Decision Analysis Cases

- Object and Context of Presentation
- Overview of Cases
- Haneda Airport (Tokyo, Japan) in Detail
- Overall Conclusions

Object and Context of Presentation

Object:

- To illustrate Decision Analysis by Examples

Context:

- Decision Analysis is Simplest Approach to identifying Valuable Flexibility
- Includes all necessary elements – provides basis for investigating flexibility and increasing value over standard design method

Sample Cases

- **Abisoye Babajide "Real Options Analysis as a Decision Tool in Oil Field Development," Master in SDM, MIT, 2007**
- **Katherine Dykes et al "Real Options for a Wind Farm in Wapakoneta, Ohio: Incorporating Uncertainty into Economic Feasibility Studies for Community Wind," MIT 2008**
- **Masahiro Kimura "Strategic Planning for Newcomer in Silicon Wafer Industry," Master in MOT, MIT, 1995**
- **Dai Ohama "Using Design Flexibility and Real Options to Reduce Risk in Private Finance Initiatives: the Case of Japan," Master in TPP, MIT, 2008**

Babajide: Gulf Oil

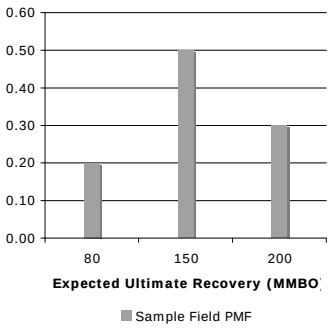
- **Summary Perspective**

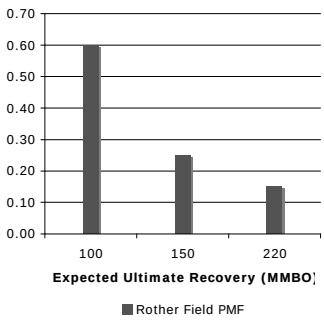
Babajide: Gulf Oil Platform	
Uncertainty Recognition	Derived from actual data
Bayesian Updating	From first round of test wells
Modeling Approach	High level economic models
Economies of Scale	Yes, over 2 fields
Deferral of Costs	Yes; vertical risers later, if at all
Decision Analysis	Fields 1 or 2, Both, and w/ Flexibility
Multiple Criteria	Yes, VARG diagram and Capex

The Gulf of Mexico Case

- **Oil recovery in Gulf of Mexico**
- **"shallow water" ~ 100 m**
- **Real case: numbers disguised for company confidentiality**
- **Two fields: "Sample" and "Rother"**
- **Reservoirs 'fractured' – that is, they consist of several smaller pools that each require wells to suck out oil**

Probability Mass Functions (PMF)

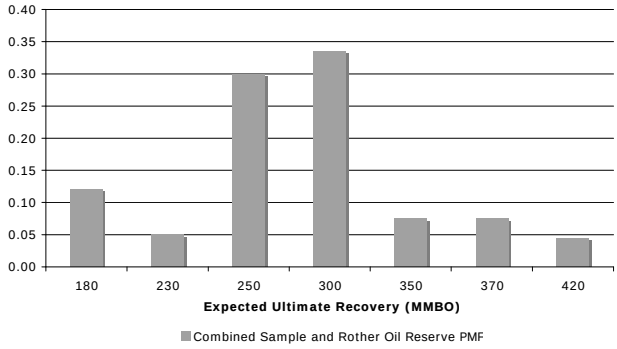




Note: "Most likely" scenarios are 150 and 100

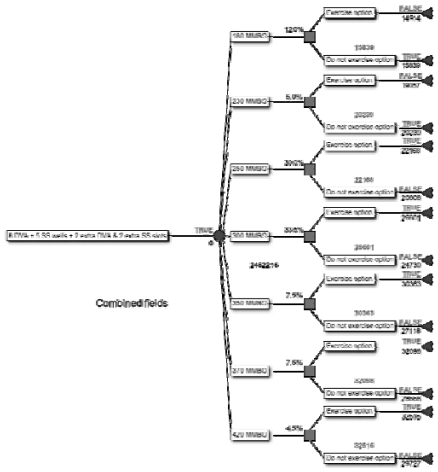
Source: Babajide et al paper

Combined PMF



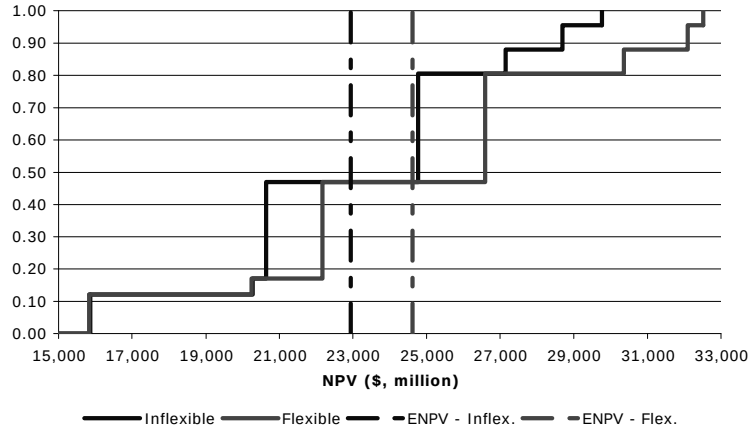
Source: Babajide et al paper

Flexible Combined Fields



Source: Babajide et al paper

Cumulative Probability Distributions Inflexible vs. Flexible



Source: Babajide et al paper

Comparison of Economic Metrics

($, million)	Designs		Which better?
	Inflexible	Flexible	
ENPV	22,935	24,622	Flexible.
Minimum NPV	15,868	15,839	Same
Maximum NPV	29,761	32,516	Flexible.
Initial CAPEX	956	990	Inflexible.
NPV/CAPEX	24	25	Flexible

No alternative best on all measures.

Source: Babajide et al paper

Benefit-Cost of Flexibility

Cost of flexibility ($, M)	34
Average Value of flexibility ($, M)	1,712
Cost-Benefit ratio	50

Note: Value of Flexibility very high (in this case)

Source: Babajide et al paper

Take-Aways: Gulf of Mexico Oil

- **Economies of Scale large, so larger (two field) development chosen**
- **Flexibility adds great value**
- **Benefit-cost ratio can be very large!**
- **Flexibility changes tails significantly**
- **Improves design over many criteria**

Dykes: Wind Farm

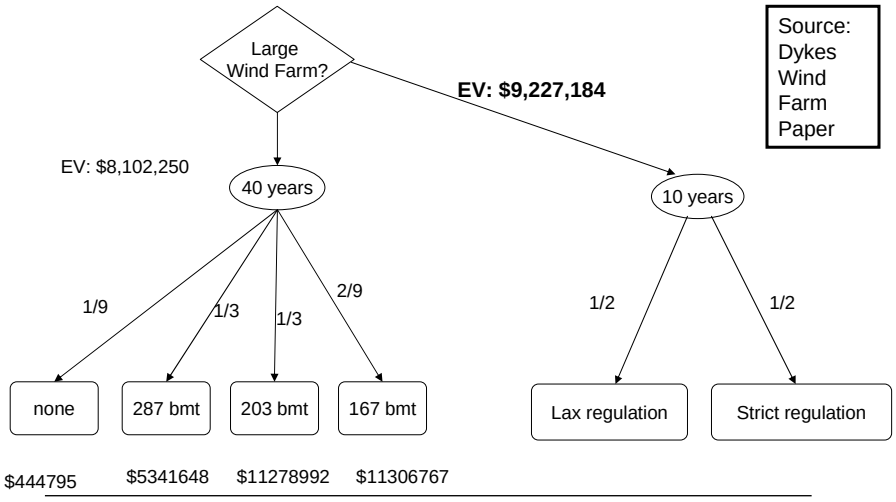
- **Summary Perspective**

Dykes: Wind Farm	
Uncertainty Recognition	Growth and Possible Step Change
Bayesian Updating	Observation over time
Modeling Approach	Economic
Economies of Scale	Yes, for production
Deferral of Costs	Yes, possible expansion later
Decision Analysis	Two Stage: immediate and later
Multiple Criteria	not used

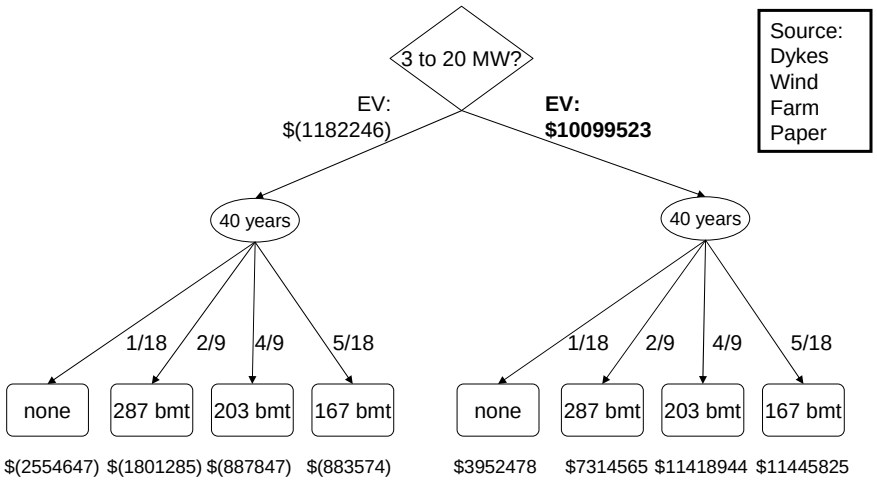
The Wind Farm Case

- **Potential Wind Farm in Mid-West USA**
- **Two development choices:**
  - **Build Big, Use Economies of Scale**
  - **Build Small, See how things develop**
- **Two Uncertainties**
  - **Growth in demand**
  - **Regulatory Regime**

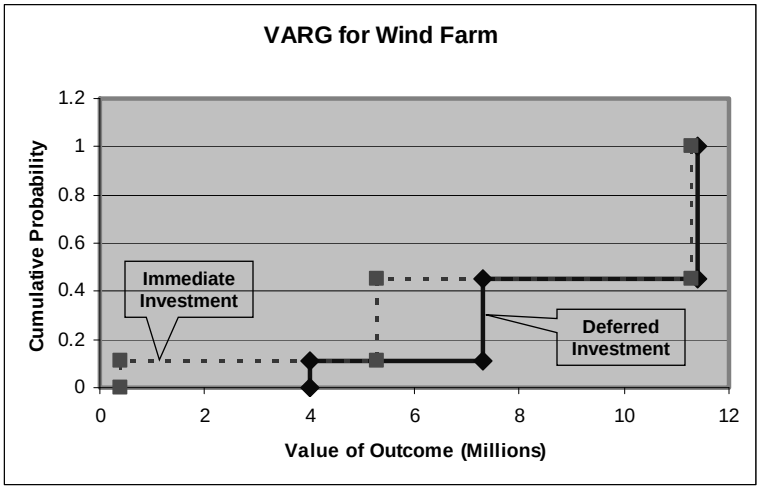
Build Now or Delay?



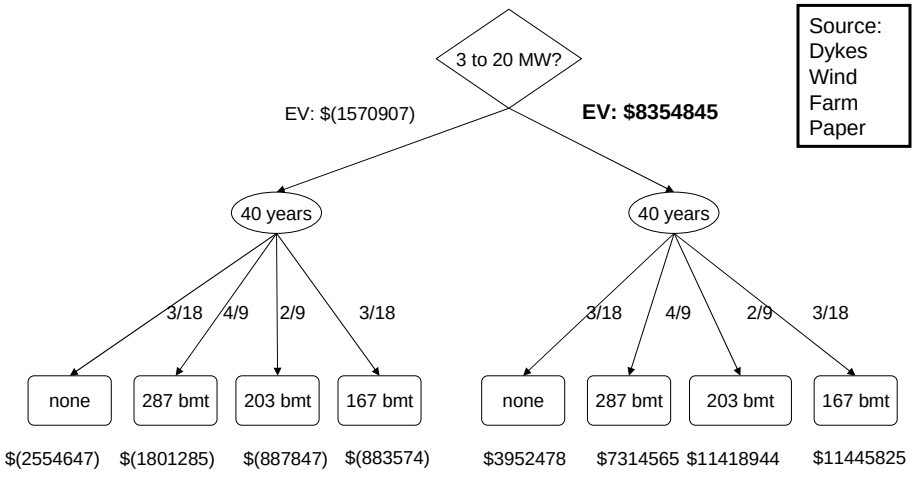
Branch if "Strict Regulation"



Cumulative Distribuion for Wind Farm



Branch if "Lax Regulation"



Take-Aways: Wind Farm Case

- **Economies of Scale exist, but not large enough to compensate for value of deferring investment**
- **Case illustrates value of deferral – valuable even though choice is same!**
- **Flexibility changes tail significantly**

Kimura: Production of Si Wafers

- **Summary Perspective**

Kimura: Production of Silicon Wafers (1995)	
Uncertainty Recognition	Estimated
Bayesian Updating	After 1st period
Modeling Approach	Technical cost model for production
Economies of Scale	Yes, in wafer size
Deferral of Costs	Yes, possible expansion later
Decision Analysis	Two stage, possible expansion later
Multiple Criteria	not used

The Silicon Wafer Production Case

- Japanese company faced with issue: should they make 4” or 8” silicon wafers
- 8 inch wafers have significant economies of scale – if sales reach capacity of plant!
- Classic trade-off between
  - Economies of Scale
  - Advantages of Deferred Expenses
  - Risk tilts balance toward smaller plant
- Context of Design of Production Process

Take-Aways: Si Wafer Production

- Economies of Scale exist, but not large enough to compensate for value reducing exposure to possible big losses
- Analysis leads to Strategy
- Build smaller, expand (or not) depending on market development, technical success in production
- Note: Company focused on Econ. of Scale, went for big design, lost heavily…

Ohama: Tokyo/Haneda Airport

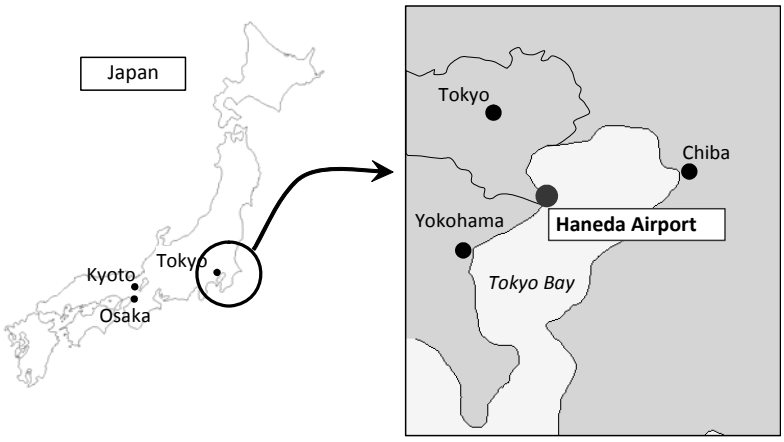
- **Summary Perspective**

Ohama: Design of Airport Runway	
Uncertainty Recognition	In traffic growth trends
Bayesian Updating	simulation of future levels
Modeling Approach	detailed technical analysis
Economies of Scale	not applicable
Deferral of Costs	Yes, possible taxiway later
Decision Analysis	Two stage
Multiple Criteria	Yes, VARG diagram and Capex

The Tokyo/Haneda Case

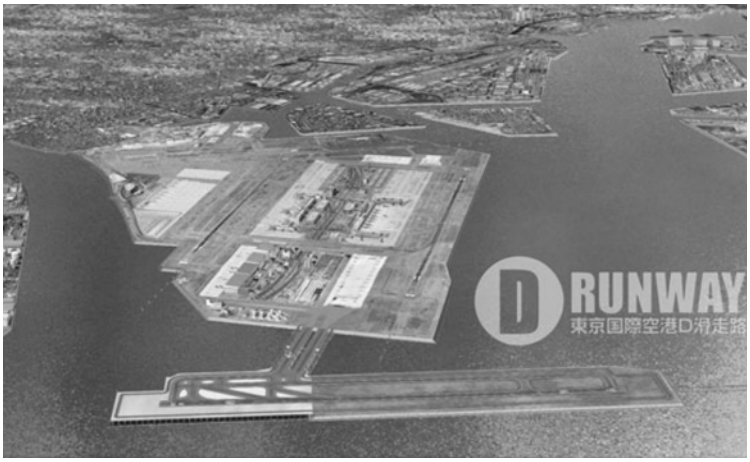
- **Case is about an expansion of runway at Haneda airport, in Tokyo Bay.**
- **Issue: should design have conventional parallel taxiway?**
- **This question "never" asked in practice**
- **However, value of runway (= contribution to capacity) depends on level and direction of use of runway**

Location of Tokyo/Haneda Airport



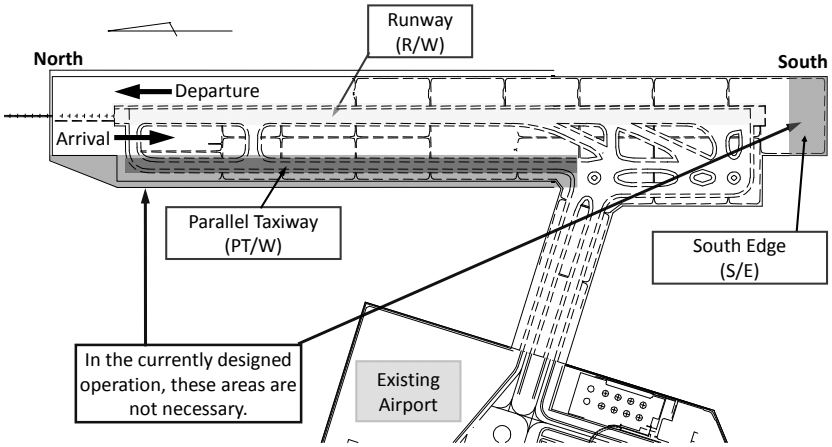
Source: Ohama MIT Thesis

New Runway for Tokyo/Haneda



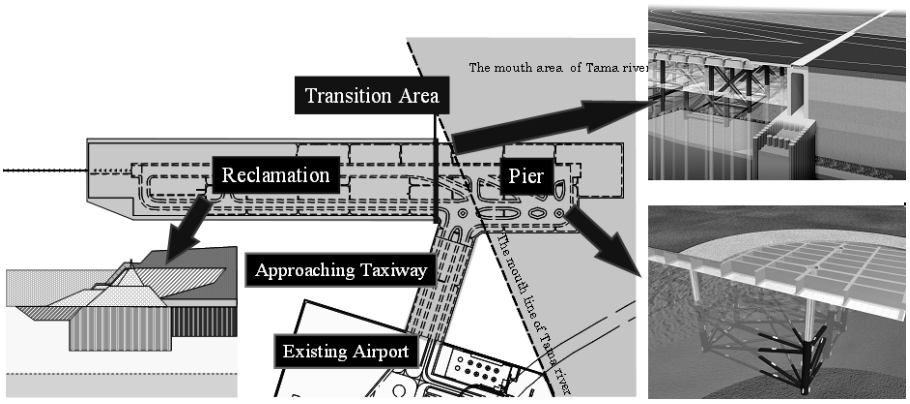
Source: Ohama MIT thesis; Japan Ministry of Land, Infrastructure and Transport

Possibility for Flexible Design



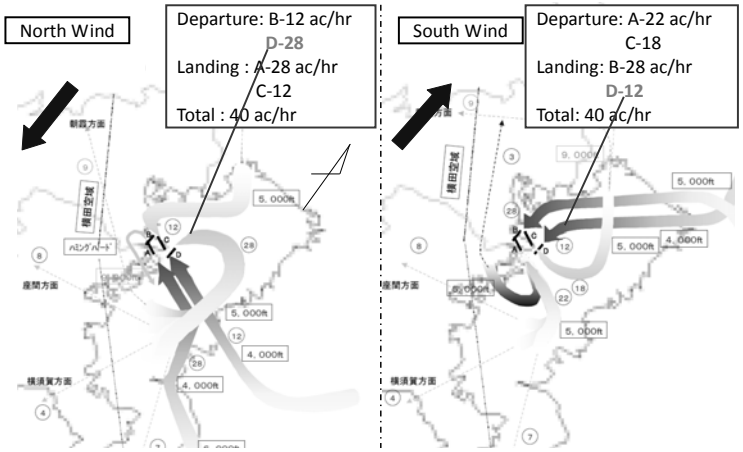
Source: Ohama MIT Thesis

Technical Details



Source: Ohama MIT Thesis

Directional Issues



Source: Ohama MIT Thesis

The Capacity Issue

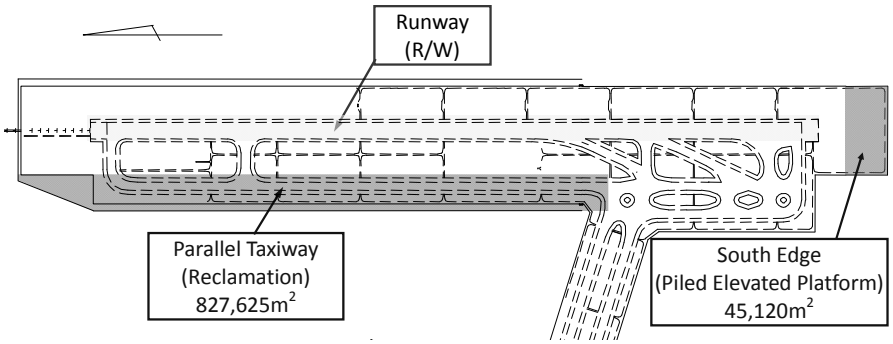
- **Runway Capacity is not a fixed amount (when demand exceeds "capacity", this means traffic delays, not that aircraft will not be able to land…**
- **New runway will be inconvenient, and thus used for "overflow"**
  - **Relatively little use**
  - **Mostly for landings (to left, or South)**
  - **These operations can taxi on runway**
  - **This reason taxiway not immediately needed**

3 Scenarios for Analysis

	Base Case	Scenario 1	Scenario 2
Initial Investment	R/W, PT/W&S/E	N/A	N/A
Future Uncertainty	R/W, PT/W&S/E	Recognizing	N/A
Flexibility	R/W	Recognizing	Future Expansion (PT/W & S/E)

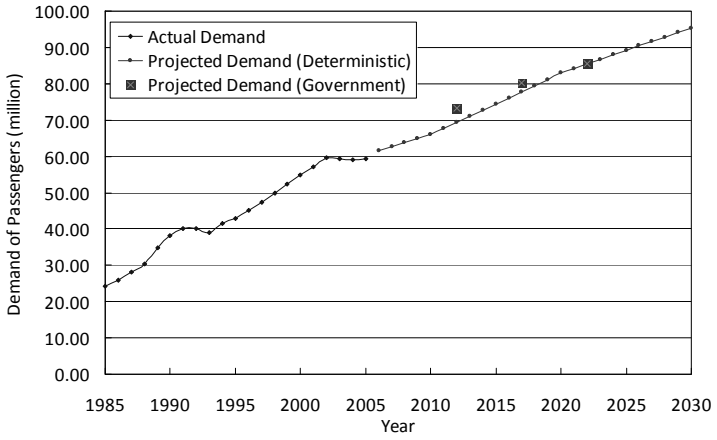
Source: Ohama MIT Thesis

Details of Flexible Design



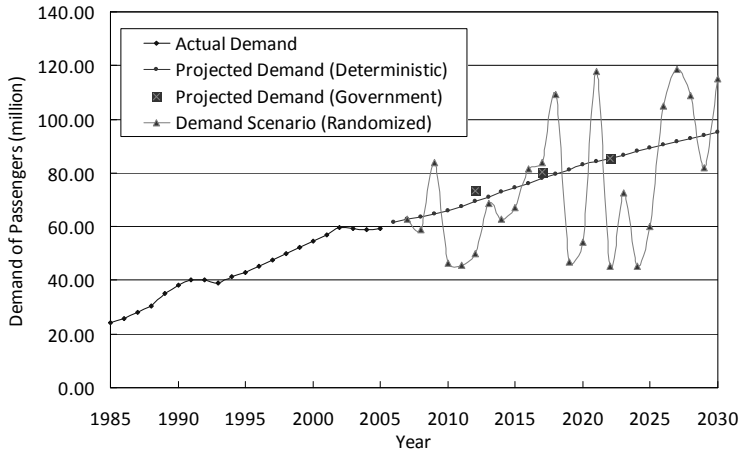
Source: Ohama MIT Thesis

Deterministic Forecasts



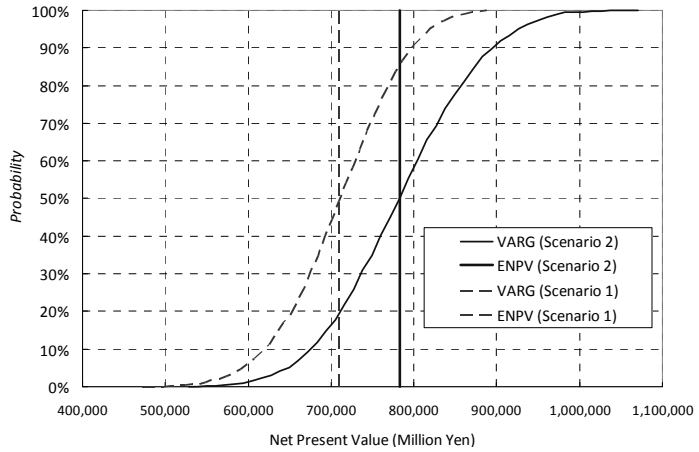
Source: Ohama MIT Thesis

Example Simulated Demand



Source: Ohama MIT Thesis

Cumulative Distributions for Runway



Source: Ohama MIT Thesis

Comparison across Criteria

Criteria	Design		Comparison
	Scenario 1 (No Flexibility)	Scenario 2 (Flexible)	
Expected Net Present Value (Million)	¥713,642	¥785,120	Flexibility Better
Initial Cost (Million)	¥570,000	¥505,019	Flexibility Better
Maximum Value (NPV) (Million)	¥919,795	¥1,077,365	Flexibility Better
Minimum Value (NPV) (Million)	¥452,671	¥532,827	Flexibility Better
Flexibility Value (Million)	-	¥71,478	-

Source: Ohama MIT Thesis

Take-Aways: Tokyo/Haneda

- Technological Understanding, coupled with appreciation of uncertainties, leads to opportunities for flexible development
- Improvements
  - About 10% over conventional, on average
  - Almost 20% in terms of minimum results
- Flexibility creates stochastically dominant outcomes

Decision Analysis Take-Aways

- Decision Analysis approach Can be used Effectively in many situations
- It gives insight into relative importance of trade-offs between Economies of Scale and Savings by deferring Investments
- Provides a reasonably transparent view of
  - effect of uncertainties …
  - way flexibility increases average project value
  - and reduces downside and increases upside