Recognition of Uncertainty and Complexity

- **Uncertainty: Wide Range of Futures**
  - The forecast is "always wrong"
    - “risks” that is, the bad things that can happen
    - “opportunities” that is, the other side of the distribution, the good things that can happen

- **Complexity: Wide Range of Choices**
  - Number of Choices is Enormous
    - “Pure” solutions only 1 or 2% of possibilities
    - Most possibilities are “hybrid”, that combine elements of “pure” solutions
    - “Hybrid” choices provide most flexibility

Recognition of Uncertainty

- **The usual error**
  - Search for correct forecast

- **However: the forecast is "always wrong"**
  - What actually happens is quite far, in practically every case, from what is forecast
  - Examples: costs, demands, revenues and production

- **Need to start with a distribution of possible outcomes to any choice or decision**
Cost Growth Experience
NASA Microgravity Projects

Ratio of Actual or Current to Estimated Cost

Case I Case II LPE MADOL TOOLS ZENO BOSS PES SECC AVO COOM

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Slide 3 of 22

Ratio of Real Costs

Expressed in constant dollars, to estimated costs for routine airport projects

Median 1.25

Real/Estimated Cost Ratio

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Slide 4 of 22
DOE Oil Price Forecasts

Source: M. Lynch, MIT

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Slide 5 of 22

DOE Oil Price Forecasts

Source: M. Lynch, MIT

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EMF6 Oil Price Forecasts


Source: M. Lynch, MIT

EMF6 Oil Price Forecasts (Low)


Source: M. Lynch, MIT
Forecasts of 1990 Price of Oil

Source: M. Lynch, MIT -- IEW Survey

DOE Forecasts
Non-OPEC LDC Production

Source: M. Lynch, MIT
Error in OPEC Revenue Forecast
EMF6 1980 - 1995

Source: M. Lynch, MIT

Forecasts of Water Use in Boston
(MWRA Members)

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Recognition of Uncertainty Slide 12 of 22
Forecasts of Water Use in Boston (MWRA Service Area)

Why we can’t predict well: Surprises!

- Surprises
  - All forecasts are extensions of past
  - Past trends always interrupted by surprises, by discontinuities:
    - Major political changes
    - Economic booms and recessions
    - New industrial alliances or cartels
- The exact details of these surprises cannot be anticipated, but it is sure surprises will exist!
- Example: MWRA Quincy pellet plant
  - When the s.... Hit the fan!
Why we can’t predict well: Ambiguity

- Ambiguity
  - Analysis can look at many ranges of historical record
  - Moreover, from any set of historical data many extrapolations possible
    - Different explanations (independent variables)
    - Different forms of explanations (equations)
    - Different number of periods examined
  - Many of these extrapolations will be "good" to the extent that they satisfy usual statistical tests
  - Yet these extrapolations will give quite different forecasts!
  - Example: Forecasts of Airport Traffic for Los Angeles

Consequences of Uncertainty

- The Resulting Problem: Wrong Plans
  - Wrong Size of Plant, of Facility
    - Boston Water Treatment Plant
  - Wrong type of Facility
    - Although "forecast" may be "reached"…
    - Components that make up the forecast generally not as anticipated, thus requiring
    - Quite different facilities or operations than anticipated
    - Baltimore Airport Buildings – US Airways / Southwest
Rear View Mirror Analogy

- Relying on forecasts is like driving by looking in a rearview mirror --

- Satisfactory for a while, so long as trends continue, but soon one runs off the road.

Range Of Choices -- Limited View

- The Usual Error
  - Polarized Concept
  - Choices Narrowly Defined around simple ideas, on a continuous path of development

- Examples
  - Mexico City Airport: A Major New One   Yes or No?
  - Compliance with Laws: As written?   Yes or No?
    - Experience of Planning for Electric Vehicles for Los Angeles, California
Range Of Choices -- Correct View

- The Correct View
  - All Possibilities must be considered
  - The Number of Possible Developments, considering all the ways design elements can combine, is very large

- The general rule for locations, warehouses
  - Possible Sizes, S
  - Possible Locations, L
  - Possible Periods of Time, T
  - Number of Combinations: \( S^{L \times T} \)

- Practical Example: Mexico City Airport
  - Polarized View: “Texcoco” of “Zumpango”
  - All Combinations: \((2^{4})^{3} = 4000+!!\)

Problem from Limited View of Choices

- Blindness to “98%” of possible plans of action
  - These are the "combination" (or "hybrid") possibilities that combine different tendencies
  - The "combination" designs allow greatest flexibility -- because they combine different tendencies

- Blindness to many possible developments
  - those that permit a variety of futures
  - because they do not shut off future decisions

- Inability to adapt to risks and opportunities

- Significant losses or lost opportunities
Real Range Of Choices

- Practical Example: Mexico City Airport
  - Most of the possible developments are combinations of operations at 2 sites (instead of only 1)
  - The simultaneous development at 2 sites allows the mix and the level of operations to be varied over time
  - The development can thus follow the many possible patterns of development that may occur
  - There is thus great flexibility
  - Also ability to act economically and efficiently

- Recommended Action
  - Acquire rights to Zumpango Site (this is an “option”)
  - Wait until next 6-year Presidential term
  - Then decide next step

Take-aways from presentation

- The forecast is “always wrong”
  - And there is no escape from this:
  - … Analysis based on too many assumptions
  - … and there are inevitable surprises

- There are many design choices beyond the obvious ones
  - … Typically, they combine different characteristics
  - … That enable different future developments
  - … and are thus more flexible