



NAVAL  
POSTGRADUATE  
SCHOOL

## **Issues in Total Ownership Cost Modeling for DoD Systems**

**Raymond Madachy  
Naval Postgraduate School**

**[rjmadach@nps.edu](mailto:rjmadach@nps.edu)**

Ground Systems Architecture Workshop 2014

February 26, 2014

Monterey, California

Published by the Aerospace Corporation with Permission

[WWW.NPS.EDU](http://WWW.NPS.EDU)





- NPS participating in research and development of Next-Generation, Full-Coverage Cost Estimation Model Ensembles for DoD Systems Engineering Research Center.
- Beginning with space domain with USAF/SMC and the Aerospace Corp. to research and develop an ensemble of cost estimation models covering the systems engineering, development, production, operations, sustainment, and retirement.



- Total Ownership Cost (TOC) is the total cost of acquisition, development and operating costs.
  - All direct and indirect costs of a product, product line, system, project or program.
- Life-cycle cost consists of research and development costs, investment costs, operating and support costs, and disposal costs over the duration of a program.
- Total ownership cost is broader in scope. It includes the elements of life-cycle cost, as well as other infrastructure or business process costs not normally attributed to a program.



# Cost Modeling Across Domains

- Structuring canonical TOC tools to address multiple DoD domains efficiently.
  - Included phases, activities, cost sources depend on domain
- Cost model architecting is similar to product line engineering
  - Identify multi-domain commonalities and variabilities (e.g. cost factors, product structures, lifecycle phases, activities)
  - Identify fully, partially sharable commonalities
  - Develop model interfaces and extensions for variabilities
- Comparing MIL-STD 881 Work Breakdown Structures (WBS) to find commonalities and variabilities across DoD domains, and identify suggested improvements.
  - Some domains have 1-n repeating system structures (e.g. spacecraft networks), others are single system
  - Example “Common Elements” include Systems Engineering and Management



# Product Line TOC Modeling

- Will extend models and tools to analyze Total Ownership Cost (TOC) for a family of systems. The value of investing in product-line flexibility using Return-On-Investment (ROI) and TOC is assessed with parametric models adapted from the Constructive Product Line Investment Model (COPLIMO).
  - Spacecraft and ground system application focus
- Models are implemented in separate tools for 1) System-level product line flexibility investment model and 2) Software product line flexibility investment model. The detailed software model includes schedule time with NPV calculations.





# Systems Product Line Model



## Systems Product Line Flexibility Value Model

[Preferences](#)

Welcome SERC Collaborator

### System Costs

Average Product Development Cost (Burdened \$M)  Ownership Time (Years)

Annual Change Cost (% of Development Cost)  Interest Rate (Annual %)

### Product Line Percentages Relative Costs of Reuse (%)

Unique %  Relative Cost of Reuse for Adapted

Adapted %  Relative Cost of Reuse for Reused

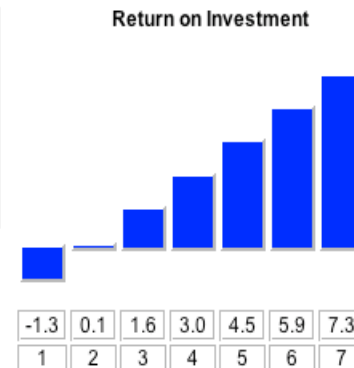
Reused %

### Investment Cost

Relative Cost of Developing for PL Flexibility via Reuse

### Results

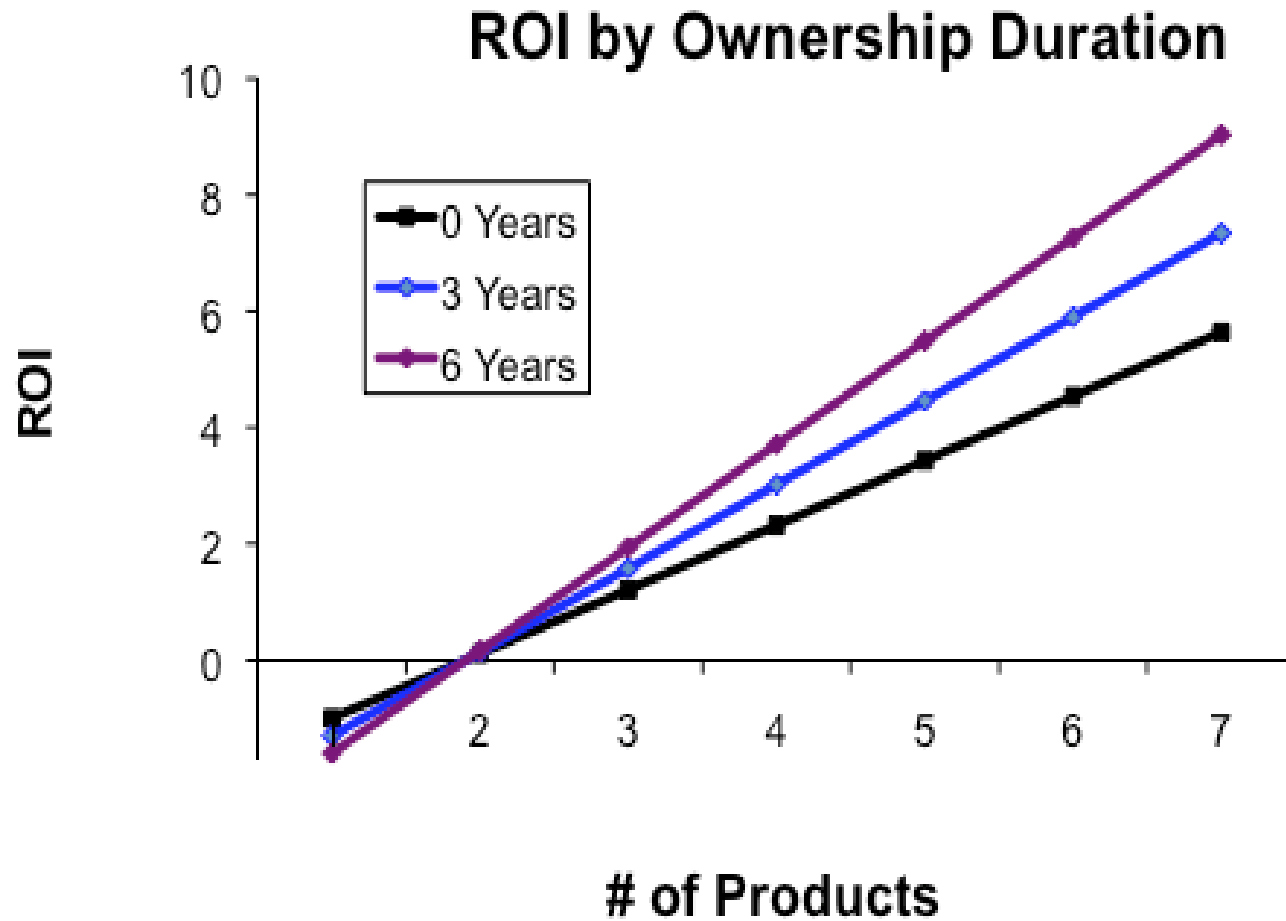
# of Products	1	2	3	4	5	6	7
Development Cost (\$M)	\$7.1	\$2.7	\$2.7	\$2.7	\$2.7	\$2.7	\$2.7
Ownership Cost (\$M)	\$2.1	\$0.8	\$0.8	\$0.8	\$0.8	\$0.8	\$0.8
Cum. PL Cost (\$M)	\$9.2	\$12.7	\$16.2	\$19.7	\$23.1	\$26.6	\$30.1
PL Flexibility Investment (\$M)	\$2.1	\$0	\$0	\$0	\$0	\$0	\$0
PL Effort Savings	(\$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 # **6**



# Sensitivity Analysis Example





- Multi-mission needs of ground systems and others call for extension of the top-level COPLIMO model to handle subsystems
- Each subsystem has respective cost factors and product line characteristics including
  - Fractions of system fully reusable, partially reusable and cost of developing them for reuse
  - Fraction of system variabilities and cost of development
  - System lifetime and rates of change





# Extended Product Line Model

For Set of Products:

For each subsystem:

- 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  
Product Line  
Model**

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

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