Estimating for Lifecycle and Product Line Affordability

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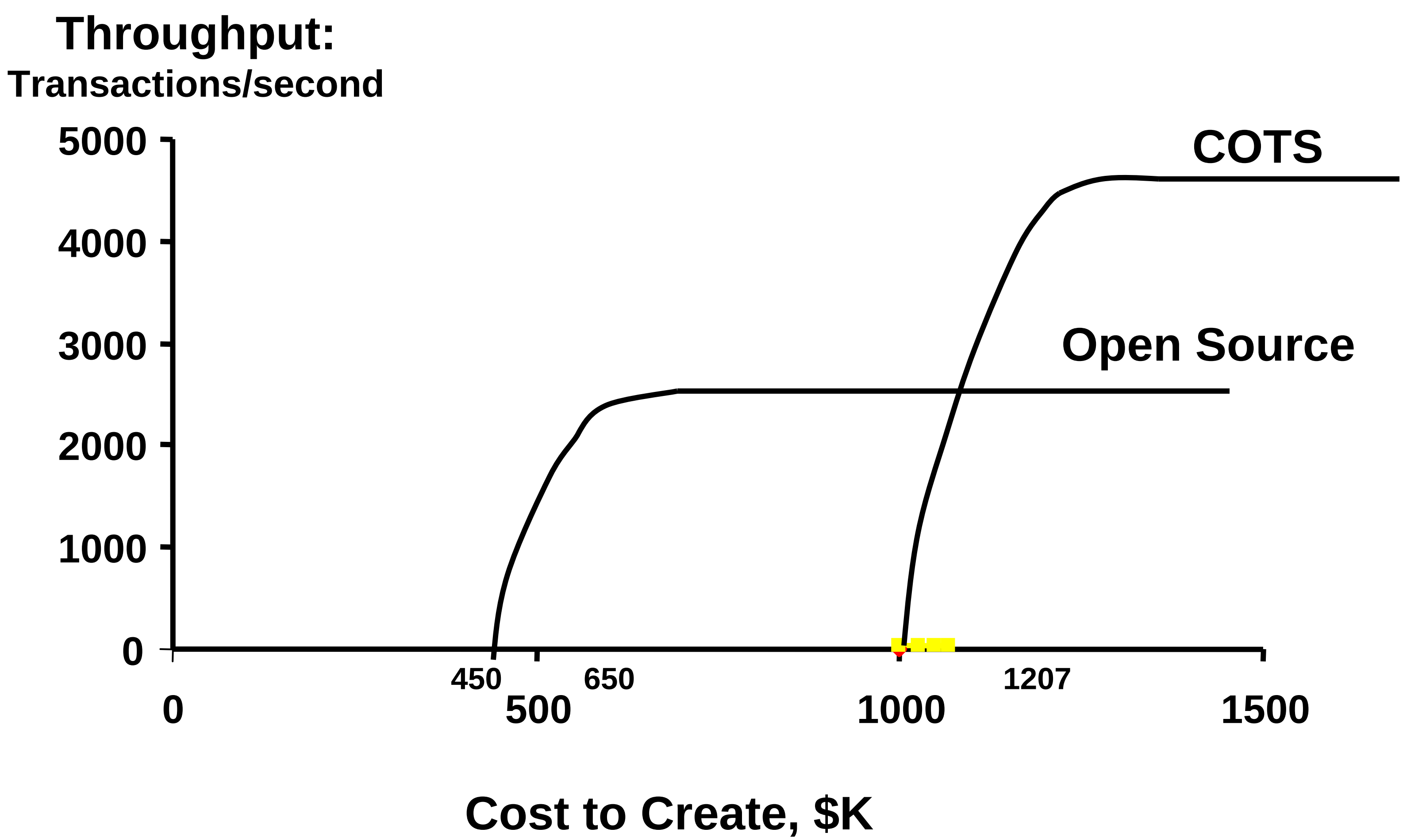
SCEA-ISPA Joint Conference
June 2012

Outline

- Perspectives on Affordability
  - Relations to value propositions and constraints
  - Affordability context considerations
- Utility of Total Ownership Cost Approaches
  - For a single system's life cycle
  - For the life cycles of a family of systems
- Conclusions

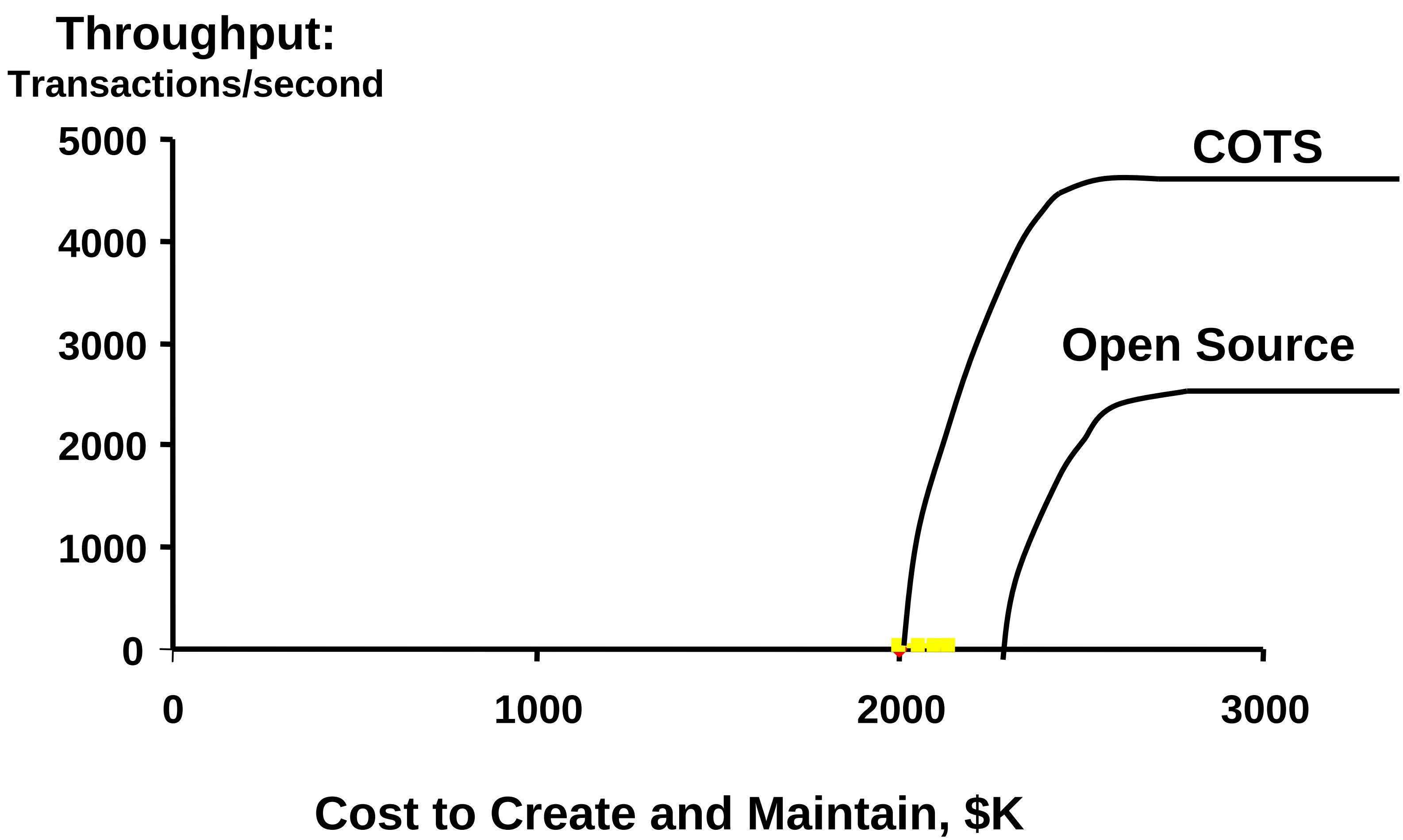
Which Is More Affordable?

Important to consider value, constraints



Which Is More Affordable?

Important to consider total ownership cost



Outline

- Perspectives on Agility and Affordability
  - Primary agility failure modes
  - Affordability context considerations

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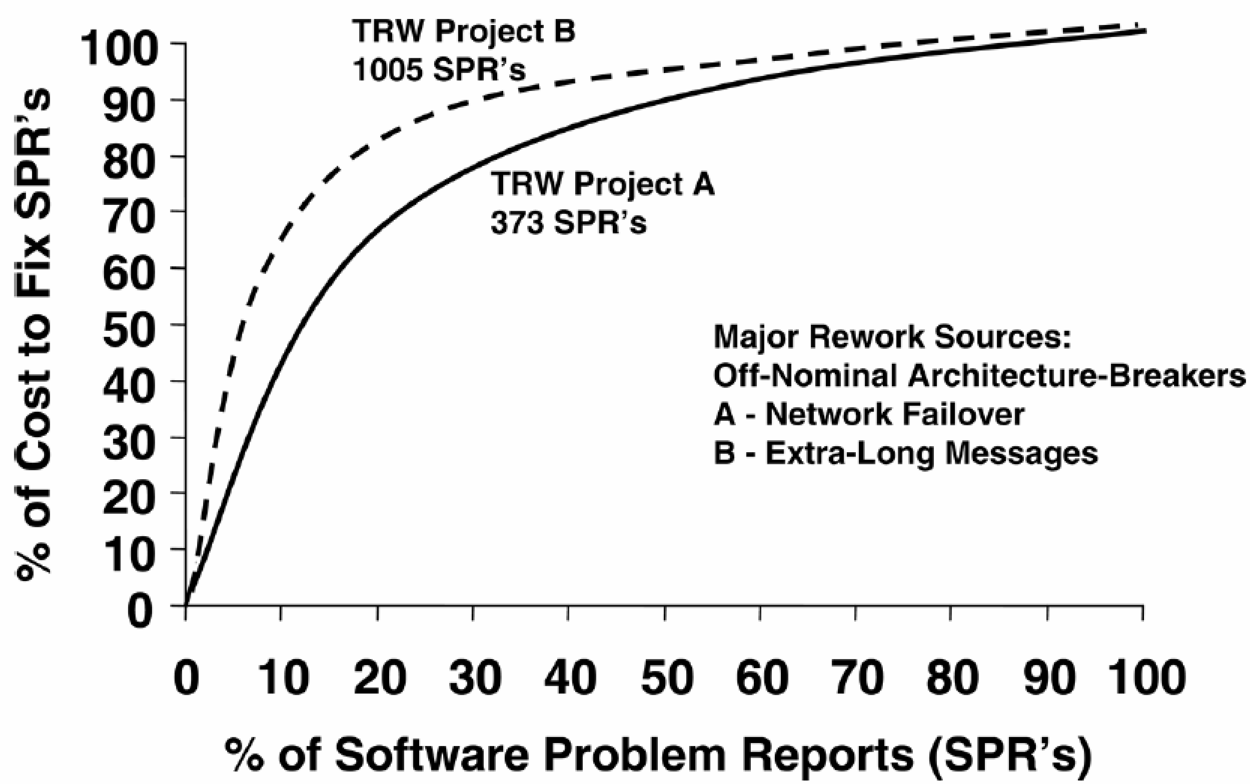
Overfocus on Acquisition Cost

C4ISR Contracts: Nominal-case requirements; 90 days to PDR



Rework Sources Analysis: Projects A and B

- Change processing over 1 person-month = 152 person-hours

Category	Project A	Project B
Extra long messages		3404+626+443+328+244= 5045
Network failover	2050+470+360+160= 3040	
Hardware-software interface	620+200= 820	1629+513+289+232+166= 2832
Encryption algorithms		1247+368= 1615
Subcontractor interface	1100+760+200= 2060	
GUI revision	980+730+420+240+180 =2550	
Data compression algorithm		910
External applications interface	770+330+200+160= 1460	
COTS upgrades	540+380+190= 1110	741+302+221+197= 1461
Database restructure	690+480+310+210+170= 1860	
Routing algorithms		494+198= 692
Diagnostic aids	360	477+318+184= 979
TOTAL:	**13620**	**13531**

C4ISR Project C: Architecting for Change
USAF/ESC-TRW CCPDS-R Project*

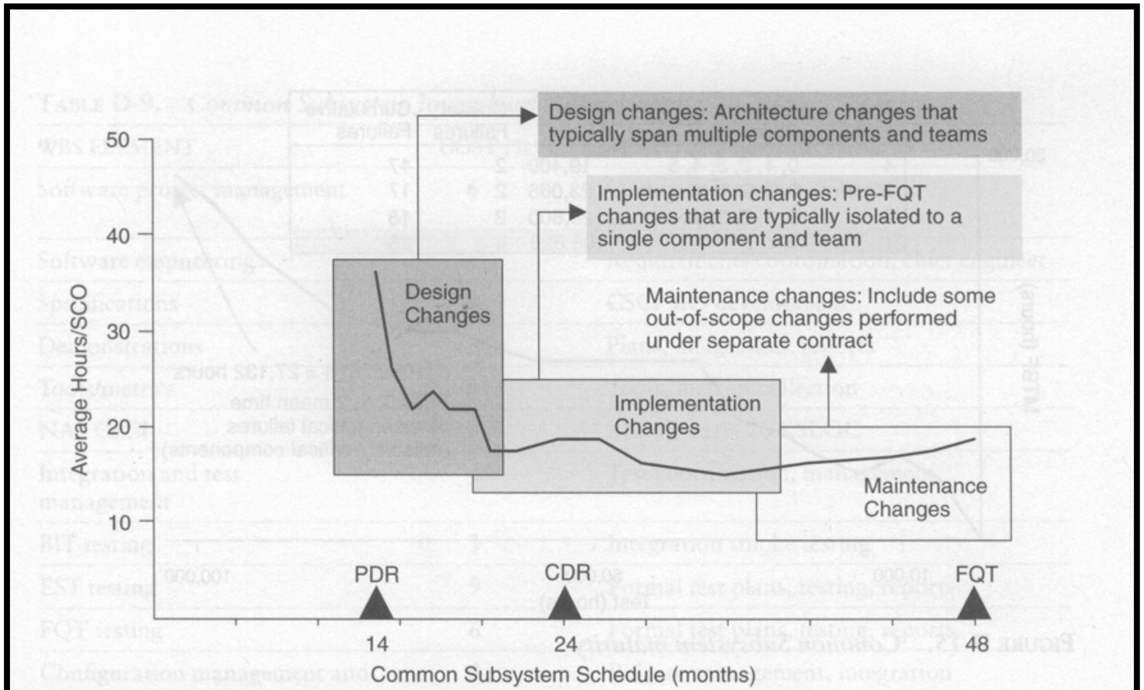


FIGURE D-14. *Common Subsystem adaptability*

When investments made in architecture, average time for change order becomes relatively stable over time…

*** Walker Royce, *Software Project Management: A Unified Framework*. Addison-Wesley, 1998.**

Current TOC-Single System Model

The simple initial TOC-SS model has the following inputs:

%D: The % of development cost invested in Design for Flexibility

System Size: For software, the equivalent KSLOC (thousands of source lines of code)

- **For hardware, the COSYSMO size parameter: complexity-weighted numbers of requirements, interfaces, operational scenarios, and algorithms [Valerdi, 2005].**

#F: The number of years that the system undergoes field changes

%FC: The percentage of the fielded system size undergoing change

The TOC-SS model has the following outputs:

TOC (Devel): The TOC for development

TOC (Devel + K): TOC (Devel) + TOC (K years of fielding), K = 1, …, #F

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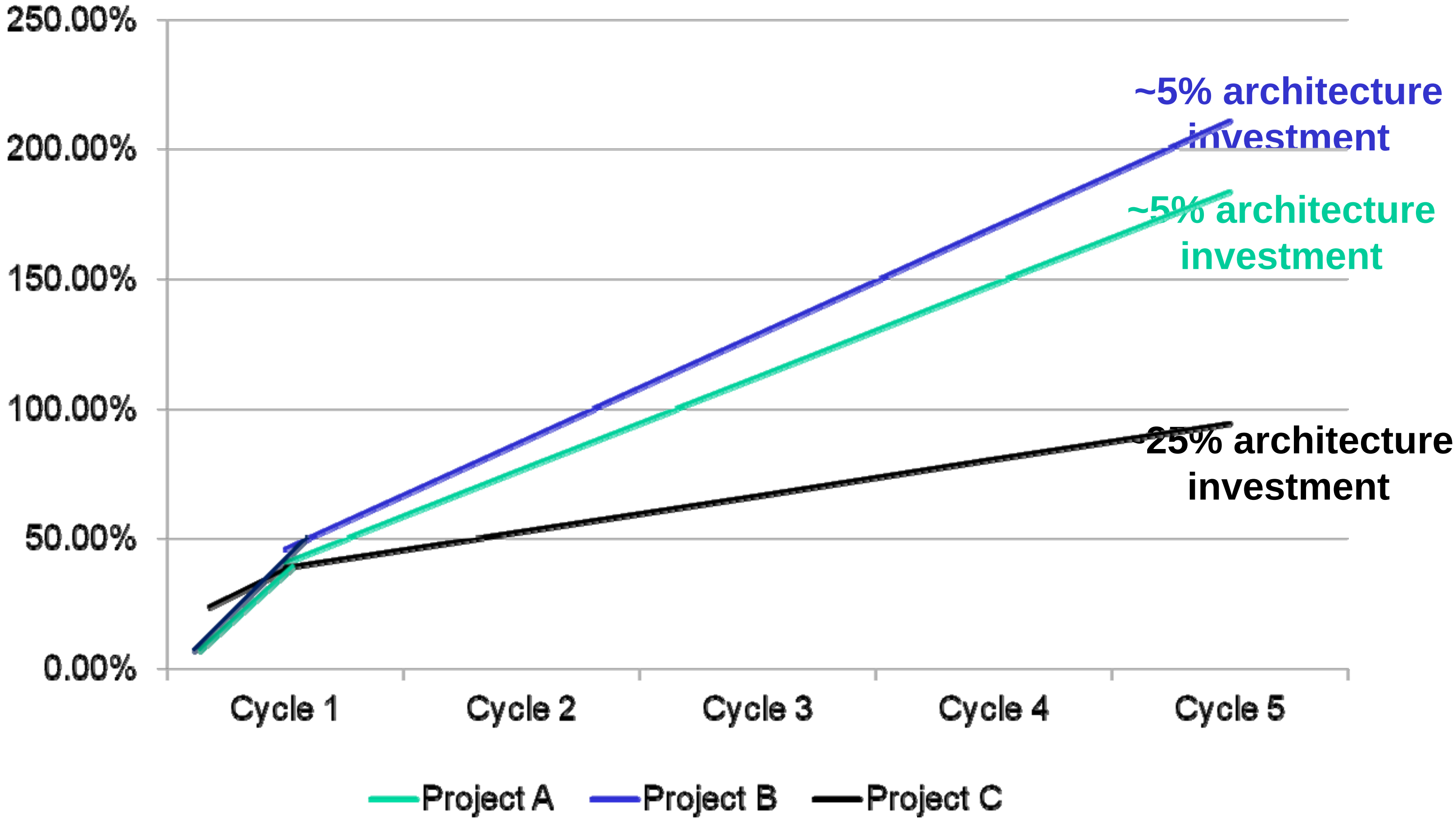
Single-System TOC Model Example

	A	B	C	D	E
1	Input Parameters	System			
2		A	B	C	
3	Software Size (KSLOC)	100	100	355	
4	# Change Requests/Release	373	1005	1600	
5	# Change Requests (I&T only)				
6	# I&T Change Requests/Release/ > 1 PM	27	22		
7	# Total Change Requests/Release/ > 1 PM			16	
8	Change Request Fix Time (See assumption #2)	261	356	263	
9	Total Effort (Person Months)	731	865	1900	
10	% Arch, RESL	5%	5%	25%	
11	% Rework, RVOL	35.70%	41.16%	13.85%	
12					
13	Cumulative Total Cost of Ownership	Project A	Project B	Project C	
14	Cycle 1	40.70%	46.16%	38.85%	
15	Cycle 2	76.41%	87.31%	52.70%	
16	Cycle 3	112.11%	128.47%	66.55%	
17	Cycle 4	147.82%	169.62%	80.40%	
18	Cycle 5	183.52%	210.78%	94.25%	

Relative* Total Ownership Cost (TOC)



*** Cumulative architecting and rework effort relative to initial development effort**

Use of life cycle cost ratios (%O&M)

- Hardware [Redman 2008]
  - 12% -- Missiles (average)
  - 60% -- Ships (average)
  - 78% -- Aircraft (F-16)
  - 84% -- Ground vehicles (Bradley)
- Software [Koskinen 2010]
  - 75-90% -- Business, Command-Control
  - 50-80% -- Complex platforms as above
  - 10-30% -- Simple embedded software
- Apply lack-of-flexibility factor to O&M component

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Systems Product Line TOC Model

For Set of Products:

- Average Product Cost
- Annual Change Cost
- Ownership Time
- Percent Mission-Unique, Adapted, Reused
- Relative Cost of Developing for PL Flexibility via Reuse
- Relative Costs of Reuse

→ **Systems ProductLine TOC Model** →

As Functions of # Products, # Years in Life Cycle:

- PL Total Ownership Costs
- PL Flexibility Investment
- PL Savings (ROI)

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Product Line Engineering and Management

SYSTEMS ENGINEERING Research Center

Preferences

Systems Product Line Flexibility Value Model

Welcome SERC Collaborator

Open | Save | Save As

System Costs

Average Product Development Cost (Burdened $M) 5 | Ownership Time (Years) 3

Annual Change Cost (% of Development Cost) 10 | Interest Rate (Annual %) 7

Product Line Percentages

Unique % 40

Adapted % 30

Reused % 30

Relative Costs of Reuse (%)

Relative Cost of Reuse for Adapted 40

Relative Cost of Reuse for Reused 5

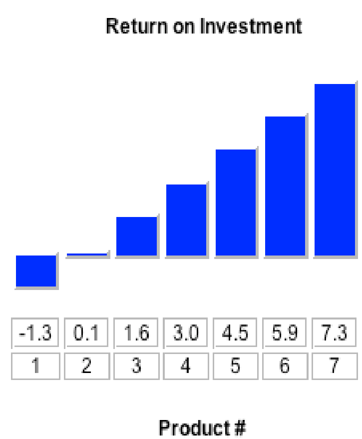
Investment Cost

Relative Cost of Developing for PL Flexibility via Reuse 1.7

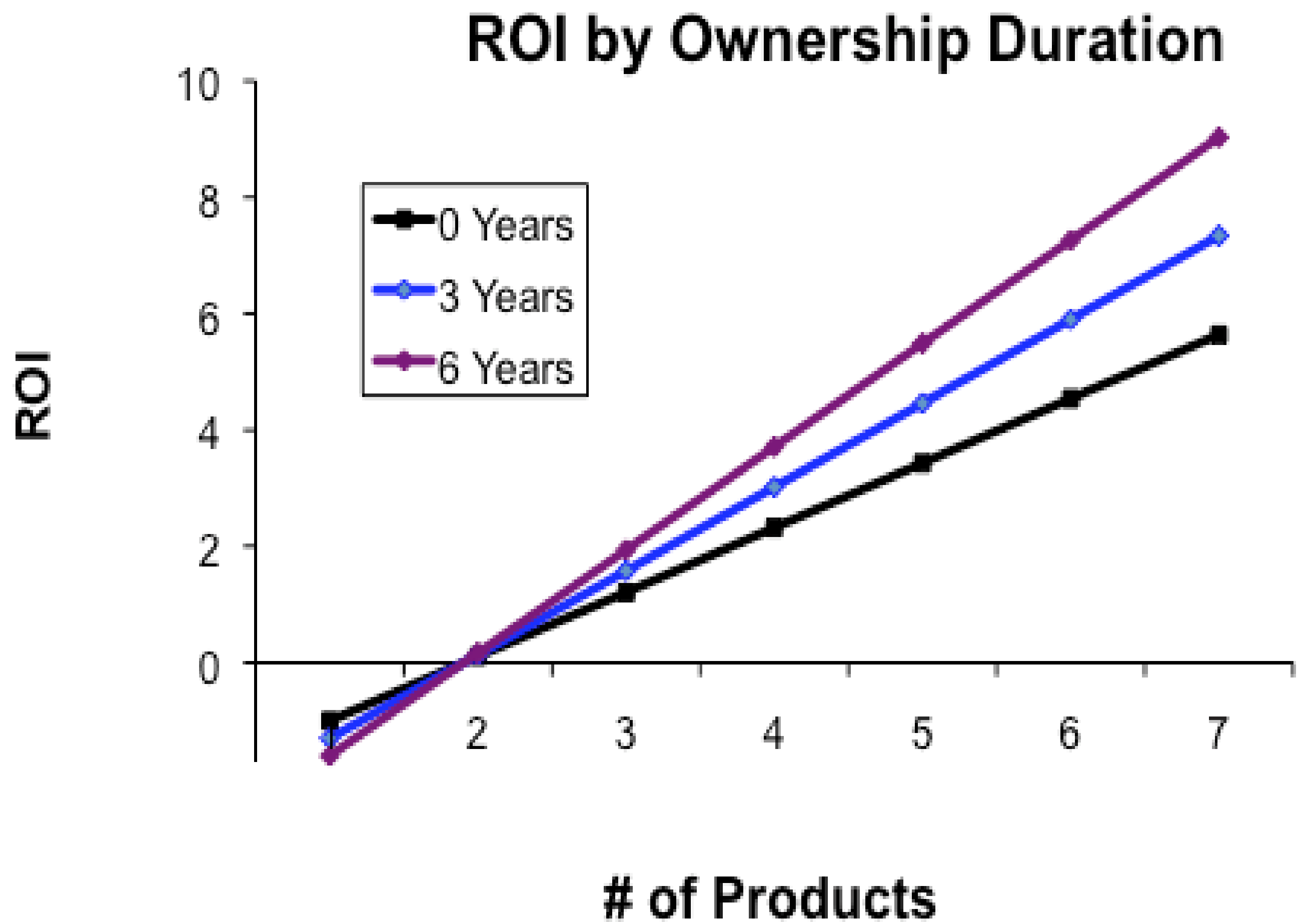
Calculate

Results

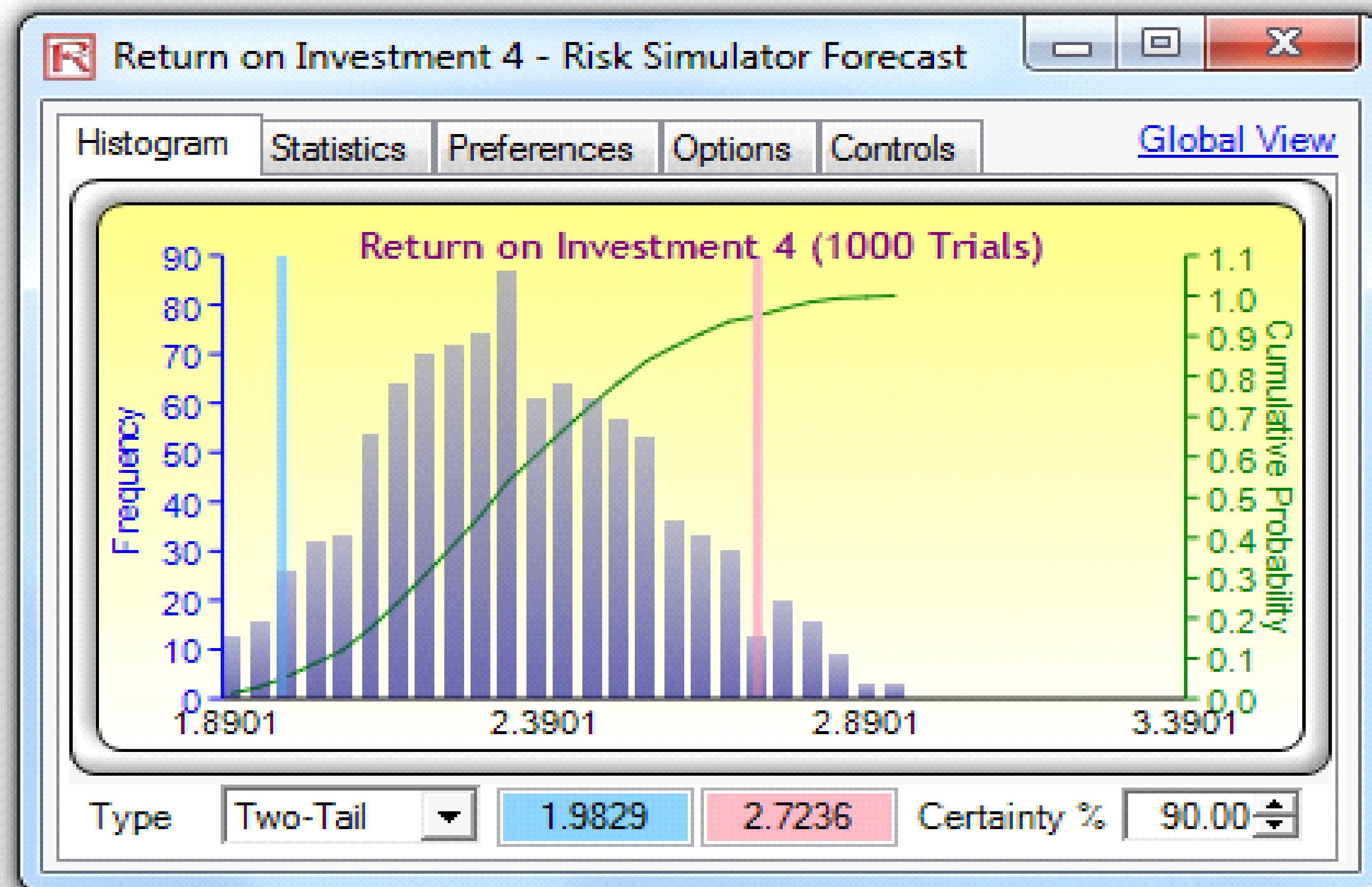
# of Products	1	2	3	4	5	6	7
Development Cost ($M)	$7.1	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7
Ownership Cost ($M)	$2.1	$0.8	$0.8	$0.8	$0.8	$0.8	$0.8
Cum. PL Cost ($M)	$9.2	$12.7	$16.2	$19.7	$23.1	$26.6	$30.1
PL Flexibility Investment ($M)	$2.1	$0	$0	$0	$0	$0	$0
PL Effort Savings	($2.7)	$0.3	$3.3	$6.3	$9.4	$12.4	$15.4
Return on Investment	-1.30	0.14	1.58	3.02	4.46	5.90	7.34



Product Line Payoff Increases with Lifetime



Extension with NPS KVA Capabilities



Conclusions

- Affordability increasingly competition-critical
  - Need to balance cost, schedule, performance, functionality
- Some improvement avenues available
  - Total Ownership Cost Analysis of Alternatives
    - Identify and architect to encapsulate sources of change
  - Product Line Engineering and Management
  - Concurrent vs. Sequential Engineering
    - Using cost-effectiveness, evidence-based decision points
  - Value-Based Engineering
    - Vs. assuming equal-value requirements, tests, defects
- No one-size-fits-all solution