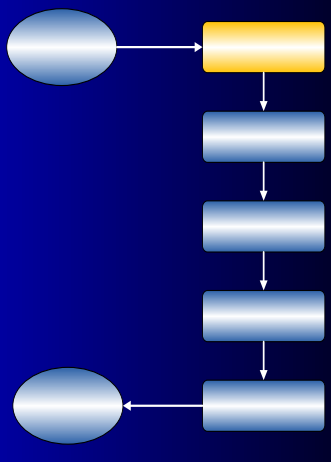
Safe Ladder Project

Suppose you are asked to design a safe ladder. Many safe ladders have already been designed, produced, and sold. So, what does it mean to start another safe ladder project?

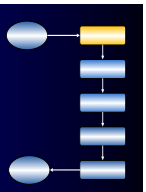
Step 1: Problem Definition

During problem definition we clarify the client's objectives and gather the information needed to develop an engineering statement of the client's wants

- **Input:**
  - Client's statement
- **Task:**
  - Clarify design objectives
  - Establish user requirements
  - Identify constraints
  - Establish functions
- **Output:**
  - Revised problem statement
  - Revised objectives
  - Constraints
  - User requirements



Step 1: Problem Definition (cont'd)

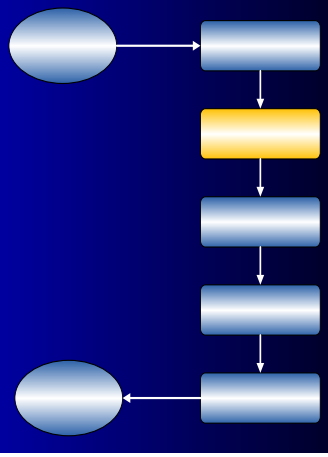


- **Input:**
  - Client's statement: Design a safe ladder
- **Task:**
  - Clarify design objectives: How is the ladder to be used?
  - Establish user requirements: Should the ladder be portable?
  - Identify constraints: How much can it cost?
  - Establish functions: Can the ladder lean against a supporting surface? Must the ladder support someone carrying something?
- **Output:**
  - *Design a portable safe ladder to be used in houses within the budget of $15 per item. Ladder can lean against a supporting surface and must support someone carrying something up to 100 lb*

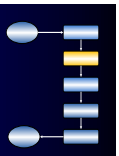
Step 2: Conceptual Design

In the conceptual design stage of the design process, we generate concepts or schemes of candidate designs

- **Input:**
  - Constraints
  - User requirements
  - Refined objectives
  - Revised problem statement
- **Task:**
  - Establish design specifications
  - Generate design alternatives
- **Output:**
  - Conceptual design(s) or scheme(s)
  - Design specifications



Step 2: Conceptual Design (cont'd)



- **Input:**
  - *Design a portable safe ladder to be used in houses within the budget of $15 per item. Ladder can lean against a supporting surface and must support someone carrying something up to 100 lb*
- **Task:**
  - Establish design specifications:

    How much weight should a safe ladder support?
    What is the allowable load on a step?
    How high should someone on the ladder be able to reach?
  - Generate design alternatives:

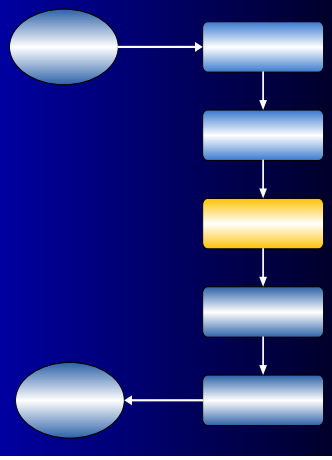
    Could the ladder be stepladder or extension ladder?
    Could the ladder be made of wood, aluminum, or fiberglass?
- **Output:**
  - Conceptual design(s) or scheme(s) with specifications

    Design should be stepladder type and made of aluminum or wood, not fiberglass

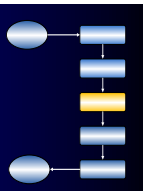
Step 3: Preliminary Design

In the preliminary design phase, we identify the principal attributes of the design concepts or schemes

- **Input:**
  - Conceptual design(s) or scheme(s)
  - Design specifications
- **Task:**
  - Model, analyze conceptual designs
  - Test, evaluate conceptual designs
- **Output:**
  - A selected design
  - Test and evaluation results



Step 3: Preliminary Design (cont'd)

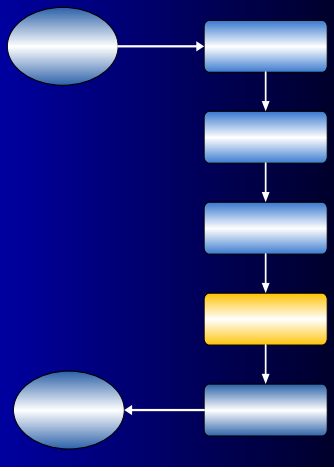


- **Input :**
  - *Design should be stepladder type and made of aluminum or wood, not fiberglass*
- **Task:**
  - Model, analyze conceptual designs:
    - What is the maximum stress in a step supporting the design load?
    - How does the bending deflection of a loaded step vary with the used material type?
  - Test, evaluate conceptual designs :
    - Can someone on the ladder reach the specified height?
    - Does the ladder meet safety specifications?
- **Output:**
  - An aluminum stepladder with a maximum step load of 300 lb

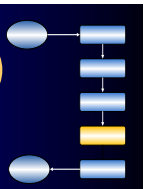
Step 4: Detailed Design

- **Input:**
  - Selected design
  - Test and evaluation results
- **Task:**
  - Refine and optimize the chosen design
- **Output:**
  - Proposed fabrication specifications
  - Final design review for client

During detailed design phase, we refine and detail the final design



Step 4: Detailed Design (cont'd)



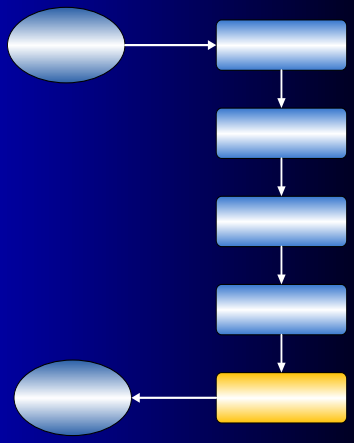
- **Input:**
  - *An aluminum stepladder with a maximum step load of 300 lb*
- **Task:**
  - Refine and optimize the chosen design:

    Is there a more economic design?
    Is there a more efficient design (e.g., less material)?
- **Output:**
  - Proposed fabrication specifications for the safe ladder
  - Final design review for client

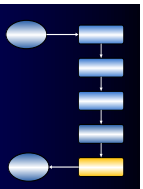
Step 5: Design Communication

During the design communication phase, we document the fabrication specifications and their justification

- **Input:**
  - Fabrication specifications
- **Task:**
  - Document the completed design
- **Output:**
  - Final report to client containing:
    - Fabrication specifications
    - Justification for fabrication specs



Step 5: Design Communication (cont'd)



- **Input:**
  - *Fabrication specifications: maximum stress in a step, bending deflection of a loaded step, minimum allowable height to be reached by users, etc.*
- **Task:**
  - Document the completed design:
    - What information does the client need to fabricate the design?
    - What is the justification for the design decisions that were made?
- **Output:**
  - Final report to client containing:
    - Fabrication specifications
    - Justification for fabrication specs

Feedback & Design

Feedback occurs in two notable ways in the design process:

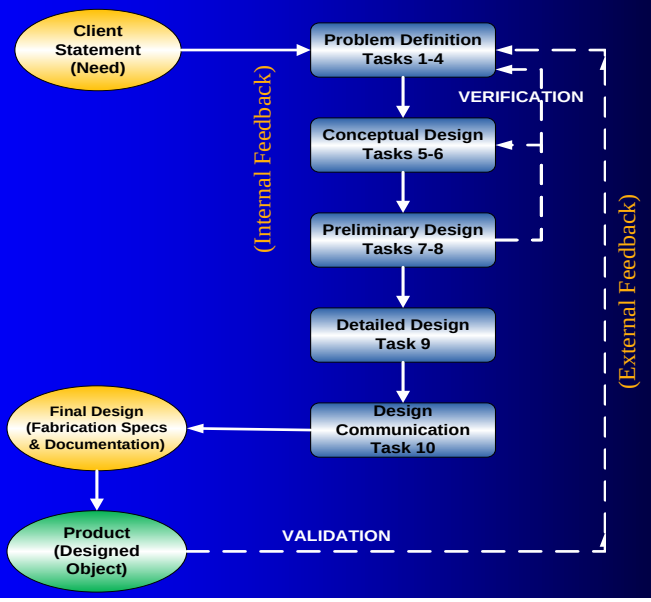
1) Internal feedback loop (Verification)

- The results of performing the test and evaluation task are fed back into the preliminary design stage to verify that the design performs as intended

2) External feedback loop (Validation)

- This occurs after the final product resulting from a design has been used in the market for which it was intended

Design Process & Feedback



FUNCTION 2:

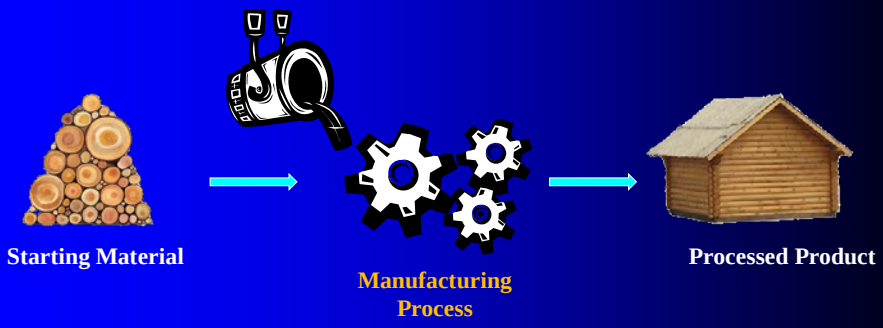
MANUFACTURING / CONSTRUCTION

Definition

Manufacturing/construction function involves the analysis of product designs to assure manufacturability/constructability; the design, selection, specification, and optimization of the required equipment, tooling, processes, and operations; and the determination of other technical matters required to make a given product according to the desired volume, timetable, cost, quality level, and other specifications

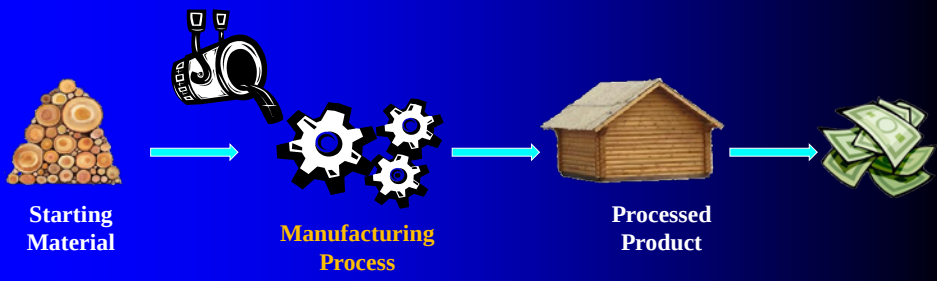
Manufacturing/Construction Technologically

- Manufacturing/construction also includes assembly
- In general, carried out as a sequence of operations



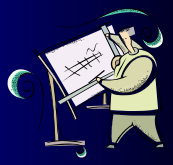
Manufacturing/Construction Economically

- Manufacturing/construction ***adds value*** to the material by changing its geometry or properties, or by combining it with other materials



Information for Manufacturing

- Sketches, drawings, product specifications, and design alternatives



- A detailed understanding of production and assembly processes

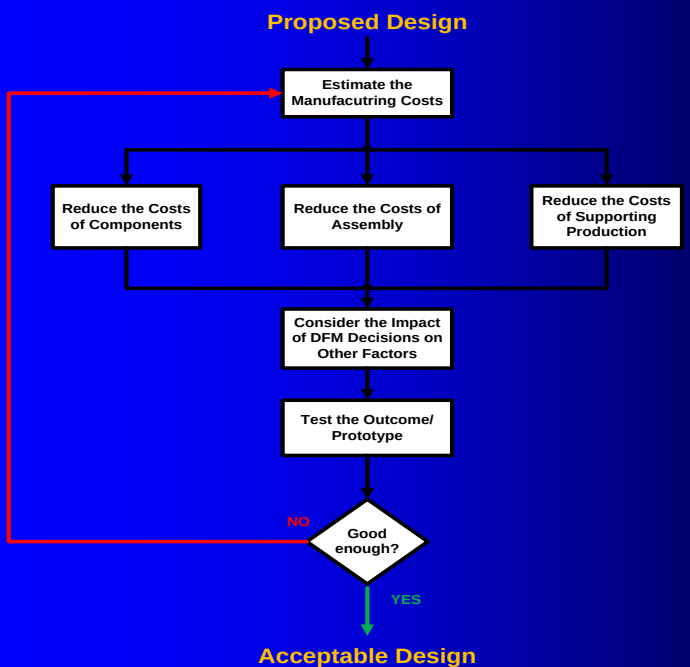
- Estimates of manufacturing costs, production volumes, and ramp-up timing.

Design for Manufacturability (DFM)

Definition

- DFM describes the process of designing or engineering a product in order to facilitate the manufacturing/construction process to reduce its manufacturing costs
- DFM will allow potential problems to be fixed in the design phase, which is the *least expensive* place to address them
- Other factors may affect the manufacturability/constructability such as the type of raw material, the form of the raw material, dimensional tolerances, and secondary processing such as finishing

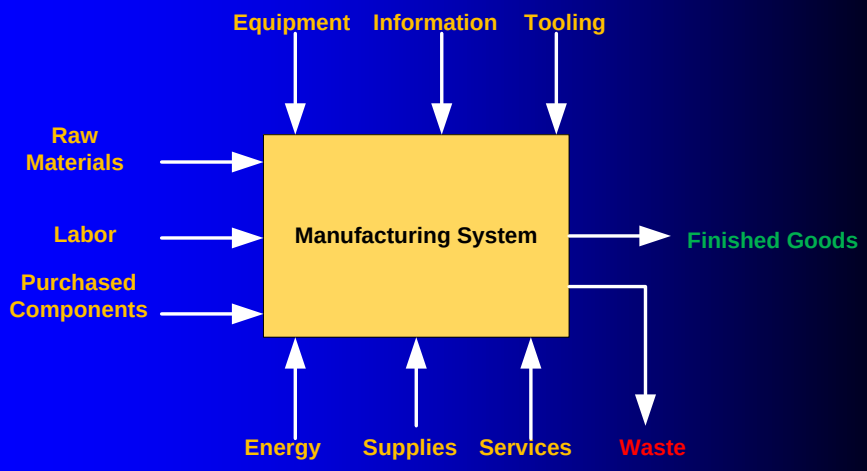
DFM Process



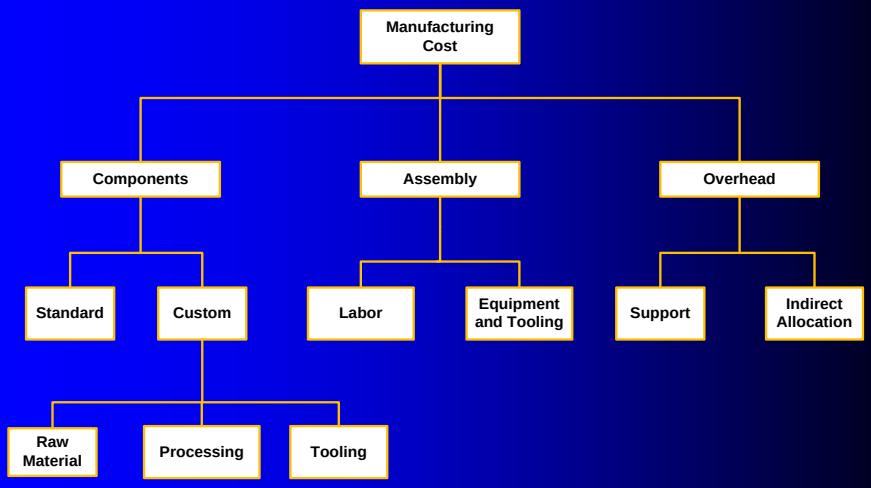
DFM Process (cont'd)

1) Estimate the manufacturing costs for the proposed design
2) Reduce the costs of components
3) Reduce the costs of assembly
4) Reduce the costs of supporting production
5) Consider the impact of design and manufacturing decisions on other factors
6) Test the outcome/prototype

1. Estimate the Manufacturing Costs



Elements of the Manufacturing Cost of a Product



2. Reduce the Cost of Components

- Understand the process constraints and cost drivers
- Redesign components to eliminate processing steps
- Choose the appropriate economic scale for the part process
- Standardize components and processes

3. Reduce the Costs of Assembly

- Determine minimum number of parts
- Maximize ease of assembly
- Consider customer assembly

4. Reduce the Costs of Supporting Production

- Minimize systemic complexity (inputs, outputs, and transforming processes)
  - Use smart design decisions
- Minimize potential errors
  - Anticipate possible failure modes
  - Take appropriate corrective actions in the early stages

5. Consider the Impact of DFM Decisions on Other Factors

- Development time
- Development cost
- Product quality
- External factors
  - Component reuse
  - Life-cycle costs

6. Test the Outcome/Prototype

- A prototype may reduce the risk of costly iterations
- A prototype may expedite other development steps
- A prototype may restructure task dependencies

FUNCTION 3:

OPERATION
&
MAINTENANCE (O&M)

Definition

O&M encompass all that broad spectrum of services required to assure the built environment or designed engineering product will perform the functions for which it was designed and constructed/manufactured

- Operations and maintenance are combined into the common term O&M because an engineering design product cannot operate at peak efficiency without being maintained; therefore, the two are discussed as one

O&M Goals

The goals of an O&M engineer include the following:

1) Reduce capital repairs
2) Reduce unscheduled shutdowns and repairs
3) Extend equipment life, thereby extending facility life
4) Realize life-cycle cost savings
5) Provide safe, functional systems and facilities that meet the design intent

Maintenance

In engineering in general, the term maintenance has the following two meanings:

1. **For any activity**—such as tests, measurements, replacements, adjustments, and repairs intended to retain or restore a functional unit or to a specified state in which the unit can perform its required functions
2. **For material**—all action taken to retain material in a serviceable condition or to restore it to serviceability. It includes inspection, testing, servicing, classification as to serviceability, repair, rebuilding, and reclamation.

Source: Wikipedia

Maintenance Types

1. Corrective Maintenance

Repairs are made after the equipment is failed and cannot perform its normal function anymore

- Well justified in small factories where:
  - Downtimes are non-critical
  - Repair costs are less compared to the other types of maintenance
  - Financial justification for scheduling is not felt

2. Scheduled Maintenance

- Scheduled maintenance incorporates:
  - inspection
  - lubrication
  - repair and overhaul of equipment
- If not performed on time, can result in breakdown
- Generally followed for:
  - overhauling of machines
  - changing of heavy equipment oils
  - cleaning of water and other tanks, etc.

3. Preventive Maintenance

Principle–Prevention is better than cure!

Procedure–Stitch in time

- Preventive maintenance:
  - Locates weak spots of equipments ahead of time
  - Provides them periodic/scheduled inspections and minor repairs to reduce the risk of unexpected breakdowns

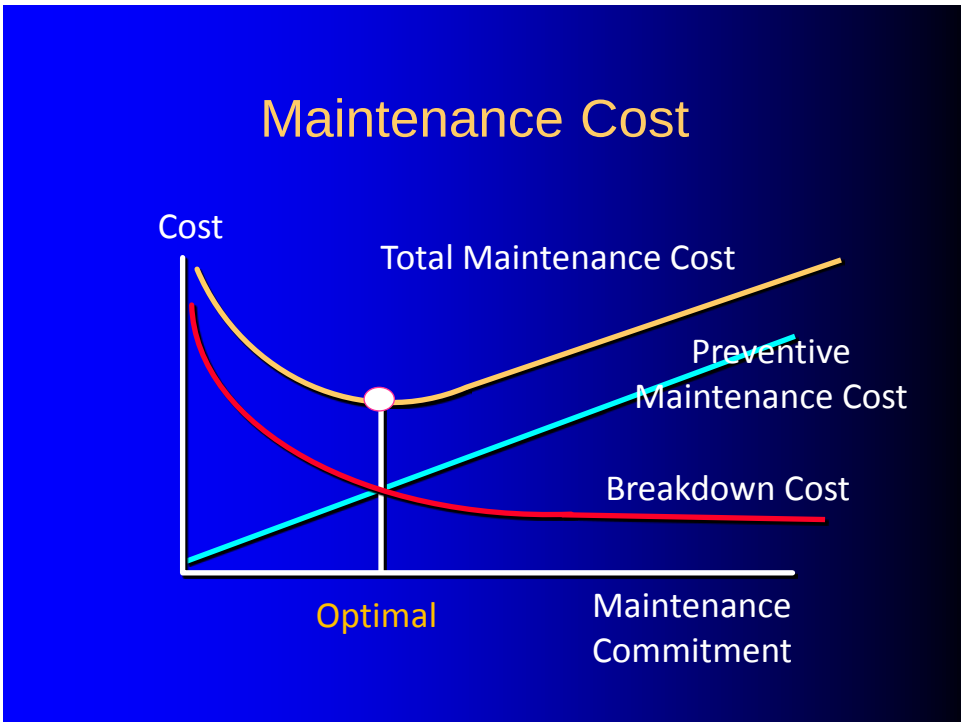
4. Predictive Maintenance

Machinery and operating conditions are periodically monitored to enable:

- Taking timely actions
- Reducing future large-scale breakdown costs

Indicators for Predictive Maintenance

- Unusual sounds coming out of machinery
- An overheated equipment or electric cable
- Simple hand touch can point out many unusual equipment conditions and thus predicts a trouble


Maintenance Cost
Cost
Total Maintenance Cost
Preventive
Maintenance Cost
Breakdown Cost
Optimal
Maintenance
Commitment

Appendix D: Lecture Slides for Module 4

Complex Engineering Systems and Systems Engineering

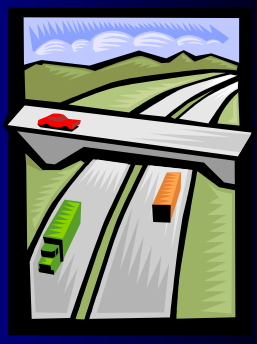
Learning Objectives for Module 4

By the end of Module 4, students should be able to:

- Describe the characteristics of complex engineering systems and the systems design process.
- Adopt systems thinking as an integrative holistic approach to problem solving.
- Develop a systems engineering plan for a project in the student's industry of choice.
- Abstract a complex technical system into quantitative models and/or qualitative frameworks that represent that system.
- Understand the essential systems engineering concepts (e.g., modularity), and apply it to realistic problems.
- Recognize the value and limitations of modularity in the systems engineering process.
- Identifying the key system stakeholders, and balance their diverse interests.

What is a System?

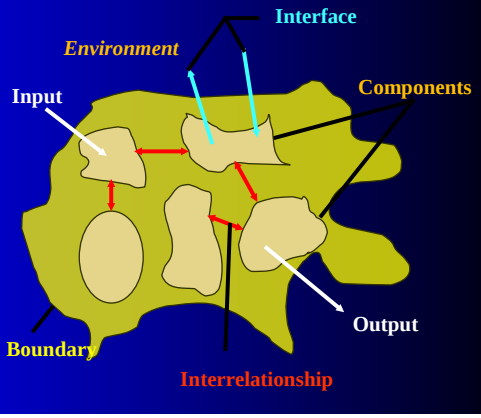
- A purposeful collection of interrelated components working together toward some common objective
- System components can be dependent on other system components, or act independently
- All components work together to achieve a common objective
- E.g., freeway (transportation system)



System Characteristics

- **A system has nine characteristics:**

1. Components/Subsystems
2. Interrelated components
3. A boundary
4. A purpose
5. An environment
6. Interfaces
7. Input
8. Output
9. Constraints



System Characteristics (cont'd)

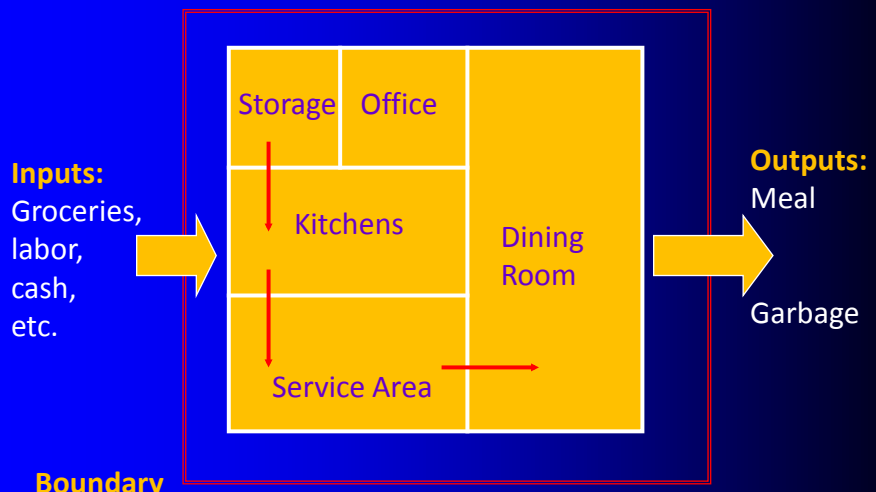
- A component
  - An irreducible part or aggregation of parts that make up a system, also called a subsystem
- Interrelated components
  - Dependence of one subsystem on one or more subsystems
- Boundary
  - The line that marks the inside and outside of a system and that sets off the system from its environment
- Purpose
  - The overall goal or function of a system
- Environment
  - Everything external to a system that interacts with the system

System Characteristics (cont'd)

- Interface
  - Point of contact where a system meets its environment or where subsystems meet each other
- Constraint
  - A limit to what a system can accomplish
- Input
  - Whatever a system takes from its environment in order to fulfill its purpose
- Output
  - Whatever a system returns from its environment in order to fulfill its purpose

Example: A diner as a system

Environments: customers, food distribution, banks, etc.



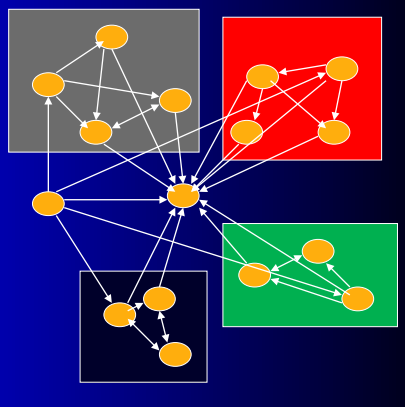
System Engineering Process

- Usually follows a waterfall model because of the need for parallel development of different parts of the system
- Inevitably involves engineers from different disciplines who must work together

Important System Concepts

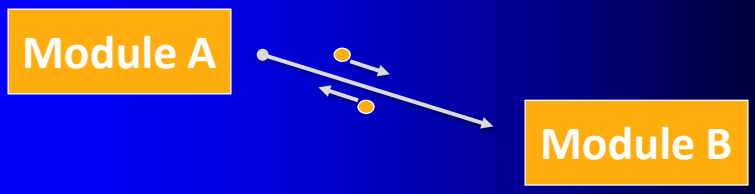
Modularity: The process of dividing a system up into chunks or modules of a relatively uniform size to simplify the redesign and rebuild process

- Modularity makes complexity manageable
- Modularity enables parallel work
- Modularity is tolerant of *uncertainty*



Modular Engineering Design

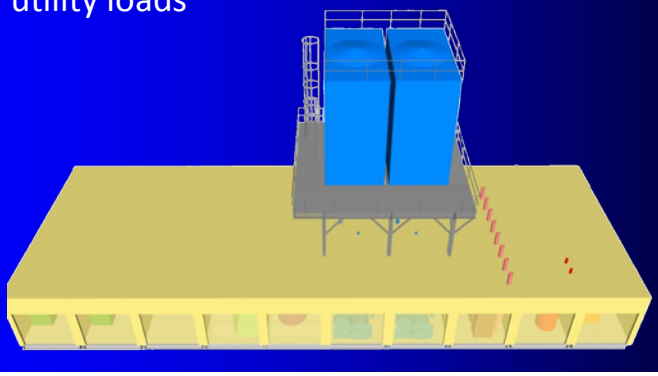
- Modular engineering design is decomposed of design modules such that *a change in one module has minimal effect on other modules*



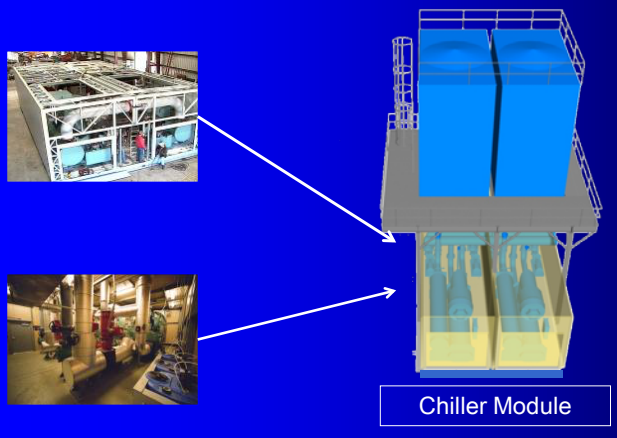
- A design module itself may consists of procedures, functions, and criteria that
  - can be separately compiled and
  - independently callable

Example: Medical Facility
Modular Central Utility Plant

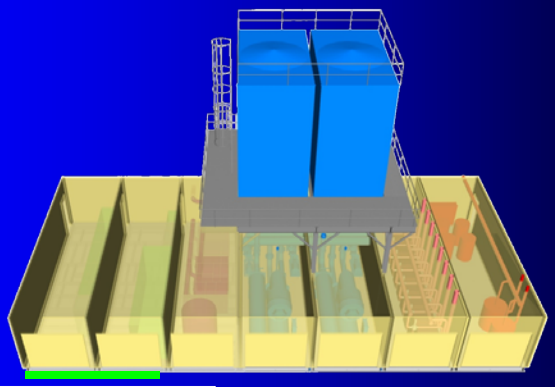
The design is based on a *plug and play* design concept whereby all hospital utility plant components are skid mounted and put together like Legos at the site to match the required utility loads



Medical Facility
Modular Central Utility Plant (cont'd)

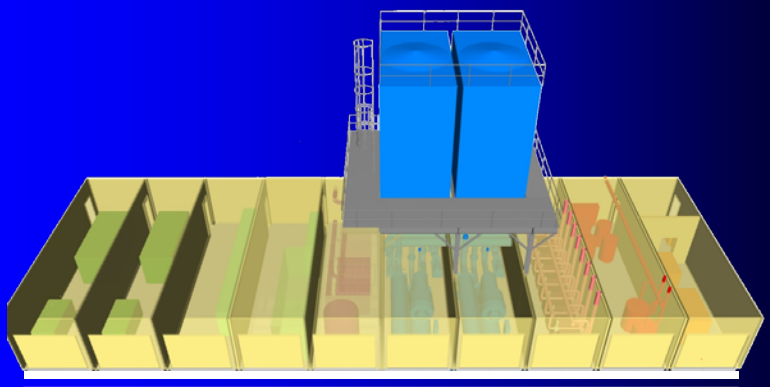


Medical Facility
Modular Central Utility Plant (cont'd)



Electrical Module

Medical Facility
Modular Central Utility Plant (cont'd)



Modular Central Utility Plant

Uses

- *Clinics*
- *Ambulatory Surgery*
- *Hospitals*
- *Mobile Medical Units*
- *Deployable Medical Assets*

Limitations of Modularity

- Modularity requires a great deal of extra work
  - Designers must design meticulously in a top-down fashion
- Requires perfect communication between designers of different modules
  - Seeing the big picture may become rather difficult
- Modular approach may occasionally require more work power & man-hours
- Manufacturing a single part that does many things might be faster and more economical

Integrality and Modularity

- Modular systems are, ideally, those in which
  - Functions can be associated simply and directly with modules more or less one to one
  - Only predefined interactions occur between modules
  - Interactions occur at, and only at, predefined interfaces
- Integral systems differ as follows:
  - Functions are shared among modules
  - Interactions that were not defined can occur, and they can occur at undeclared interfaces

The Value of Modularity

- Modularity not only accommodates change
- It encourages innovation by decentralizing decision making on hidden modules
- Technically, it creates the *option* for third parties to innovate on a module
  - Parties compete to create a better module
  - A few experiments likely to create superior module whose value to users exceeds cost of experiments
- *Cluster* of innovators emerge around architecture, resulting in new industry

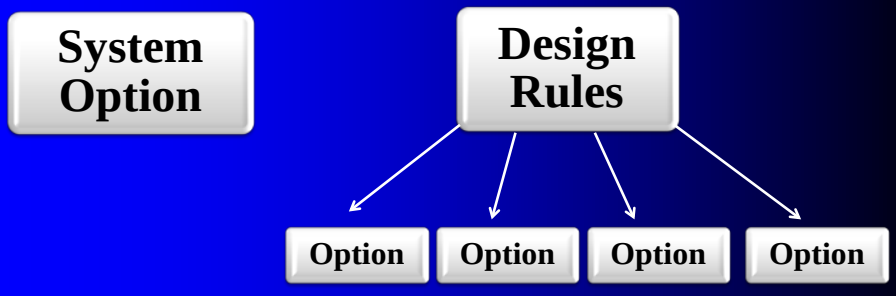
Design & Value

- Design structure/Modularity (of products and processes) determines industry structure
  - Transaction costs are low at module boundaries
  - Every thin crossing point/module boundary is a potential place to put a transaction, i.e., bring in a different firm
- Option value of designs determines rate of change/industry evolution
  - Option value makes design experiments worthwhile
  - Experiments yield new designs (of products and processes)
  - Better new designs replace or augment the older ones!

Designs as Options

- A fundamental property of design is that at the start of any design process, the final outcome is *uncertain*
- Uncertainty about final value in turn causes new designs to have option-like properties
  - In finance, an option is the right but not the obligation to choose a course of action and obtain an associated payoff
  - In engineering, a new design creates the ability but not the necessity—the right but not the obligation to do something in a different way

Designs as Options (cont'd)

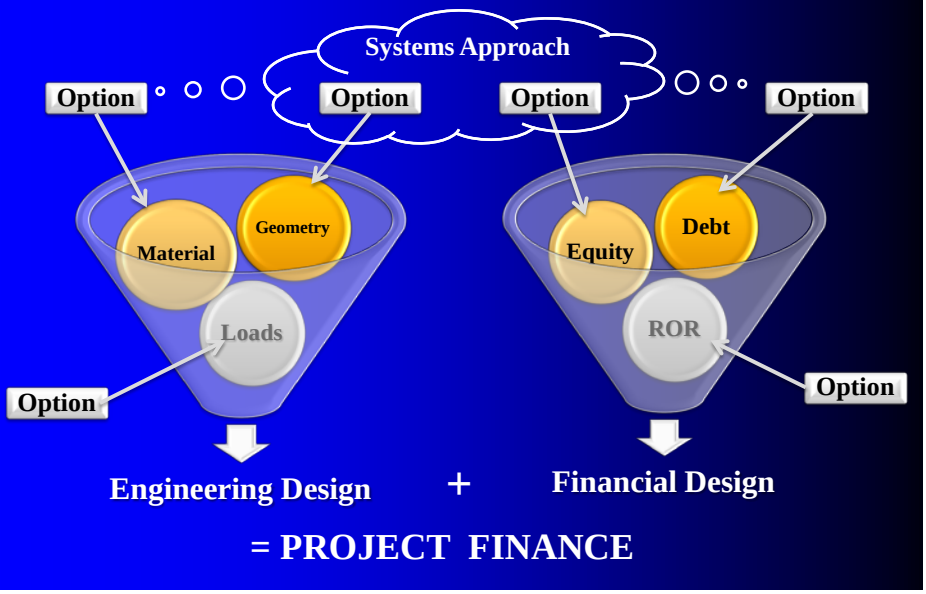


- The system goes from having one large design option (i.e., to take the whole design or leave it) to having many smaller options, one per module

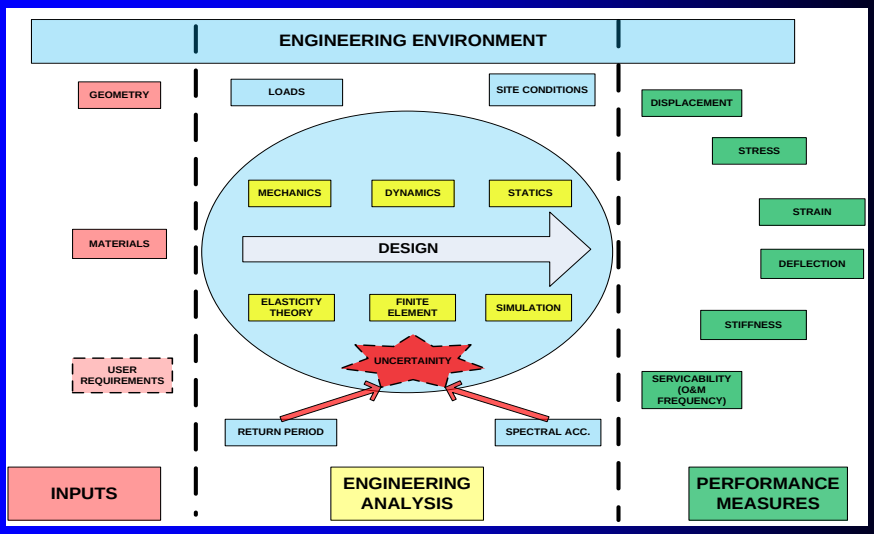
Options & Optional Substitution

- The *right but not the obligation* to take an action
  - Action = use a new design
  - If new is better than old, use new
  - Otherwise, keep the old (*optional substitution*)
- Unit of *optional substitution* is a module (which can be changed without changing something else)
  - Thus option value resides in modules

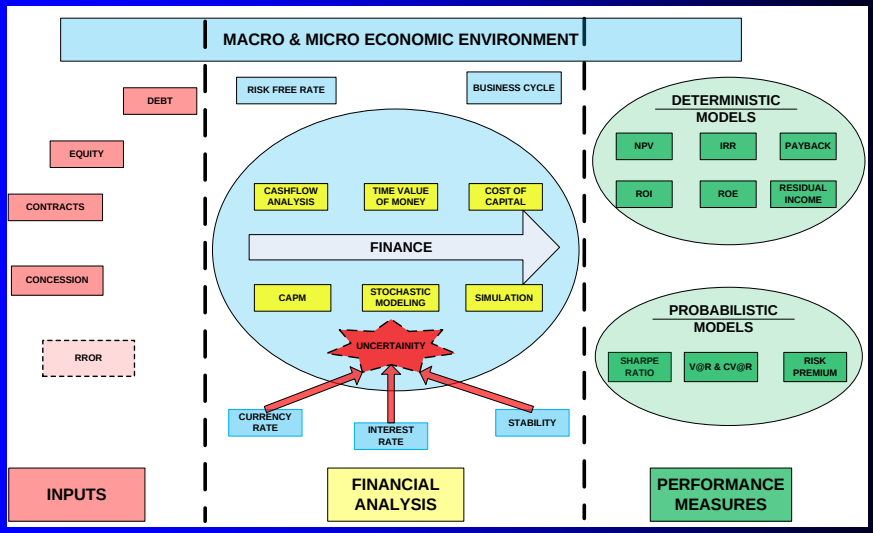
Engineering & Finance



Big Picture (Engineering)



Big Picture (Finance)



Appendix E: Lecture Slides for Module 5

Special Purpose Vehicles (SPVs) and Public-Private Partnerships (PPPs)

Learning Objectives for Module 5

By the end of Module 5, students should be able to:

- Understand the concepts of SPVs and their accounting implications.
- Describe the capital structuring issues and the use of SPVs: debt, equity, and securitization.
- Understand the role of SPVs in securitization and project financing.
- Structure and evaluate SPVs based on the project/sponsor/investor needs.
- Explain the framework and use of PPPs.
- Understand the stakeholder roles and perspectives in PPPs.
- Describe legal and contractual issues in PPP projects.
- Describe financing issues: sources of funds and credit enhancement for PPPs.
- Analyze the benefits of PPPs for economic and social Infrastructure.
- Know how to manage and allocate risks in PPPs.

Special Purpose Vehicles (SPVs) & Public-Private Partnerships (PPPs)

Part I
Special Purpose Vehicles

Introduction

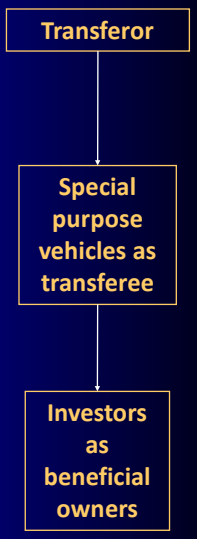
- Governments and private industry often create independent institutions or entities to perform certain functions on their behalf
  - Widely used in recent years
- These independent institutions are called
  - Special Purpose Vehicles
    - ✓Securitization
    - ✓Project financing

Definition of SPVs

- An SPV is an entity that is created, through the transfer of *assets*, *liabilities*, or *rights*, to carry out a well - specified activity or series of transactions
  - These activities are directly related to the specific purpose for which it was formed
- An SPV can take the form of a corporation, trust, partnership, or a limited liability company
- An SPV is a vehicle whose operations are typically limited to the acquisition and financing of specific assets or liabilities

Definition of SPVs (cont'd)

- Transferor (Sponsor)
  - ✓ The entity that transfers the assets, liabilities, or rights
  - ✓ The entity that creates the SPV
  - ✓ Equity could be vested in transferor and/or partners
- Transferee (SPV)
  - ✓ The entity that receives the assets, liabilities, or rights
- Investors
  - ✓ Typically provide all funding requirements for SPV activities through loans



Characteristics of SPVs

- ❖ They are thinly capitalized
- ❖ They have no independent management or employees
- ❖ The administrative functions are performed by a trustee who follows pre-specified rules with regard to the receipt and distribution of the cash; there are no other decisions
- ❖ Assets held by the SPV are serviced via a service arrangement
- ❖ They are structured so that they cannot become bankrupt

Some Uses of SPVs

Two most common application fields are:

1) **Securitization of assets and liabilities**
   - ➢ *Asset securitization*
   - ➢ *Liability securitization*
2) **Project finance**
   - ➢ *PPPs*
   - ➢ *Build-own-operate-transfer (BOOT) schemes*
   - ➢ *Joint ventures*

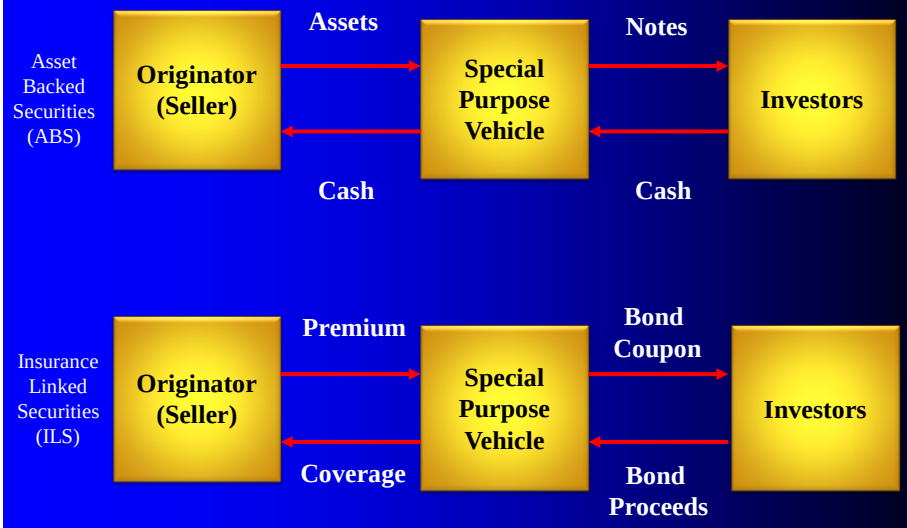
1. Securitization

"Securitization is defined as the pooling and repackaging by a special purpose entity of assets or other credit exposures that can be sold to investors" (1)

- ❖ Securitization is a financing mechanism
- ❖ It transfers financial assets from their owner (sponsor) to a SPV that, in turn, funds the acquisition by issuing publicly rated securities (notes or bonds) to various parties (investors)

(1) Definition by the Office of the Comptroller of the Currency (OCC), the Federal Deposit Insurance Corporation (FDIC), the Federal Reserve Board, and the Office of Thrift Supervision (OTS), Attachment OCC 2002-22

Typical Securitization Structures



SPV Motivations for Securitization

- Funding and Liquidity
- Varying Investor Needs
- Bankruptcy Remoteness
- Risk Management
- Accounting
- Taxes

Motivations

Funding and Liquidity

- Access to additional sources of funding and liquidity
- Transform less liquid, non-rated exposures into more liquid, rated securities to enhance liquidity
- Accessing the securitization markets *anonymously*
- Cheaper access to capital markets.

Motivations (cont'd)

Bankruptcy Remoteness

- Assets in the SPV are legally isolated
- In case of a bankruptcy procedure, the creditors cannot seize the assets of the SPV

Varying Investor Needs

- Short-term investments vs. long-term investments
- Fixed rate vs. floating rate interest rates

Motivations (cont'd)

Risk Management

- Diversification of the risk through pooling
- To varying degrees, the SPV will transfer credit risk, interest rate risk, market risk, and insurance risk to other parties

Accounting

- Off-balance sheet treatment:
  - The sponsor may remove assets from its balance sheet
- Off-balance sheet allows the sponsor(s) to:
  - show better financial ratios, such as higher returns on assets
  - show higher tangible capital ratios, and will not have to reserve against the assets in the SPVs

Motivations (cont'd)

Taxes

- SPVs are often *tax neutral*: Profits are ***not*** taxed
- Failure to achieve *tax neutrality* results in double tax scenario
  - once on the income of the investor
  - once again on the distributions from the SPV
- Tax neutrality can by achieved by establishing the SPV in a tax haven jurisdiction (Cayman Islands)
  - ✓ The SPV will be treated as exempted company

2. Project Finance

What does a project need?

Customized capital structure/asset-specific governance systems to minimize cash flow volatility and maximize firm value

What is project finance?

The financing of projects and public services based upon a *non-recourse* or *limited recourse* financial structure where the funds used to finance the project are paid back from the cash flows generated by the project

Source: Investopedia

PF Structure Highlights

- **Extensive contracting**
  - As many as 15 parties in up to 1000 contracts.
  - Contracts govern inputs, off take, construction, and operation.
  - Government contracts/concessions: BOOT
  - Ancillary contracts include financial hedges, insurance for Force Majeure (i.e., natural disasters), etc.

PF Structure Highlights

- **Highly concentrated equity and debt ownership**
  - Multiple equity sponsors (sometimes more than 3)
  - Syndicate of banks and/or financial institutions provide credit
- **Extremely high debt levels**
  - Generally 70% and as high as nearly 100%
  - Debt *is* ***non-recourse*** **or** ***limited recourse*** to the sponsors
  - Debt service depends exclusively on project cash flows

Motivations: Agency Costs

Agency costs may arise because the company's executives (the agents) may act in their own interest in a way that is detrimental to shareholders (the principals)

- Extensive contracting through SPV reduces discretion
- Concentrated equity ownership provides critical monitoring
- The counterparty incentives are aligned via joint ownership with related parties to share asset control and cash flow rights

Motivations: Debt Overhang

Underinvestment occurs in Positive NPV projects at the sponsor firm due to limited corporate debt capacity

- Equity is not a valid option due to agency or tax reasons
- Non recourse debt in SPV allocates returns to new capital providers without any claims on the sponsor's balance sheet
  - Preserves corporate debt capacity

Motivations: Risk Contamination & Mitigation

A high-risk project can potentially drag a healthy corporation into distress. Short of actual failure, the risky project can increase cash flow volatility and reduce firm value. Conversely, a failing corporation can drag a healthy project along with it

- Project-financed investment exposes the corporation to losses only to the extent of its equity commitment
- Sponsors can share project risk with other sponsors
  - The overall distress costs are reduced.

Part II
Public-Private Partnerships (PPPs)

Definition

"A contractual agreement between a public agency and a private-sector entity to share the risk and rewards of project delivery"

Reasons for Establishing PPPs

- Argument for private-sector involvement
  - Leverage scarce public resources
  - Benefit from private-sector expertise
  - Expedite project delivery
  - Improve cost-effectiveness of project development
  - Transfer the risk to the private-sector
  - Increase efficiency

Reasons for Establishing PPPs (cont'd)

- Increased access to capital markets through applications of alternative approaches to project:
  - Funding
  - Financing
  - Contract delivery
  - Preservation
- Infrastructure for *free*
  - Tempting particularly for cash-strapped governments trying to meet fiscal targets

International Experience of PPPs as a Delivery Method

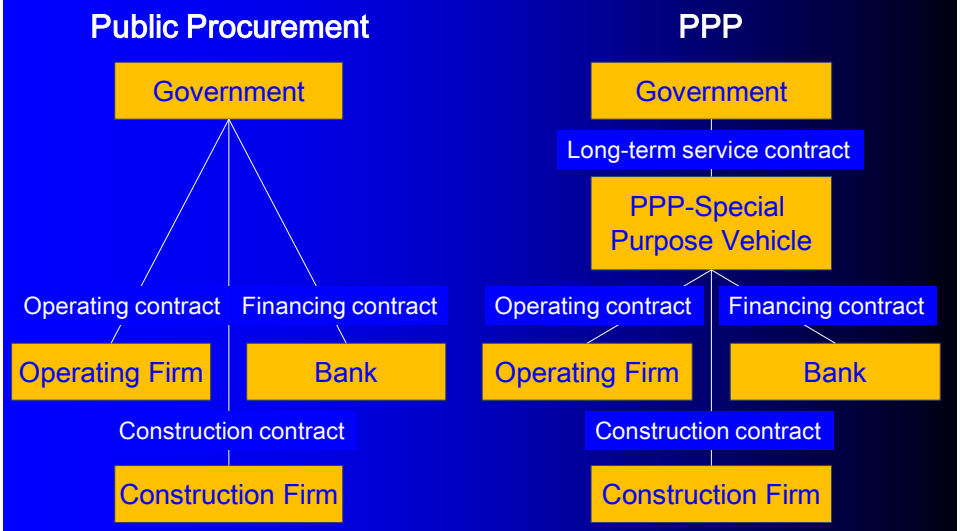
- The table below reflects the **UK National Audit Office** report on the performance of PPP procurements (2003) and a PPP study by Allen Consulting/**University of Melbourne** (2007)

		PPP procurement	Non-PPP procurement
Time overrun	UK	22%	73%
	Australia	12%	35%
Cost overrun	UK	24%	70%
	Australia	13%	26%

Concerns about PPPs

- Potential higher life-cycle costs
  - Private sector may demand higher rate of return than public sector
- Taxation constraints
  - Federal government does not allow accelerated depreciation
  - Concession uses only taxable debt and equity (no tax-exempt debt financing)
- Moral hazard
- Loss of control over assets

Structure of PPPs



Nature of Collaboration

The government may collaborate with the private service provider in any one of the following ways:

- As a funding agency
  - providing grant/capital/asset
- As a buyer
  - buying services on a long-term basis

Funding Pattern

The funding pattern and collaboration between the public sector and the private sector could take any one of the following forms:

- **Type I PPP**: Public Ownership, Finance & Sales Operations
- **Type II PPP**: Private Ownership, Finance; Public Sales Operations
- **Type III PPP**: Public Ownership; Private Finance, Sales Operations
- **Type IV PPP**: Joint Ownership, Finance and Sales Operations

Payment Mechanism

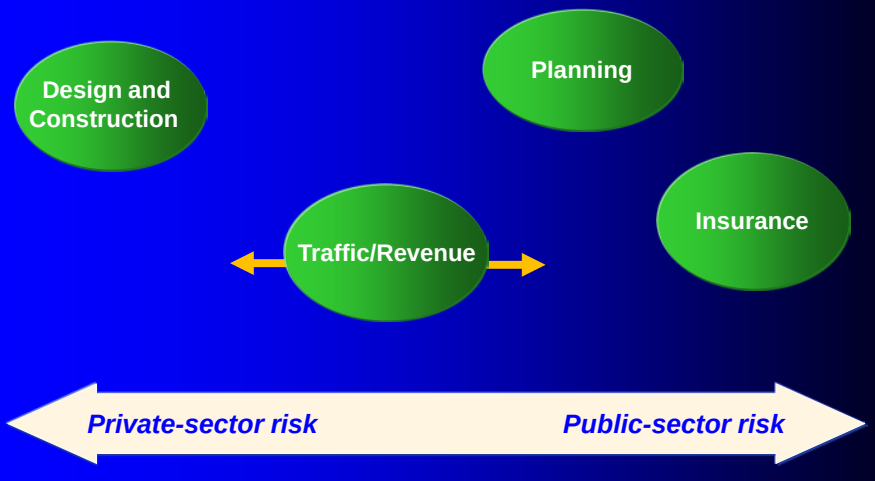
- **Demand/Revenue Based**: The private-sector controls and collects user fees, which serve as their only source of revenue to service debt and generate a return (e.g., toll road PPP projects)
- **Availability Payment**: The private-sector receives periodic payments over the operational contract period from the public sector if the project is available and maintained to the standard specified (e.g. non-tolled roads or social infrastructure)
- **Shadow Payment**: The public sector retains control of fare policy, but the private-sector is paid based on the number of users, so takes demand risk. A risk-sharing approach, although pricing of risk by the private sector is questionable since they arguably cannot control demand

Risks of PPPs

- Design and Construction (D&C) risks, Operation and Maintenance (O&M) risks, compliance risks, market risks, financial risks, political risks, etc.
- Who should bear the risk?
  - ✓ Private sector → construction risk
  - ✓ Public sector → political risk
- ➢ Appropriate level of risk transfer depends on each project and country
- ➢ *Adequate risk sharing is essential to achieve value for money!*

Risk Allocation

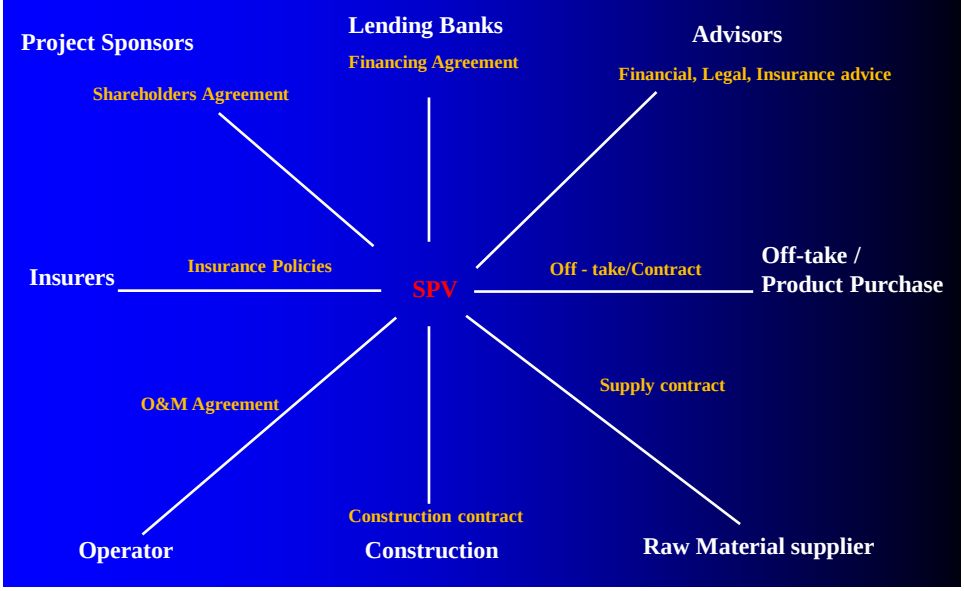
Each project is different and needs individual risk allocation



Risk Allocation Matrix

	PPP MODEL			
Risks	**Type I**	**Type II**	**Type III**	**Type IV**
D&C	**Private**	**Private**	**Private**	**Public & Private**
O&M	**Private**	**Private**	**Private**	**Public & Private**
Compliance	**Public & Private**	**Public & Private**	**Private**	**Public & Private**
Market	**Private**	**Public**	**Private**	**Public & Private**
Financial	**Private**	**Private**	**Private**	**Private**
Legal	**Private**	**Private**	**Private**	**Public & Private**

Risk Allocation via Contracts



Project Contracts

- The project contracts provide a basis for the project company's construction and operation of the project
- The most important of these is the *Project Agreement*
  - The contract that provides the framework under which the project company obtains its revenues
- There are two main models for a Project Agreement:
  1) An ***off-take contract***
  2) A ***concession agreement***

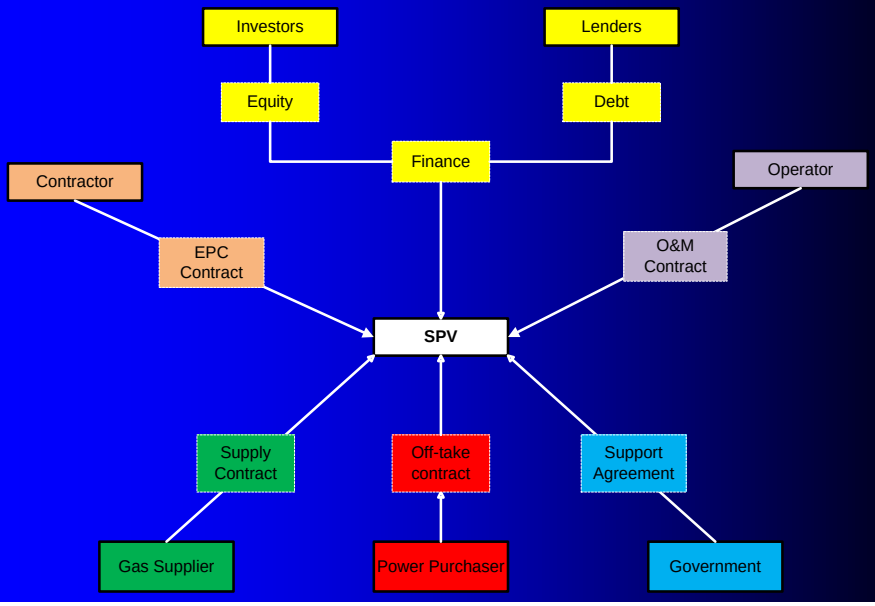
1) Off-take Contract

- An off-take contract is used for a project that produces a product (e.g., a PPP for electricity)
- It provides the off-taker (purchaser) with a secure supply of the required product and the project company (SPV) with the ability to sell its products on pre-agreed basis
- Off-take contract is the *easiest* way of limiting the risks taken by the SPV in selling its products
- Very important if a high ratio of debt is to be raised

Types of Off-take Contracts

- Take-or-Pay Contract
- Take-and-Pay Contract
- Long-term Sales Contract
- Hedging Contract
- Contract for Differences

Power Project Finance Structure



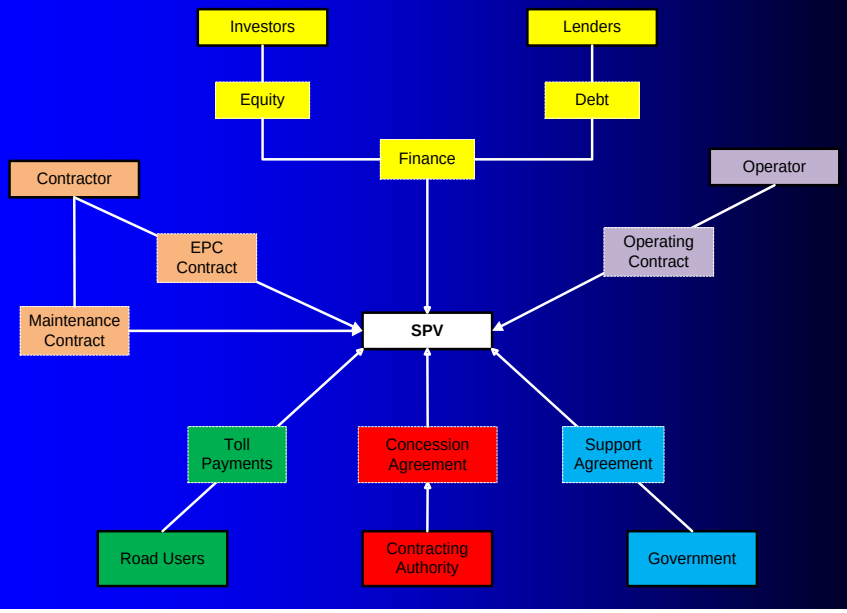
2) Concession Agreement

- A concession agreement is a contract between a public-sector entity and the SPV under which a project is constructed to provide a service
- Examples of such agreements include:
  - Toll roads, bridges, or tunnels for which the public pays tolls
  - Ports and airports, usually with payments made by airlines
  - Water and sewage systems, with payments made by municipalities or by end users, etc.

Types of Concession Agreements

- Service Contracts
  - SPV constructs a project to provide a service for which the contracting authority pays
  - The usage risk is transferred to the contracting authority
- Toll contracts
  - SPV constructs a project to provide a service for which private-sector users pay, with revenues thus being entirely dependent on usage
  - The usage risk is transferred to the SPV

Toll Road Project Finance Structure



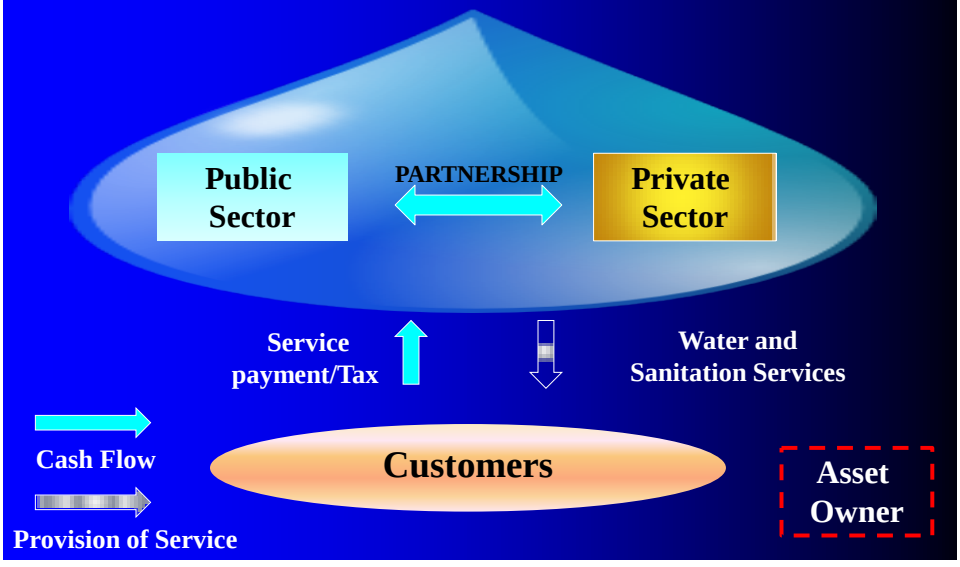
Ancillary Contracts

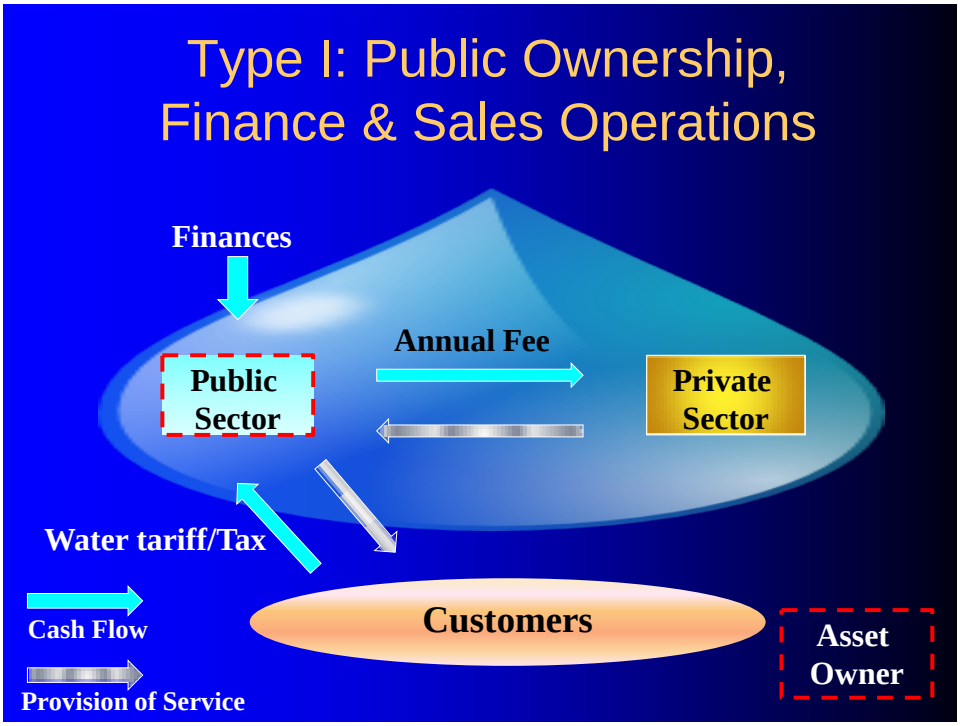
- The project contracts that *may* be signed by the SPV apart from the Project Agreement discussed earlier can be summarized as following:
  - Construction (EPC) Contract
  - Operation and Maintenance Contract
  - Supply Contract
  - Government Support Agreement
  - Insurance
  - Direct Agreements and Permits

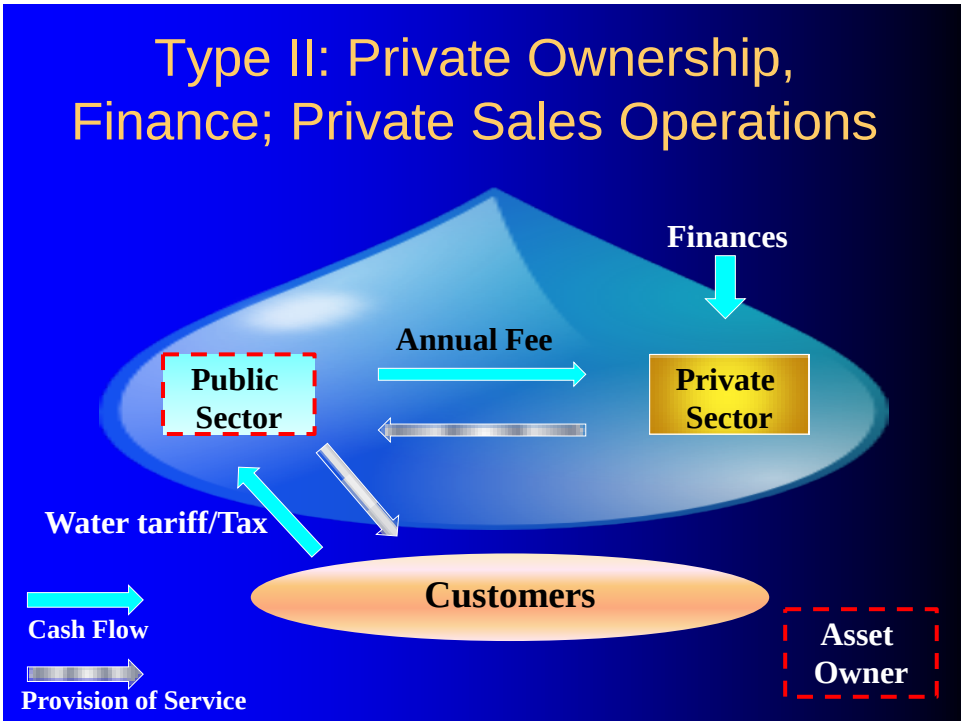
An Illustrative PPP Example: Provision of Water and Wastewater Services

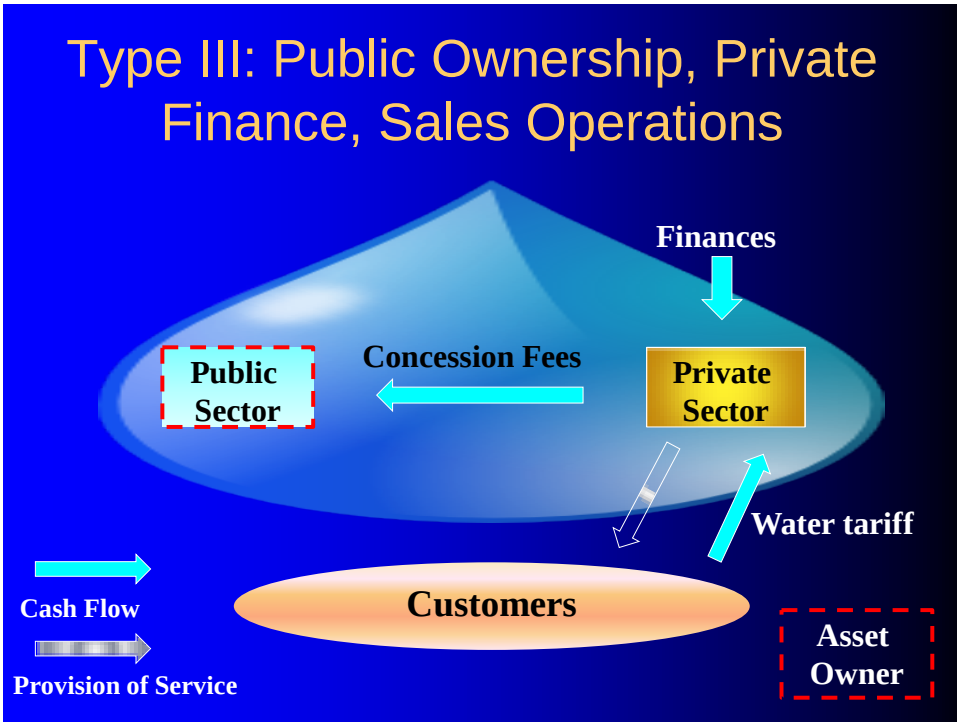
Source: Thames Water, *Risk sharing in various PPP Arrangements*, 2005
ttp://www0.hku.hk/cicid/3_events/32/slides/16.pdf

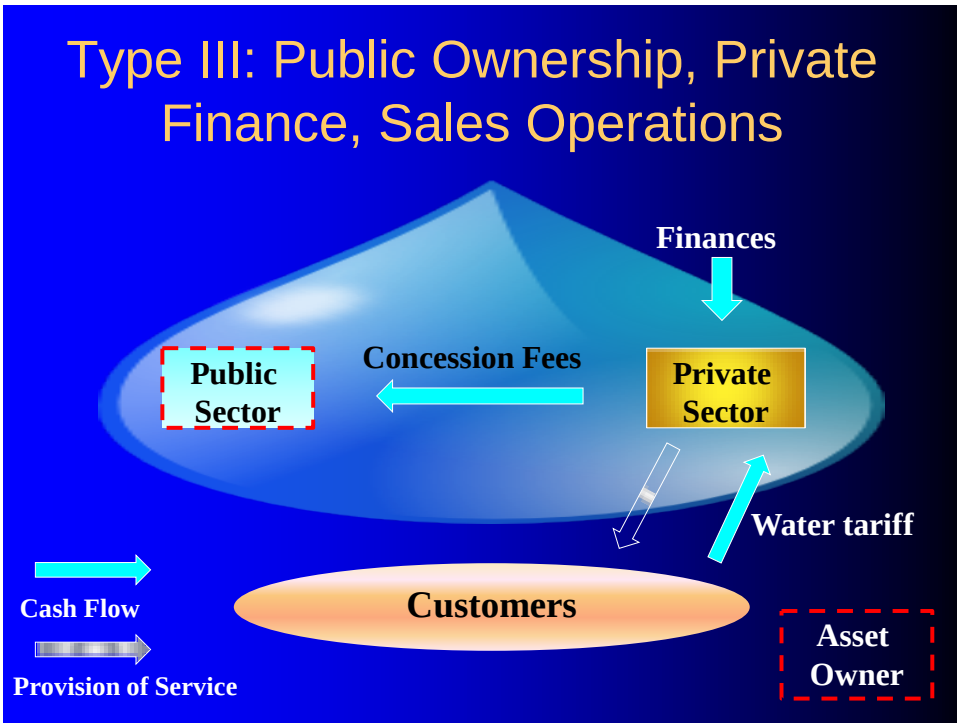
General Structure




Type I: Public Ownership, Finance & Sales Operations
Finances
Annual Fee
Public Sector
Private Sector
Water tariff/Tax
Cash Flow
Customers
Asset Owner
Provision of Service


Type II: Private Ownership, Finance; Private Sales Operations
Finances
Annual Fee
Public Sector
Private Sector
Water tariff/Tax
Customers
Cash Flow
Asset Owner
Provision of Service


Type III: Public Ownership, Private Finance, Sales Operations
Finances
Public Sector
Concession Fees
Private Sector
Water tariff
Cash Flow
Customers
Asset Owner
Provision of Service


Type III: Public Ownership, Private Finance, Sales Operations
Finances
Public Sector
Concession Fees
Private Sector
Water tariff
Cash Flow
Customers
Asset Owner
Provision of Service

Risk Allocation Matrix

	PPP MODEL			
Risks	**Type I**	**Type II**	**Type III**	**Type IV**
D&C	**Private**	**Private**	**Private**	**Public & Private**
O&M	**Private**	**Private**	**Private**	**Public & Private**
Compliance	**Public & Private**	**Public & Private**	**Private**	**Public & Private**
Market	**Private**	**Public**	**Private**	**Public & Private**
Financial	**Private**	**Private**	**Private**	**Private**
Legal	**Private**	**Private**	**Private**	**Public & Private**

Conclusion

PPP is an option, not the only answer

- PPP should be one of the procurement and financing options considered for capital by state and local governments
- PPP needs to be **evaluated against other procurement routes**, and only used where it offers better value
- Consider the characteristics present in most successful PPP projects:
  - **Statutory** and **political** environment
  - **Organized** structure (public-sector delivery capability)
  - Guaranteed **revenue** stream
  - **Stakeholder** support
  - Careful selection of **partner**

Appendix F: Lecture Slides for Module 6

Project Risk Management

Learning Objectives for Module 6

By the end of Module 6, students should be able to:

- Understand the fundamental relationship between risk and opportunity.
- Determine project-specific risk preferences and utilities.
- Develop risk management plans for different projects.
- Conduct a comprehensive assessment of potential risks (engineering, financial, political, etc.) associated with the project under consideration.
- Provide a realistic assessment of those risks along the risk matrix.
- Identify alternative options for mitigating actions.
- Internalize the value of risk management.
- Articulate the difference between systematic and unsystematic risk.
- Be able to measure systematic and unsystematic risk.

What is Risk?

Risk *is the possibility that an undesirable event will occur*

- Risk involves two aspects:

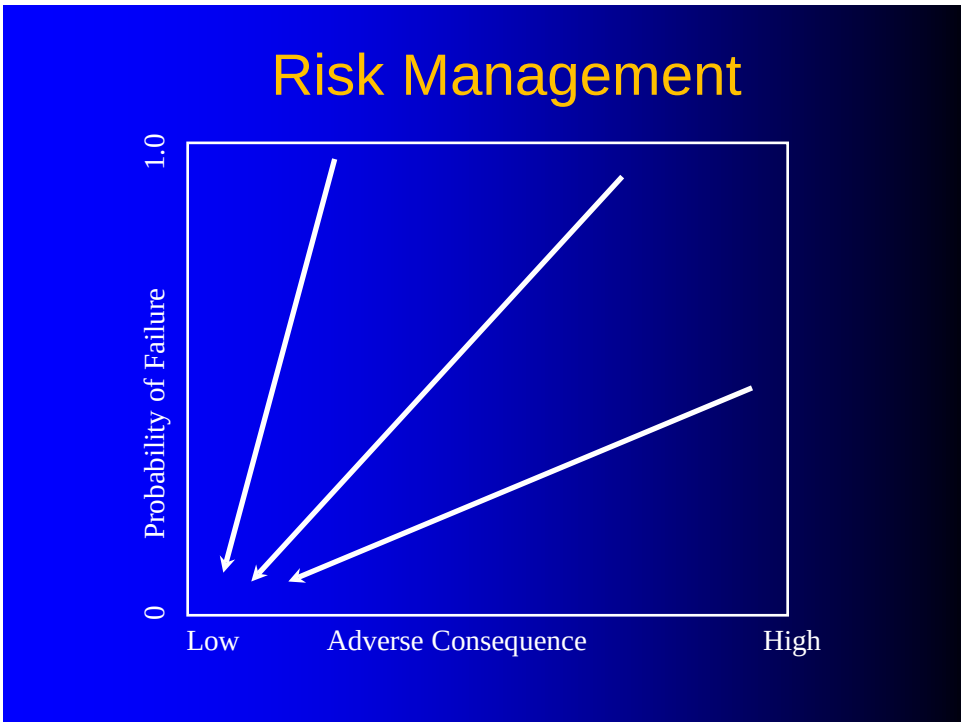
1) Probability of a hazard taking place

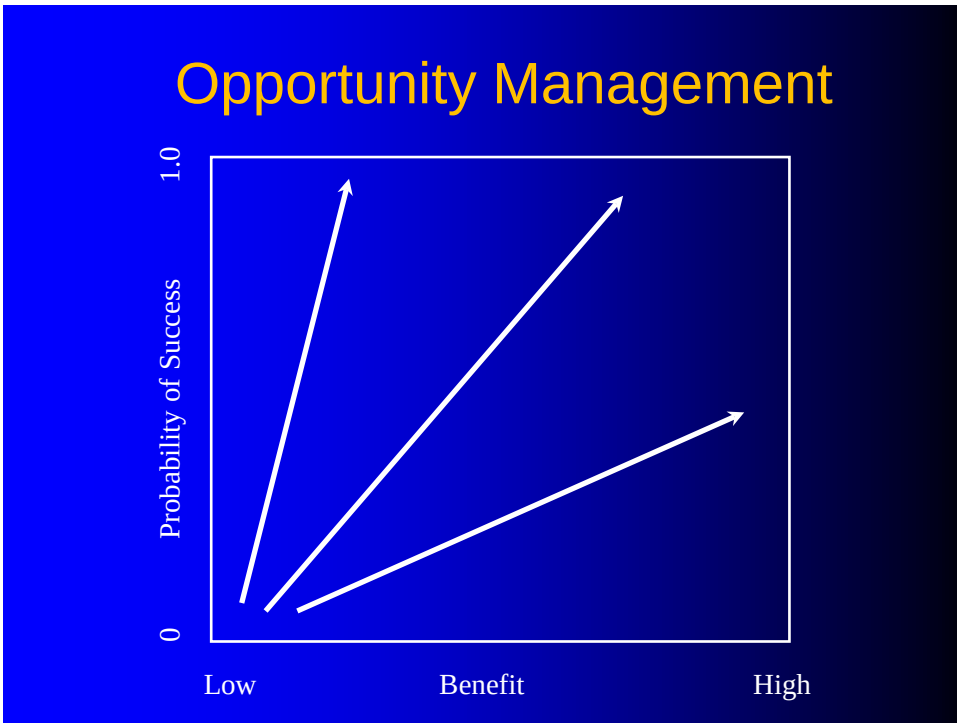
2) The severity of the harm that occurs

Why Take Risks?

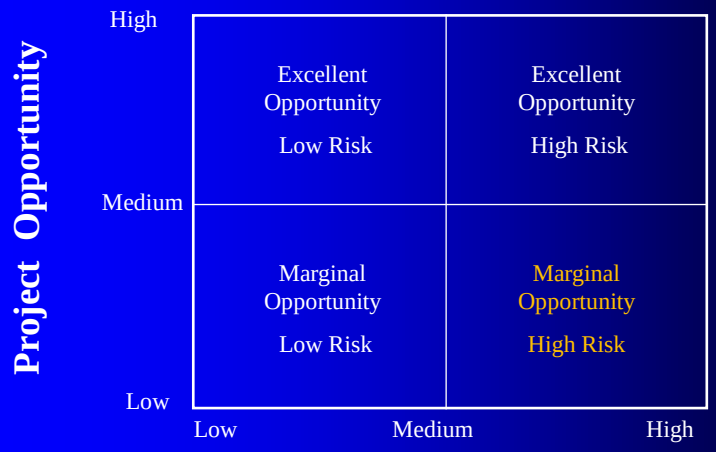
Because of Opportunities!

Try to balance risks and opportunities

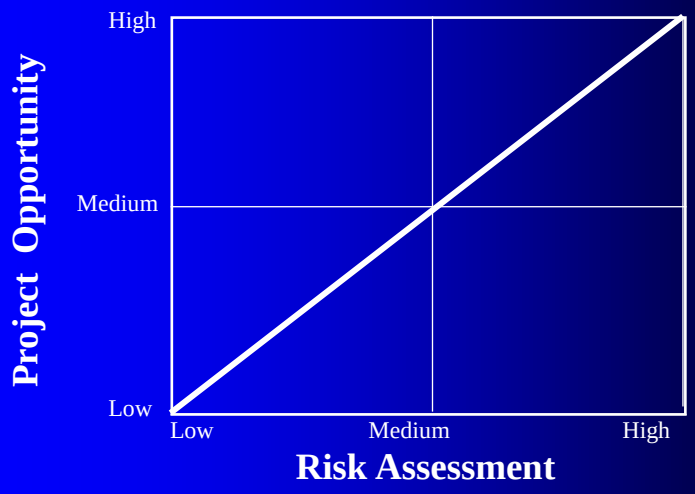

Risk Management
1.0
Probability of Failure
0
Low
Adverse Consequence
High


Opportunity Management
1.0
Probability of Success
0
Low
Benefit
High

Risk & Opportunity Assessment Model (ROAM)



Where Do YOU Draw the Line?



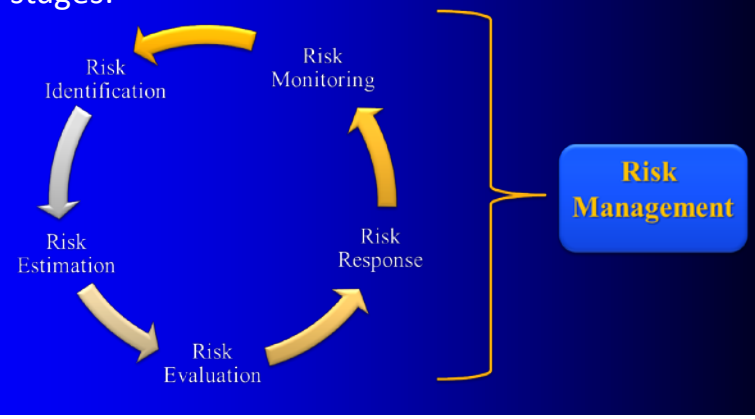
Will You Take the Risk?
The Importance of Risk Management

- Risk management is the art and science of identifying, assigning, and responding to risk throughout the life of a project and in the best interests of meeting project objectives
- Risk management is often overlooked on projects, but it can help improve project success by helping select good projects, determining project scope, and developing realistic estimates
- Risk management is a form of insurance; it is an investment

Risk Management Process

The systematic application of management policies, procedures, and practises to the tasks of identifying, analysing, evaluating, responding, and monitoring risk

- Five stages:



1) Risk Identification

- Risk identification is the process of understanding what potential events might hurt or enhance a particular project
  - This is an ongoing process throughout the project life-cycle as things change
  - You cannot manage risks that you don't identify
- Risk identification tools and techniques include:
  - Brainstorming
  - Strengths, weaknesses, opportunities, and threats (SWOT) analysis
- Output of risk identification process is used to create a ***risk register***

2) Risk Estimation

- After potential risks have been identified, we now need to assess:
  - Probability of occurrence
  - Severity if occurs
- Can be done in two main ways:
  - Qualitatively
    - ✓ in a linguistic manner
  - Quantitatively
    - ✓ in a numerical manner

3) Risk Evaluation

- Need to combine the severity and probability of the identified risks
- Can be done using a risk matrix:

	Likelihood				
Impact	Rare	Unlikely	Possible	Likely	Very likely
Catastrophic	moderate	moderate	high	critical	critical
Major	low	moderate	moderate	high	critical
Moderate	low	moderate	moderate	moderate	high
Minor	very low	low	moderate	moderate	moderate
Insignificant	very low	very low	low	low	moderate

4) Risk Response

- After identifying and quantifying risks, you must decide how to respond to them
- There are four main methods of responding to such risks:
  - Risk Avoidance
  - Risk Transfer
  - Risk Retention/Acceptance
  - Risk Reduction/Mitigation

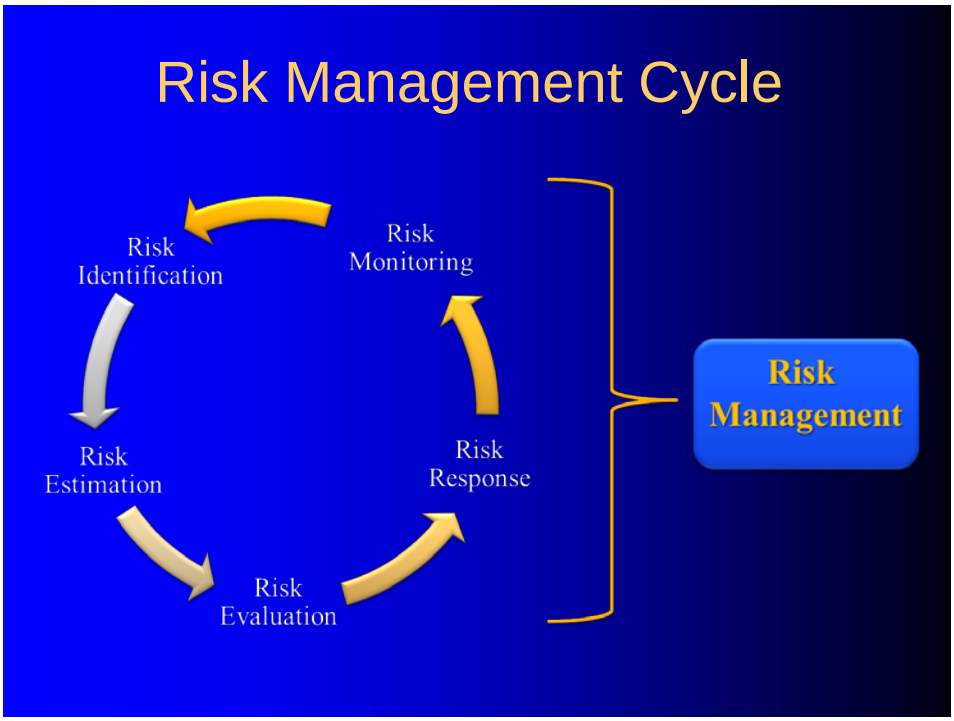
Response Methods

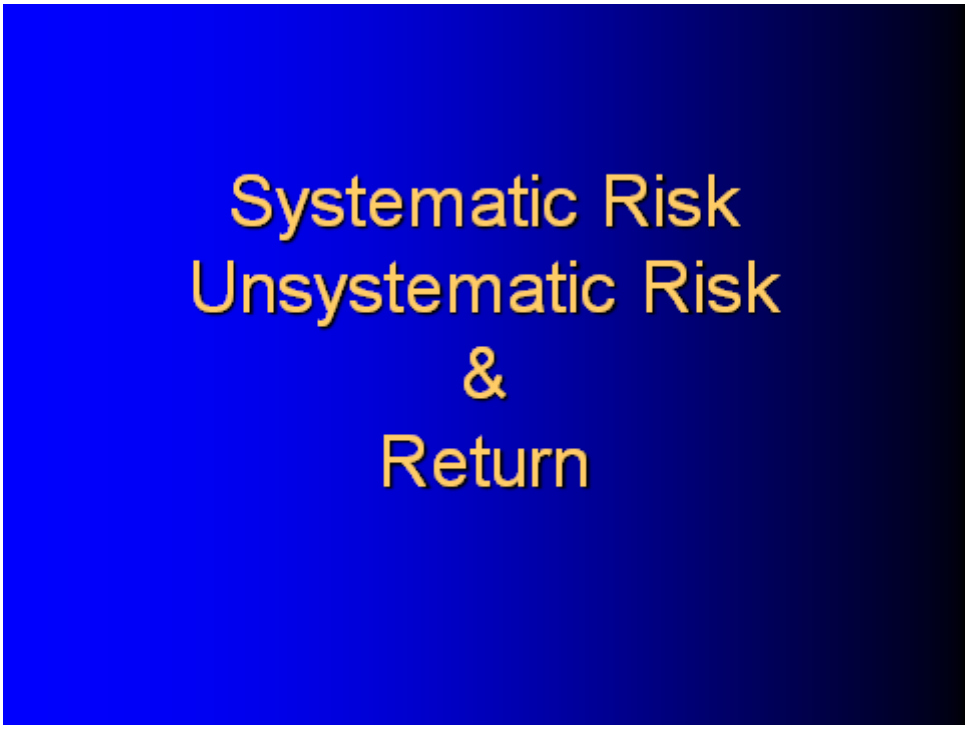
- The choice of method used to respond to risk will largely depend on company policy
- Using the risk matrix model, a typical company scenario may be:

Category of Occurence	Consequences			
	Catastrophic	Major	Severe	Minor
Frequent	Transfer	Transfer	Retain	Avoid
Probable	Reduce	Transfer	Retain	Avoid
Occasional	Reduce	Transfer	Transfer	Retain
Remote	Reduce	Transfer	Transfer	Retain
Improbable	Avoid	Transfer	Transfer	Retain
Incredible	Avoid	Transfer	Transfer	Retain

5) Risk Monitoring

- Risk situation will continue to change throughout the life of the project
  - New risks will become present
  - Existing risks will disappear or change
- The management must be continually monitored, reviewed, and improved
- Existing risks may be managed differently
- Risk monitoring completes cycle back to risk identification


Risk Management Cycle
Risk Identification
Risk Monitoring
Risk Estimation
Risk Response
Risk Evaluation
Risk Management


Systematic Risk
Unsystematic Risk
&
Return

Risk: Systematic and Unsystematic

- Total risk of any investment can be divided into two components, namely:
  1) **Market risk** (which can't be diversified)
  2) **Diversifiable risk** (which can be minimized or eliminated by diversification in a portfolio)
- The market risk is called ***systematic***, and the diversifiable risk is called ***unsystematic***

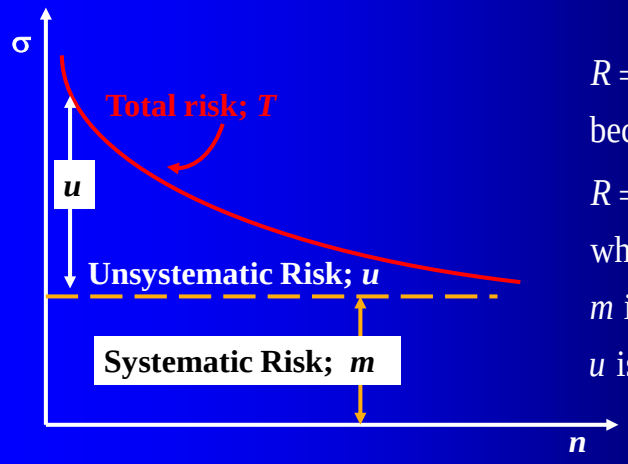
Total risk = **Systematic risk +** **Unsystematic risk**
(market risk) (diversifiable risk)

Systematic vs. Unsystematic

- A *systematic risk* is any risk that affects a large number of assets, each to a greater or lesser degree
- An *unsystematic risk* is a risk that specifically affects a single asset or small group of assets
- Unsystematic risk can be diversified away
- Examples of systematic risk include uncertainty about general economic conditions, such as, interest rates, or inflation
- On the other hand, announcements specific to a company, such as a gold mining company striking gold, are examples of unsystematic risk.

Risk Components

❖ We can break down the total risk, *T*, of holding a stock into two components: systematic risk and unsystematic risk:



$R = \overline{R} + T$

becomes

$R = \overline{R} + m + u$

where

m is the systematic risk

u is the unsystematic risk

Risk Bearing Principle

❖ There is a reward for bearing risk

❖ There is *not* a reward for bearing risk *unnecessarily*

❖ The expected return on a risky asset depends only on that asset's systematic risk since unsystematic risk can be diversified away

Appendix G: Lecture Slides for Module 7

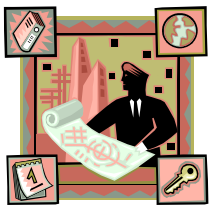
Project Performance Modeling

Learning Objectives for Module 7

By the end of Module 7, students should be able to:

- Identify the key project performance criteria.
- Understand the impact of uncertainty over project cost.
- Estimate uncertainties individually (for each work package) and comprehensively (aggregated uncertainty distribution of work packages working together).
- Model the total project cost with uncertainty.
- Model the project revenue with uncertainty.
- Adopt numerical and analytical methods to analyze project cash flow with uncertainty.
- Analyze the auto-correlation between cost accounts and revenue.

Project Performance Models

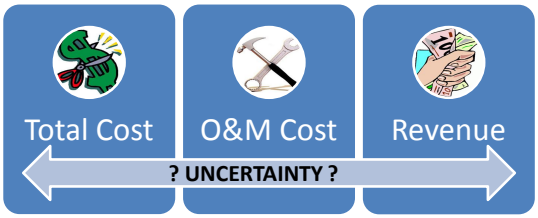


Project Performance Criteria

Some of the project performance criteria are:

- Total project cost
- O&M cost
- Revenue generated

How do you model these ?



Uncertainty is the common denominator!

What is Uncertainty?

- Uncertainty is the indefiniteness about the outcome of a situation
  - includes *favorable* and *unfavorable* events

"The only certainty is uncertainty"

Pliny the Elder (Gaius Plinius Secundus)

AD 23-79, Roman Senator, Imperial Fleet Commander

- We analyze uncertainty for the purpose of measuring risk!
- In a situation that includes favorable and unfavorable events, risk is the probability an unfavorable event occurs

Uncertainty & Project

- Uncertainty analysis is a process of quantifying the impacts of ***uncertainties*** over:
  - Project Cost
  - O&M Cost
  - Revenue

?

What is Cost Uncertainty? Cost uncertainty is a measure of the chance that, due to some unknown event, the planned or budgeted cost or O&M cost of the project will differ from the actual cost of the project

What is Revenue Uncertainty? Revenue uncertainty is a measure of the chance that, due to some unknown event, the planned or budgeted future cash flow of the project will differ from the actual cash flow of the project

Project Cash Flow

Project Cash Flow = ($\underbrace{\text{Total Project Cost}}_{x}$) + {$\underbrace{\text{Revenue}}_{y}$} + [$\underbrace{\text{O\&M Cost}}_{h}$]

$$PW = -x + \sum_{t=1}^{N} \frac{y_t}{(1+r)^t} - \sum_{t=1}^{N} \frac{h_t}{(1+r)^t} = -x + \sum_{t=1}^{N} a_t (y_t - h_t)$$

x is total project cost discounted to time 0

y_t is the net revenue in time period t

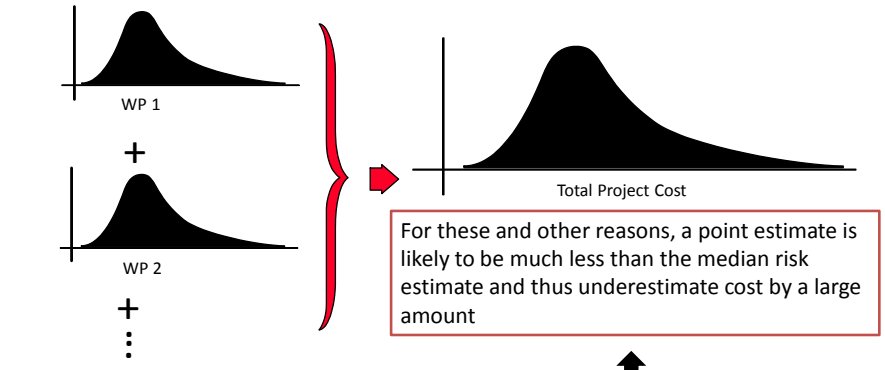
h_t is the O&M cost in time period t and

r is the specified discount rate (fixed)

a_t is the discount factor in time period t $\quad a_t = \frac{1}{(1+r)^t}$

Total Project Cost

Total Cost = $\sum$ Cost Element (Work Package) = $\sum$ WP



For these and other reasons, a point estimate is likely to be much less than the median risk estimate and thus underestimate cost by a large amount

There is uncertainty about each work package, and it is usually not symmetric

Work packages are often ***correlated***

Uncertainty in Work Packages

- The cost of each work package is uncertain
- Two common sources of uncertainty explicitly addressed in cost risk estimates are technical risk and estimation risk
  - Technical risk is associated with uncertainty in model inputs
    - ✓ Technical and management parameters, etc.
    - ✓ Has it ever been done before?
  - Estimation risk is associated with uncertainty in the estimation tools
    - ✓ Cost estimating relationship (CER) standard errors

Estimating Uncertainty in WPs

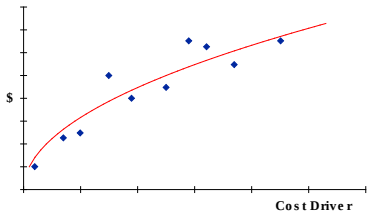
- Estimating methods usually involve some uncertainty
  - For example, CERs that are based on historical data involve a high degree of uncertainty
    - ✓ CERs are equations that relate a variable or a set of variables that drive the cost (or define the scope of a project), such as dollars per pound or per horsepower and cost per square foot as in construction
    - ✓ Classic example:

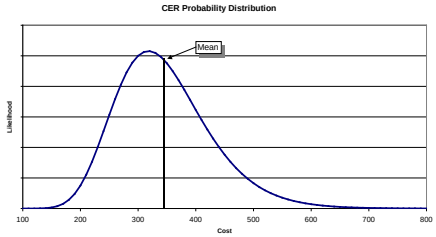
$$Y = a + bX^{c}$$

where Y represents cost and X represents weight

Probabilistic Nature of Cost-Estimating

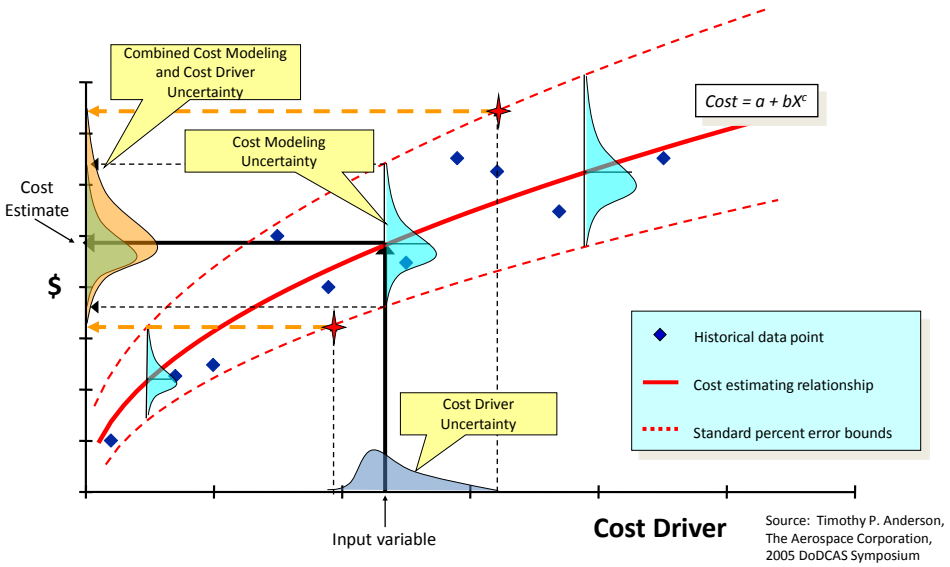
- Typical CERs are based on historical cost data
- Typical cost estimates have probability distributions





- Cost estimates are probability distributions and *not* deterministic

The Problem



Source: Timothy P. Anderson, The Aerospace Corporation, 2005 DoDCAS Symposium

Correlation Between Work Packages (WPs)

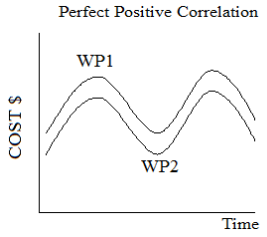
Correlation describes the interaction between cost account *j* and cost account *k*

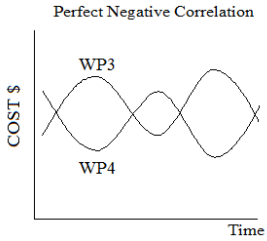
- If an increase in the cost of WP_j is associated with an increase in the cost of WP_k, then it can be said that they are positively correlated

$$\rho_{jk} > 0$$

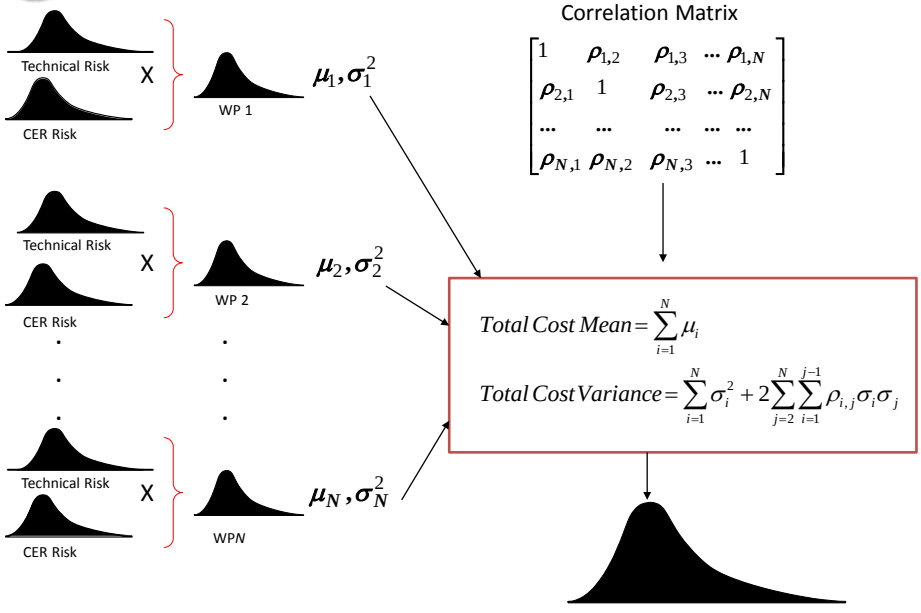
- If an increase in the cost of WP_j is associated with a decrease in the cost of WP_k, then it can be said that they are negatively correlated

$$\rho_{jk} < 0$$





The Big Picture



MODELING COST WITH UNCERTAINTY

Linear Models

- Analytical solution with Second Moment Method
  - Total cost = sum of work package costs
- Can be easily computed
  - By spreadsheets
  - By hand calculators
- Parameters:
  - Means
  - Variances
  - Correlation coefficients

Linear Project Cost Model (Bottoms-Up Cost)

- For every work package or cost account, j, there is a cost X_j which is uncertain
- Assume that for every cost account there is an estimate of:
  - The mean value: $\mu_j = E\left[X_j\right]$
  - The variance: $\sigma_j^2 = E\left[\left(X_j - \mu_j\right)^2\right]$
  - The standard deviation: $\sigma_j = \sqrt{E\left[\left(X_j - \mu_j\right)^2\right]}$

Linear Project Cost Model

For every pair of work packages or cost accounts, j and k, there is a correlation coefficient, ρ_{jk}

$-1 \le \rho_{jk} \le +1$ for all j and k;

Note that $\rho_{jk} = \rho_{kj}$ (symmetry)

$\rho_{jk} = 1$ if $k = j$

Linear Project Cost Model (cont'd)

- The variance of work package *j* is given by:

$$\text{var}\left[X_j\right] = \sigma_j^2 = E\left[\left(X_j - \mu_j\right)^2\right]$$

- The covariance of WP_j and WP_k is given by:

$$\begin{aligned}\text{cov}\left[X_j, X_k\right] &= \rho_{jk}\sigma_j\sigma_k \\ &= E\left[\left(X_j - \mu_j\right)\left(X_k - \mu_k\right)\right]\end{aligned}$$

Linear Project Cost Model (cont'd)

- If the total cost is the sum of the costs for *N* work packages (cost accounts), then the mean of the sum is the sum of the WP means:

$$\mu_T = E[\sum_{j=1}^{N} X_j] = \sum_{j=1}^{N} E[X_j] = \sum_{j=1}^{N} \mu_j$$

- The variance of the sum is the sum of the covariances:

$$\begin{aligned}\text{var}[T] = \sigma_T^2 &= \sum_{j=1}^{N}\sum_{k=1}^{N} \rho_{jk}\sigma_j\sigma_k \\ &= \sum_{j=1}^{N} \sigma_j^{\,2} + 2\sum_{j=1}^{N-1}\sum_{k=j+1}^{N} \rho_{jk}\sigma_j\sigma_k\end{aligned}$$

Linear Project Cost Model

- The covariances from an N*x*N matrix:

$$V \equiv \begin{pmatrix} \sigma_{11} & \sigma_{12} & \sigma_{1N} \\ \sigma_{21} & \sigma_{22} & \sigma_{2N} \\ \sigma_{N1} & \sigma_{N2} & \sigma_{NN} \end{pmatrix} \equiv \begin{pmatrix} \sigma_1^2 & \rho_{12}\sigma_1\sigma_2 & \rho_{1N}\sigma_1\sigma_N \\ \rho_{12}\sigma_1\sigma_2 & \sigma_2^2 & \rho_{2N}\sigma_2\sigma_N \\ \rho_{1N}\sigma_1\sigma_N & \rho_{2N}\sigma_2\sigma_N & \sigma_N^2 \end{pmatrix}$$

- Using a spreadsheet:
  - Generate the covariance matrix from the standard deviations and correlation coefficients
  - Compute the sum of the terms in the covariance matrix

MODELING REVENUE WITH UNCERTAINTY

Modeling Revenue

❖How do you model revenue?

$$\text{Revenue} = \sum_{t=1}^{N} \frac{y_t}{(1+r)^t}$$

y_t is the net revenue in time period t

- e.g., A power plant project
  - ✓Uncertainty in electricity prices?
- e.g., A toll road project
  - ✓Uncertainty in toll rates?

Modeling Revenue (cont'd)

❖Linear Models

- Second Moment Approach
  - ✓Same as described in "Cost Modeling" chapter

❖Time Series Models

- Geometric Brownian Motion (GBM)

❖Autoregressive Models

- Autoregressive Process (AR)
- Moving Average Process (MA)

Time Series Revenue Model: GBM

- A stochastic process S_t is said to follow a Geometric Brownian Motion if it satisfies the following stochastic differential equation:

$$dS_t = \mu S_t dt + \sigma S_t dW_t$$

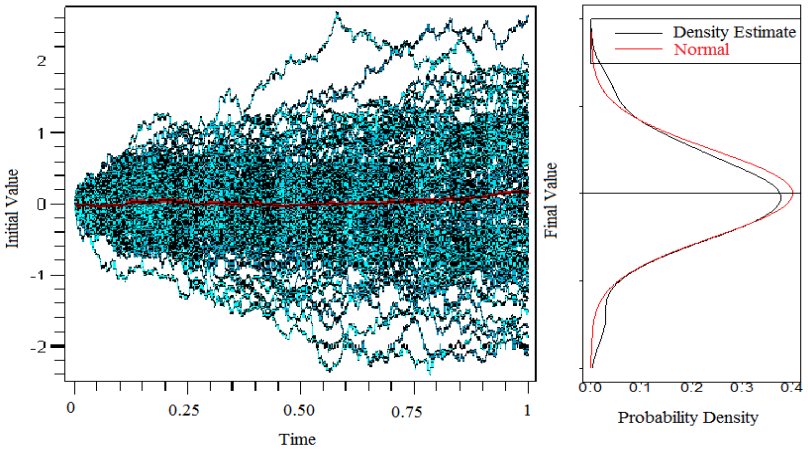
  - W_t is a Wiener process or Brownian motion and μ (the percentage drift) and σ (the percentage volatility) are constants

- For an arbitrary initial value S_0 the equation has the analytic solution

$$S(t) = S(0)\exp\left(\sigma W(t) + \left(\mu - \frac{1}{2}\sigma^2\right)t\right)$$

  - which is a log-normally distributed random variable with expected value $E(S_t) = S_0 e^{\mu t}$ and variance $Var(S_t) = S_0^2 e^{2\mu t}(e^{\sigma^2 t} - 1)$

Two Properties of Brownian Motion



- At any time the value of Brownian motion is normally distributed
- The variance increases with time

Autoregressive Models: AR Process

- The equation for an autoregressive process of order p, or AR(*p*), is

$$r_t = K + \sum_{i=1}^{p} a_i r_{t-i} + \varepsilon_t$$

where ε_t is independent Normal$(0,\sigma)$ random variable

$$\text{AR(1)} = r_t = K + a r_{t-1} + \varepsilon_t$$

$$\text{AR(2)} = r_t = K + a_1 r_{t-1} + a_2 r_{t-2} + \varepsilon_t$$

- You can see that this is just a regression model where r_t is the dependent variable and r_{t-i} is the explanatory variable

Autoregressive Models: MA Process

- The equation for a moving-average process of order q, or MA*(q),* is

$$r_t = \mu + \varepsilon_t + \sum_{i=1}^{q} b_i \varepsilon_{t-i}$$

This says that variable r_t is normally distributed about a mean equal to

$$\mu + \sum_{i=1}^{q} b_i \varepsilon_{t-i}$$

where ε_t is an independent Normal$(0,\sigma)$ random variable

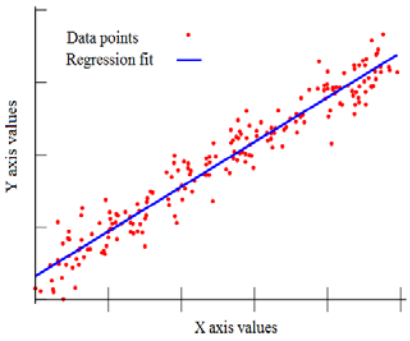
- In other words, the mean of r_t is the mean of the process as a whole mu plus some weighting of the variation of *q* previous terms from the mean

Cost & Revenue Correlation?

- Total Project Cost vs. O&M Cost
  - Generally (though not necessarily) (-) correlation
- Revenue vs. O&M Cost
  - Generally (though not necessarily) (+) correlation
- Total Project Cost vs. Revenue
  - Generally (though not necessarily) (0) correlation
- *Correlations between cost variables and revenue variables are usually assumed to be 0*

Other Methods for Uncertainty Modeling

Multivariate Statistical Models: Regression



- ❖ Quality of the model is represented by "r"
  - ❖ Good "r" value is needed, however
  - ➢ **r** increases when averaging over a larger time scale
    - ✓ $r_{Monthly} > r_{Hourly}$
  - ➢ Even if r = 1, the uncertainty in the prediction is not negligible

❖ Technically, the quality of the model is defined by:

- ➢ The confidence limits of the estimated model parameters
- ➢ The number of data points

Stochastic Simulation Models

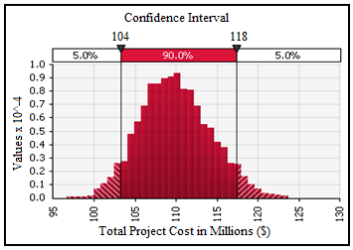
❖ Monte Carlo Simulation (MCS) is widely used

❖ Why?

➢ Extremely flexible

✓ inputs

✓ models



➢ Relatively straightforward to conceptualize

Using Distributions for Simulation

- Model uncertain inputs with probability distributions
  - Generate random numbers from different probability distributions
- Fitting probability distributions to raw data to generate a predictive model is possible
- The outputs of the simulation model will be represented by probability distributions
  - Learn how to compute various measures from distributions
  - Understand and analyze different simulation scenarios
    - ✓ Compare features of distributions with each other

Discrete Event Simulation (DES)

- The methodology of discrete-event simulation provides a promising alternative solution to designing and analyzing dynamic, complicated, and interactive construction
- Several DES systems are being used to facilitate the modeling of complicated construction operations
  - To compute demand (e.g., Highway systems)
  - To compute expected cost and utilization of resources (e.g., Toll road)
  - To compute rate of production (e.g., Power plant)
  - To compute expected schedule (e.g., Arrival of materials to the site
- Useful direction is available regarding the utilization and idleness of resources, rate of production, and the expected delays during construction.
- Comprehensive details are available regarding the construction project without the actual commencement of the work
- Due to the availability of adequate details before the real construction, the plans are flexible and can be modified for improvements in cost and techniques

Appendix H: Lecture Slides for Module 8

Lenders' Analysis of Project

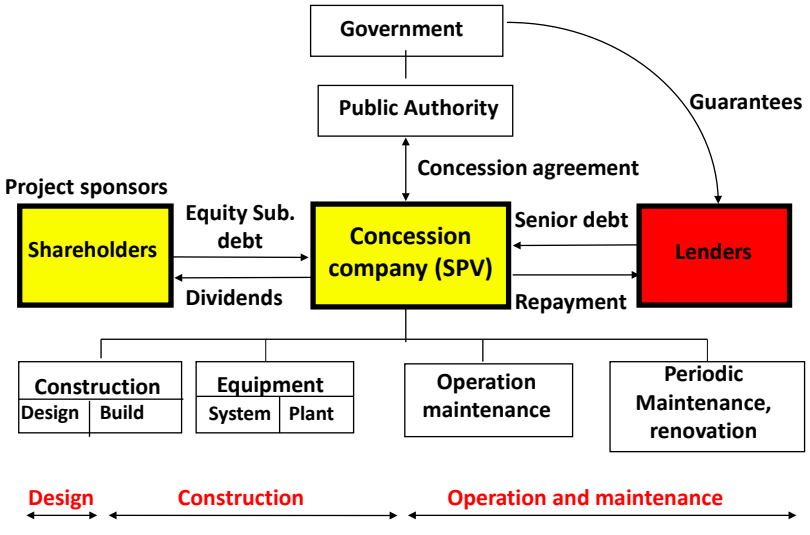
Learning Objectives for Module 8

By the end of Module 8, students should be able to:

- Calculate cost of debt to lenders.
- Evaluate a project from the lenders' perspective.
- Recognize major criteria to look at in a project finance transaction.
- Develop models to estimate the risks.
- Develop models to price the estimated risks.
- Analyze the impact of different utilities (risk appetites) on cost of debt.
- Use debt cover ratios to price the lenders' risk.

How Do Lenders Evaluate a Project?

General PPP Structure



Evaluating a Project

Five major criteria to look at:

1) Loan Structure
2) Balance Sheet (Capital Position)
3) Income Statement and Cash Flow (Capacity)
4) Collateral
5) Management

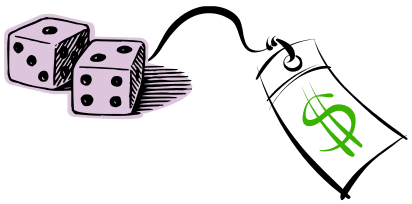
How Do Lenders Determine The Cost of Debt?

- Cost of Debt is the *interest rate* or *the required rate of return* on investment (loan) of the lenders of a company/project
  - After-tax cost of debt = yield x (1 - tax rate)
- Lenders determine the interest rate on the loan based on the projected cash flow of the project under consideration
  - Future cash flow is uncertain → risk

How Do Lenders Price the Risk?

1. Quantitative pricing models

2. Debt Cover Ratios

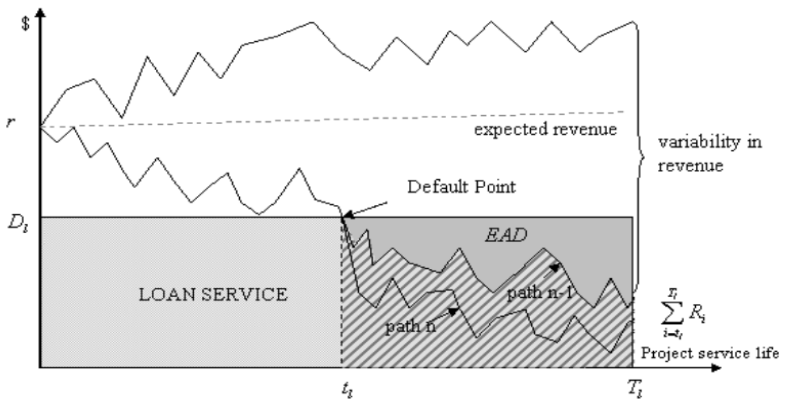


1. Quantitative Pricing Models

❖ Key uncertainty parameters

- ➢ Probability of default (PD)
- ➢ Exposure at default (EAD)
- ➢ Losses given default (LGD)
- ➢ Expected losses (EL)

1) Quantitative Pricing Models (cont'd)



EL and Risk Premium

- Risk premium corresponds to the difference between the expected losses and market implied value of the expected losses
  - Risk aversion level of the lender
  - Familiar project or not
  - Profit margin of the lender

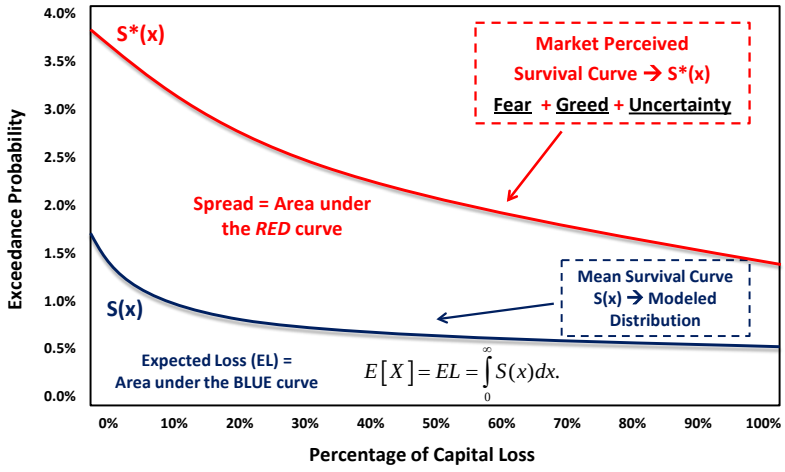
Risk Pricing Models

I. Transformation Models

II. Regression Models

III. Utility Models

I. Transformation Models



$$S(x) = P\{X > x\} = 1 - P\{X \le x\} = 1 - F(x)$$

$$EL^* = RP = \int_0^\infty S^*(x)dx = \int_0^\infty \left(S(x)\right)^{1/\rho} dx$$

Example

The following table shows the ratio of risk-adjusted values to the underlying mean for a normal variate with varying coefficient of variation and risk aversion level (RAL)

	Coefficient of Variation						
RAL	5%	7.5%	10%	12.5%	15%	20%	25%
1	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.2	1.008	1.013	1.017	1.021	1.025	1.034	1.042
1.4	1.016	1.024	1.032	1.040	1.048	1.064	1.080
1.6	1.023	1.034	1.046	1.057	1.069	1.092	1.115
1.8	1.029	1.044	1.058	1.073	1.088	1.117	1.146
2	1.035	1.053	1.070	1.088	1.105	1.140	1.175
3	1.059	1.088	1.180	1.147	1.176	1.235	1.249
5	1.09	1.135	1.180	1.225	1.270	1.359	1.449

Wang Transform Model

- Let Φ be standard normal distribution
- Wang (2002) introduces a new transform while considering financial pricing models:

$$S^*(x) = \Phi\left[\Phi^{-1}(S(x)) + \lambda\right]$$

- $\lambda = \{ E[R] - r \}/\sigma[R]$ = Sharpe Ratio (SR)
  - SR = the excess return per unit of volatility
  - λ also called *market price of risk*

II. Regression Models

Morton Lane (2001) "Pricing of Risk Transfer tTansactions" **(Hachemeister Prize Paper)** proposed a 3-parameter model:

$$EER = 0.55\ (PFL)^{0.49}\ (CEL)^{0.57}$$

- PFL: Probability of First Loss ➔ PD
- CEL: Conditional Expected Loss ➔ LGD

  (as % of principal)
- EER: Expected Excess Return

III. Utility Models

- Utility is a measure of the total worth of a particular outcome and can reflect decision maker's attitude toward risk, profit, or loss
- Payoffs in the problem are replaced by *utility measurement*
- The function (utility function) that determines this measurement is usually nonlinear

Utility Models (cont'd)

- In normal Expected Value Theory, the expected value of the random variable *x* is

$$E[x] = \int_{-\infty}^{\infty} xf(x)dx$$

where *f*(*x*) is the probability density function on x

- Von Neumann and Morgenstern (1944) introduced the utility function, *u*(*x*), so that the expected utility is:

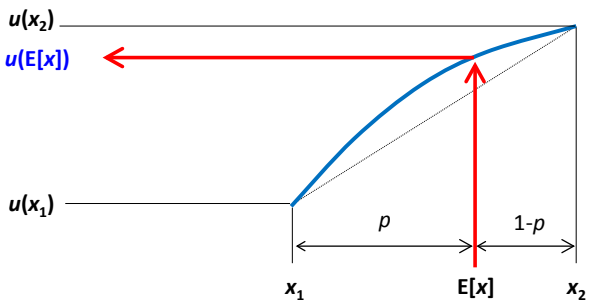
$$E[u(x)] = \int_{-\infty}^{\infty} u(x)\, f(x)dx$$

Utility of the Expected Value

- The expected value of *x*, E[*x*], is

$$E[x] = (p)\, x_1 + (1 - p)x_2$$

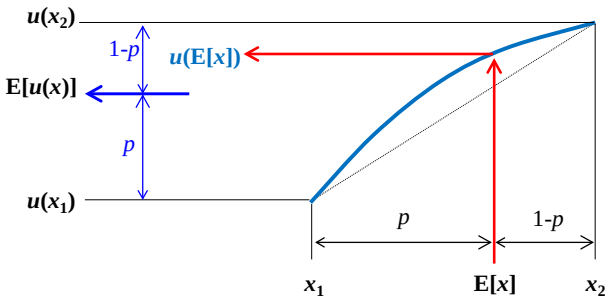
- Then the utility of the expected value *u*(E[*x*]) can be obtained from the utility function



Expected value of the utility

❖ Then the expected value of the utility is given as the combination of:

$$\mathrm{E}[u(x)] = (p)u(x_1) + (1 - p)u(x_2)$$

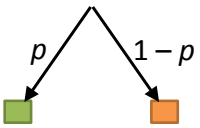


Two Projects with the Same Expected Monetary Profit

Project 1

Probability 1

Project 2



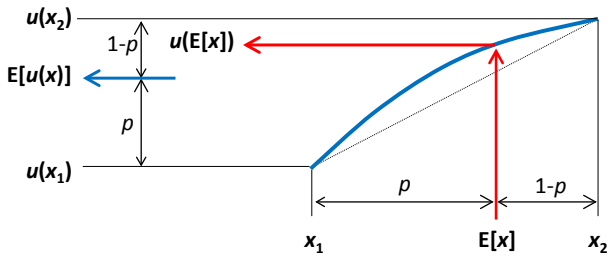
$$\mathrm{E}[x] = (p)\,x_1 + (1 - p)x_2 \quad = \quad x_1 \qquad x_2$$

❖ For example, if x_1 = \$20,000 and x_2 = 0 and p=0.01

- Project 1: \$200 with probability 1
- Project 2: \$20,000 with probability 0.01

Risk Aversion

- Using the von Neumann–Morgenstern utility function $u(x)$, the utility of the first lottery is $u(E[x])$ and the utility of the second lottery is $E[u(x)]$
- If you are ***risk averse***, as in the figure, you would choose Project 1 because $u(E[x]) > E[u(x)]$

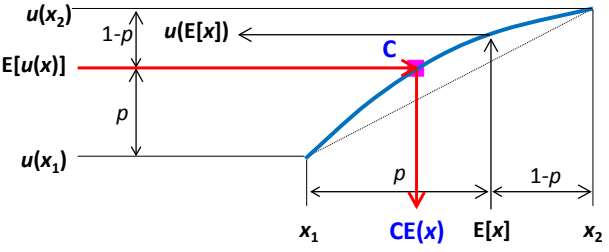


Certainty Equivalent

- We can find the certainty equivalent by taking the inverse of the utility function at the utility $E[u(x)]$.

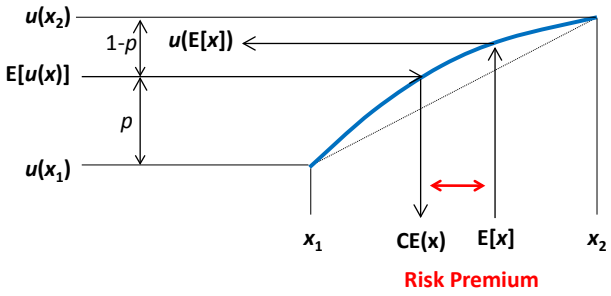
$$E[u(x)] = u(CE(x))$$
$$u^{-1}E[u(x)] = CE(x)$$

- Note that $CE(x) < E[x]$; the certainty equivalent is less than the expected value if one is risk averse.

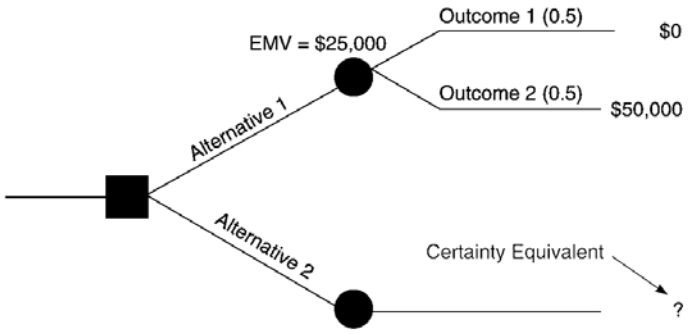


Risk Premium

- The ***risk premium*** RP(x) is the difference between the expected value and the certainty equivalent value: RP(x) = E[x] – CE(x)
- It is the amount that a decision maker is willing to forgo in order to obtain a risk-free gain.
- It is the amount that one would have to pay a risk-averse individual to accept a risky outcome instead of a certain result.



Lender's Utility Assessment



Lender is asked: What is the minimum amount that would cause you to choose Alternative 2?

Lender's Utility Assessment (cont'd)

- Suppose lender says $15,000
- Lender would rather have the *certainty* of getting $15,000 rather the *possibility* of getting $50,000
- Utility calculation:

U($15,000) = U($0) x 0.5 + U($50,000) x 0.5

where U($0) = U(worst payoff) = 0

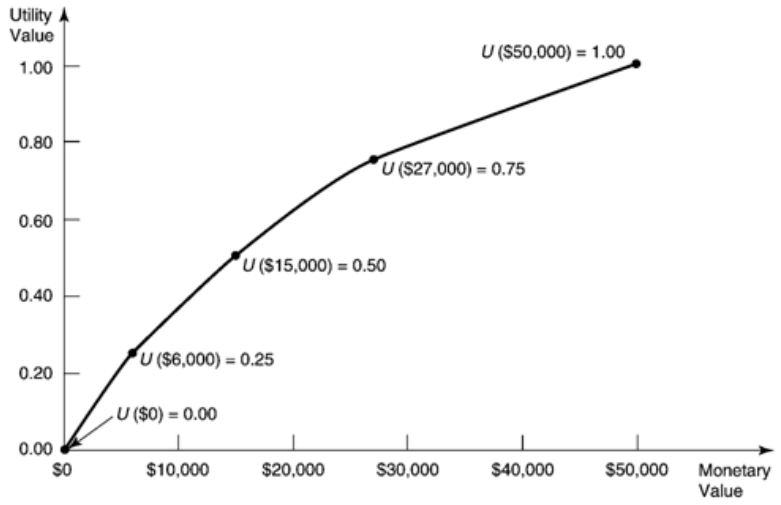
U($50,000) = U(best payoff) = 1

U($15,000) = 0 x 0.5 + 1 x 0.5 = 0.5 (for lender)

Lender's Utility Assessment (cont'd)

- The same gamble is presented to the lender multiple times with various values for the two payoffs
- Each time lender chooses his minimum certainty equivalent, and his/her utility value is calculated
- A *utility curve* plots these values

Lender's Utility Curve



Lender's Utility Assessment

- Different people will have different curves
- Lender's curve is typical of a *risk avoider*
- *Risk premium* is the EMV a person is willing to give up to avoid the risk

Risk premium = (EMV of the gamble)
– (Certainty equivalent)

Lender's risk premium = $25,000 - $15,000
= $10,000

2) Debt Cover Ratios

- The level of debt that can be raised for a project is based primarily on its projected ability to pay interest payments as they fall due, with a comfortable margin of safety
- To asses this margin of safety, lenders calculate cover ratios

Annual Debt Service Cover Ratio (ADSCR)

- The ADSCR assesses the project company's ability to service its debt from its annual cash flow

$$ADSCR = \frac{Annual\ Operating\ Cash\ flow}{Annual\ Debt\ Service}$$

$$ADSCR = \frac{\text{operating revenues - operating expenses}}{\text{interest payments + principal payments}}$$

- Approximate minimum ADSCR ratios for standard projects:
  - 1.2:1 for an infrastructure project with no usage risk
  - 1.3:1 for a power plant project with off-take contract

Loan Life Cover Ratio (LLCR)

- The LLCR is based on a similar calculation as ADSCR, but taken over the whole term of the loan

$$LLCR = \frac{Projected\ Operating\ Cash\ flow}{Debt\ Service}$$

- Projected operating cash flow (calculated as for the ADSCR) from the date on which the project is projected to begin operations, to the date on which the loan is repaid, discounted to its net present value (NPV)
- Debt service is the debt outstanding on the calculation date minus the balance of debt-related reserve accounts

Average ADSCR and LLCR

- If the projected ADSCR from year to year is at the same level, the average ADSCR will be the same as the LLCR
- If the ADSCR is higher in the earlier years, the average ADSCR will be higher than the LLCR, and vice versa
- The average LLCR (i.e., recalculating the LLCR every 6 months for the remainder of the loan, and then taking the average of these figures) is also used by some lenders, although its usefulness is perhaps questionable

Project Life Cover Ratio

- Does the project have capacity to make repayments after the original maturity of the debt, in case there have been difficulties in repaying all of the debt in time?
- This extra debt service capacity is known as the *tail*

$$PLCR = \frac{Projected\ Operating\ Cash\ flow}{Debt\ Outstanding}$$

- Projected operating cash is the net cash flow before debt service for the whole life of the project (not just the term of the debt as for the LLCR), discounted to its NPV

Cover Ratio Calculations

Year	0	1	2	3	4	5	6	7	8	9	10
(a) Operating cash flow		220	220	220	220	220	220	220	220	220	220
(b) NPV of (a)	1352	1267	1174	1071	958	834	697	547	382	200	
(c) Loan repayments		100	100	100	100	100	100	100	100	100	100
(d) Loan outstanding (year end)	1000	900	800	700	600	500	400	300	200	100	0
(e) Interest payments		100	90	80	70	60	50	40	30	20	10
(f) Total debt service **(c)+(e)**		200	190	180	170	160	150	140	130	120	110
ADSCR **(a) ÷ (f)**		1.1	1.16	1.22	1.29	1.38	1.47	1.57	1.69	1.83	2
Avg ADSCR		1.47	1.51	1.56	1.6	1.66	1.71	1.77	1.84	1.92	
LLCR **(b) ÷ (d)**	1.35	1.41	1.47	1.53	1.6	1.67	1.74	1.82	1.91	2	
Avg LLCR	1.65	1.68	1.72	1.75	1.79	1.83	1.87	1.91	1.95	2	

Appendix I: Lecture Slides for Module 9

Investors' Analysis of Project

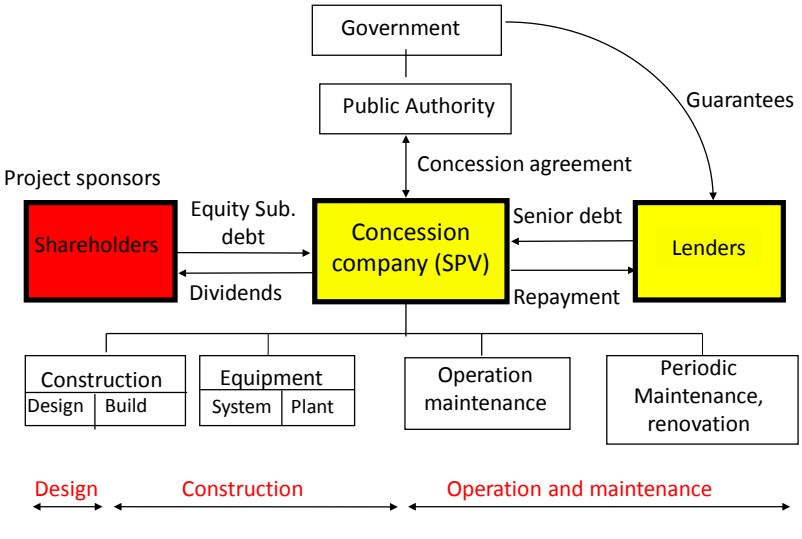
Learning Objectives for Module 9

By the end of Module 9, students should be able to:

- Calculate cost of capital (cost of equity and cost of debt combined).
- Use weighted average cost of capital (WACC) to determine minimum required rate of return.
- Calculate the Beta values for different assets.
- Implement basics of Capital Asset Pricing Model (CAPM) to evaluate project finance transactions from lenders' perspective.
- Examine the impact of:
    - Equity resale.
    - Timing of equity commitment.
    - Refinancing.

How Do Investors Evaluate a Project?

General PPP Structure



Investors' Point of View

- Investors usually aim at minimum level of internal rate of return (IRR) on their equity (investors' return)
- Required level of investors' return may vary depending on when investors come into project (timing of equity commitment)
- A resale of equity when the project is complete and operating as intended may give the investors an opportunity to quicker realization of value on their investment (effect of equity resale)
- The investors' return may be significantly improved by a debt refinancing at this stage (benefit of refinancing)

1) Investors' Returns

- Investors usually have *hurdle rates* for the IRR on their equity above which an investment is acceptable and below which it is not
- The hurdle rate is generally fixed based on:
  - Investors' cost of capital (i.e., discount rate for NPV calc.)
  - Additional return over cost of capital required for particular types of risk (e.g., type of project, location, etc.)
- Investors may require minimum payback period in addition to meeting IRR hurdle

Cost of Capital

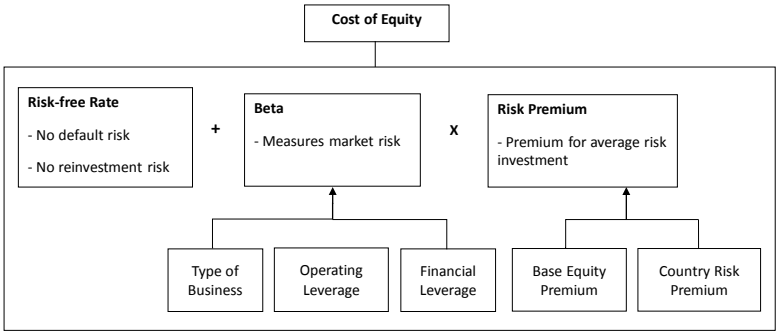
- Let's say a project has a *cost of capital* of 15%
  - The project can only have a positive NPV if the generated return exceeds 15%
  - The project must earn 15% just to compensate investors for the use of their capital in a project
  - The use of capital in a project must earn 15% or more
    - ✓ This does not mean that the cost of borrowing is 15%
- Cost of capital depends primarily on the *use* of funds, not the *source* of funds

Cost of Capital (cont'd)

If a project uses both debt and equity financing, the cost of capital must include the cost of each, weighted to proportion of each (*debt* and *equity*) in the project's capital structure

Cost of Equity

The cost of equity is the rate of return that investors require to make an equity investment in a project



$k_e = RE = Rf + \beta_E \times (RM - Rf)$

or Return on Equity = Risk-free rate + (risk factor x risk premium)

Cost of Debt

- The cost of debt is generally easier to calculate
  - Equals the current interest cost to borrow new funds
  - Current interest rates are determined from the going rate in the financial markets
  - The market adjusts fixed-debt interest rates to the going rate through setting debt prices at a discount (current rate > than face rate) or premium (current rate < than face rate)

    Cost of debt = k_d = Long-term borrowing rate *x* (1 - tax rate)
- The cost of debt is *not*
  - the interest rate at which the company obtained the debt that it has on its books.

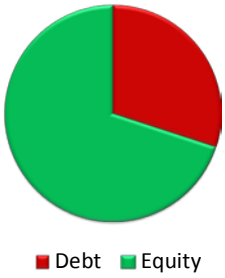
Weighted Average Cost of Capital (WACC)

- A firm's overall cost of capital must reflect the required return on the firm's assets as a whole
- If a firm uses both debt and equity financing, the cost of capital must include the cost of each, weighted to proportion of each (debt and equity) in the firm's capital structure
- This is called the Weighted Average Cost of Capital (WACC)

WACC Example

cven689 capm.xlsx

Debt	$300	30%
Equity	$700	70%
	$1,000	
Cost of Debt (interest rate), r_d		8.0%
Tax rate (t)		40%
Risk-free rate (r_f)		4.0%
Equity Risk Premium (ERP)		5.0%
Beta (β)		1.6
Cost of equity (k_e)		12.0%
Weighted Average Cost of Capital (WACC)		9.84%



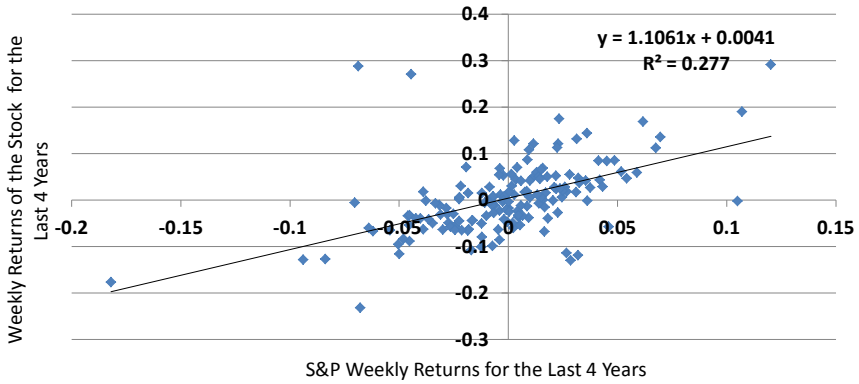
$WACC = w_d r_d (1-t) + w_e k_e$

Beta

- Beta is the measure of market risk (systematic risk)
- What does beta tell us?
  - A beta of 1 implies the asset has the same systematic risk as the overall market
  - A beta < 1 implies the asset has less systematic risk than the overall market
  - A beta > 1 implies the asset has more systematic risk than the overall market

Beta

- For a particular Stock, you can plot the returns on the market (e.g., Standard and Poor's (S&P) 500) against your stock and see how your stock moves in relation to the market



Data and Analysis

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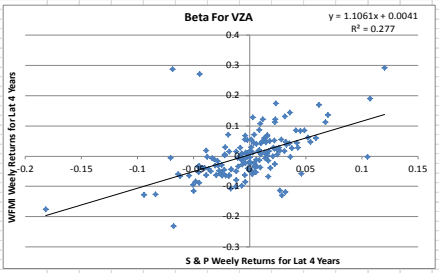
Date	S&P 500 Adj	VZAClose Adj	S & P Weely Returns for Last 4 Years	WFMI Weely Returns for Last 4 Years
			Weekly Return S & P	Weekly Return WFMI
11/9/2007	1453.7	42.51		
11/12/2007	1458.74	44.4	0.003467015	0.044460127
11/19/2007	1440.7	39.94	-0.012366837	-0.10045045
11/26/2007	1481.14	42.15	0.028069688	0.055332999
12/3/2007	1504.66	42.19	0.01587966	0.000948992
12/10/2007	1467.95	39.77	-0.024397518	-0.057358564
12/17/2007	1484.46	41.73	0.011246977	0.049283379
12/24/2007	1478.49	40.77	-0.004021664	-0.023005032
12/31/2007	1411.63	37.16	-0.045221814	-0.088545499
1/7/2008	1401.02	36.96	-0.007516134	-0.005382131
1/14/2008	1325.19	34.57	-0.054124852	-0.064664502
1/22/2008	1330.61	37.01	0.00408998	0.070581429
1/28/2008	1395.42	40.17	0.048706984	0.085382229
2/4/2008	1331.29	38.81	-0.04595749	-0.033856112
2/11/2008	1349.99	38.55	0.014046526	-0.006699304
2/19/2008	1353.11	36.23	0.002311126	-0.060181582
2/25/2008	1330.63	34.64	-0.016613579	-0.043862682
3/3/2008	1293.37	33.58	-0.028001774	-0.030600462
3/10/2008	1288.14	30.72	-0.0040437	-0.085169744
3/17/2008	1329.51	32.18	0.032116874	0.047526042
3/24/2008	1315.22	32.01	-0.010748321	-0.005282784
3/31/2008	1370.4	33.4	0.041954958	0.04342393
4/7/2008	1332.83	31.76	-0.027415353	-0.049101798
4/14/2008	1390.33	32.67	0.043141288	0.028652393
4/21/2008	1397.84	30.92	0.005401595	-0.053569631
4/28/2008	1413.9	34.68	0.011489155	0.12160414
5/5/2008	1388.28	32.5	-0.018120093	-0.062860438
5/12/2008	1425.35	28.83	0.026702106	-0.113538462
5/19/2008	1373.93	27.38	-0.036072186	-0.049635541
5/27/2008	1400.38	28.75	0.017769799	0.050036523
6/2/2008	1360.68	28.25	-0.028349448	-0.017391304
6/9/2008	1360.03	26.93	-0.00047703	-0.046725664
6/16/2008	1317.93	26.06	-0.0309552	-0.031191979
6/23/2008	1278.38	24.44	-0.030009181	-0.063242622
6/30/2008	1262.9	22.51	-0.012109076	-0.078968903
7/7/2008	1239.49	21.04	-0.018536703	-0.065304309
7/14/2008	1260.68	21.38	0.017095741	0.016159696
7/21/2008	1257.76	22.52	-0.00231621	0.053320861
7/28/2008	1260.31	21.42	0.002027414	-0.048845471
8/4/2008	1296.32	18.65	0.028572335	-0.129318394

Slope
1.106121838 Amount of systematic risk
Correllation*SD_{WFMI}/SD_{M}
1.106121838

Correlation tells us the strength and direction of the line (between -1 and 1)
S_{WFMI}/SD_{M} = Amount of Standard Deviation of WFMI per 1 unit of Market Standard Deviation
Together they say direction and strength of Systematic Risk for WMFI



Security Market Line (SML)

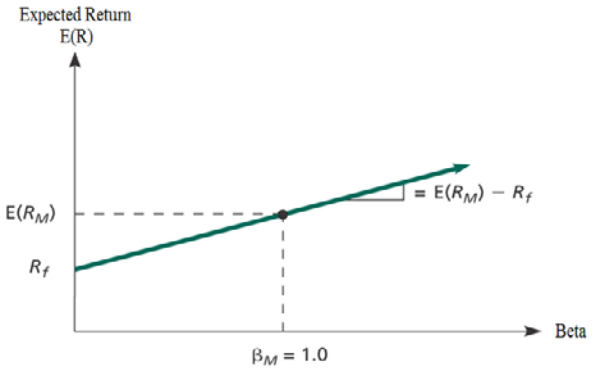
- Indicates the reward for bearing risk (i.e., investing in a stock) in the financial markets

$$\frac{E(R_A) - R_f}{\beta_A} = \frac{E(R_M) - R_f}{\beta_M}$$

- Since Beta of Market = 1

  SML Slope = Market Risk Premium = $E(R_M) - R_f$

SML (cont'd)



- The slope of the SML is equal to the market risk premium, i.e., the reward for bearing an average amount of systematic risk

- The equation describing SML cane be written:

$$E(Ri) = Rf + Bi \times [E(Rm)-Rf]$$

- Which is the capital asset pricing model (CAPM)

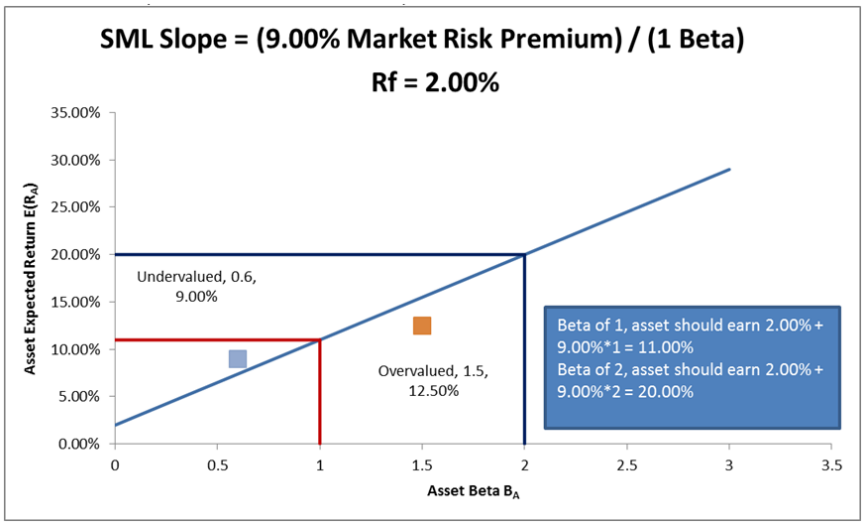
SML into CAPM

$$\frac{E(R_A)-R_f}{\beta_A} = E(R_M)-R_f$$

$$E(R_A)-R_f = \left[E(R_M)-R_f\right]*\beta_A$$

$$E(R_A) = R_f + \left[E(R_M)-R_f\right]*\beta_A$$

CAPM Example



CAPM

- If an asset's (physical or financial) systematic risk is known
  - CAPM can be used to determine its expected return

2. Timing of Equity Commitment

- The return required by the investors varies depending on when they come into the project
- Projects have different levels of risk over time
- If the project develops successfully, the equity IRR required by new investors declines

3. Effect of Equity Resale

- A sale of part or all of their equity investment when the project is complete and operating successfully is likely to offer investors a chance for significant improvement in their originally projected return

Example Project

Project Cost: $570

Construction Period: 2 years with ½ of the cost paid on day 1, and the balance at the end of each following year

Funding: 85% debt, 15% equity

Net revenues: $70 per annuity (over a 20 year project life)

Debt service: Debt is repaid on an annuity basis over the first 15 years of operation at an interest rate of 7%

Effect Of Equity Resale

		Construction			Operation							
Year:		0	1	2	3	4	5	…	17	18	19	…	22
(1)	Initial Project Finance												
(a)	Project Cost	-190	-190	-190									
(b)	Net Revenues				70	70	70	…	70	70	70		70
(c)	Debt Payments	162	162	162	-53	-53	-53	…	-53				
(d)	Net Cash flow [(a)+(b)+(c)]	-29	-29	-29	17	17	17	…	17	70	70		70
	Equity IRR = 18%												
(2)	Sale at the end of year 2 of operation												
	Position of the Original												
(i)	Investor												
	Project Cash flow	-29	-29	-29	17	17							
	Sale					130							
	Net Cash flow	-29	-29	-29	17	147							
	Equity IRR = 25%												
	Position of the New												
(ii)	Investor												
	Purchase					-130							
	Project Cash flow						17	…	17	70	70	…	70
	Net Cash flow					-130	17	…	17	70	70	…	70
	Equity IRR = 15%												

4. Benefit of Refinancing

- A sale of part or all of their equity investment when the project is complete and operating successfully is likely to offer investors a chance for significant improvement in their originally projected return

Example Project

Consider the previous example with the benefit of a refinancing of the debt 2 years into operation. The refinancing adds two years on to the final maturity of the loan, and also increases the loan outstanding at the end of the year

Benefit of Refinancing

		Construction			Operation							
Year:		0	1	2	3	4	5	...	17	18	19	...	22
(1)	Initial Project Finance												
(a)	Project Cost	-190	-190	-190									
(b)	Net Revenues				70	70	70	...	70	70	70	...	70
(c)	Debt Payments	162	162	162									
(d)	Debt Repayments					-19	-21	-22	...	-50			
(e)	Year-end debt outstanding [(e) {previous year} + (c) + (d)]	162	323	485	465	445	423	...	0				
(f)	Interest payments [(e)@7%]				-34	-33	-31	...	-3				
(g)	Debt Service [(d)+(f)]				-53	-53	-53	...	-53				
(h)	Net Cash flow [(a)+(b)+(c)]	-29	-29	-29	17	17	17	...	17	70	70	...	70
	ADSCR [(b) ÷ (g)]				1.32	1.32	1.32	...	1.32			...	
	PLCR [NPV(b) ÷ 465] end year 2*	1.53											
	Equity IRR = 18%												
(2)	Refinancing												
(a)	Project Cost	-190	-190	-190									
(b)	Net Revenues				70	70	70	...	70	70	70	...	70
(c)	Debt Payments	162	162	162		65							
(d)	Debt Repayments				-19	-21	-20	...	-46	-49	52	...	
(e)	Year-end debt outstanding	162	323	485	465	510	489	...	101	52	0	...	
(f)	[(e) {previous year} + (c) + (d)]												
(g)	Interest payments [(e)@7%]				-34	-33	-36	...	-10	-7	-4	...	
(h)	Debt Service [(d)+(f)]				-53	-53	-56	...	-56	-56	-56	...	
	Net Cash flow [(a)+(b)+(c)]	-29	-29	-29	17	82	14	...	14	14	14	...	70
	ADSCR [(b) ÷ (g)]				1.32	1.32	1.25	...	1.25	1.25	1.25	...	
	PLCR [NPV(b) ÷ 465] end year 4*	1.38											
	Equity IRR = 24%												

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