Outline of Phase 1 : Recognition of Risk and Complexity Reality

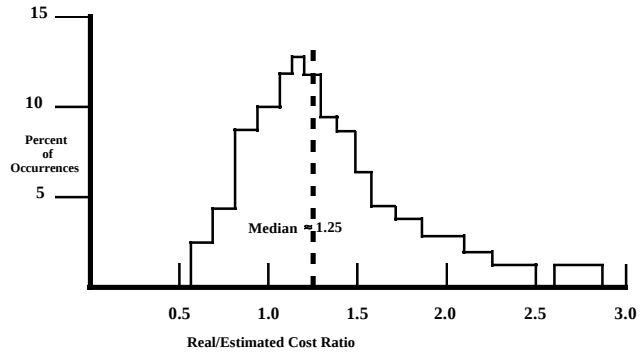
- **Risk: Wide Range of Futures**
  - **The forecast is "always wrong"**
- **Complexity: Wide Range of Choices**
  - **Number of Choices is Enormous**
    - **“Pure” solutions only 1 or 2% of possibilities**
    - **Most possibilities are “hybrid”, that combine elements of “pure” solutions**
    - **“Hybrid”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

Recognition Of Risk (1)

- **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**

Ratio of Real Costs

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

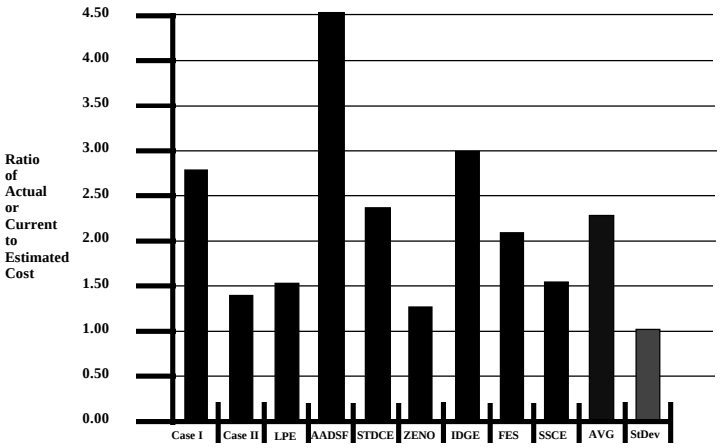


Actual vs. Forecast: Capital Cost of new US Mass Transit Projects

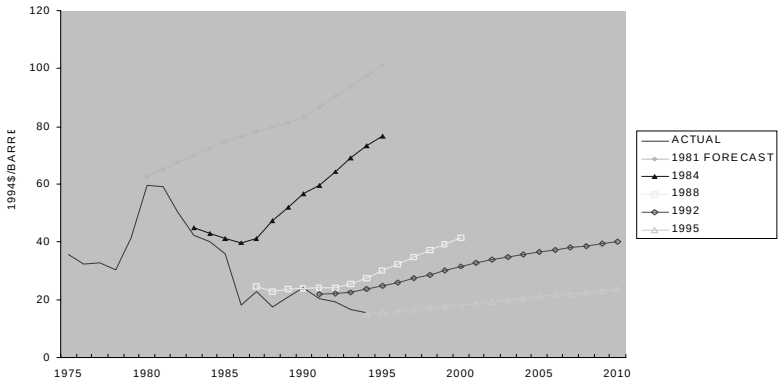
System Type	City	Cost ($, millions 1988)		Difference		
		Forecast	Actual	%		
Heavy Rail	Atlanta	1,723	2,720	58		
	Baltimore	804.0	1289.0	60		
	Miami	1092.0	1516.0	39		
	Washington	4352.0	7968.0	83		
Light Rail	Buffalo	478.0	722.0	51		
	Pittsburgh	699.0	622.0	-11		
	Portland	172.0	266.0	55		
	Sacramento	165.0	188.0	13		

Source: Urban Rail Transit Projects: forecast versus actual ridership and costs, D.H.Pickrell, U.S.Department of Transportation, Urban Mass Transit Administration, Oct.1990, DOT-T-91-04

NASA Microgravity Projects Cost Growth Experience

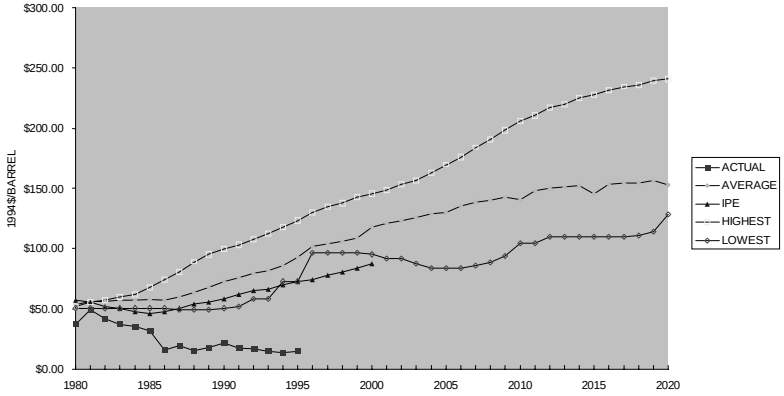


DOE Oil Price Forecasts



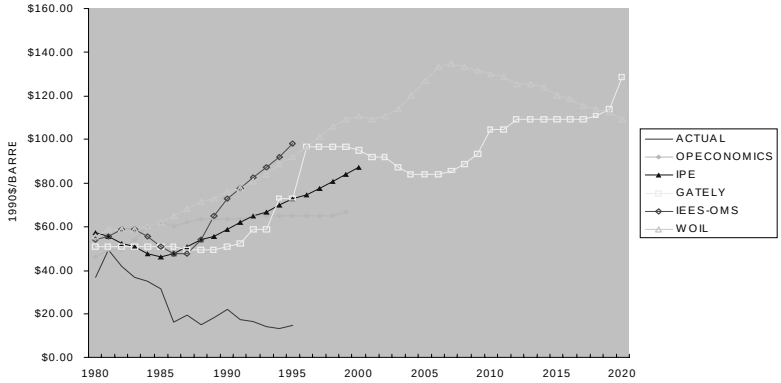
Source: M. Lynch, MIT

EMF6 Oil Price Forecasts



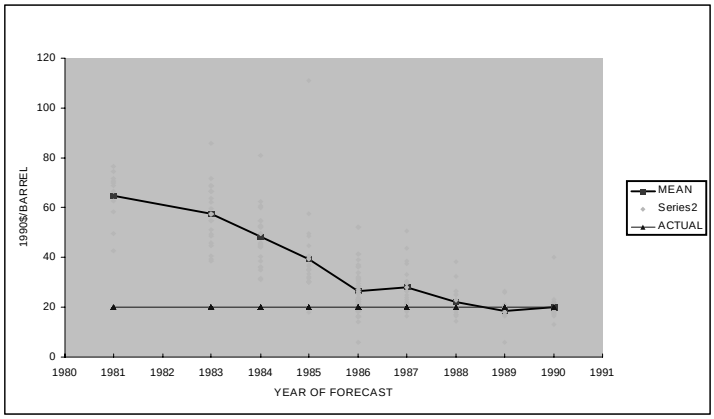
Source: M. Lynch, MIT

EMF6 Oil Price Forecasts (Low Forecasts)



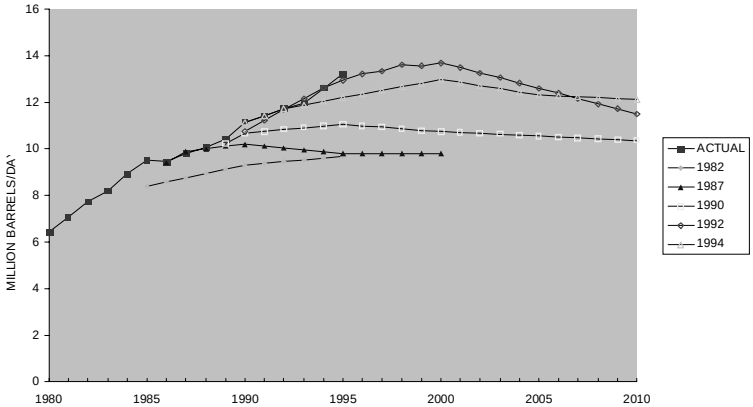
Source: M. Lynch, MIT

Forecasts of 1990 Price of Oil (IEW Survey)



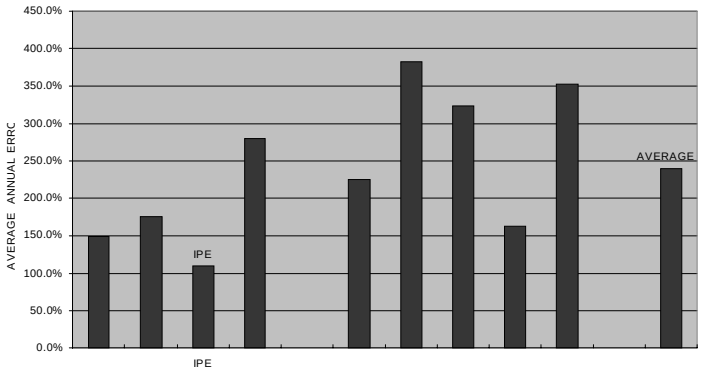
Source: M. Lynch, MIT

DOE Forecasts of Non-OPEC LDC Production



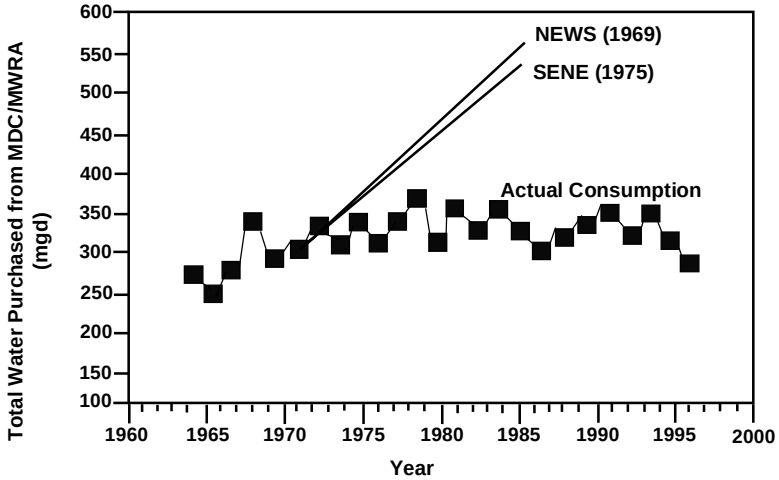
Source: M. Lynch, MIT

Error in OPEC Revenue Forecast at EMF6 1980 - 1995

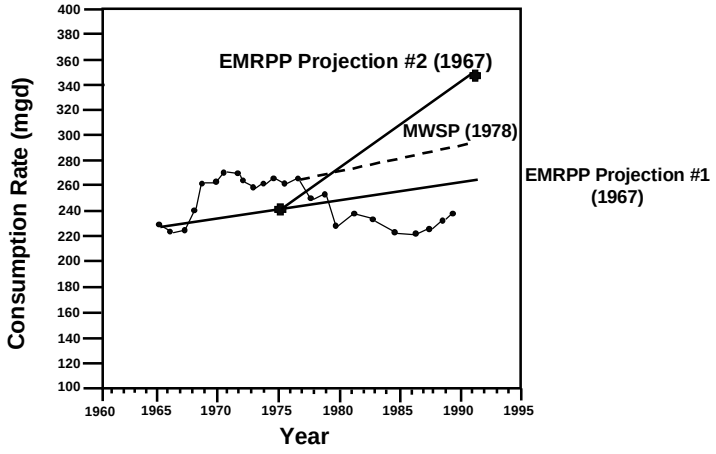


Source: M. Lynch, MIT

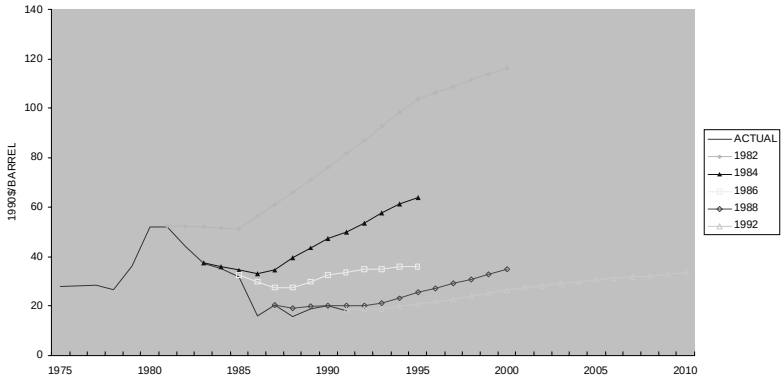
Forecasts of Water Use in Boston (MWRA Members)



Forecasts of Water Use in Boston (MWRA Service Area)



DOE Oil Price Forecasts



Source: M. Lynch, MIT

Actual vs. Forecast: Ridership on new US Mass Transit Projects

System Type	City	Date		Passengers (1000/wk)		Difference
		Forecast	Actual	Forecast	Actual	%
Heavy Rail	Atlanta	1978	1987		184.5	
	Baltimore	1980	1987	103.0	42.6	-59
	Miami	1985	1988	239.9	35.4	-85
	Washington	1977	1986	569.6	411.6	-28
Light Rail	Buffalo	1995	1989	92.0	29.2	-68
	Pittsburgh	1985	1989	90.5	30.6	-66
	Portland	1990	1989	42.5	19.7	-54
	Sacramento	2000	1989	50.0	14.4	-71
People Mover	Detroit	1985	1988	67.7	11.3	-83
	Miami	1985	1988	41.0	10.8	-74

Source: Urban Rail Transit Projects: forecast versus actual ridership and costs, D.H.Pickrell, U.S.Department of Transportation, Urban Mass Transit Administration, Oct.1990, DOT-T-91-04

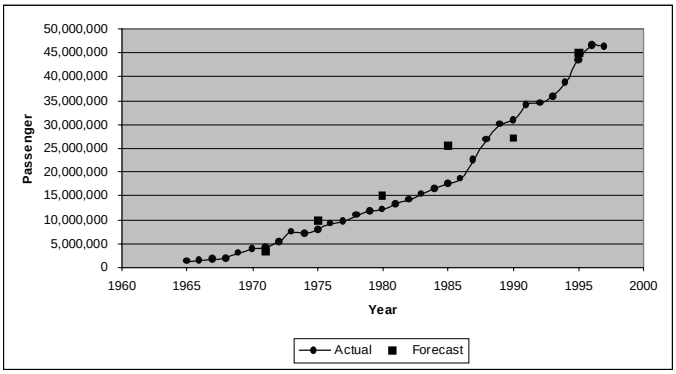
Actual vs. Forecast: International Air Passengers for Japan (5 year view)

Year		Passenger (million)		Error
Target	Forecasted	A. Actual	B. Forecast	C. B/A (%)
1971	1966	4.3	3.5	81
1975	1970	7.9	10.0	127
1980	1975	12.1	15.0	124
1985	1980	17.6	25.5	145
1990	1985	31.0	27.0	87
1995	1990	43.6	45.0	103

Error: B/A	%
Average	111
Average Deviation from 100%	22

Sources:
1. Actual Data: Embarkation and Disembarkation Statistics, Ministry of Justice, Japan
2. Forecast: Airport investment 5-year plans, Ministry of Transportation, Japan

Actual vs. Forecast: International Air Passengers for Japan (Graph, 5 years)



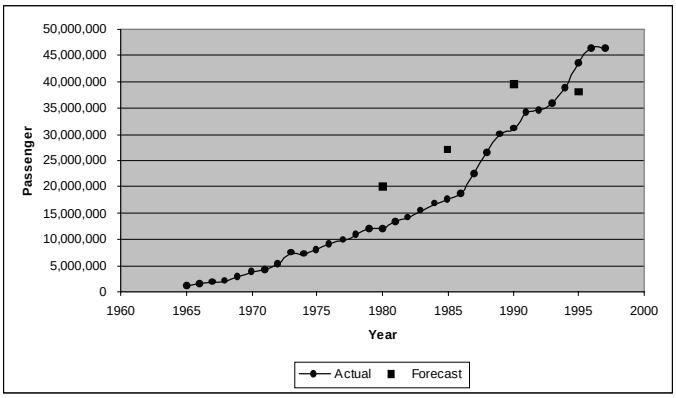
Actual vs. Forecast: International Air Passengers for Japan (10 year view)

Year		Passenger (million)		Error
Target	Forecasted	A. Actual	B. Forecast	C. B/A (%)
1980	1970	12.1	20.0	165
1985	1975	17.6	27.0	153
1990	1980	31.0	39.5	127
1995	1985	43.6	37.9	87

Error: B/A	%
Average	133
Average Deviation from 100%	40

Sources:
1. Actual Data: Embarkation and Disembarkation Statistics, Ministry of Justice, Japan
2. Forecast: Airport investment 5-year plans, Ministry of Transportation, Japan

Actual vs. Forecast: International Air Passengers for Japan (Graph, 10 years)



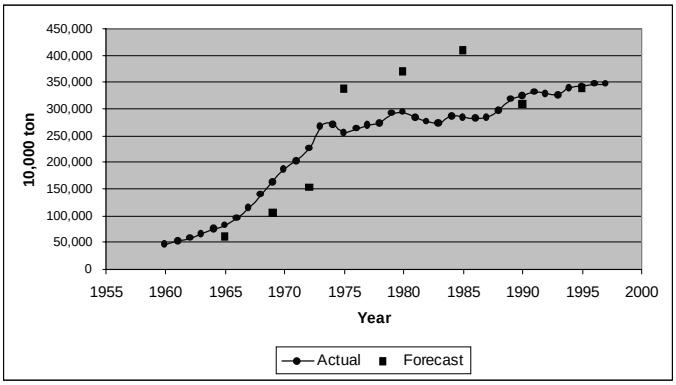
Actual vs. Forecast: Seaport Cargo for Japan (5 years)

Year		Volume (100 million ton)		Error
Target	Forecasted	A. Actual	B. Forecast	C. B/A (%)
1965	1960	8.3	6.2	75
1969	1964	16.0	10.5	66
1972	1967	22.2	15.3	69
1975	1970	25.3	33.8	134
1980	1975	29.1	37.0	127
1985	1980	28.3	41.0	145
1990	1985	32.5	30.8	95
1995	1990	34.2	34.0	99

Error: B/A	%
Average	101
Average Deviation from 100%	25

Sources:
1. Actual Data: Port Statistics, Ministry of Transportation, Japan
2. Forecast: Seaport investment 5-year plans, Ministry of Transportation, Japan
Note: Actual data use calendar year while forecasts use fiscal year.

Actual vs. Forecast: Seaport Cargo for Japan (Graph)



Recognition Of Risk (2)

- **Reason 1 : 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!**

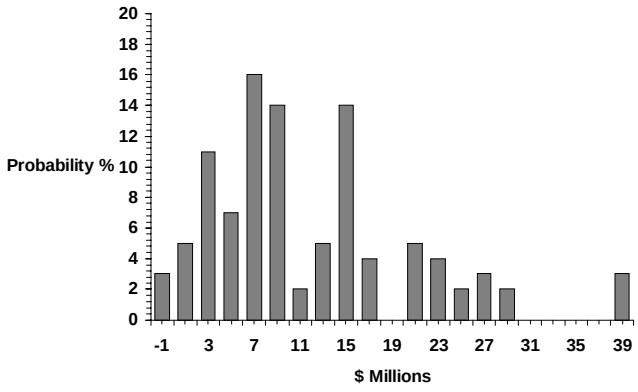
Recognition Of Risk (3)

- **Reason 2 : Ambiguity**
  - **Many extrapolations possible from any set of historical data**
    - **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!**

Recognition Of Risk (4)

- **The Resulting Problem: Wrong Plans**
  - **Wrong Size of Plant, of Facility**
    - **Denver Airport**
    - **Boston Water Treatment Plant (See Case Studies)**
  - **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**

Forecast By Detailed Simulation



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 (1)

- **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?**
  - **Size of Power Plants: 6 Megawatts Yes or No? (See Case Study of South African Power)**
  - **Compliance with Laws: As written? Yes or No?**
    - **Experience of Planning for Electric Vehicles for Los Angeles, California**
    - **Venezuela (See Case Study)**

Range Of Choices (2)

- **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 exponent L} exponent T**
- **Practical Example: Mexico City Airport**
  - **Polarized View: "Texcoco" of "Zumpango"**
  - **All Combinations: {2 exp 4}exp 3 = 4000+ !!!**

Range Of Choices (3)

- **The Resulting Problem**
  - **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 options**
  - **Inability to adapt to risks and opportunities**
  - **Significant losses or lost opportunities**

Range Of Choices (4)

- **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**
  - **Option on Zumpango Site**
  - **Wait until next sexennial**
  - **Then decide next step**

Range Of Choices (5)

- **The Solution**
  - **Enumeration of Possible Combinations**
  - **General: Lists, Exact Numbering of Possibilities**
  - **Detailed: Simulations**
- **Practical Examples**
  - **General Enumeration**
    - **New Airports at Mexico City, Sydney (See Case Study)**
  - **Detailed Simulation**