UNCERTAINTY MANAGEMENT
FOR ENGINEERING SYSTEMS PLANNING AND DESIGN

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Starting Premise

- Uncertainty is a foundational issue in engineering design
- Loads are probabilistic
- "The forecast is always wrong"
  - Because of trend breakers such as new technology, new rules, economic booms and busts, new competitors, etc, etc

Forecast is “always wrong”

- Well-documented phenomenon
- Many examples
  - Oil prices and supplies
  - Communications: Internet, G3, etc
- Unavoidable
  - Major changes in past trends
  - Better analysis will not provide solution

... Especially for Engrg Systems

- Uncertainty greater because systems:

- Last longer than component artifacts
- May affect more parts of society
  - E.g.: Automobile transport vs. a car
  - Transport system persists yet cars junked
  - Transport shapes city, single cars don't

Argument

- Traditional Engineering approach to uncertainty is limited
- Dealing with Engineering Systems requires a broader perspective
- We have opportunity here given:
  - New technology … IT, computer power
  - New methodology … options analysis
- Improvements of 30% possible…

Traditional Approach

- "Good designs do not fail"
- Criterion is "Technical Safety"
- Focus on Downside, on Risk
  - "bullet proofing" against eventualities, generally a passive approach
  - Factors of Safety
  - Redundancy
  - Robustness

Tradition Limited Substantively

- Focus on "technological failure" ignores upside opportunities
  - Yet these can be important e.g. Internet
- Focus on "technological failure" ignores economic, market issues
  - E.g. Commo satellites: technological marvels –yet economic embarrassments

Tradition Limited Conceptually

- **Focus on Passive Response to loads ignores Leadership capability to respond Actively**
  - **Management not within technical paradigm**
- **Active Management of Uncertainty**
  - **Demand Management e.g., via pricing**
  - **System Management via flexibility, options**

Opportunity

- **Engineering Systems Groups, by integrating economics, management can move practice**
  - **from passive "risk management"**
  - **to active "uncertainty management"**
- **Engrg Systems paradigm includes**
  - **"non-technical" approaches**

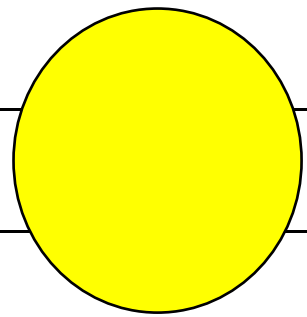
Research Opportunities

- Differ along at least 2 dimensions
- Time
  - Short to longer to longest term
  - Operational, Tactical, Strategic
- By mode of response
  - On loads – demand management etc
  - On Systems – passive and active (robustness or flexibility)

Two-Way Typology of Research

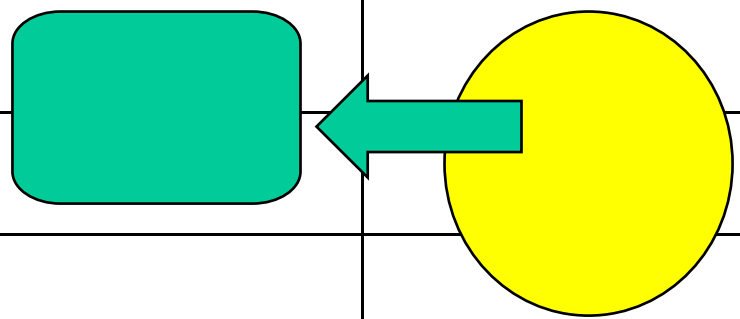
Time Scale and Mode of Response	Uncertainty Management	System Modification	
		Passive: Robustness	Active: Flexibility
Operational			
Tactical			
Strategic			

Focus of Current Practice

Time Scale and Mode of Response	Uncertainty Management	System Modification	
		Passive: Robustness	Active: Flexibility
Operational			
Tactical			
Strategic			

Demand Management

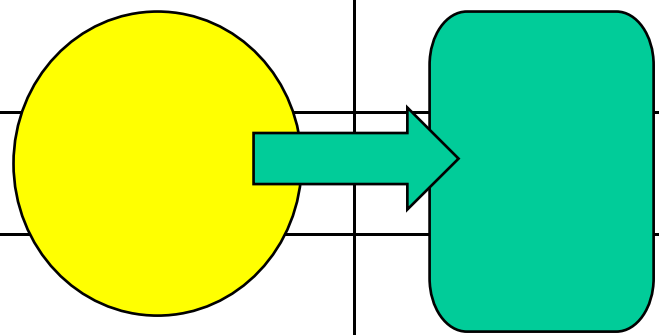
Time Scale and Mode of Response	Uncertainty Management	System Modification	
		Passive: Robustness	Active: Flexibility
Operational			
Tactical			
Strategic			



Demand Management Examples

- Peak / off peak pricing
- Metering / diversion of traffic
  - Highway ramps
  - Reliever / secondary airports
  - Load Shifting – night storage heating
- Quality of service differentiation
  - A different form of incentives
  - 1-day or 2-day deliveries

Use of Flexibility, Options

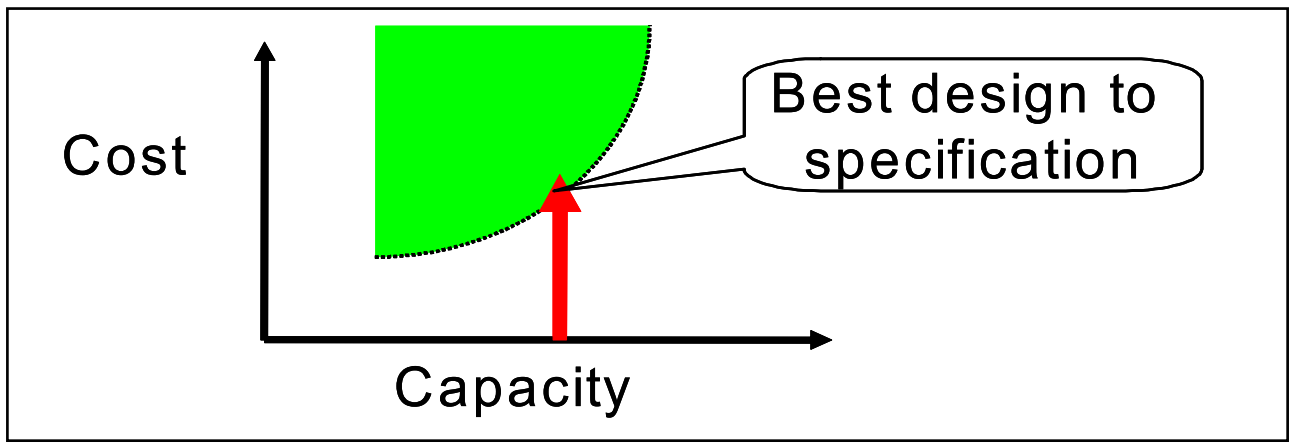
Time Scale and Mode of Response	Uncertainty Management	System Modification	
		Passive: Robustness	Active: Flexibility
Operational			
Tactical			
Strategic			

Flexibility Examples

- Staging / Timing of Implementation
  - Prepare now, for possible future expansion
  - Bigger foundations, for more floors
  - Satellite example (de Weck et al)
- Altering of Facilities
  - Operationally – Swing gates at airports
  - Tactically – Expansion plans, space
  - Strategically – Major shift: Tagus Bridge

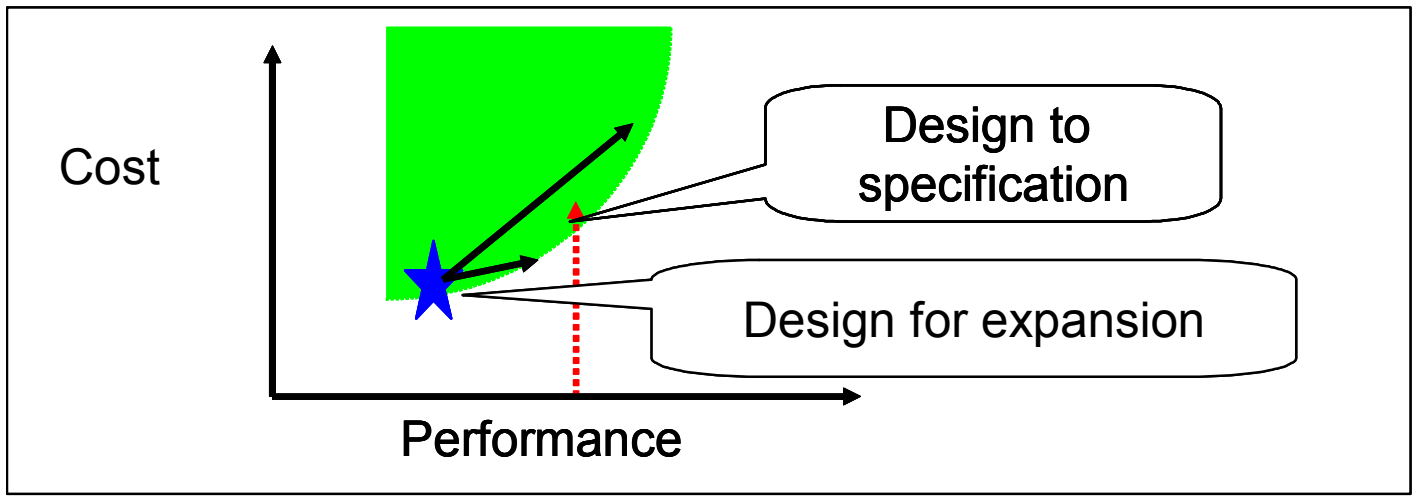
Extended Flexibility Example

- **Implementation of Communication Satellite Systems – old style**
  - **"Define" needed capacity**
  - **Explore ways to provide that capacity**
  - **Choose best value for money**



Extended Flexibility Example

- **Implementation of CSS – with flexibility**
  - Estimate range of possible capacity demands
  - Explore ways to provide capacity as needed
  - Chose initial design – expand as needed
  - About 30% improvement in value/money



Summary

- Conventional Engineering deals with
  - Risk – only 1 side of distribution
  - Passively – robustness, safety factors
  - In technical space alone
- We can do better, however
  - Look at Opportunity side of uncertainty
  - Actively – managing events and responses
  - Incorporating management and economics into implementation of engineered products

Opportunity

- For competitive advantage
- Integrating economics, management
- We can move practice
  - from passive “risk management”
  - to active “uncertainty management”
- And increase performance
  - Exploiting opportunities
  - Dealing with risks more efficiently