Real Options Analysis of Public Sector Investments

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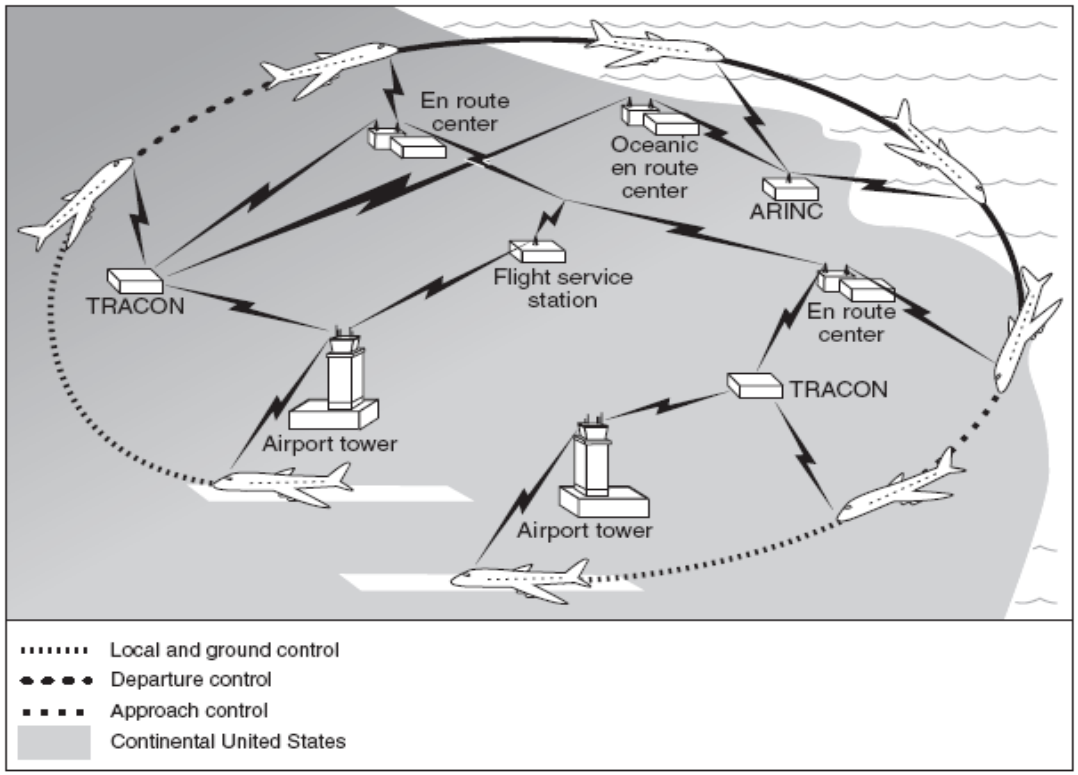
June 13, 2006

Enterprise Architecture and Infrastructure in Transition



GAO-05-266: Stronger Architecture Program Needed to Guide Systems Modernization Efforts

- **95% total FAA spending is in support of the NAS**
- **FAA estimates it will spend $7.6B over next 2 years to complete key modernization projects**

EA and Infrastructure in Transition

“ . . (E)nterprise architecture connects an organization’s strategic plan with program and system solution implementations . . . It should provide a clear and comprehensive picture . . . (that) consists of snapshots of both the enterprise’s current environment and its target environment, as well as a capital investment road map for transitioning from the current to the target environment.”

GAO-05-266: Stronger Architecture Program Needed to Guide Systems Modernization Efforts

EA and Infrastructure in Transition

"Employed in concert with other important management controls, such as portfolio-based capital planning and investment control practices, architectures can greatly increase the chances that an organization's operational and IT environments will be configured to optimize its mission performance."

GAO-05-266: Stronger Architecture Program Needed to Guide Systems Modernization Efforts

Problem: Investing under Uncertainty

- The nature of government acquisition is that it involves long-term planning for uncertain projects that evolve over time as the operational environment and the needs of the users change.

- Fundamental reality: actual value of any investment in system design can only be known probabilistically[1]

- There are multiple sources of uncertainty[1]:
  - Future user needs
  - Future technology
  - Future market and political factors

- In order to deal with uncertainty, need to move from deterministic system design and valuation to method that incorporates flexibility

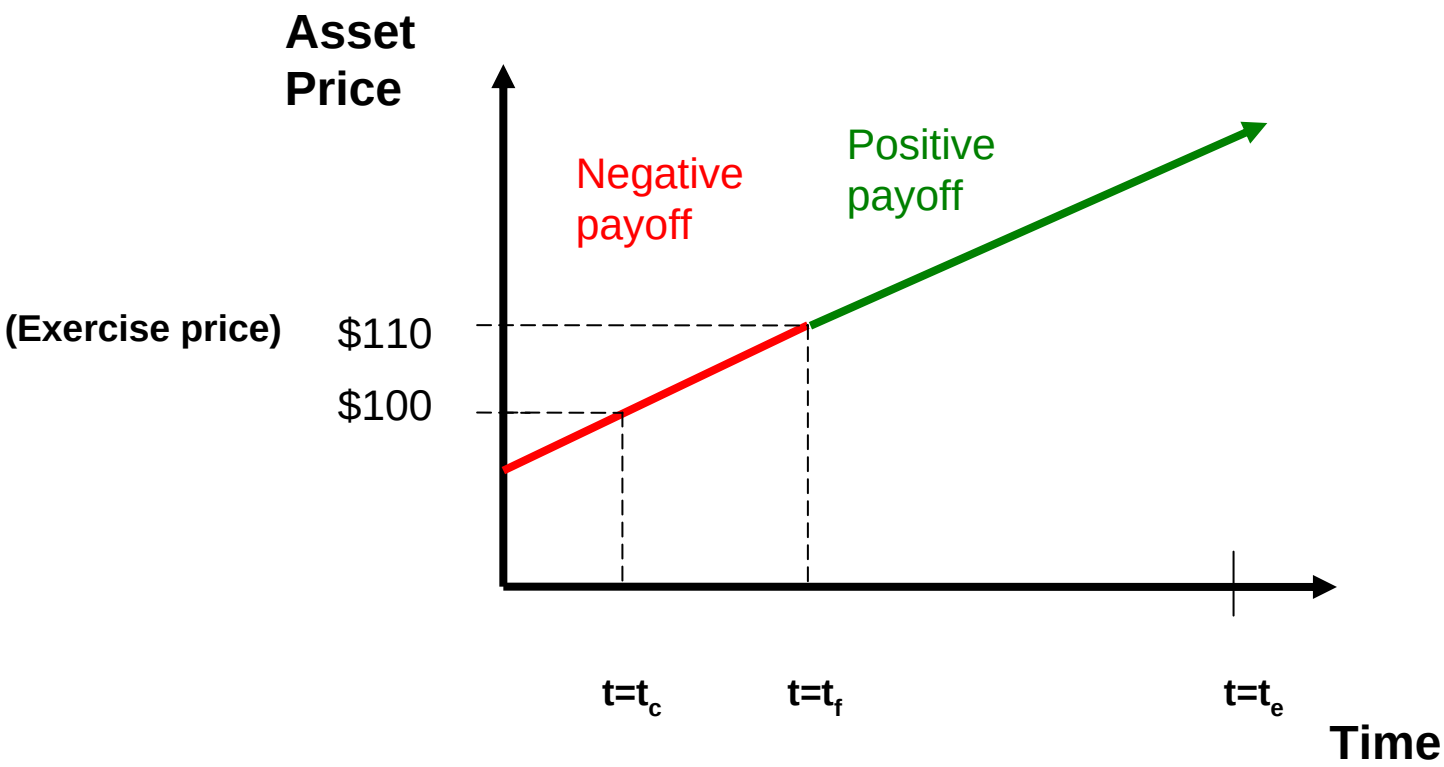
[1] *Richard de Neufville, "Real Options" presented at MITRE January 25, 2006*

Real Options Analysis

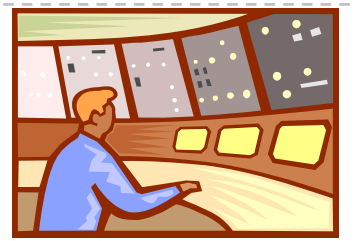
- **Real options analysis is the analysis of a complex system for the purposes of identifying uncertainty and creating flexibility.**
- **Flexibility enables decision-makers to proactively manage risk in order to achieve the system's strategic objectives in a cost-effective manner that maximizes system value.**

Defining a Financial Option

- **A financial option is a market contract that specifies the price at which the holder of the option can buy or sell some asset (such as a stock or a commodity) within a specific timeframe.**
- **An option is a *right*, but not an *obligation*.**

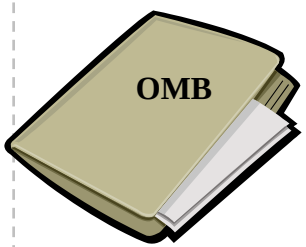


Framework for Government Decision-Making

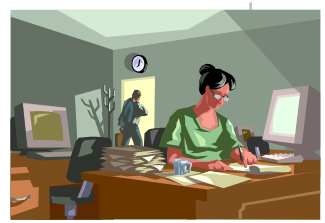


FAA Policy

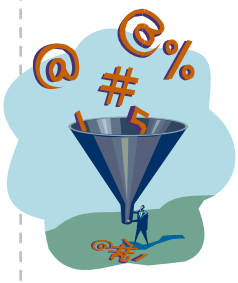
DoD Policy



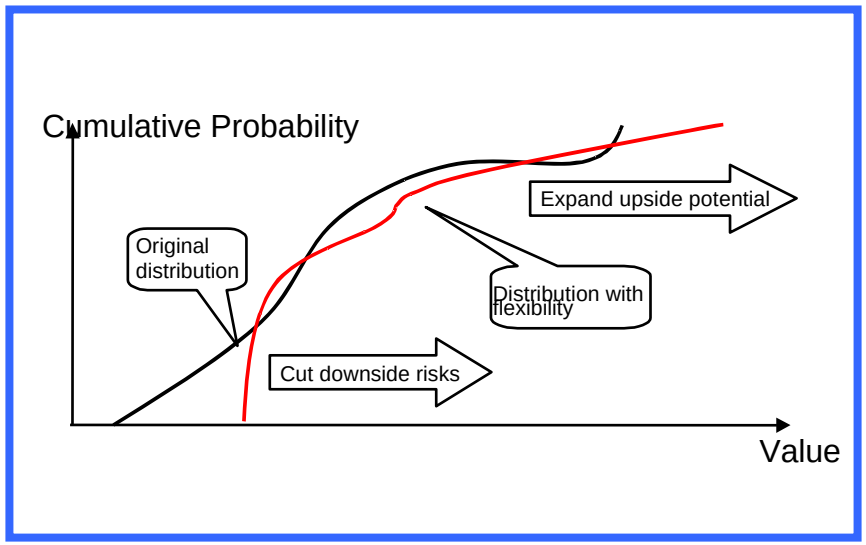
Regulations



Resources



Information



Adding value through flexibility

Other Policy

Parking Garage Case

- **Simple, easy to understand example of benefits of flexibility in system design.**
- **Uses spreadsheet analysis of readily-available data to communicate additional value of handling uncertainty with flexible design.**
- **From R. de Neufville, S. Scholtes, and T. Wang, "Real Options by Spread Sheet: Parking Garage Case Example," *ASCE Journal of Infrastructure Systems*, June 2006.**

Parking Garage details

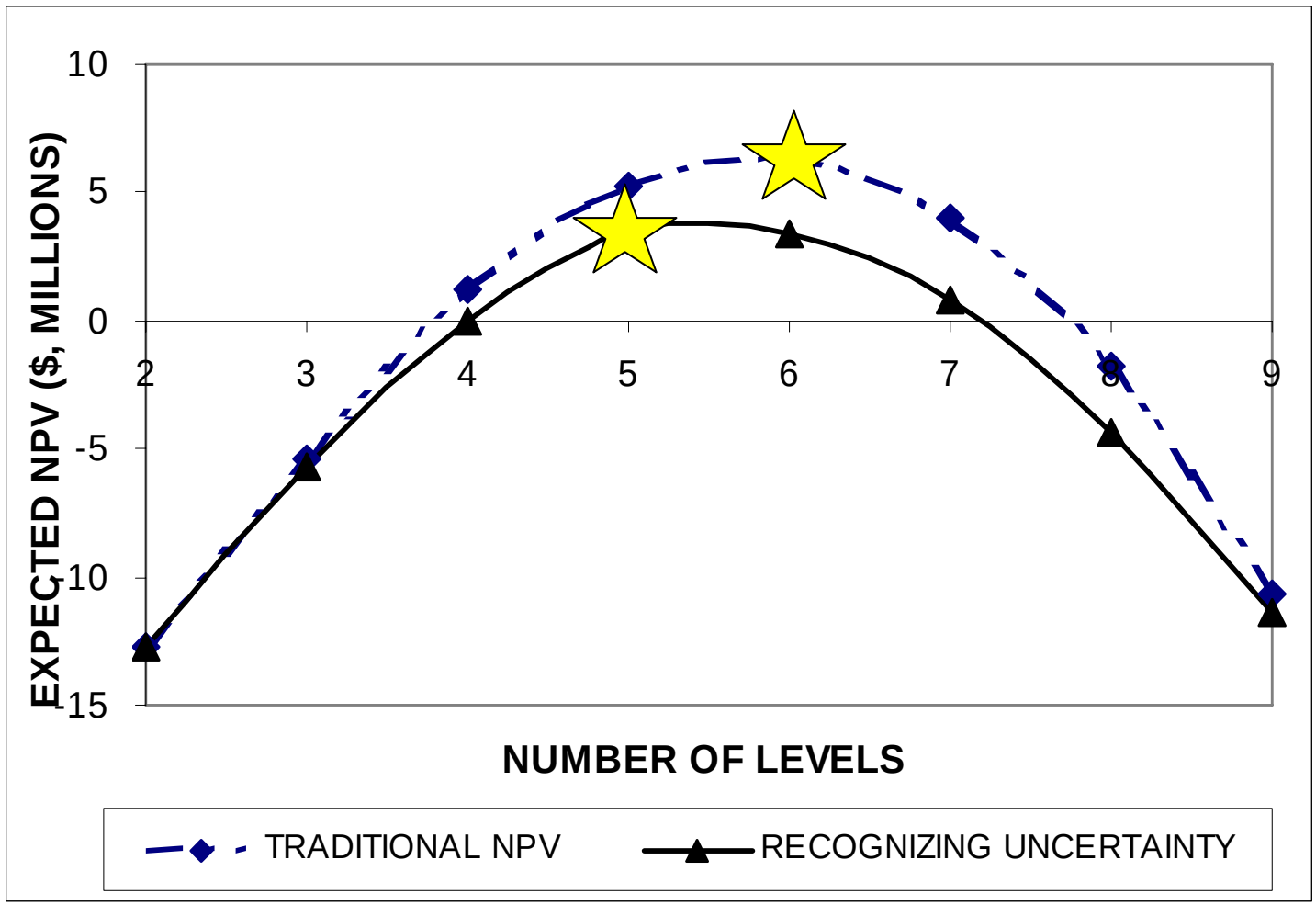
- **Projected Demand is uncertain**
  - **750 spaces at start**
  - **750 spaces over next 10 years**
  - **could be +/- 50% off the projections,**
  - **Annual volatility for growth is 10%**

- **Costs can be considered fixed…**
  - **Operating costs = $2,000 /year/space**
  - **Land lease = $3.6 Million/year**
  - **Construction = $16,000/space + 10% for each higher level**

Traditional Analysis Using Point-Estimate for Demand

Category	Type	Units	Year					
			0	1	2	3	…	20
Demand		Spaces		750	893	1,015	…	1,696
Capacity	Initial			1,200	1,200	1,200		1,200
Revenue		$ M		7.50	8.93	10.15		12.00
Cost	Initial		22.74					
	Annual		3.60	6.00	6.00	6.00		6.00
Cash Flow	Actual		- 26.34	1.50	2.93	4.15		6.00
NPV			6.24					

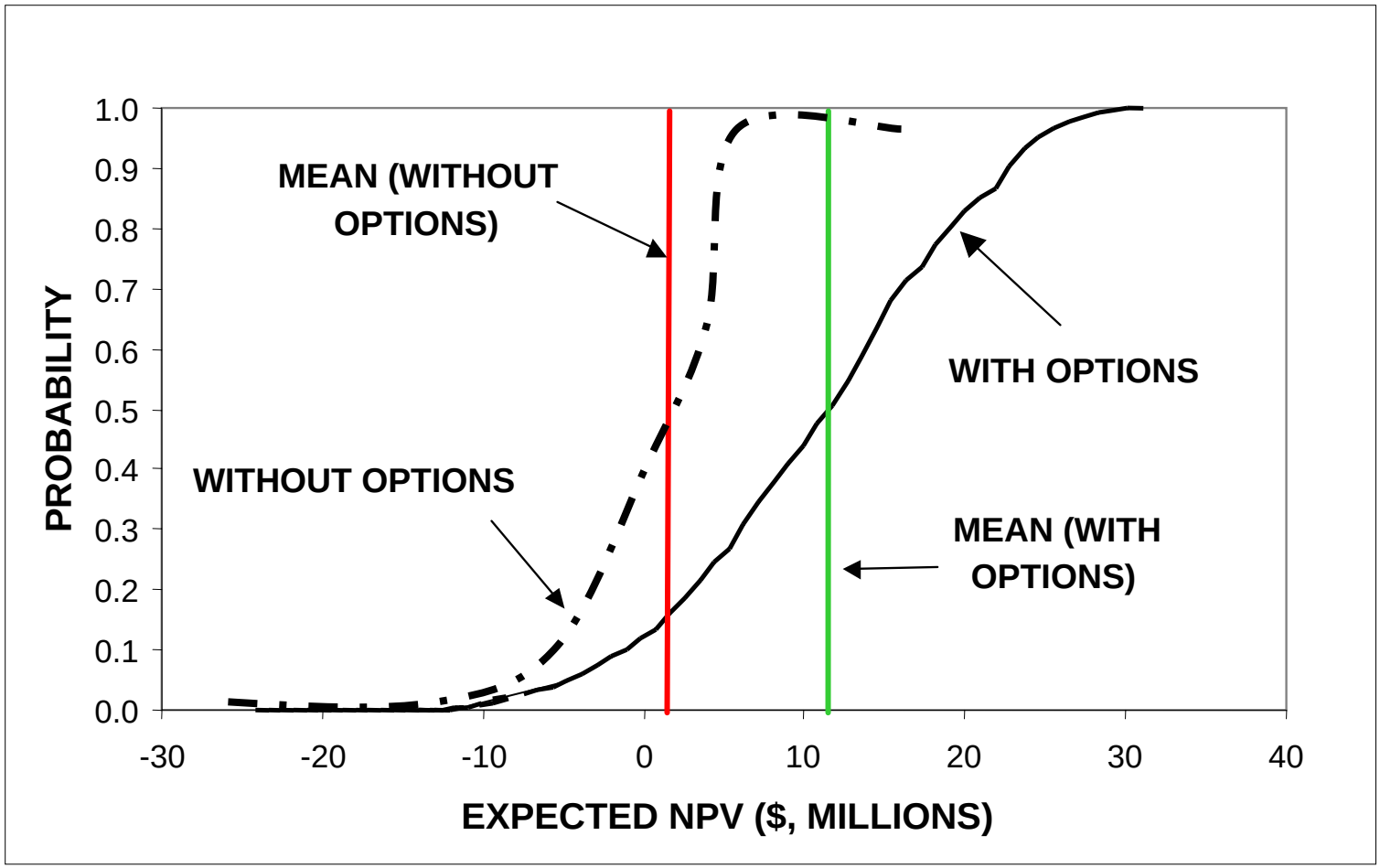
Expected NPV for Design Alternatives



Design with Simulated Demand Scenario and Option to Expand

Category	Type	Units	Year					
			0	1	2	3	…	20
Demand		Spaces		1055	1141	1234	…	2002
Capacity	Initial			800	800	**1,200**		**2,000**
	Added				**400**	**400**		
Revenue		$ millions		8.00	8.00	12.00		20.00
Cost	Initial		13.79					
	Later				**8.94**	**10.82**		
	Annual		3.60	5.20	5.20	**6.00**		**7.60**
Cash Flow	Actual		-26.34	- 2.80	-6.14	-4.82		12.40
NPV			**18.73**					

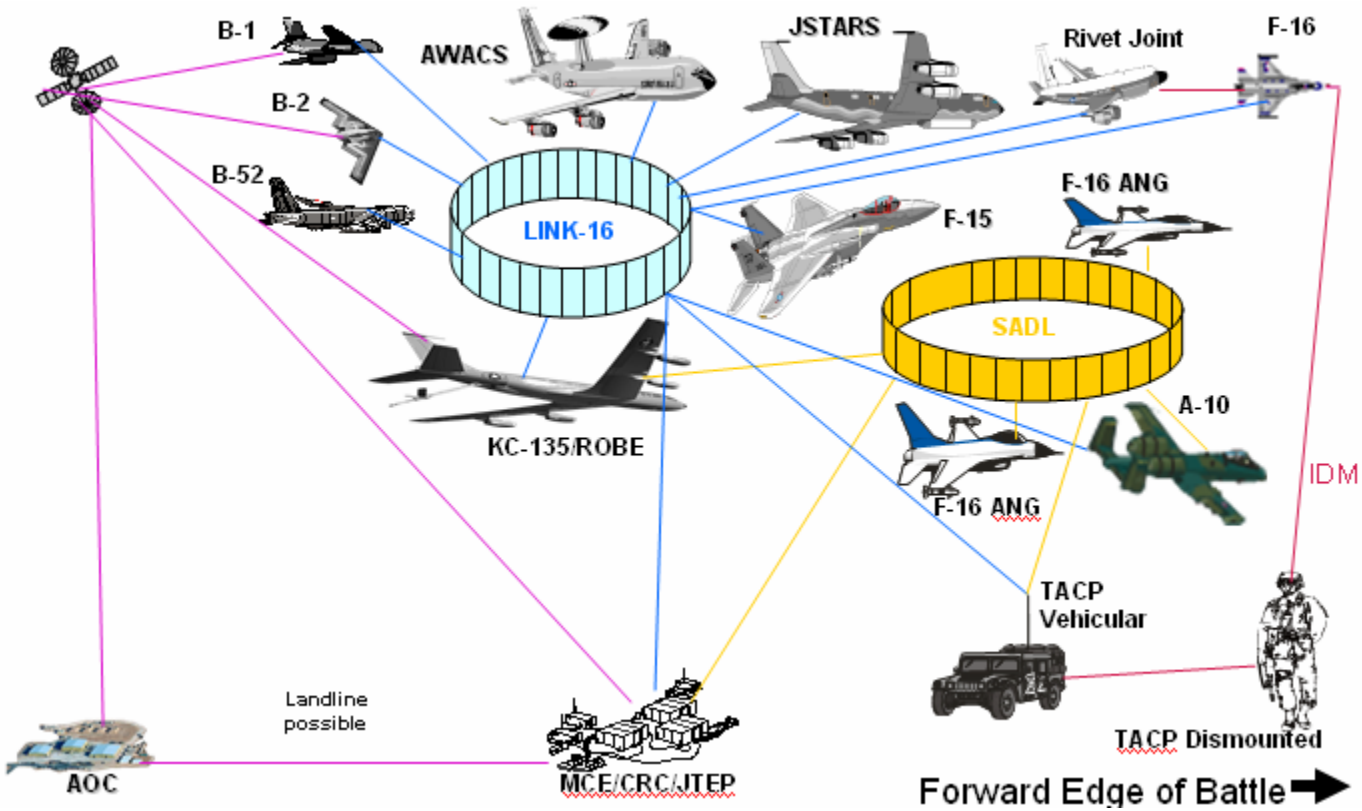
Comparing VaR with and without Option



Performance Improvements with Flexible Design

Metric $, millions	Design		Comparison
	No Flexibility	Flexible	
Initial Investment	22.74	8.08	*Flexibility Better*
Expected NPV	3.39	10.52	*Flexibility Better*
Minimum NPV	-10.94	- 9.36	*Flexibility Better*
Maximum NPV	6.89	30.12	*Flexibility Better*

DoD Case Study: Tactical Data Link (TDL)



TDL Application

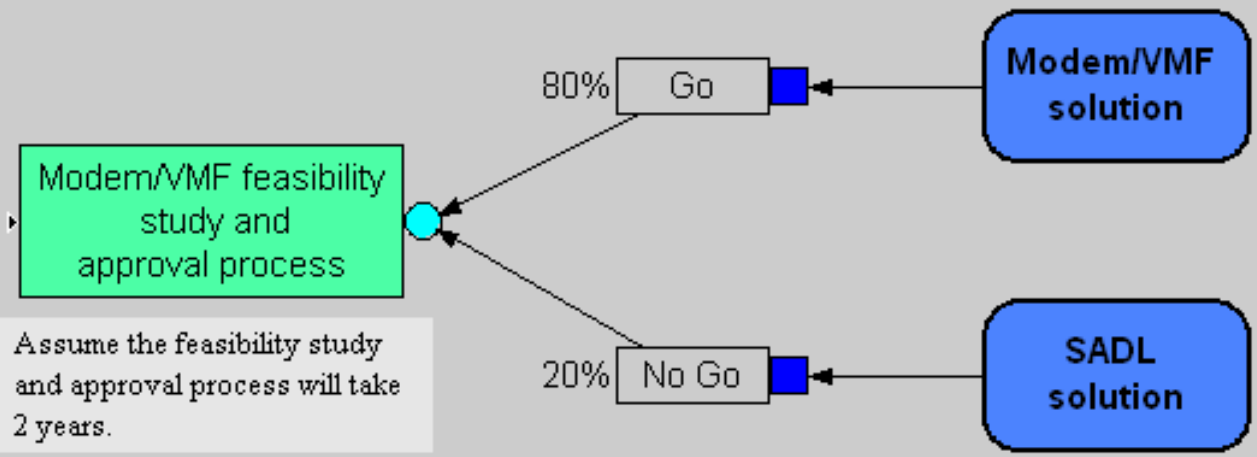
- **Uncertainty:**
  - **Project development?**
  - **Technology implementation?**
  - **Funding?**
- **Flexibility:**
  - **Deliver short-term operational capability.**
  - **Investigate long-term, “100%” solution.**
  - **Integrate multiple platform operations.**
- **Strategy:**
  - **Enable dynamic management over system life-cycle.**
  - **Respond to changing user needs and capabilities.**
  - **Respond to technological advances.**

Starting a decision tree for solution strategy A

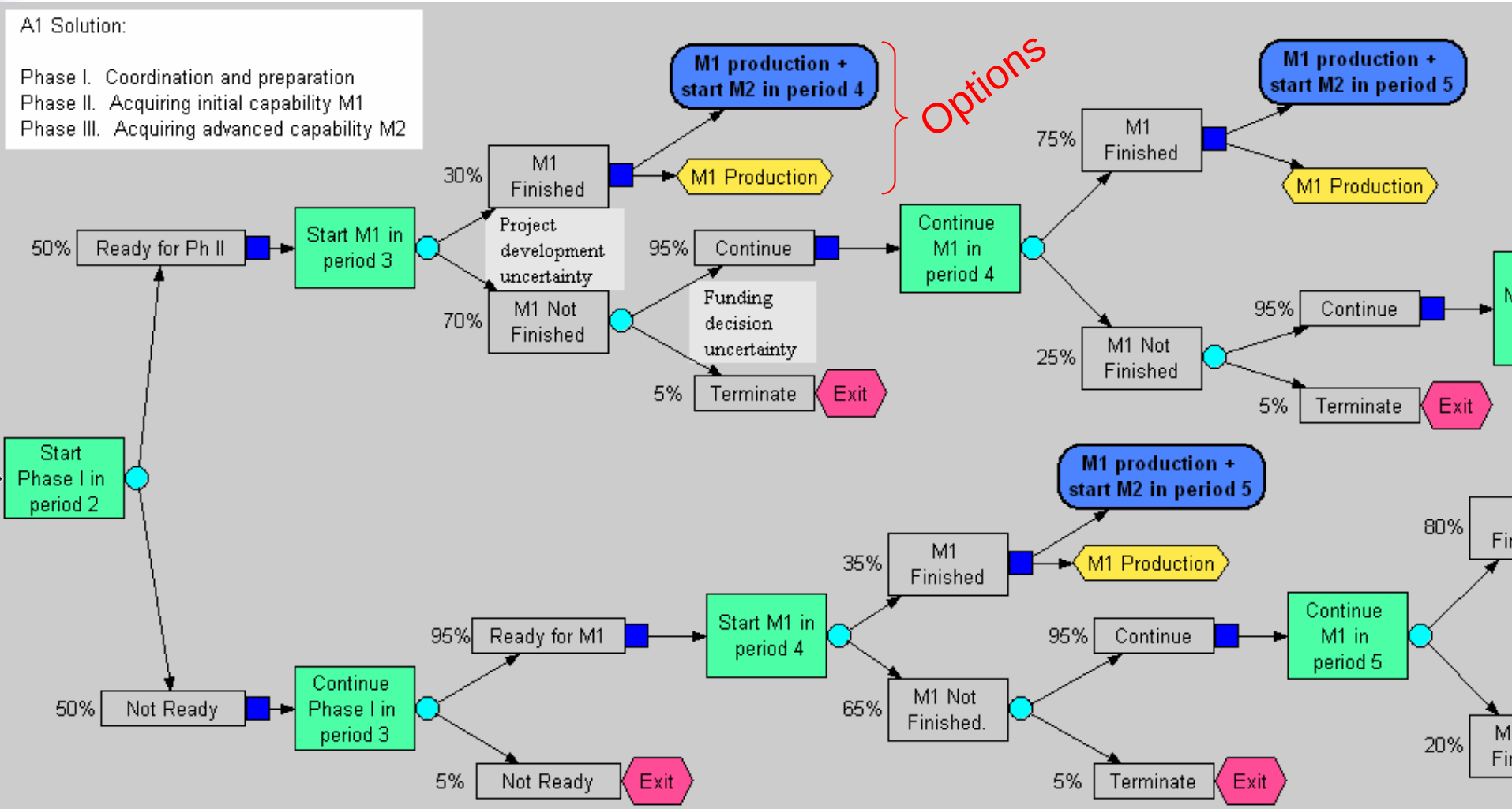
Solution Strategy A - Modem/VMF or SADL

Modem/VMF solution:
M1 - Providing standalone capabilities for primary CAS aircraft pilots to receive digital 9-Line briefing
M2 - Digitally integrating the 9-Line briefing with the aircraft Operational Flight Program (OFP)

SADL solution:
Developing and fielding light-weight SADL to JTAC with suitable TACP system interface to enable direct connectivity to SADL aircraft.



Decision tree for the A1 solution



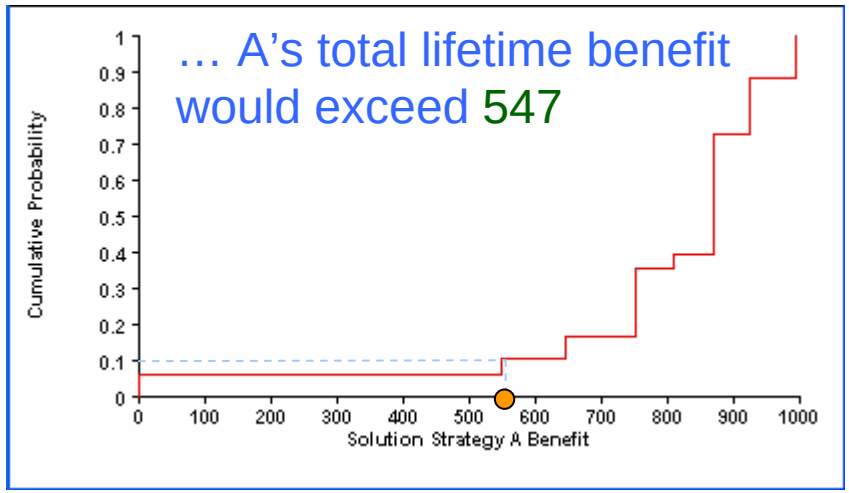
Valuation of solution strategy A

We are 90% certain that …

input data are notional

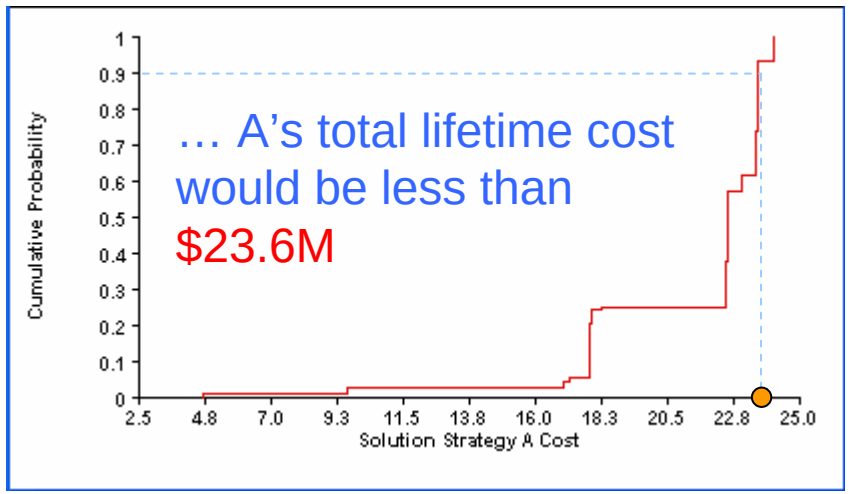
Benefit

Min	0
Median	871
Mean	786
Max	994
Std. Dev.	231



Cost

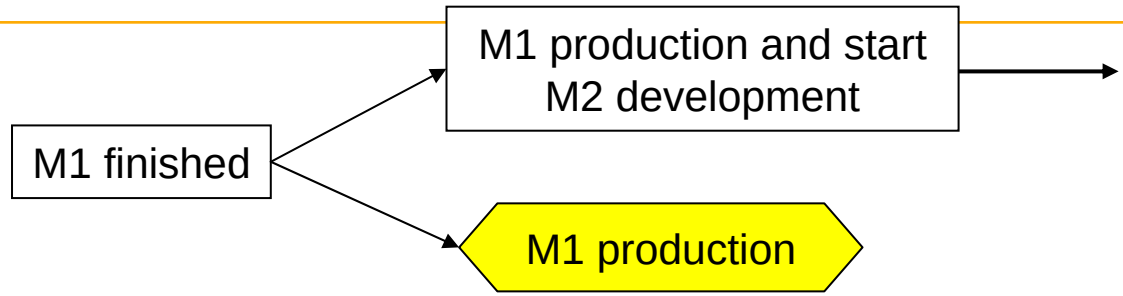
Min	4.7
Median	22.5
Mean	21.5
Max	24.1
Std. Dev.	3.3



The value of any solution strategy can only be known probabilistically.

Value-at-Risk (VaR) analysis

The value of flexibility in solution strategy A

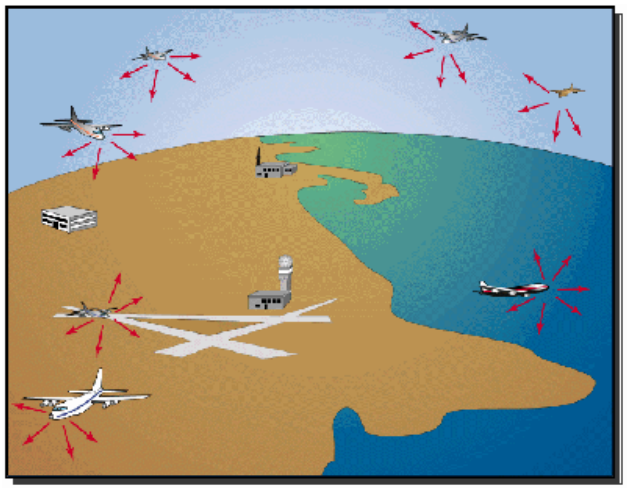


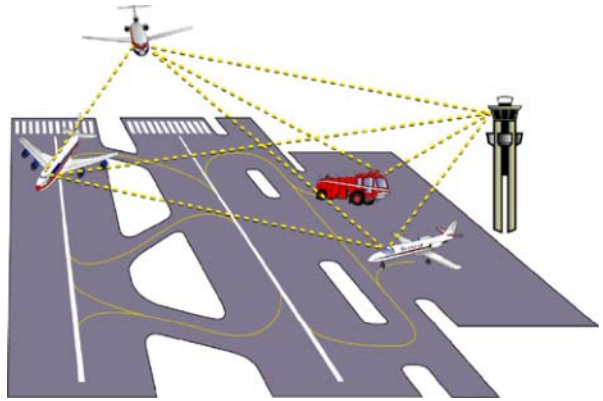
- **M2 is an increment built on the basis of M1. After M1 is done, the project can either continue to do M2 or just stop and enjoy M1. What's the value of this stop option?**

	A – without option	A – with option	B
Min	0	0	0
Median	33	39	33
Mean	36	39	35
Max	224	211	166
Std. Dev.	21	20	21
90% VaR	23	27	24

- **The option enhances the value of A and gives it an edge over B.**
- **Without the option, there is no clear winner.**

Other Applications





Conclusion

- **EA practice demands planning and control of investments through acquisition roadmap.**
- **Uncertainty and risk in defining the transition from the "as is" to the "to be" NAS requires flexible system design.**
- **Decision-makers are constrained by OMB, agency policy, and practical limits to resources for analysis, as well as availability and quality of data and information.**
- **Real options analysis can provide a framework that meets decision-maker needs within the public sector environment.**