Increasing Systems Engineering Effectiveness Through Operational Risk Considerations

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Problem Statement

- **Many programs fail to address real operational needs when fielding new capabilities resulting in a gap between business and mission needs and operational capabilities.**
- **Two major root causes**
  - Requirements failed to capture true mission and business needs
  - The mission and business needs evolve during development and project team fails to evolve as quickly
- **The existence of gaps between operational needs and delivered capabilities increases operational risk.**

Example: ECSS Air Force

- **Expeditionary Combat Support System (ECSS) began development in 2004**
- **Program had vague set of objectives**
- **Lack of clarity in operational needs and the mission and business needs that were being addressed**
- **Major disconnect between solving critical operational threats and risks versus solving strategic needs (cost reduction, affordability, consolidation, etc.)**
- **Result: $1.1B in wasted funding and a system that was not deployable**

"The Air Force's Expeditionary Combat Support System, or ECSS., is a prime example of how a system designed to save money can actually waste billions of taxpayer dollars without producing any usable capability." – Sen. John McCain

Example: Improvised Explosive Device (IED) Defeat

- **During Operation Iraqi Freedom, IEDs posed a new and real threat**
  - Existing capabilities couldn't detect or defeat the threat
  - The military urgently needed new capabilities fast
- **Army created the Joint IED Defeat Organization (JIEDDO) with the sole purpose of defeating this new operational risk**
  - Ability to bypass traditional acquisition process
  - Fielded less mature, but effective solutions
  - Lives were saved
- **Quickly fielded systems lacked certain quality attributes such as robustness, evolvability, and maintainability**
- **Tactical mission risks mitigated yet strategic business risks ignored: Total Cost of Ownership and Logistical Complexity Increased**

Operational Risk to Balance the Need

- The purpose of any new system, component or capability development should be to mitigate operational risk
- During development, operational risk changes
- Systems engineering activities during the project lifecycle should evolve through operational risk considerations

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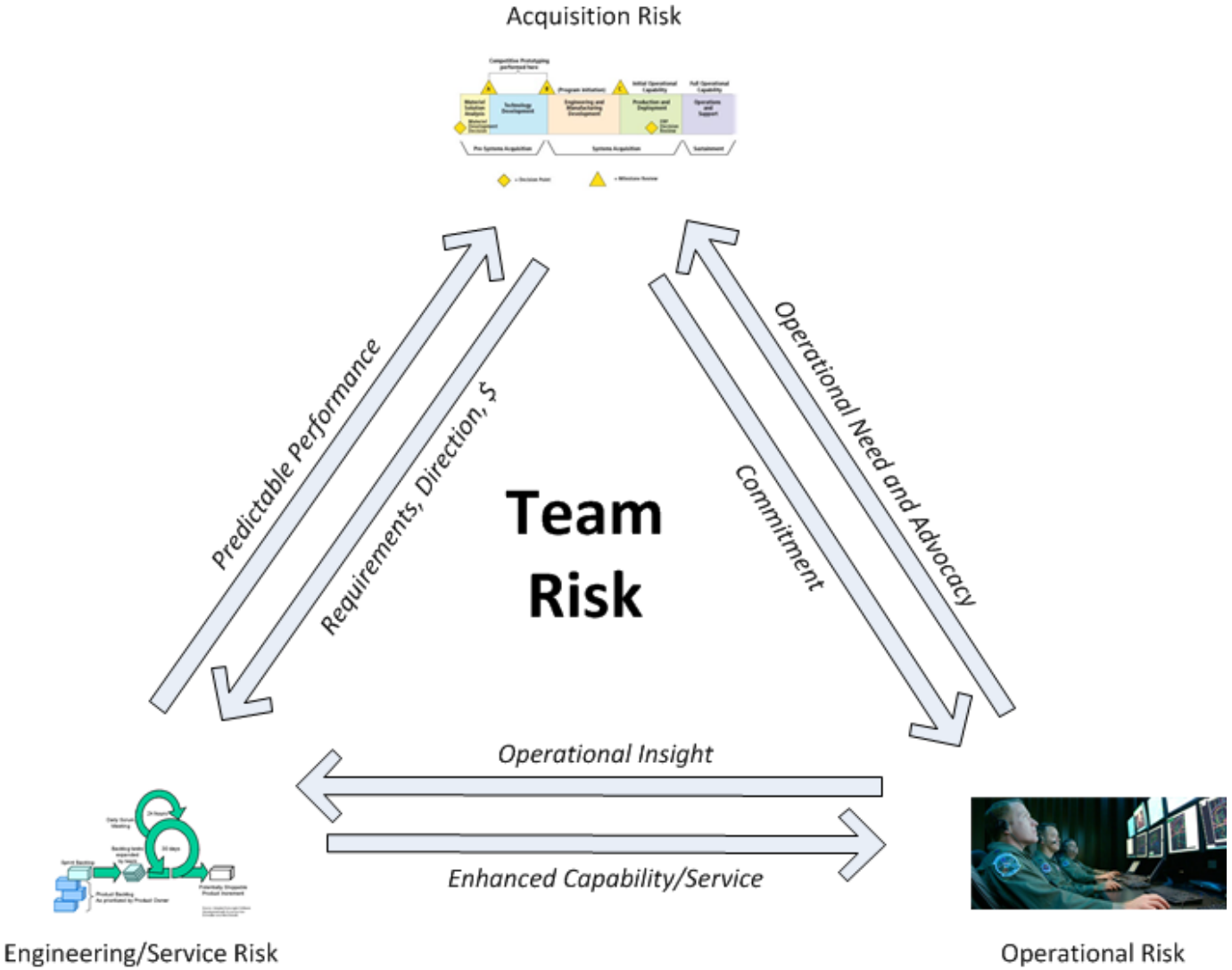
Research Questions

- What techniques can be used to influence Systems Engineering with Operational Risk considerations?
- Does a focus on Operational Risk during the Systems Engineering lifecycle improve program outcomes?

Typical Risk Management

- **Acquisition Risk Management During Acquisition Planning and Execution**
  - Focus is on programmatic risk
- **Program and Engineering Risk Management During Development**
  - Identify and mitigate risks associated with cost and schedule
  - Identify and mitigate technical risks associated with technical approach
- **Concept of Operational Risk is Lacking**

The More Effective Approach



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Gallagher, B.P., *Interpreting Capability Maturity Model Integration (CMMI) for Operational Organizations.* 2002.

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Traditional Operational Risk Management

- **Financial and Banking Industry**
  - Focused on the goal of reducing the probability of loss due to events such as fraud, mismanagement, system failures, failed investments, or legal considerations.

Jarrow, R.A., *Operational risk.* Journal of Banking & Finance, 2008. 32(5): p. 870-879.

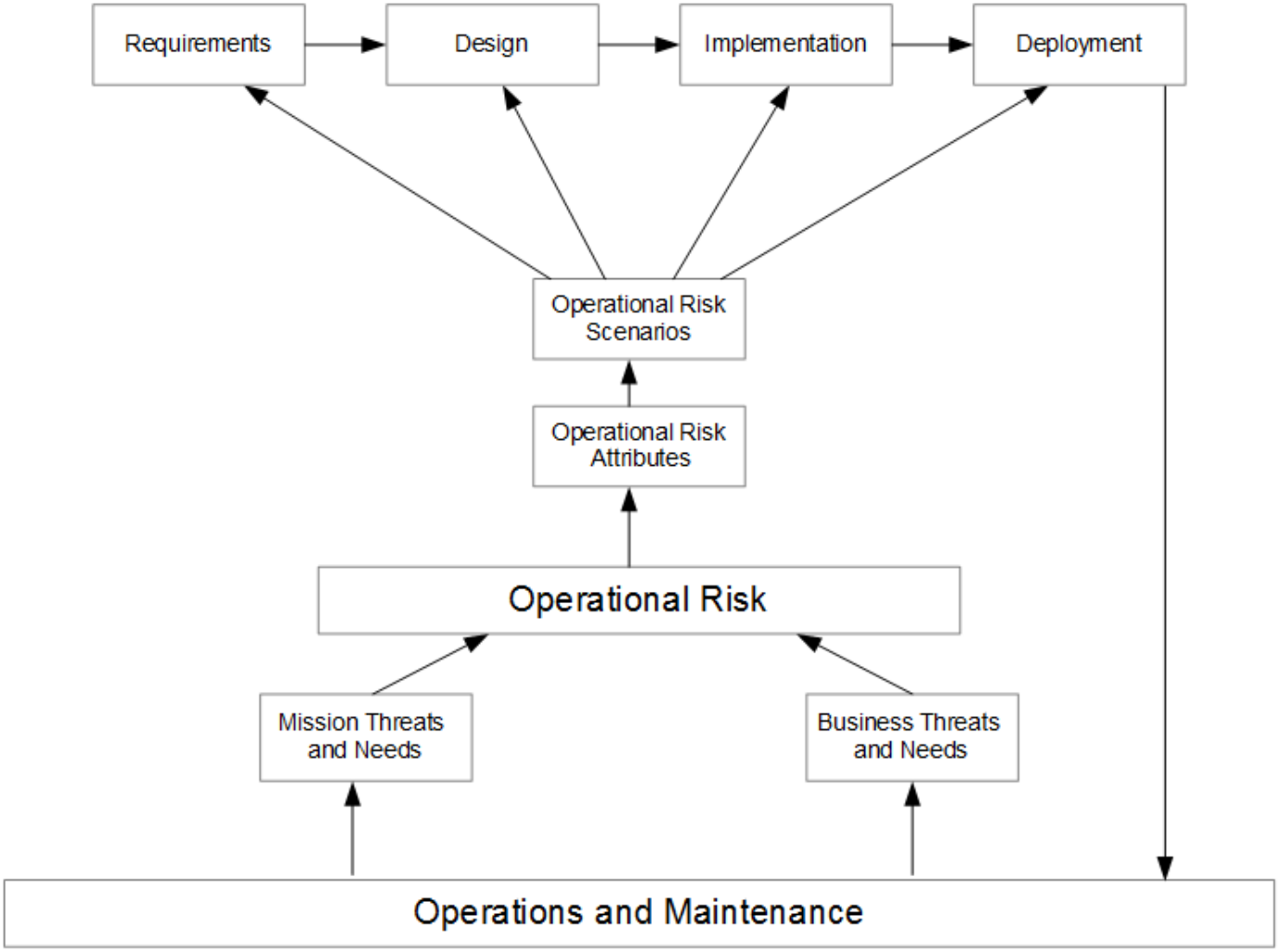
- **Military Operations**
  - Focused on the identification and elimination of hazards. A hazard is defined as :
    - "Any real or potential that can cause personal injury or death, property damage or mission degradation or damage to environment"

OPNAV, *3500.39 B.(2004).* Operation risk management, 2004.

More General Definition

Operational Risk	*The possibility of suffering mission or business loss.*
Operational Risk Management	*An operational practice with processes, methods, and tools for managing risks to successful mission and business outcomes.* *It provides a disciplined environment for proactive decision making to:* *- continually assess what could go wrong (operational risks)* *- determine which operational risks are most important to deal with, and* *- implement strategies to address operational risk*

Operational Risk-Driven Engineering Requirements/ Engineering Development (ORDERED)



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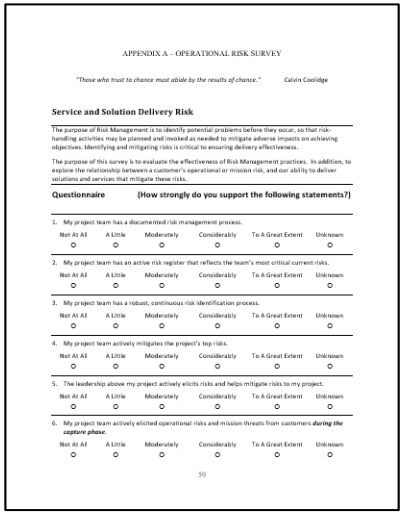
ORDERED Risk Taxonomy

ORDERED Taxonomy	
A. MISSION	B. BUSINESS
1. Mission Planning	1. Resource Planning
a. Stability	a. Workforce
b. Completeness	b. Budget
c. Clarity	c. Facilities
d. Feasibility	d. Equipment and Systems
e. Precedents	
f. Agility	
2. Mission Execution	2. Governance
a. Efficiency	a. Policies
b. Effectiveness	b. Procedures
c. Repeatability	c. Organizational Structure
d. Agility	d. Contracts
e. Affordability	e. Analytics
f. Security	f. Compliance
g. Safety	g. Risk Management
3. Mission Outcomes	3. Strategic Planning
a. Predictability	a. Vision and Mission
b. Accuracy	b. Values
c. Usability	c. Goals
d. Timely	d. Objectives
e. Efficient	e. Monitoring
4. Operational Systems	4. Stakeholder Management
a. Throughput	a. Identification
b. Usability	b. Stakeholder Mgmt Plan
c. Flexibility	c. Engagement
d. Reliability	d. Controlling
e. Evolvability	
f. Security	
g. Supportability	
h. Inventory	
5. Operational Processes	5. Continuous Improvement
a. Suitability	a. Problem Identification
b. Repeatability	b. Opportunity Identification
c. Predictability	c. Root Cause Analysis
d. Agility	d. Improvement Planning
e. Security	e. Implementation
6. Operational Staff	
a. Skill Level	
b. Training	
c. Turnover	
d. Affordability	

Does a Focus on Operational Risk Help?

- **Survey of 104 Program Managers**
  - Examined Risk Process Effectiveness
  - Explored the Project's focus on Operational Risk and Quality Attributes during early lifecycle activities and during execution
  - Explored project performance
- **System Dynamics Model**
- **Case Study Analysis**
  - Developed characteristics of effective operational risk management practices to influence systems engineering
  - Evaluated published case studies against characteristics for successful and challenged programs



APPENDIX A – OPERATIONAL RISK SURVEY

"Those who trust to chance must abide by the results of chance." Calvin Coolidge

Service and Solution Delivery Risk

The purpose of Risk Management is to identify potential problems before they occur, so that risk-handling activities may be planned and invoked as needed to mitigate adverse impacts on achieving objectives. Identifying and mitigating risks is critical to ensuring delivery effectiveness.

The purpose of this survey is to evaluate the effectiveness of Risk Management practices. In addition, to explore the relationship between a customer's operational or mission risk, and our ability to deliver solutions and services that mitigate these risks.

Questionnaire **(How strongly do you support the following statements?)**

1. My project team has a documented risk management process.
   Not At All | A Little | Moderately | Considerably | To A Great Extent | Unknown
2. My project team has an active risk register that reflects the team's most critical current risks.
   Not At All | A Little | Moderately | Considerably | To A Great Extent | Unknown
3. My project team has a robust, continuous risk identification process.
   Not At All | A Little | Moderately | Considerably | To A Great Extent | Unknown
4. My project team actively mitigates the project's top risks.
   Not At All | A Little | Moderately | Considerably | To A Great Extent | Unknown
5. The leadership above my project actively elicits risks and helps mitigate risks to my project.
   Not At All | A Little | Moderately | Considerably | To A Great Extent | Unknown
6. My project team actively elicited operational risks and mission threats from customers ***during the capture phase.***
   Not At All | A Little | Moderately | Considerably | To A Great Extent | Unknown

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Goal 1	**Engineering Plans Mitigate Operational Risk**	
	Specific Practice 1.1	**Manage Operational Risks** *Operational risks, driven by requirements prioritization decisions, are explicitly captured as risk statements and mitigation plans developed.*
	Specific Practice 1.2	**Engineering plans mitigate operational risk** *Engineering plans (methodologies, lifecycles, etc.) are developed to mitigate both development and operational risk.*
	Specific Practice 1.3	**Engineering plans are influenced by evolving operational risk** *Engineering plans are evolved when mission or business needs evolve.*
	Specific Practice 1.4	**Transition to operations and support plans mitigate operational risk** *Operational risk considerations influence transition to operations and support plans which are developed or adjusted to mitigate operational risk.*
Goal 2	**Lifecycle engineering activities mitigate operational risk.**	
	Specific Practice 2.1	**End-users participate in systems engineering activities by identifying operational risk** *End-users participate continuously during the systems engineering process by identifying and prioritizing operational risk taking into consideration evolving mission and business needs.*
	Specific Practice 2.2	**Operational risk considerations validate system requirements** *System requirements are developed and validated based on an analysis of mission and business threats, needs and operational risk.*
	Specific Practice 2.3	**System requirements balance mission and business needs** *Validated system requirements balance short-term mission needs and longer-term business needs.*
	Specific Practice 2.4	**Operational risk considerations influence systems engineering artifacts**

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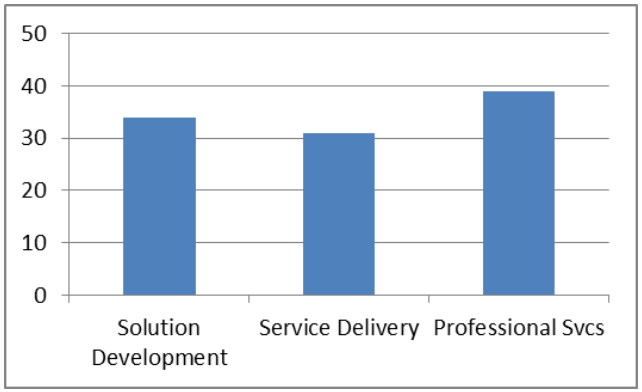
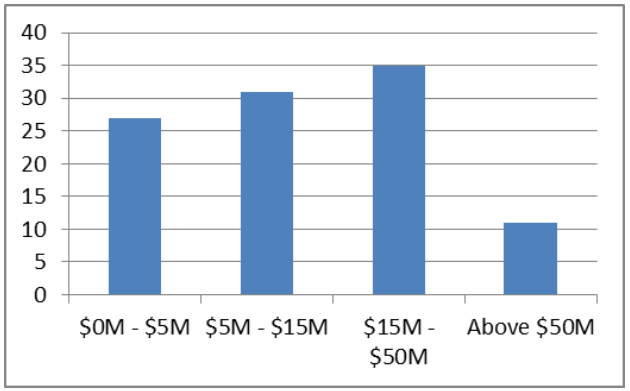
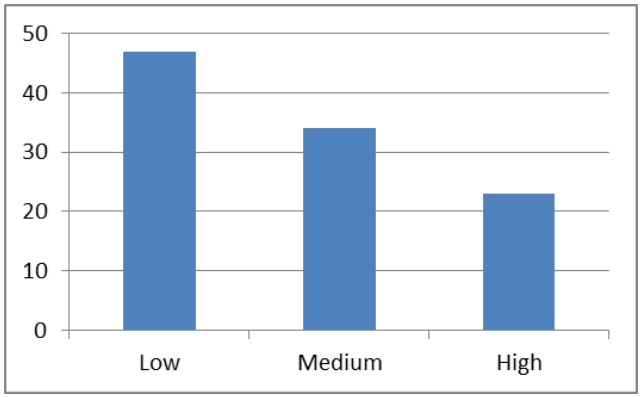
Survey Program Characteristics



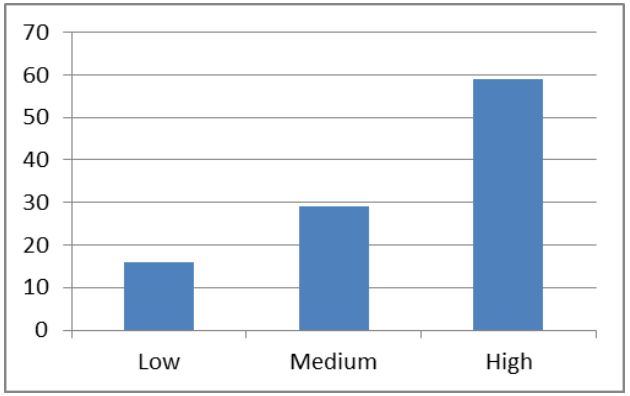
Program Type



Annual Program Value



Risk



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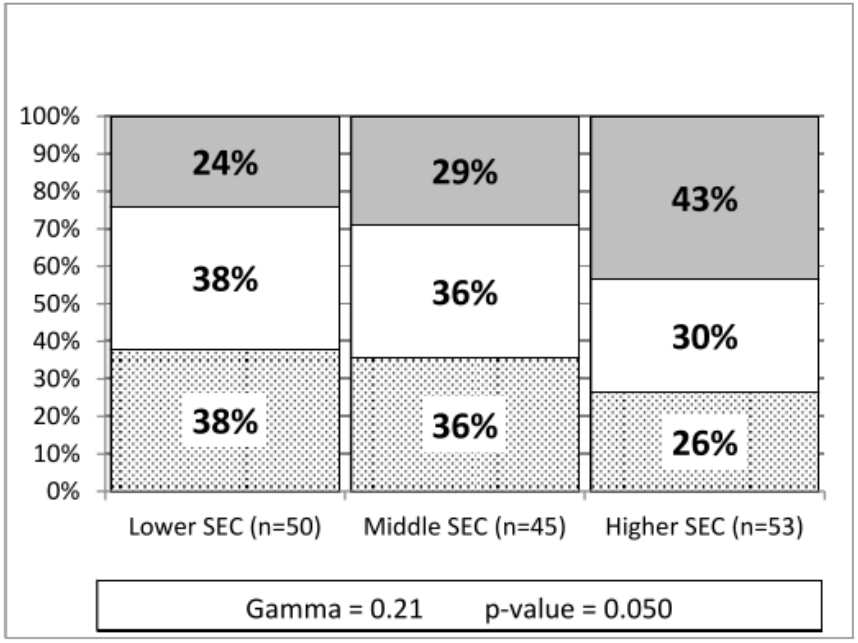
Risk Survey – Early Results

- **Results Compared to Similar Studies**



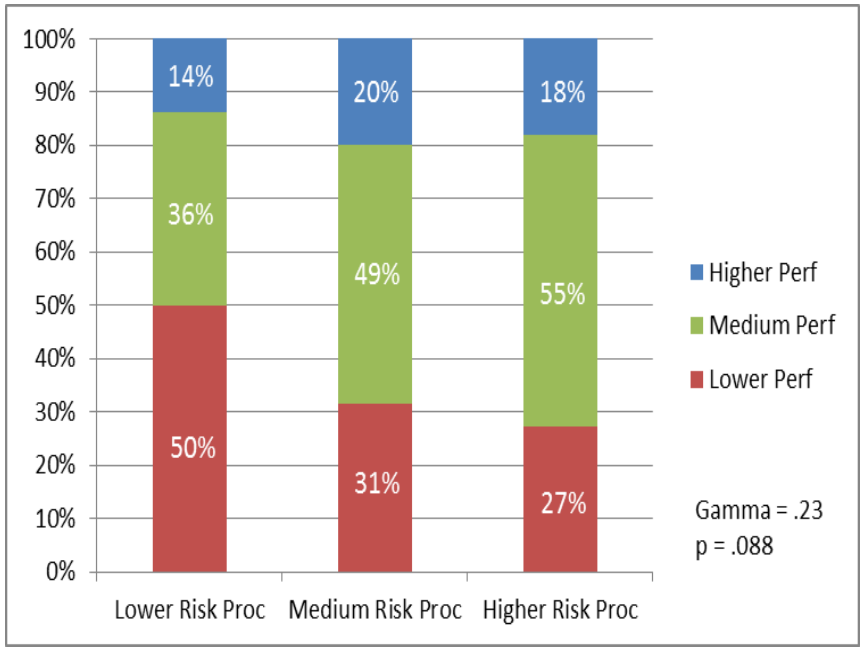


*Figure 45: **SEC-RSKM** vs. **Perf***

"Examination of this chart reveals a moderate supporting relationship between SEC-RSKM and Perf."

Elm, J.P. and D.R. Goldenson, The Business Case for Systems Engineering Study: Results of the Systems Engineering Effectiveness Survey. 2012, DTIC Document.

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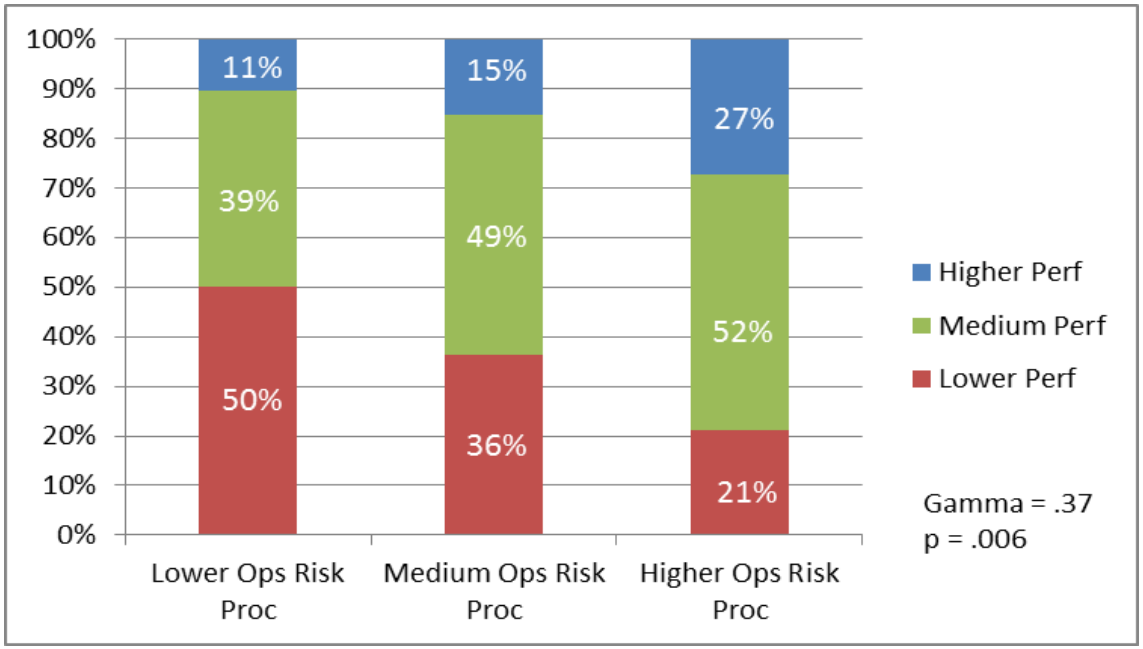
Program Performance and Operational Risk



***Operational* Risk Process Effectiveness and Program Performance**

Programs within the sample who focus on operational risk during the program lifecycle also have better program performance than programs that focus less on operational risk during the program lifecycle.

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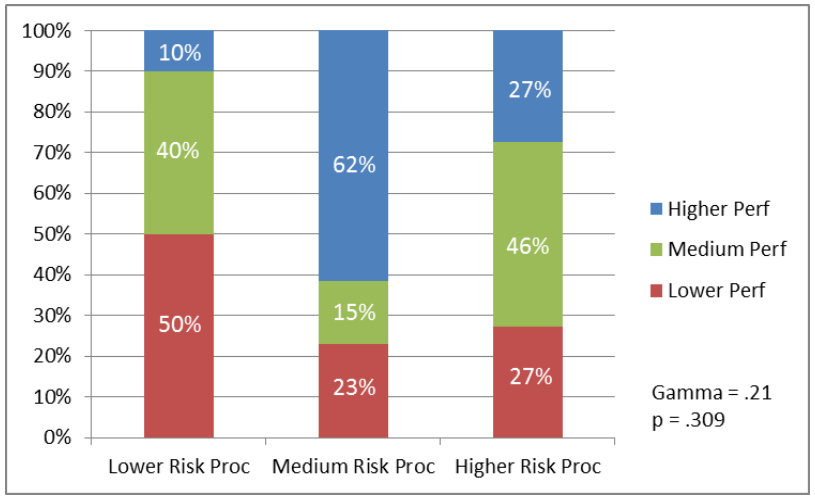
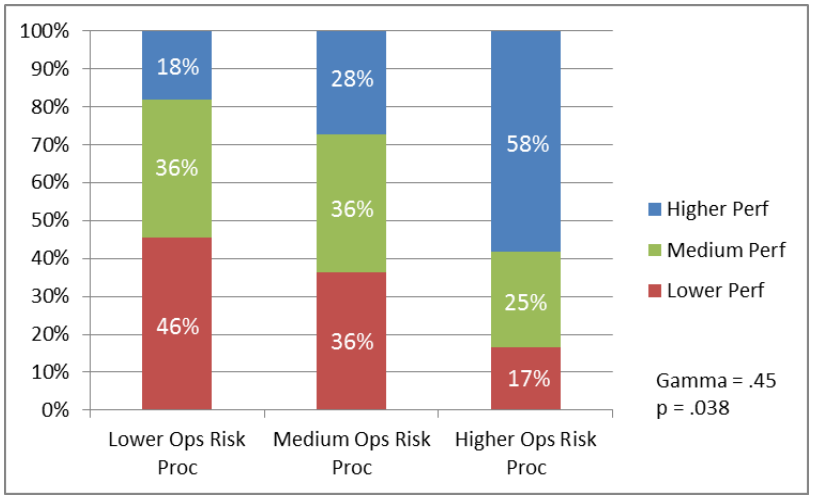
Survey Results – *Solution Development* Programs Only



Risk Process Effectiveness and Program Performance



***Operational* Risk Process Effectiveness and Program Performance**

The relationship between Operational Risk and Program Outcomes holds and is even stronger when only Solution Development projects are examined.

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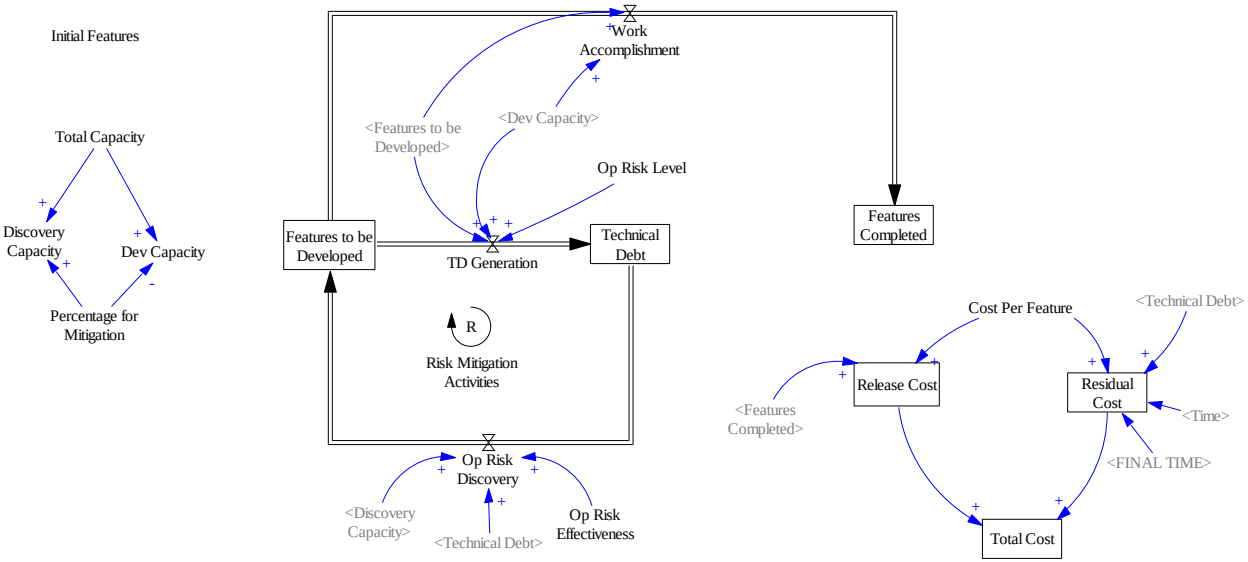
Systems Dynamics Model: Operational Risk and Technical Debt



Model Initial Variables	
Variable	**Value**
Initial Features	648
Completed Features	0
Total Capacity	30
Op Risk Level	0.2
Op Risk Effectiveness	0.5
Cost per Feature	$1,000
Technical Debt	0
Release Cost	0
Residual Cost	0
Total Cost	0

	Model Outputs						
Percentage for Mitigation	**Features Completed**	**Release Months**	**Technical Debt (features) Addressed in the Release**	**Release Cost**	**Residual Technical Debt (features)**	**Residual Cost**	**Total Cost**
0%	648	22	0	$648,000	129.6	$3,758,400	$4,406,400
10%	684	26	36	$684,000	99.3	$2,879,700	$3,563,700
20%	735	31	87	$735,000	57	$1,653,000	$2,388,000
25%	765	34	117	$765,000	29.25	$848,250	$1,613,250
30%	798	38	150	$798,000	4.2	$121,800	$919,800

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Characteristics of Effective Operational Risk Focus during Systems Engineering Process

Goal 1	**Engineering Plans Mitigate Operational Risk**	
	Specific Practice 1.1	**Manage Operational Risks** *Operational risks, driven by requirements prioritization decisions, are explicitly captured as risk statements and mitigation plans developed.*
	Specific Practice 1.2	**Engineering plans mitigate operational risk** *Engineering plans (methodologies, lifecycles, etc.) are developed to mitigate both development and operational risk.*
	Specific Practice 1.3	**Engineering plans are influenced by evolving operational risk** *Engineering plans are evolved when mission or business needs evolve.*
	Specific Practice 1.4	**Transition to operations and support plans mitigate operational risk** *Operational risk considerations influence transition to operations and support plans which are developed or adjusted to mitigate operational risk.*

Label	Meaning
LOW	The intent of the model practice is judged absent or inadequately addressed in the approach; goal achievement is judged unlikely because of this absence or inadequacy.
MEDIUM	The intent of the model practice is judged to be partially addressed in the approach, and only limited support for goal achievement is evident.
HIGH	The intent of the model practice is judged to be adequately addressed in the set of practices (planned or deployed) in a manner that supports achievement of the goal in the given process context

Goal 2	**Lifecycle engineering activities mitigate operational risk.**	
	Specific Practice 2.1	**End-users participate in systems engineering activities by identifying operational risk** *End-users participate continuously during the systems engineering process by identifying and prioritizing operational risk taking into consideration evolving mission and business needs.*
	Specific Practice 2.2	**Operational risk considerations validate system requirements** *System requirements are developed and validated based on an analysis of mission and business threats, needs and operational risk.*
	Specific Practice 2.3	**System requirements balance mission and business needs** *Validated system requirements balance short-term mission needs and longer-term business needs.*
	Specific Practice 2.4	**Operational risk considerations influence systems engineering artifacts** *Derived and sub-system requirements, architecture, designs, and technical decisions are influenced by operational risk considerations.*
	Specific Practice 2.5	**Technical solutions are influenced by evolving operational risk** *Technical solutions are evolved when mission or business needs evolve.*
	Specific Practice 2.6	**Operational risk considerations influence technical decisions** *Technical decisions to defer or accelerate capabilities during development are made based on a thorough consideration of operational risk.*

Case Studies Evaluated

- Business Transformation within a Russian Information Technology Company
- The Hubble Space Telescope
- Mission INtegration and Development
- Enterprise Resource Planning (ERP) Systems Implementation at Pharma Inc.
- Titan Survey portion of the NASA/ESA Cassini/Huygens Mission to Saturn
- Denver International Airport (DIA) Baggage Handling System
- The Air Force's Expeditionary Combat Support System (ECSS)
- The Marine Corps' Expeditionary Fighting Vehicle
- New York Subway Communications System

Case Study Results

Successful Programs											
	SP 1.1	SP 1.2	SP 1.3	SP 1.4	SP 2.1	SP 2.2	SP 2.3	SP 2.4	SP 2.5	SP 2.6	Score
Case 1	H	H	H	M	H	H	L	H	M	L	38
Case 2	H	H	M	M	H	H	M	H	H	L	37
Case 3	H	H	H	H	H	H	M	M	H	M	44
Case 4	H	H	H	M	M	H	M	H	M	L	38
										Average	39.25
Challenged Programs											
	SP 1.1	SP 1.2	SP 1.3	SP 1.4	SP 2.1	SP 2.2	SP 2.3	SP 2.4	SP 2.5	SP 2.6	Score
Case 1	M	L	L	L	H	L	L	L	L	L	16
Case 2	L	L	L	M	L	L	L	L	M	M	16
Case 3	M	L	L	L	L	L	L	L	L	L	12
Case 4	L	M	L	M	L	L	L	M	L	L	16
Case 5	L	L	L	L	M	L	L	L	L	L	11
										Average	14.2

Summary

- **Using Operational Risk considerations during the Systems Engineering lifecycle will increase the likelihood of fielding an operationally effective system, component or capability**
- **The ORDERED process is a structured approach allowing operational risk to influence systems engineering**
- **Programs that focus on operational risk during the engineering lifecycle also exhibit better program outcomes**

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Questions?

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