

Part III

Developing Projects and Programs to Deal with Problems and Opportunities

- Chapter 11 Developing a Strategy to Deal with a Problem
- Chapter 12 Public Private Partnerships
- Chapter 13 Dealing with Risks and Uncertainties
- Chapter 14 Managing Projects and Programs
- Chapter 15 Toward More Sustainable Infrastructure

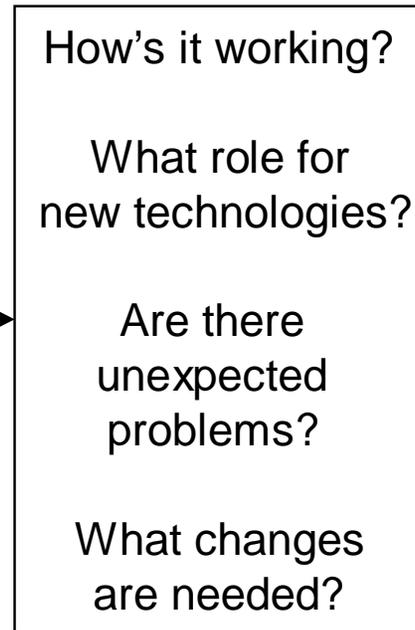
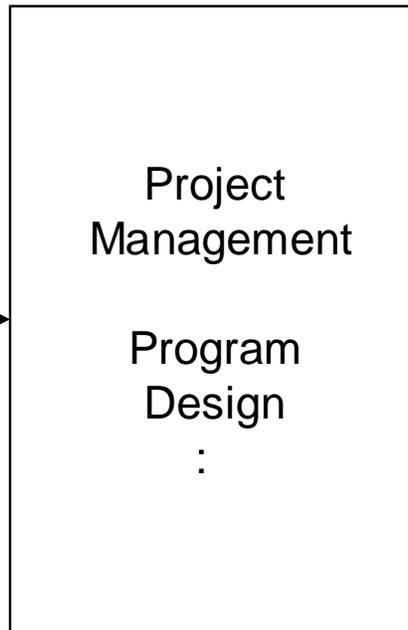
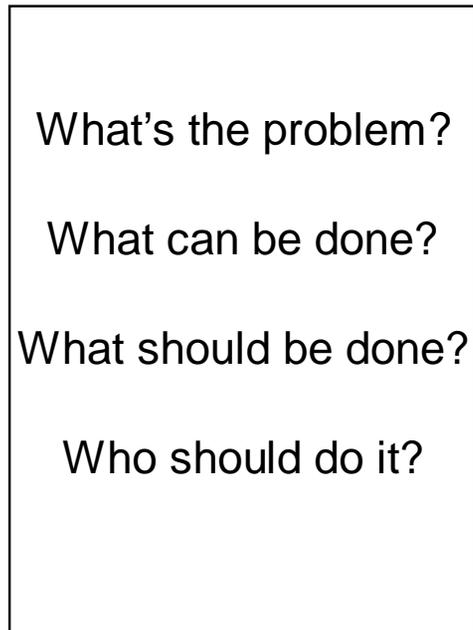
Design



Implementation



Evolution



Chapters 11, 12, 13

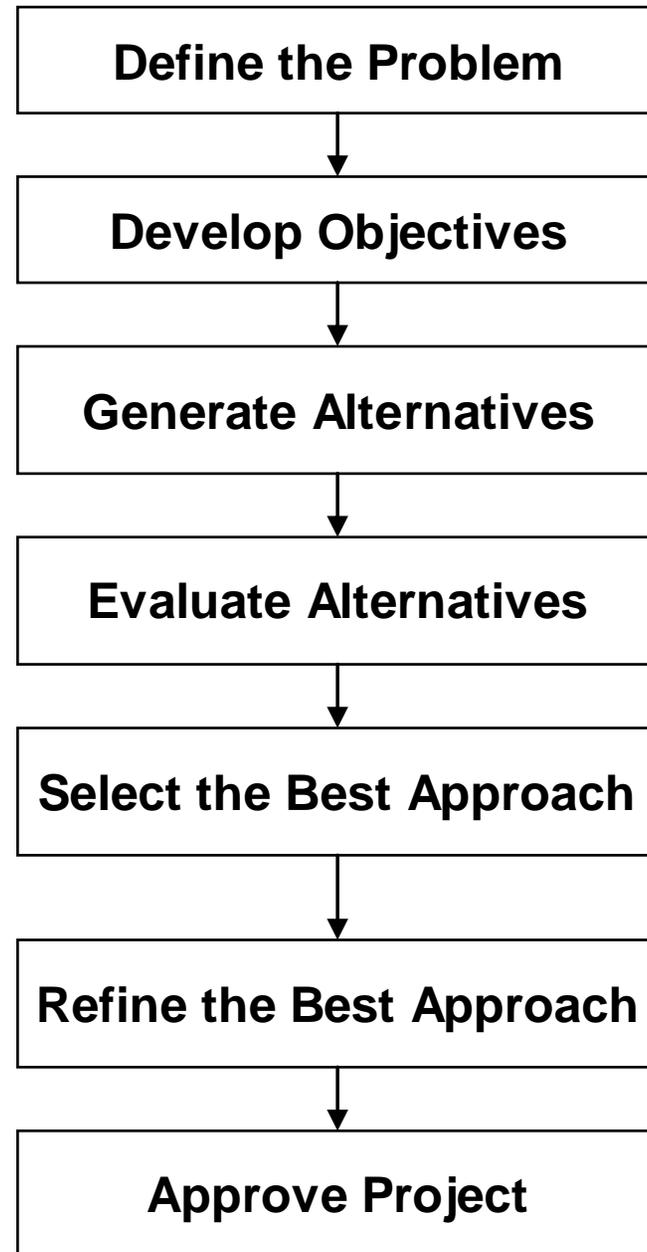
Chapter 14

Chapter 15

Chapter 11

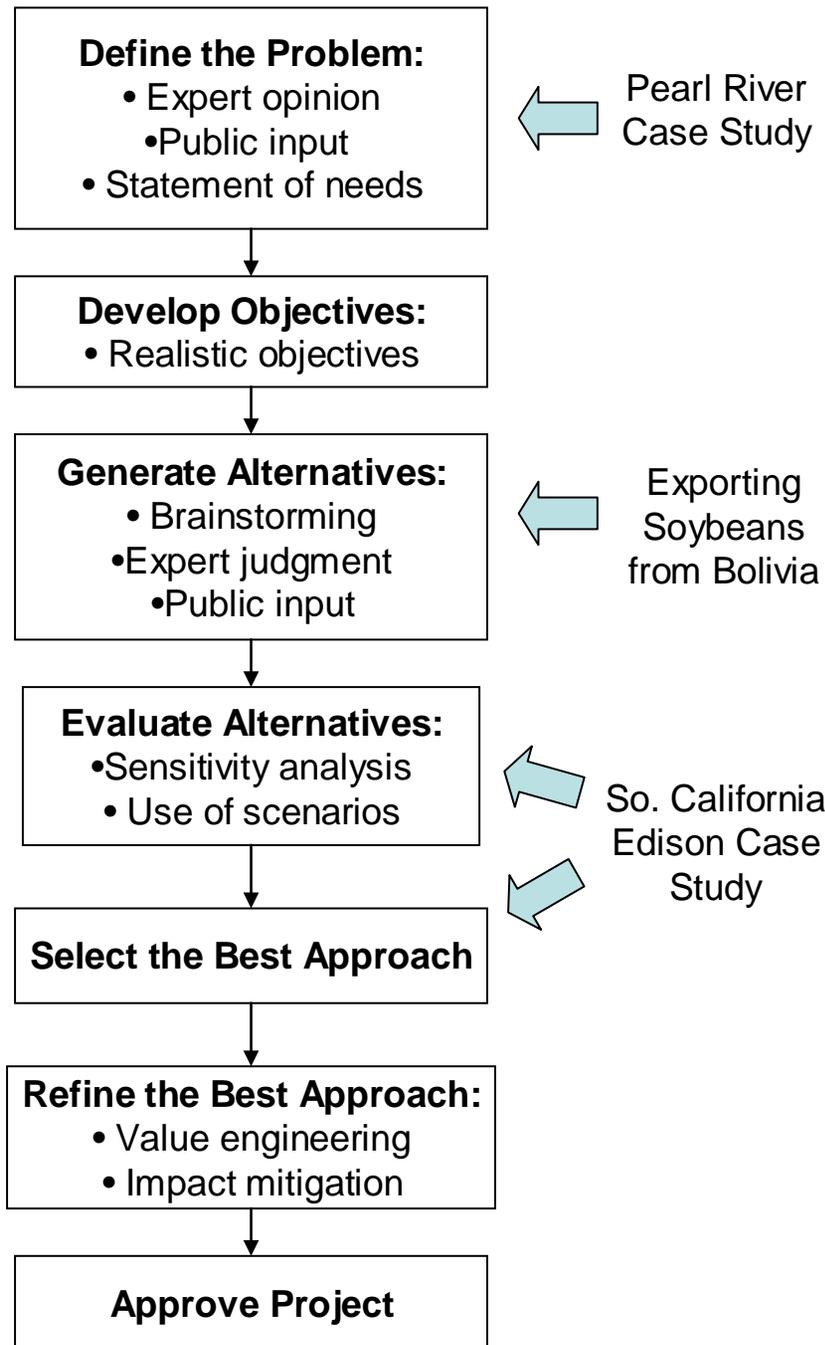
Developing a Strategy to Deal with a Problem

What can be done at each
stage of project evaluation?



I hope that ultimately it will prove feasible to build a sea-level canal. Such a canal would undoubtedly be best in the end, if feasible, and I feel that one of the chief advantages of the Panama Route is that ultimately a sea-level canal will be a possibility. But, while paying heed to the ideal perfectibility of the scheme from an engineer's standpoint, remember the need of having a plan which shall provide for the immediate building of the canal on the safest terms and in the shortest possible time.

President Theodore Roosevelt, 1905



Aspects of Project Evaluation Addressed in Chapter 11

Similarities between Project Design and Evaluation

- Neither can be readily quantified
- There are no simple rules or guidelines
- Both benefit from broad thinking
 - What are the problems?
 - What are the opportunities?
 - What are the options?
- Both require intelligence, insight, creativity, and common sense

Methods

- Preparing a statement of needs and objectives
- Generating alternatives
- Assessing alternatives and testing assumptions
- Selecting and enhancing the best alternative

Identifying Needs and Objectives

- Fundamental societal needs:
 - Mobility
 - Safe drinking water
 - Safe and secure housing
 - Communications
 - Public
- Perceptions of needs and possible improvements vary over time

Impetus for Change

- Dissatisfaction with the existing system
- Ideas and technologies for improving operation and management of the existing system
- New technologies or resources that allow new ways to satisfy needs
- Court orders requiring better service, greater equity, or reduced environmental impacts

Boston Harbor Clean-Up



Statement of Needs

- Statements that emphasize performance will be superior to ones that emphasize technologies.
- Well-conceived statements lead to many different options:
 - We need to improve the urban transportation system to ensure mobility for all residents.
- Poorly-conceived statements restrict options:
 - We need to build more roads to relieve congestion.

Needs vs. Desires

- “Need” depends in part upon cost.
- Just because we “want” something doesn’t mean we “need” it.
- There is a hierarchy of needs:
 - Public health
 - Safety of buildings
 - Relief of traffic congestion

Water Supply Needs

- The city needs more water.
- The city needs to restrict the use of water.
- The city needs to ensure that sufficient water of appropriate quality is available to meet personal, industrial, recreational, agricultural and other uses.
- The city, residents, and local companies must ensure water isn't wasted and find long-term, cost-effective strategies to manage supply and demand

Objectives

- Specific statements of what is to be achieved
- Can be formulated even if disagreement concerning needs
- Qualitative objectives are easier to formulate
- Quantitative objectives provide better targets than qualitative objectives for improving system performance

Qualitative vs. Quantitative Objectives: Transportation

Qualitative

- Reduce congestion

Quantitative

- Reduce congestion by 10% within 3 years as measured by average commuting time
- Reduce congestion on interstates by 5% and on major arterials by 20%

Qualitative vs. Quantitative Objectives: Energy

Qualitative

- Increase the use of renewable energy resources

Quantitative

- Increase the use of renewable energy resources by 5% per year for 10 years.
- Generate at least 20% of the region's electricity from renewable resources within 0 years.

Qualitative vs. Quantitative Objectives: Drinking Water

Qualitative

- Improve access to clean drinking water in developing countries

Quantitative

- Ensure that clean drinking water is available within every village in this region within the next 5 years.
- Increase the percentage of the population with access to clean water within 50 yards of their home from 35% to 75% within 10 years.

Qualitative vs. Quantitative Objectives: Homelessness

Qualitative

- Reduce homelessness.

Quantitative

- Provide sufficient shelter in the city for up to 5,000 homeless people during the up-coming winter.
- Upgrade mental health plans to ensure that patients are no longer prematurely released from state hospitals until they have a place to live.

Identifying Alternatives

- Ability to investigate alternative is limited: take care in deciding what to investigate!
- Consider options that are distinctly different.
- Options may consider a “preferred” alternative – but it might be better to reserve judgment.
- Options should always consider the “do-nothing” or “business as usual” option.

Pitfalls to Avoid

- The Good, the Bad and the Ugly
- Tweedle Dum and Tweedle Dee
- Overkill

Methods for Generating Alternatives

- Brainstorming
- Systematic identification of options
- Public input
- Best practices and expert opinion

Keys to Effective Brainstorming

- Provide a clear statement of problem
- Gather a group of knowledgeable, interested people with diverse backgrounds
- Give people sufficient time to review background information
- Choose effective facilitators to lead the discussion
- Allow everyone time to present all of their ideas
- Remember that the goal is to generate ideas, not to debate their merits
- Rearrange, combine, condense, and refine ideas
- Allow everyone to review the summary

Two Ways to Structure Brainstorming Groups

| Skills/Interests | Role |
|-------------------------|---------------------|
| Design | Developer |
| Location | Owner/Investor |
| Operation | Abutter |
| Construction Process | Government Official |
| Safety | Environmental Group |
| Economic Impact | Chamber of Commerce |

Systematic Identification of Options

- Adjust prices to manage demand
- Improve productivity by better management
- Repair or rehabilitate portions of the system
- Invest:
 - Improve capabilities of existing system
 - Expand the system
 - New types of infrastructure

Vary timing, location and staging of each option

Public Input

- Hearings
 - Present needs, opportunities, and preliminary ideas
 - Seek input from the public
 - Find out what is controversial while it is still possible to adjust plans
- Work with Public Interest Groups
 - Conservation groups
 - Public interest legal groups
 - Neighborhood organizations

Best Practices and Expert Opinion

- Best practices will be available for well-established infrastructure-based systems.
- Experts will be able to identify the available options for improving an infrastructure-based system.
- Other experts will be able to provide insight into environmental, social or other issues that may arise.

Tren Urbano's San Piedras Station (San Juan Puerto Rico)



Dealing with Uncertainty

- Sensitivity analysis
- Scenario analysis
- Probabilistic analysis

"Make Uncertainty Explicit"

(Principle 6, Sullivan et al, Engineering Economy, p. 7)

- Understand the uncertainties and the risks
- Seek protection against the most serious risk
- Use discount rates that are suitable for the risks evident for a particular project
 - ▶ Higher discount rates for riskier projects

Uncertainty

- We cannot predict the future, and we may not even have good estimates of probabilities of possible outcomes
 - ▶ Variations about the norm
 - ▶ Changes in trends
 - ▶ "New Facts"
- Projects create new demands - and we can't always refer to past experience

Risks

- Risks refer to the possibility that something will go wrong. For example:
 - ▶ Construction risks (unable to construct on time and within budget because of technical or organizational problems)
 - ▶ Competitive risks (loss of market to better, earlier, or larger projects similar to or substituting for your project)
 - ▶ Financial risks (changes in interest rates, exchange rates, credit limits that affect our ability to raise sufficient funds for project; changes in cash flows that affect ability to mortgage payment)
 - ▶ Political risks (changes in government or in regulations that limit our ability to complete, open, or receive payment for our project)

Methods

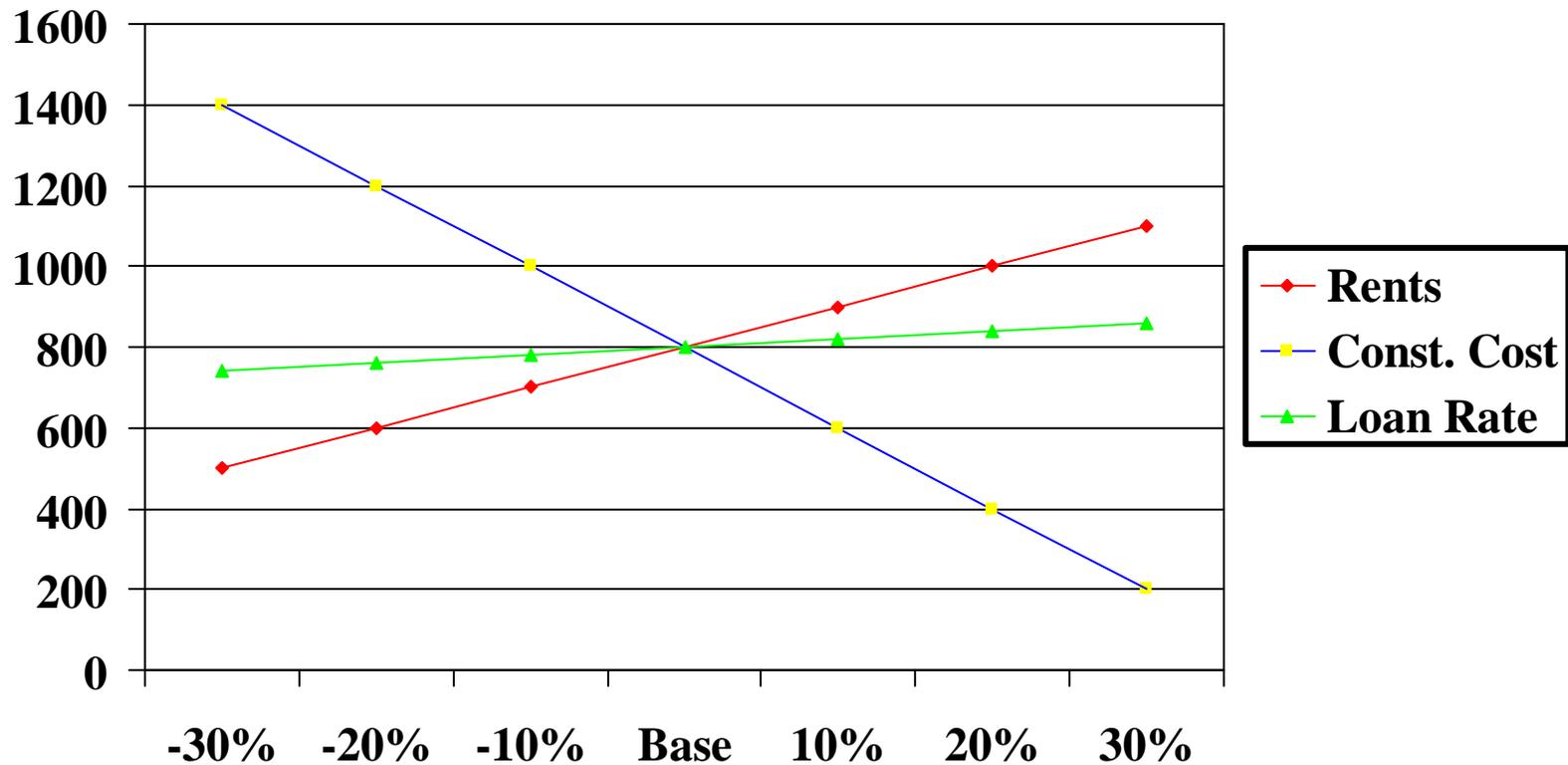
- Methods driven by the analysis
 - Sensitivity Analysis
 - Probabilistic Analysis
 - Monte Carlo Simulation
- Methods driven by the structure
 - Key drivers
 - Scenarios

Sensitivity Analysis

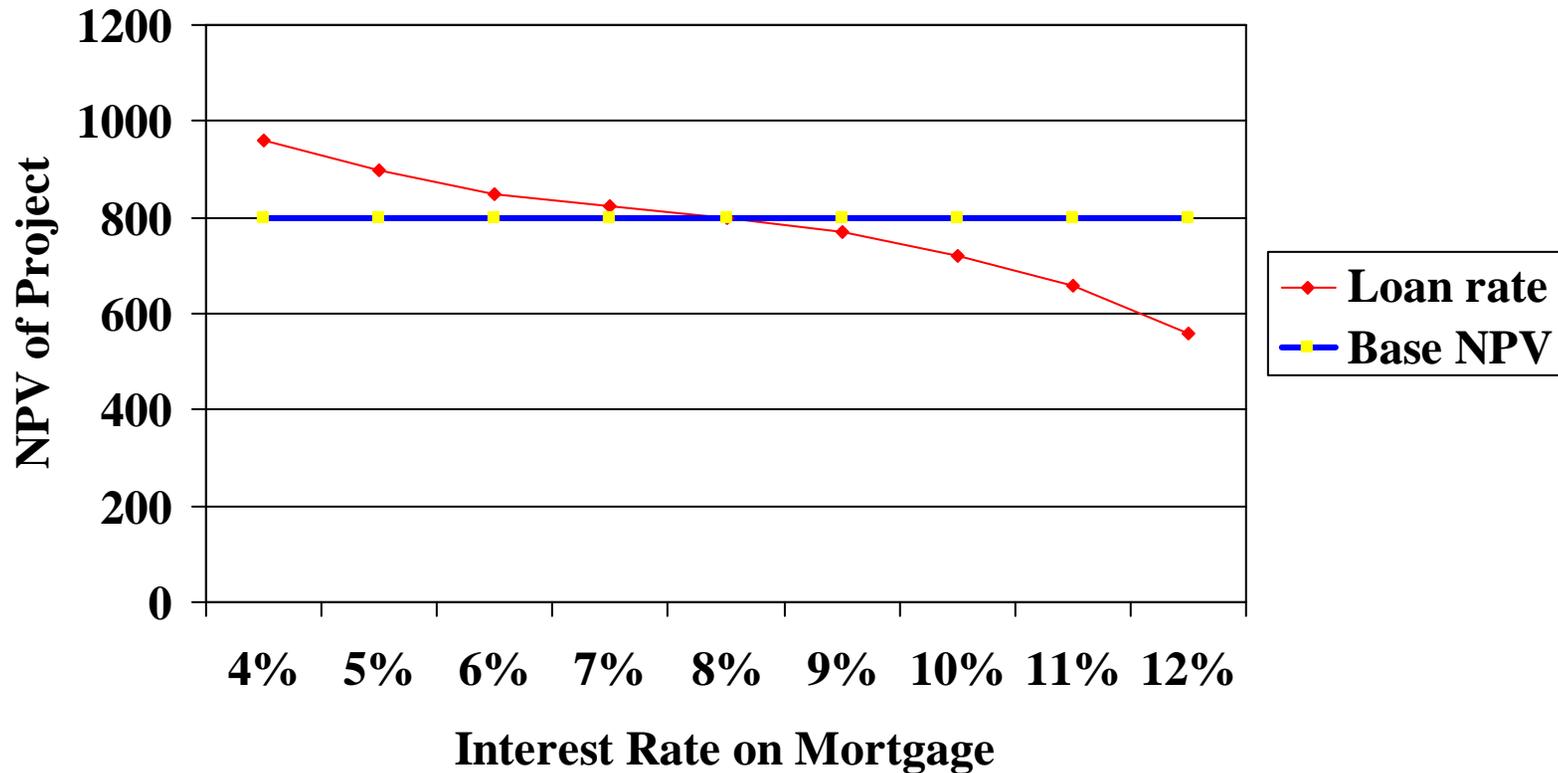
- Systematic analysis of the effects of changes in one or more variable on our results and our choice of an alternative
 - ▶ Cost factors: unit costs, discount rates, process speed
 - ▶ Benefit factors: prices, demand, external impacts
- Key choices
 - ▶ What is our base case?
 - Best estimate of all factors
 - ▶ What factors to vary? by how much?
 - Those with the greatest uncertainty and those related to known risks
 - Vary over likely range of options

Sensitivity Analysis: “Spiderplot”

(\$2 billion building with NPV of \$800 Million)



Sensitivity Analysis: Using a More Realistic Range for Varying a Single Factor (\$2 billion building with NPV of \$800 Million)



Probabilistic Analysis

- Treat the key factors as random variables (continuous or discrete)
- Develop expressions for key performance measures as functions of the random variables
- Calculate the probability that the results of the project will be unacceptable

Probabilistic Analysis: Difficulties

- We generally don't know the probabilities
- The math gets complicated very quickly
- The design process is more related to “possibilities” than to “probabilities”

Scenarios

- A "scenario" is a set of internally consistent assumptions that together provide a vision of a "possible" future within which our project will be implemented
 - ▶ Broader than sensitivity analysis
 - ▶ For example: Optimistic/Most Likely/Pessimistic
- Elements of a Scenario - the factors that we believe are important to our project that we will vary across scenarios. For example:
 - ▶ General economic conditions
 - ▶ Response of competitors to our project
 - ▶ Construction prices

Steps for Developing Scenarios

Peter Schwartz, "Art of the Long View"

- Identify the focal issue or decision
- Identify key local forces
- Identify key external forces
- Rank by importance and uncertainty
- Select scenarios defined by drivers
- Flesh out the scenarios
- Implications
- Identify and monitor leading indicators

Creating and Using Scenarios

(“Mobasheri, Orren, and Sioshansi, “Scenario Planning at Southern California Edison”, Interfaces 19: Sept-Oct 1989, pp. 31-34)

- “Futility of plans based upon rigid forecasts”
- “Focuses on what might happen, or can go wrong, and how to deal with it”
- Developed 45 scenarios in 12 clusters related to demand for peak power: “representative of all plausible scenarios that might be constructed”
- Address strategic concerns for each scenario
- Seek strategies to “eliminate or mitigate the consequences of bad outcomes”
- “No attempt to assess probabilities”

Probabilistic Risk Assessment

- Problem: how to deal with risks related to natural disasters or unusual events (earthquakes, fires, accidents)
- Assess Risk = PROB x CON
 - ▶ PROB = Probability of event
 - ▶ CON = Expected consequences of event
- Assess cost ΔC of reducing risks
- Compare incremental cost to incremental risk
 - ▶ If $\Delta C <$ reduction in risk, then it is worth adding the extra cost
 - ▶ There may be many effective ways of reducing risks

Probabilistic Risk Assessment: Reducing Highway Risks

- Reduce probability of accidents
 - Licensing requirements
 - Enforcement (speed, drunk driving, etc)
 - Highway geometry
 - Highway maintenance
 - Free coffee at rest stops
- Reduce severity of accidents
 - Seatbelts
 - Automobile construction
 - Roadside barriers & removal of obstacles

Probabilistic Risk Assessment: Reducing Risks of Flooding

- Probability of floods
 - Hydrological records (100-year flood)
- Consequences of floods
 - Historical records (damage & fatalities associated with N-year floods)
 - Predictions of future damages
- Options
 - Dams & levees
 - Limit development in flood plain
 - Build to withstand floods

Probabilistic Risk Assessment: Evaluating Flood Control Projects

- Estimate costs of options
 - Convert to equivalent future annual cost
- Estimate expected costs of floods, for each option
 - Convert consequences of N-year floods into expected consequences per year
- Compare reduction in annual consequences to equivalent annual cost of project

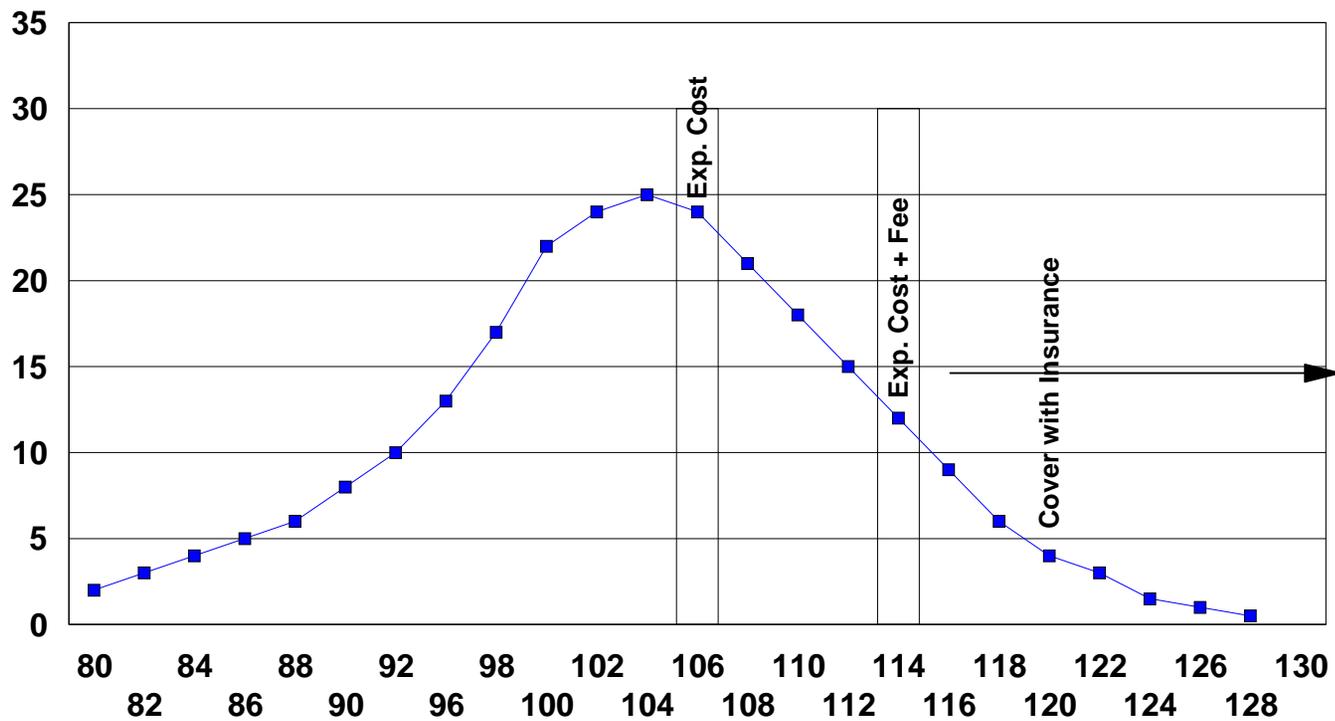
Protection Against Project Risks

- Failure to meet budget & time table
 - ▶ Studies, site surveys
 - ▶ Penalty clauses in subcontracts
 - ▶ "Cost Plus" rather than "Fixed Price" contract
- Failure to meet revenue targets
 - ▶ Studies and surveys
 - ▶ Pricing & staging options
- Natural disaster; construction accidents
 - ▶ Insurance
 - ▶ Safety plan - **WHEN** to work; **HOW** to work
- Bankruptcy
 - ▶ Minimal leveraging; loan guarantees
- Government interference
 - ▶ Partnerships with government or local firms

Risks Are Shared Among the Actors Involved in a Project

- Are MY risks commensurate with MY potential benefits
- Can I include sufficient time in the work schedule to cover the expected range of delays and a sufficient amount in my budget to cover the expected range of cost variation?
- Can I get insurance to limit my liability for the worst things that might occur?
- Can I negotiate a better deal?

Bidding on a Project: Include a "Margin of Error"



Staging

- Break the project into several stages that can be implemented if and when demand warrants
 - ▶ May lead to higher construction costs for the project if all stages are eventually build
 - ▶ Added flexibility reduces risks that insufficient demand will lead to financial problems
- Examples
 - ▶ Build one tower where there is room for two
 - ▶ Buy options for additional land
 - ▶ Build a house, but don't finish the basement or the attic

Case Study : Bridging the Pearl River Delta

- The Pearl River bisects one of the most densely populated areas of the world
 - Guangshou (15 million people)
 - Hong Kong
 - Macau
 - Several other cities with >1 million people
- Various proposals for bridges or tunnels to link Hong Kong with western side of delta

Case Study : Bridging the Pearl River Delta

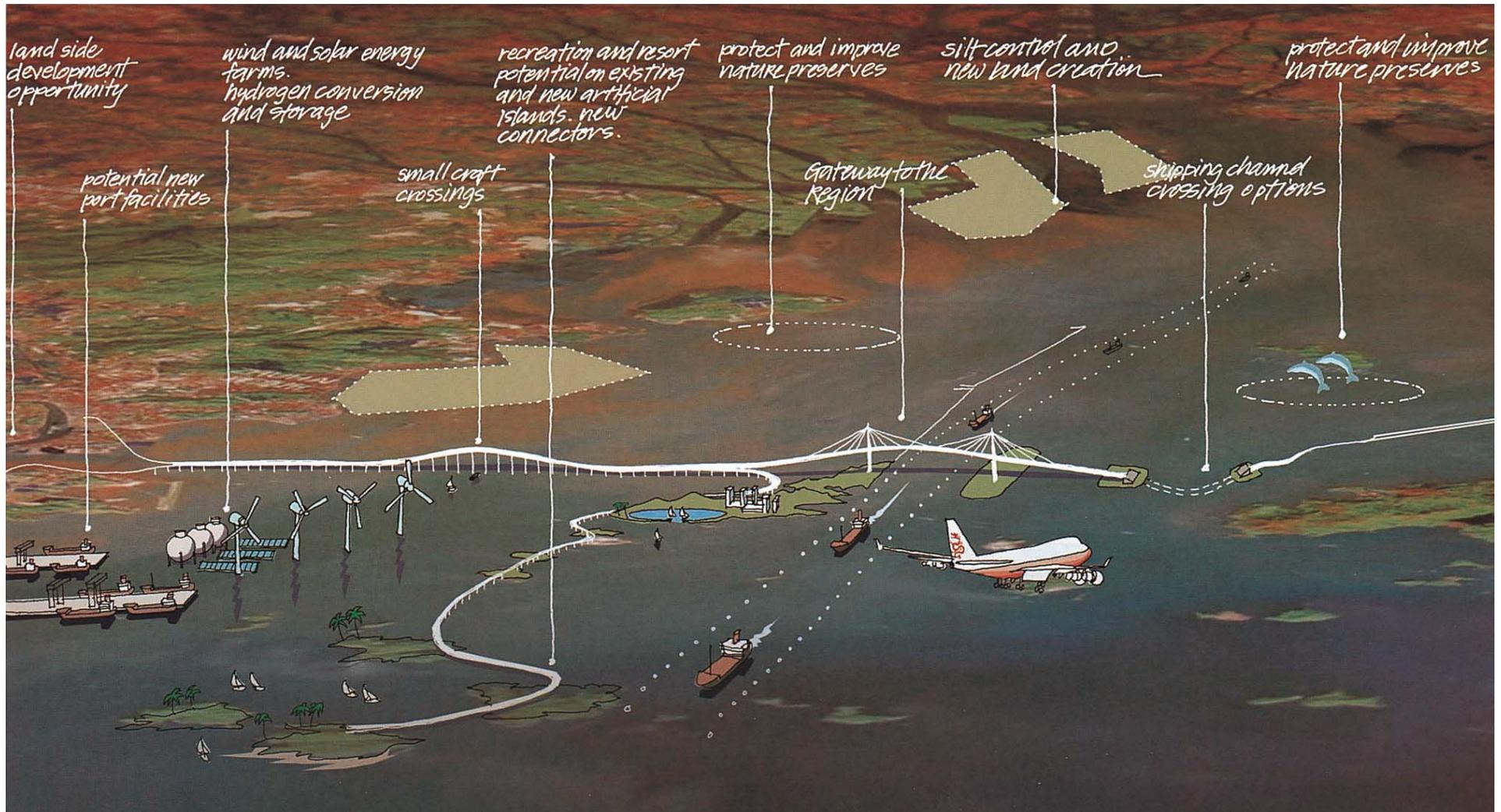
- Hong Kong 2022 Foundation
 - What issues should be considered?
 - What constraints must be recognized?
- Interdisciplinary team:
 - US and Chinese experts
 - Urban planners, transportation planners, and people with extensive government experience in implementing large projects

Key Issues

- Feasibility of construction
- Need for bridge (feasibility of financing)
- Location of bridge
- Role of bridge as key link in multi-centric region
- “More than a bridge”: what are the related opportunities?

| Bridge or Tunnel | Length | Cost | Toll |
|--------------------------------------------------------------------------------------------------------|---------------|----------------|-------------|
| Chunnel (rail tunnel connecting Great Britain and France) | 50 km | \$21 billion | \$75 |
| Lake Pontchartrain Causeway (connecting New Orleans to points north of the city) | 39 | \$0.06 billion | \$1.50 |
| Chesapeake Bay Bridge/Tunnel (connecting Norfolk VA with the Eastern Shore of VA) | 28 | \$0.4 billion | \$10 |
| Oresund (Denmark – Sweden)_ | 16 | \$2.4 billion | \$32 |
| Tokyo Bay Aqualine (connecting Tokyo with the relatively undeveloped eastern side of Tokyo Bay) | 15 | \$11.7 billion | \$20 |

“More than a Bridge!”



Lessons from the Pearl River Delta Study

- There is not time study all of the issues that are raised at the early stages of a project.
- The private sector may recognize the feasibility of a project and push for an early start. But:
 - Will they build the best project?
 - Will they consider the related issues, e.g. traffic management in the region or economic linkages across the delta?
 - Will they maximize their profits rather than overall socio-economic benefits for the region?
- An interdisciplinary team can indeed help to clarify issues and identify a broader set of alternatives.

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