DEFENCE R&D DÉFENSE

QUANTITATIVE MODELS FOR PERFORMANCE AND COST OF COMMAND, CONTROL, COMMUNICATIONS, COMPUTERS AND INFORMATION SYSTEMS

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OUTLINE

- Background
  - Capability Engineering
  - Complex Scenario
- Capability Engineering Decision Framework
  - Performance, Cost, Schedule, Risk Models
- Putting it all together - Conclusions

BACKGROUND

- Defence R&D Canada Trial
  - ‘Best Practices in Systems Engineering’
- Domestic Humanitarian Aid/Disaster Relief Scenarios
  - Major Canadian City
- Canadian Forces to support Command and Control
  - Liaison with Law Enforcement Agencies

BACKGROUND

- Command, control, communications, computers and information a capability gap
- Goal of project to come up with viable options to fill the gap
- Viability defined by performance, cost, schedule and risk

Capability Engineering Team

- Project Leader
- Operational subject matter experts
- Technological subject matter experts
- Operational research analysts
- Technological support team

TECHNOLOGICAL OPTIONS

- Operational and technological subject matter experts
  - Three technological options
    - The Status Quo
    - Option 1 - A Collaborative Information Environment
    - Option 2 - A Collaborative Information Environment combined with a Secure Broadband Wireless Network

Capability Engineering Decision Framework

- The Operational Research analysts were asked to evaluate these options
- By adding skilled personnel, construct Force Development Options
- Quantitative models for performance, cost, schedule and risk
- Based on data provided by operational subject matter experts on capability engineering team

PERFORMANCE MODEL

- Focus on decision quality in Operational Headquarters
- Based on time and effort available to
  - Orient, evaluate, decide and implement decisions
- Combine orient and implement functions into communication subtask
- Combine evaluate and decide functions into decision support subtask

COMMUNICATION FUNCTION

- **Data collected and disseminated is computed as**

$$D = P_c * t / T_c$$

- **Where**
  - **P_c is the personnel assigned to the task**
  - **t is the task time constraint in hours**
  - **T_c is the person hours required to complete the task**

DECISION SUPPORT FUNCTION

- **Data processed and decision support cycles are computed as**

$$C = P_s * t / T_s$$

- **Where**
  - **P_s is the personnel assigned to the task**
  - **t is the task time constraint in hours**
  - **T_s is the person hours required to complete the task**

DECISION QUALITY FIGURE OF MERIT

- We wanted a Figure of Merit function for decision quality
- Gives values between (0,1)
- Demonstrates diminishing returns
- Such that when personnel allocations equal to personnel requirements Q=0.5
- We chose the lognormal function

$$Q = \Phi(\ln(D * C))$$

SINGLE TASK SENSITIVITY RESULTS

Sensitivity Variables	1	2	3	4	5
Task Hours (t)	0.500	0.917	0.986	0.997	0.999
Collection Personnel (P_c)	0.864	0.963	0.986	0.993	0.996
Processing Personnel (Ps)	0.864	0.963	0.986	0.993	0.996
Collection Hours Required (Tc)	0.999	0.995	0.986	0.972	0.954
Processing Hours Required (Ts)	0.999	0.995	0.986	0.972	0.954

LIAISON WITH LAW ENFORCEMENT AGENCIES

- Seven tasks
  - Establish and maintain contact with law enforcement agencies
  - Initiate flow of information for the disaster zone
  - Assist with coordinating employment of civil mobility resources
  - Assist in crowd control
  - Conduct or assist with humanitarian aid/disaster relief distribution
  - Assist with policing operations as required and provide assistance to minimize looting
  - Handover resources and responsibilities to civilian authority at closure

LIAISON WITH LAW ENFORCEMENT AGENCIES

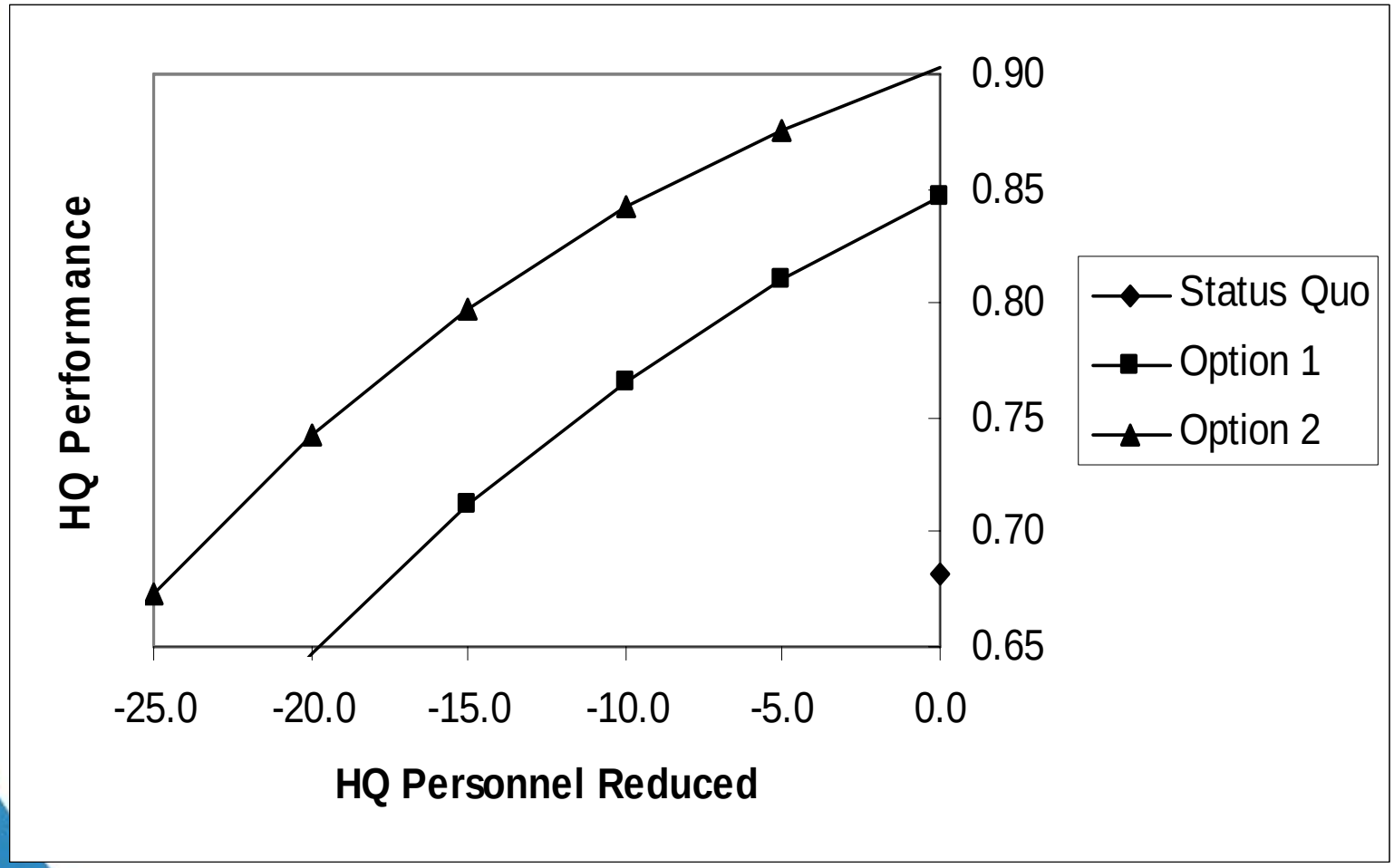
- Operational subject matter experts
  - Estimated the hours required to
    - Collect and disseminate data
    - Process information and provide decision support
  - For each of these tasks
  - For each of the technological options

PERFORMANCE RESULTS*

Personnel	Status Quo	Option 1	Option 2
70	0.68	0.85	0.90
65		0.81	0.88
60		0.77	0.84
55		0.71	0.80
50			0.74
46			0.69

*** We can improve performance and reduce personnel at the same time**

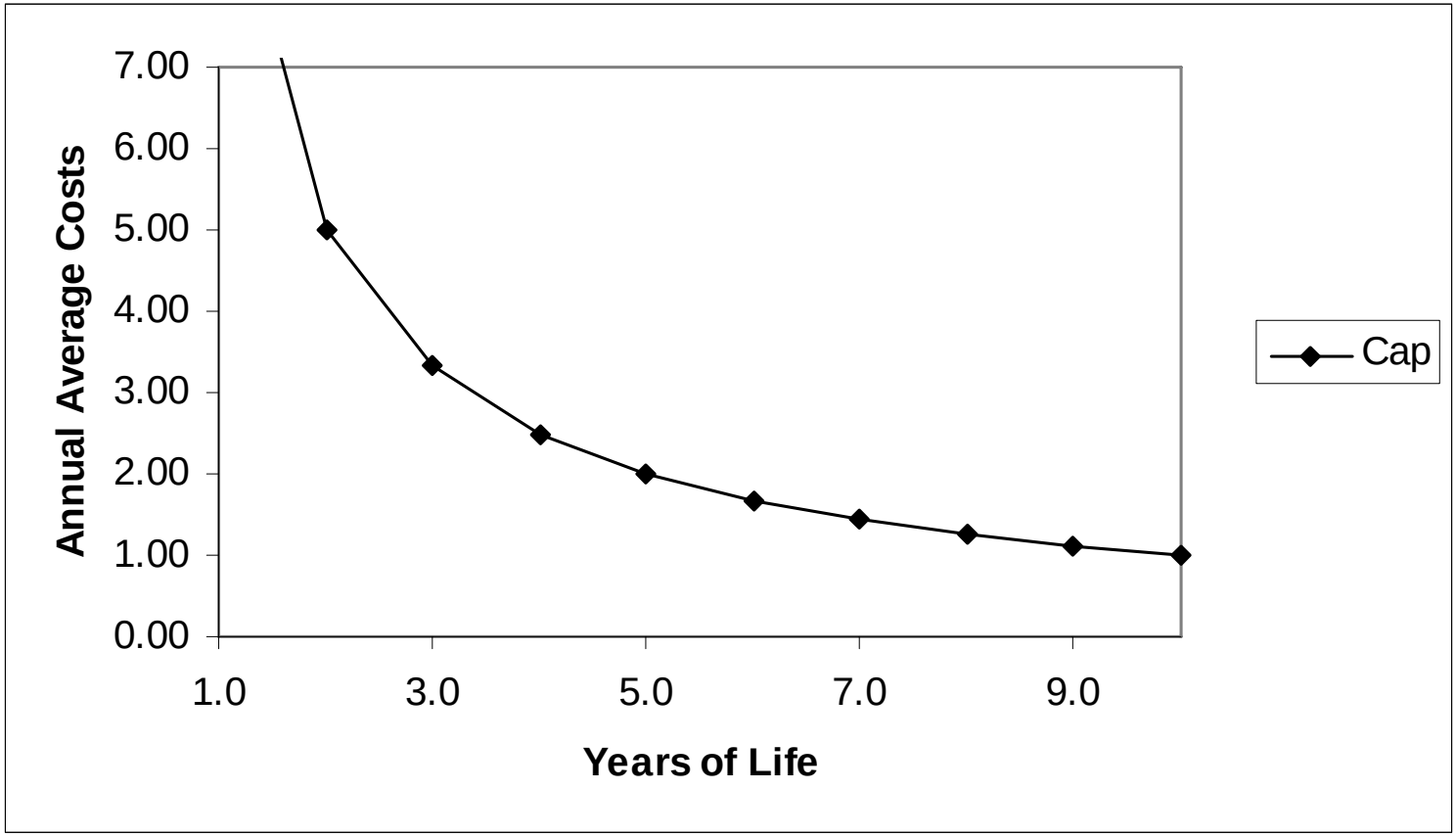
PERFORMANCE/PERSONNEL TRADEROFFS



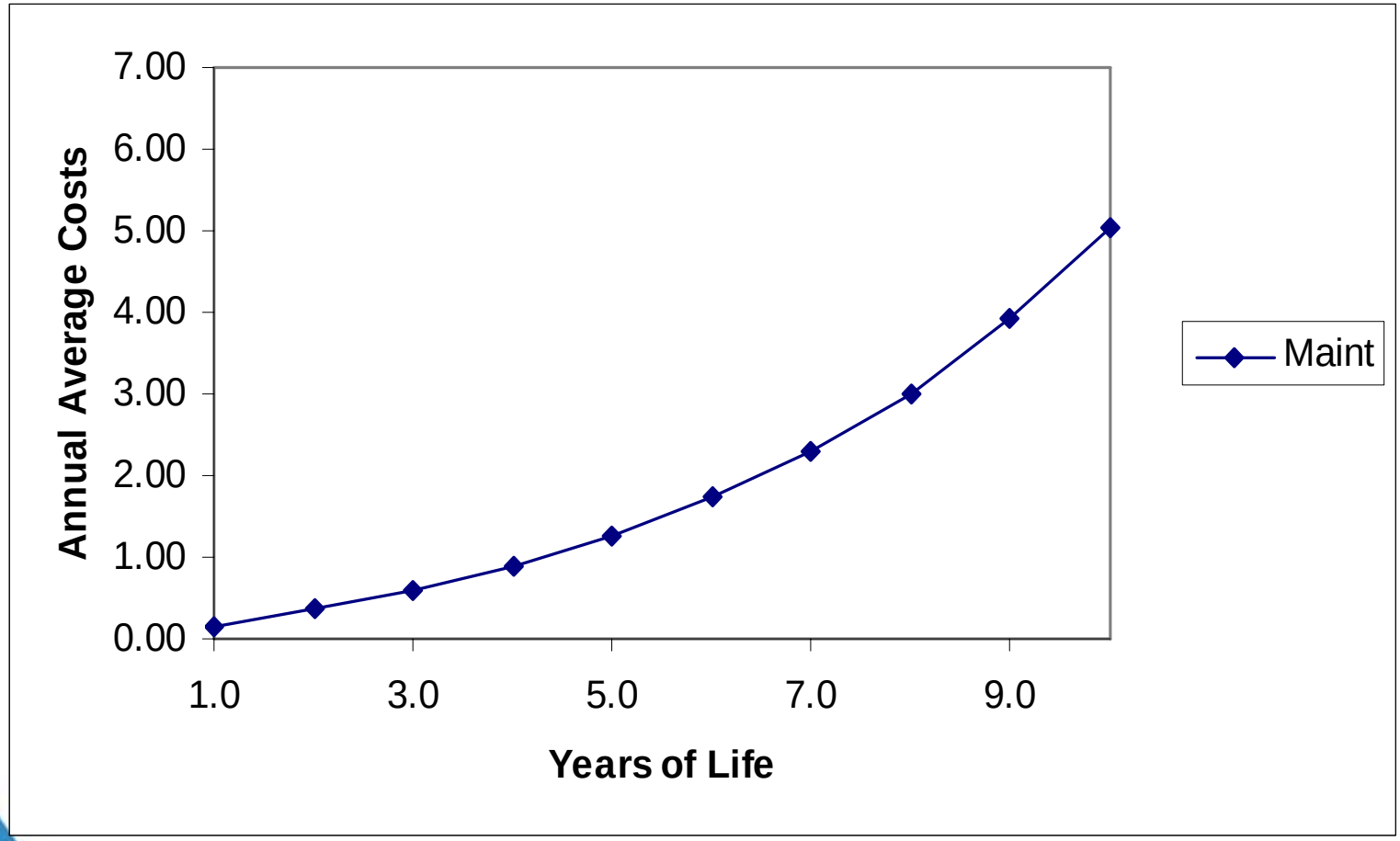
COST MODEL

- Cost model consists of
  - Capital Cost
  - Maintenance Cost
  - Personnel Cost
- We will compute the average annual cost of ownership for each option

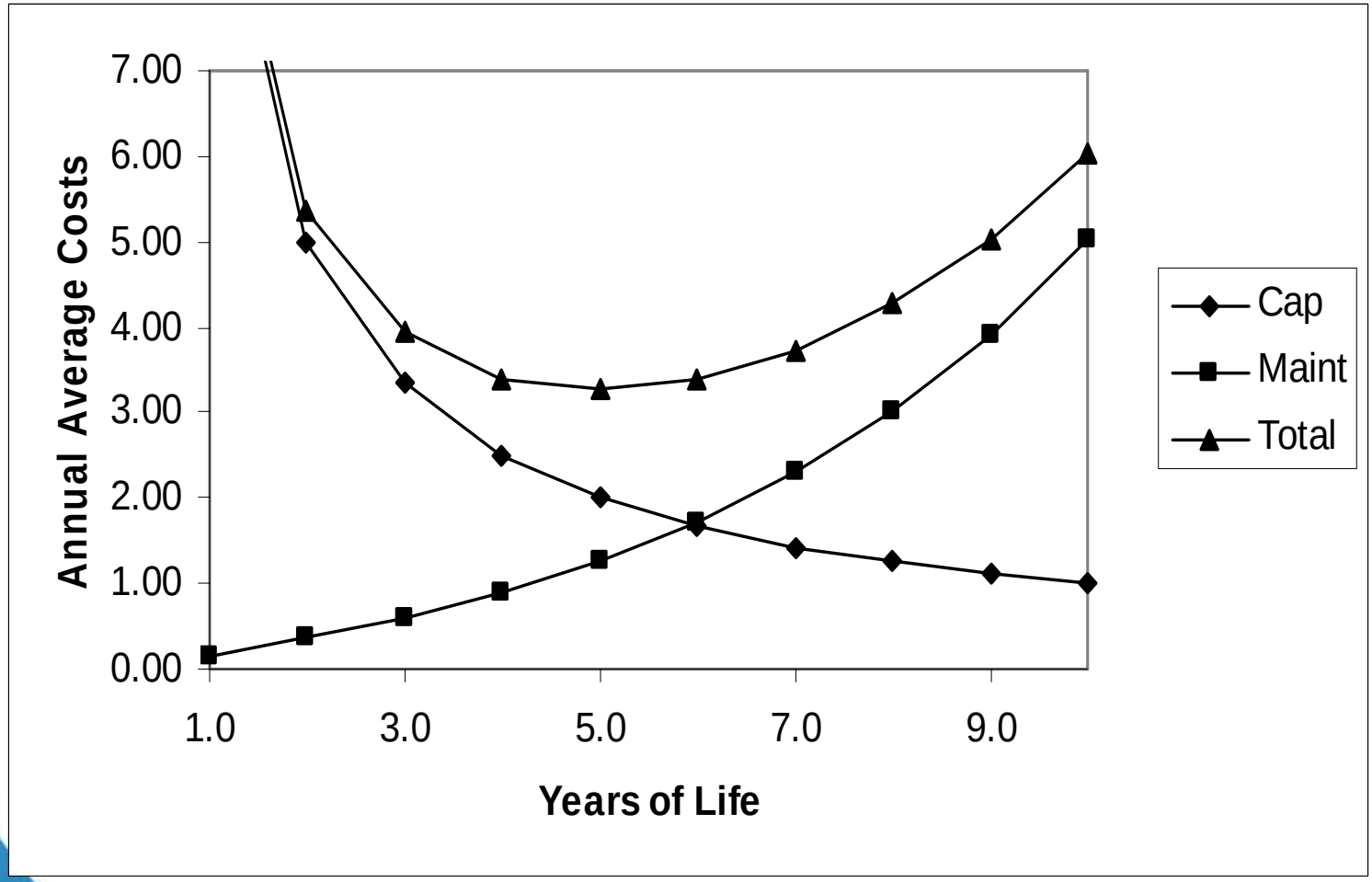
AMORTIZED CAPITAL COST



EXPONENTIALLY INCREASING MAINTENANCE COSTS



AVERAGE ANNUAL COST OF OWNERSHIP



AVERAGE ANNUAL COST OF OWNERSHIP

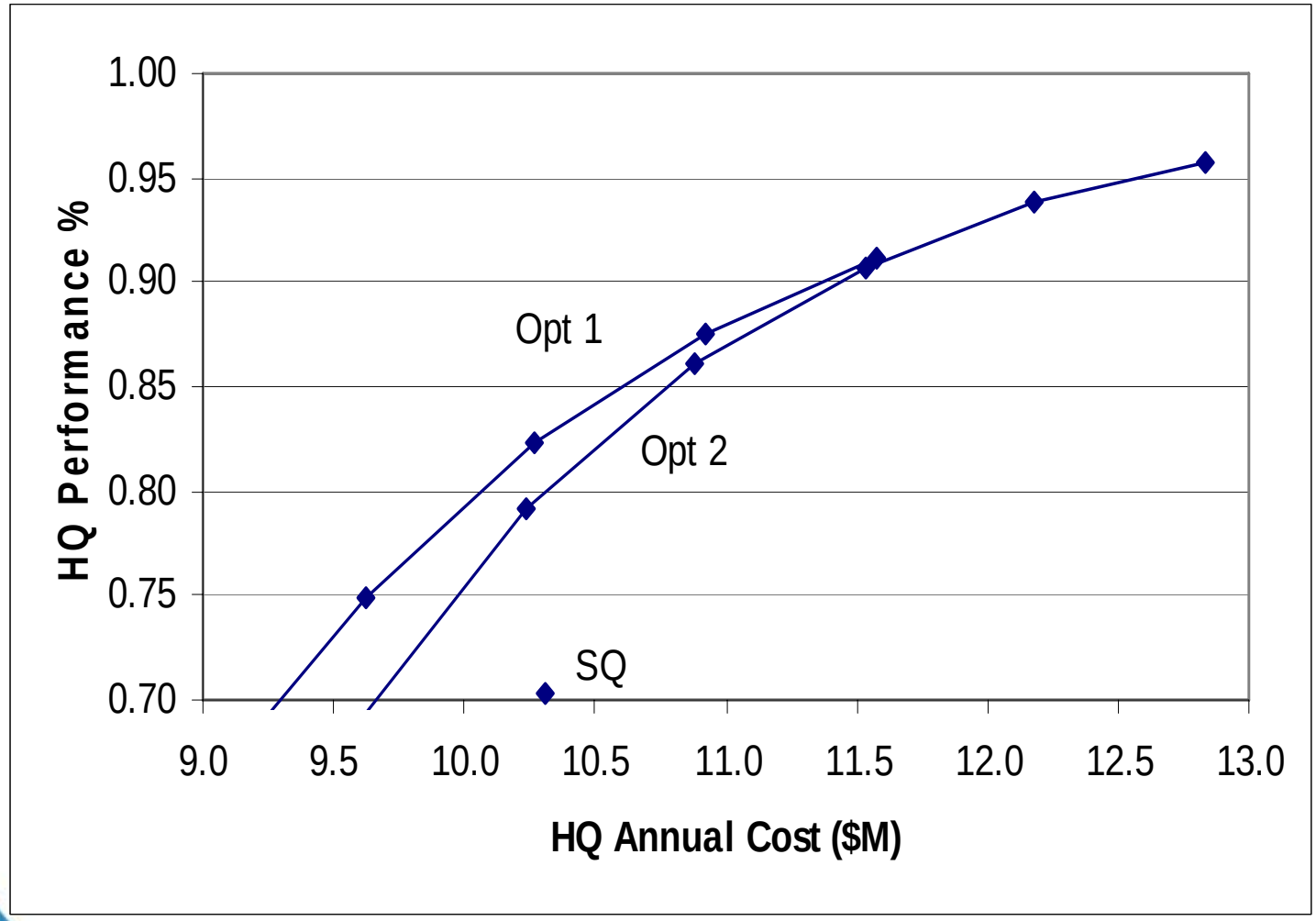
Costs ($M/yr)	Status Quo	Option 1	Option 2
Capital	0.68	1.40	2.12
Maintenance	0.55	1.08	1.63
Personnel*	9.10	9.10	9.10
Average Annual Total	10.3	11.6	12.8

*The average annual cost is dominated by the personnel costs

PERFORMANCE / COST TRADEOFFS

Option	Number of Personnel	Cost ($M/yr)	Performance (FoM)
Status Quo	70	10.3	0.68
Option 1	70	11.6	0.85
	60	10.3	0.77
	53	9.4	0.69
Option 2	70	12.8	0.90
	60	11.5	0.84
	50	10.2	0.74
	46	9.7	0.69

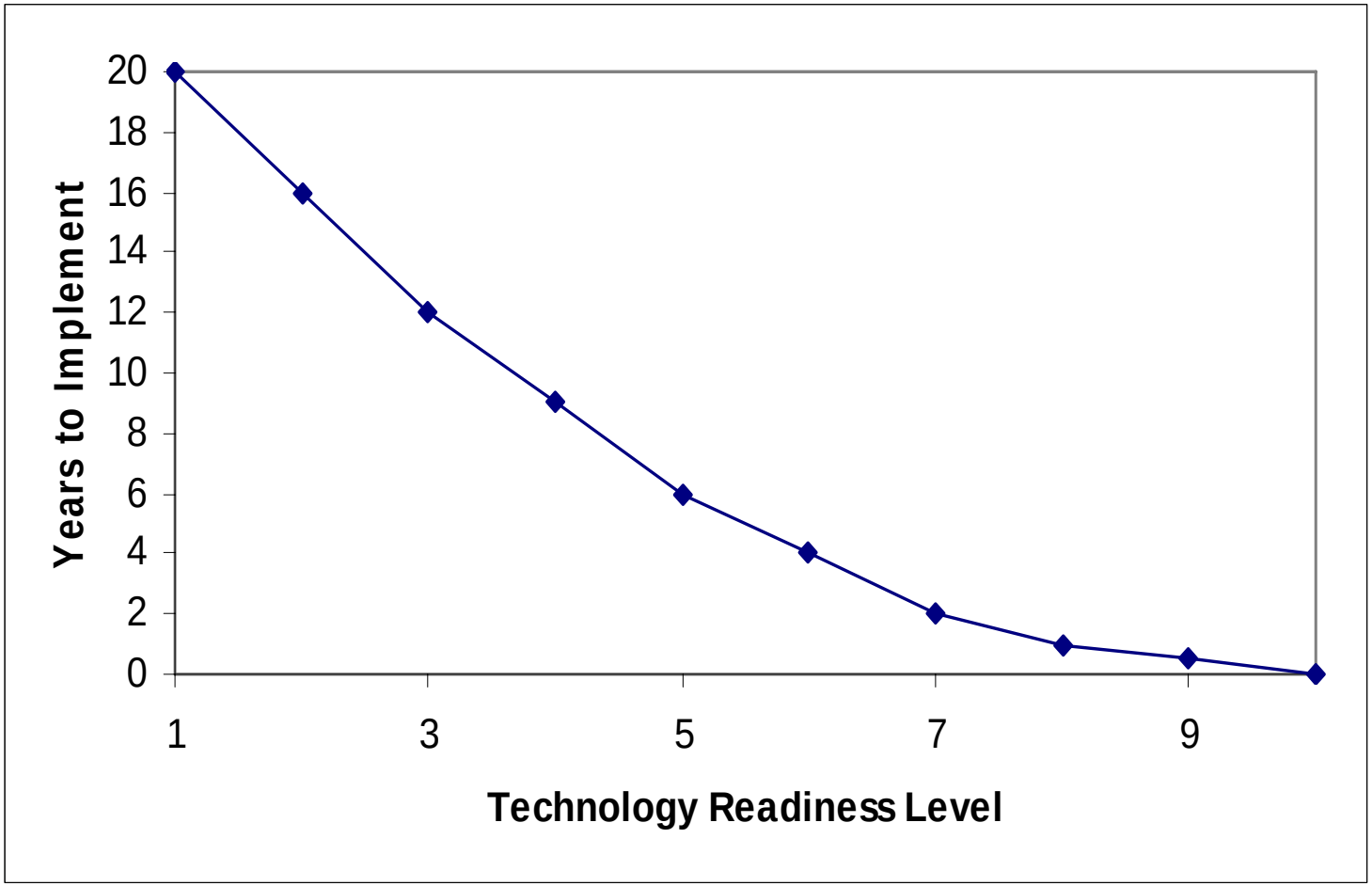
PERFORMANCE/COST TRADEOFFS



SCHEDULE AND RISK MODELS

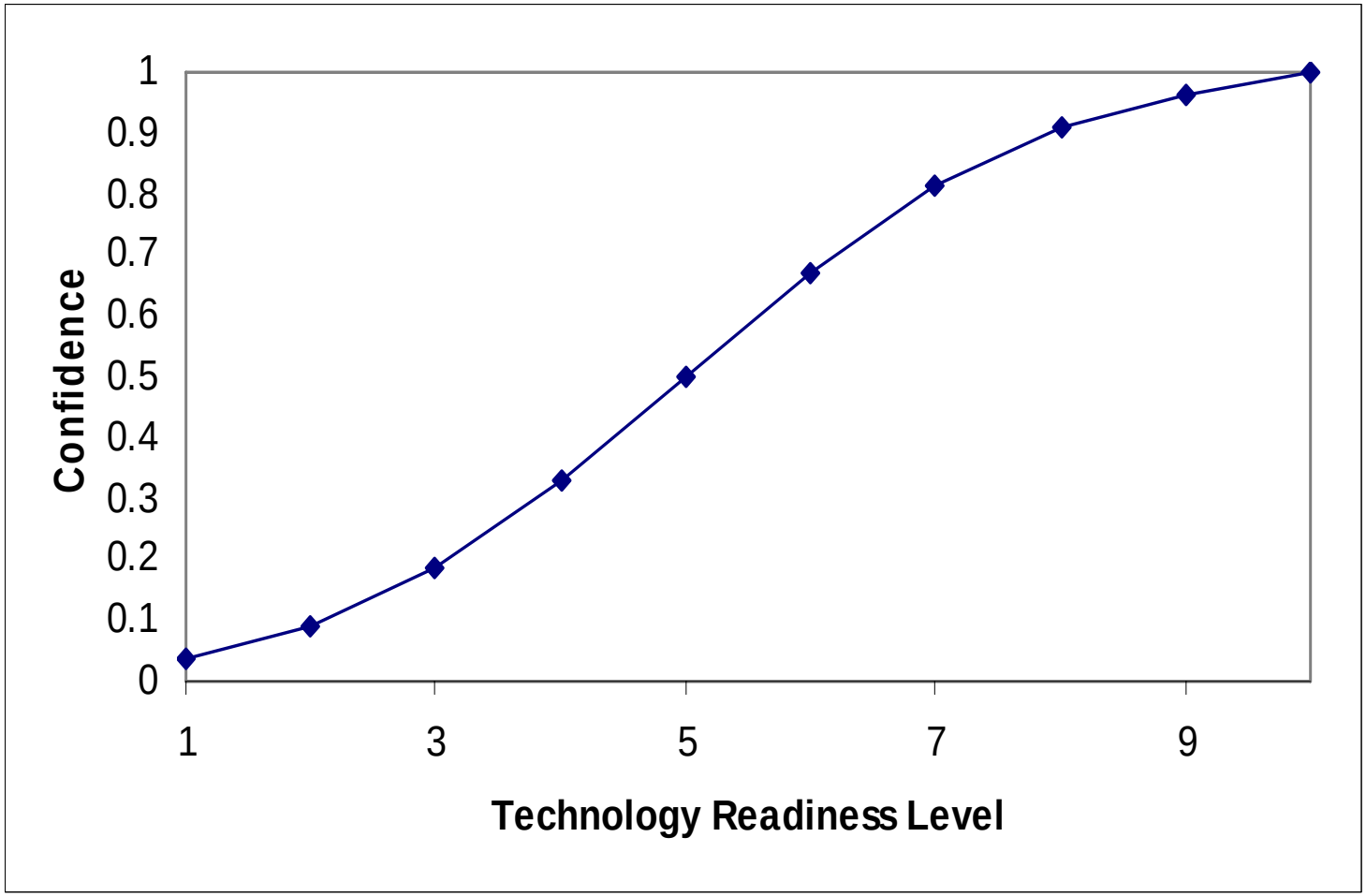
- Project Management Factors
  - Schedule defined as years to implement
  - Not deployment time
  - Risk defined as likelihood of serious problems meeting performance, cost, schedule targets
  - Not operational risk
- Based on Technological Readiness Level

SCHEDULE MODEL*



***Based on lowest Technology Readiness Level in Option**

RISK MODEL*



***Based on reliability model using series connections**

PUTTING IT ALL TOGETHER

Option	Status Quo	Option 1			Option 2			
Number of Personnel	70	70	60	53	70	60	50	46
Performance (FoM)	0.68	0.85	0.77	0.69	0.90	0.84	0.74	0.69
Cost ($M/yr)	10.3	11.6	10.3	9.4	12.8	11.5	10.2	9.7
Schedule (yrs)	0	2	2	2	9	9	9	9
Risk (FoM)	0	0.19	0.19	0.19	0.73	0.73	0.73	0.73

CONCLUSIONS

- Demonstrated the Capability Engineering Process for a Complex Scenario
- Produced Quantitative Capability Engineering Decision Framework Models
  - Performance, Cost, Schedule and Risk
- Produced Force Development Options for Command, Control, Communications, Computers and Information systems
- Demonstrated that Performance can be improved and Costs reduced within limited Schedule and with acceptable Risk

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QUESTIONS

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