



Annie Oakleying the Risk Cube – Management Goes Better with Analysis

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Abstract

Despite advances in both Risk Management and Risk Analysis over the past two decades, there remains a persistent divide between the two disciplines. Risk Management, with its predisposition to discrete risks (“what could go wrong?”) and central construct of the Risk Cube, tends to have a myopic focus on Issues and struggles to accurately assess and portray Likelihood and Consequence. Risk Analysis, with its predisposition to continuous risks (“what is the range of possible outcomes?”) and central construct of the S-Curve, brings the mathematical tools needed for fidelity in risk calculations but struggles to put a recognizable face on these necessary abstractions. This paper seeks to unify these two fields by drawing the best from each. It identifies fundamental deficiencies in the Risk Cube, such as lack of basis, distortion of linear scales, misleading color codes, and junk math, and remedies them with principles from Risk Analysis to better inform decision-makers.

Track: Management, EVM, and Scheduling

<https://www.iceaaonline.com/atl25sessions/#MESTrack>

Keywords: *Communication, IPM, Methods, Modeling, Risk, Risk Management, Risk Analysis*

Meet the Authors



Peter Braxton

Subject Matter Expert

Mr. Peter Braxton is a Subject Matter Expert and Employee Owner at Technomics, Inc. He has over 25 years of experience performing cost and risk analysis and delivering associated training for a broad spectrum of federal government clients. The inaugural VP for Professional Development and a multiple ICEAA Educator of the Year winner, he has shown a long-standing commitment to knowledge sharing within the community.



Dave Brown

Subject Matter Expert

Mr. Dave Brown is a SCEC/CCEA certified Subject Matter Expert for Technomics, Inc. He has more than 30 years of experience providing cost estimating and analysis to DoD and DHS clients. His primary area of expertise is in IT and software estimating, with products such as life cycle cost analysis, applied cost estimating, independent cost assessment, cost research, risk analysis, program management support (including risk management), modeling and simulation, data analysis, and database development.



Robert Fatzinger

Capture Director

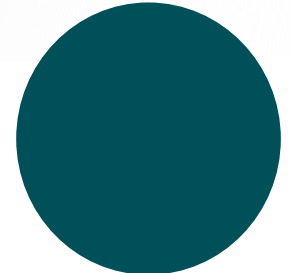
Mr. Bob Fatzinger's capabilities and industry experience allow him to resolve complex problems and provide analytics-based decision support relevant to critical resource investment choices. He currently serves as a Project Manager and subject matter expert on several DOE contracts. Mr. Fatzinger previously participated in major acquisition programs with DHS, the Intelligence Community, and U.S. Navy.



Sean Wells

Lead Analyst

Mr. Sean Wells has been with Technomics since July 2023 and currently provides cost support to Navy Integrated Warfare Systems 6.0 and the Canadian National Shipbuilding Service. Sean has an MS in Contracts Acquisition and Management from the Florida Institute of Technology and has 5+ years of professional experience working Ford Class Carrier and Virginia Class Submarine estimates. He is an ICEAA Certified Cost Estimator/Analyst (CCEA).



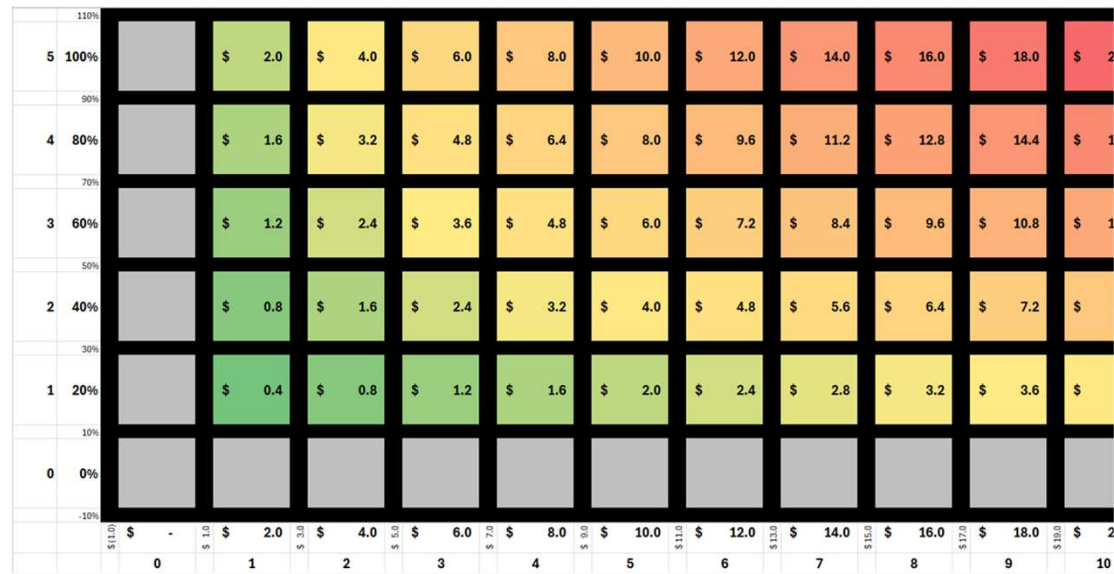
Bottom Line Up Front (BLUF) – The Epiphany

Broke – Traditional Risk Cube

IMPACT / CONSEQUEN	Cost	Rare < 20%	Unlikely > 20% < 40%	Possible > 41% < 60%	Likely > 60% < 80%	Almost Certain > 81%
		A	B	C	D	E
>= \$100M Severe	5	5A	5B	5C	5D	5E
	4	4A	4B	4C	4D	4E
\$25M to <\$100M Major	3	3A	3B	3C	3D	3E
	2	2A	2B	2C	2D	2E
\$5M to <\$25M Moderate	1	1A	1B	1C	1D	1E
	<\$1M Insignificant					



Woke – Centered Risk Cube



“Fence Posts and Fence Rails” -R. Coleman

Outline

○ Risk Management (RM) vs. Risk Analysis (RA)

○ Risk Current State of Practice

○ Risk Management Notional Example

○ Risk Framework

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○ Risk Register, Risk Cube, and Risk Data Visualization

2

○ Risk Management and Risk Analysis – Best of Both Worlds

3



Annie Oakleying the Risk Cube

Management Goes Better with Analysis

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*“Anything you can do, I can do better /
I can do anything better than you”*

Annie Oakley, Annie Get Your Gun

Cost Analysts and Annie Oakley

Discipline	Standard Practice	Example Cost Contributions
Earned Value Management (EVM)	“Statistical” Estimate At Completion (EAC)	Progress-Based EAC
Contract Management	Cost Plus vs. Fixed Price vs. Incentive Contracts	Risk-Based Contract Price Methodology (RCPM)
Agile Software	Jira, Burndown Charts	Sizing Uncertainty, Feature Efficiency
Data Science	Data Wrangling, Machine Learning (ML)	Data Normalization, Bespoke Regression Models
Risk Management	Risk Registers, the Risk “Cube”	...stay tuned...

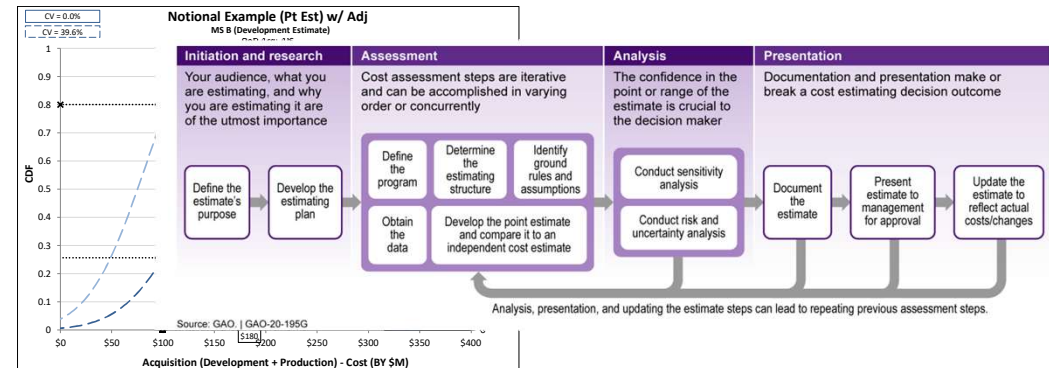
- Cost Analysts have the annoying habit thinking they can do a better job of sister disciplines than practitioners themselves!
 - Cost Analysts have polymath tendencies, are naturally curious, and are trained to learn by immersion
 - Strong analytical skills, the parametric thought process, and a fresh perspective enable us to transcend braggadocio and make meaningful contributions



Risk Management (RM) vs. Risk Analysis (RA)

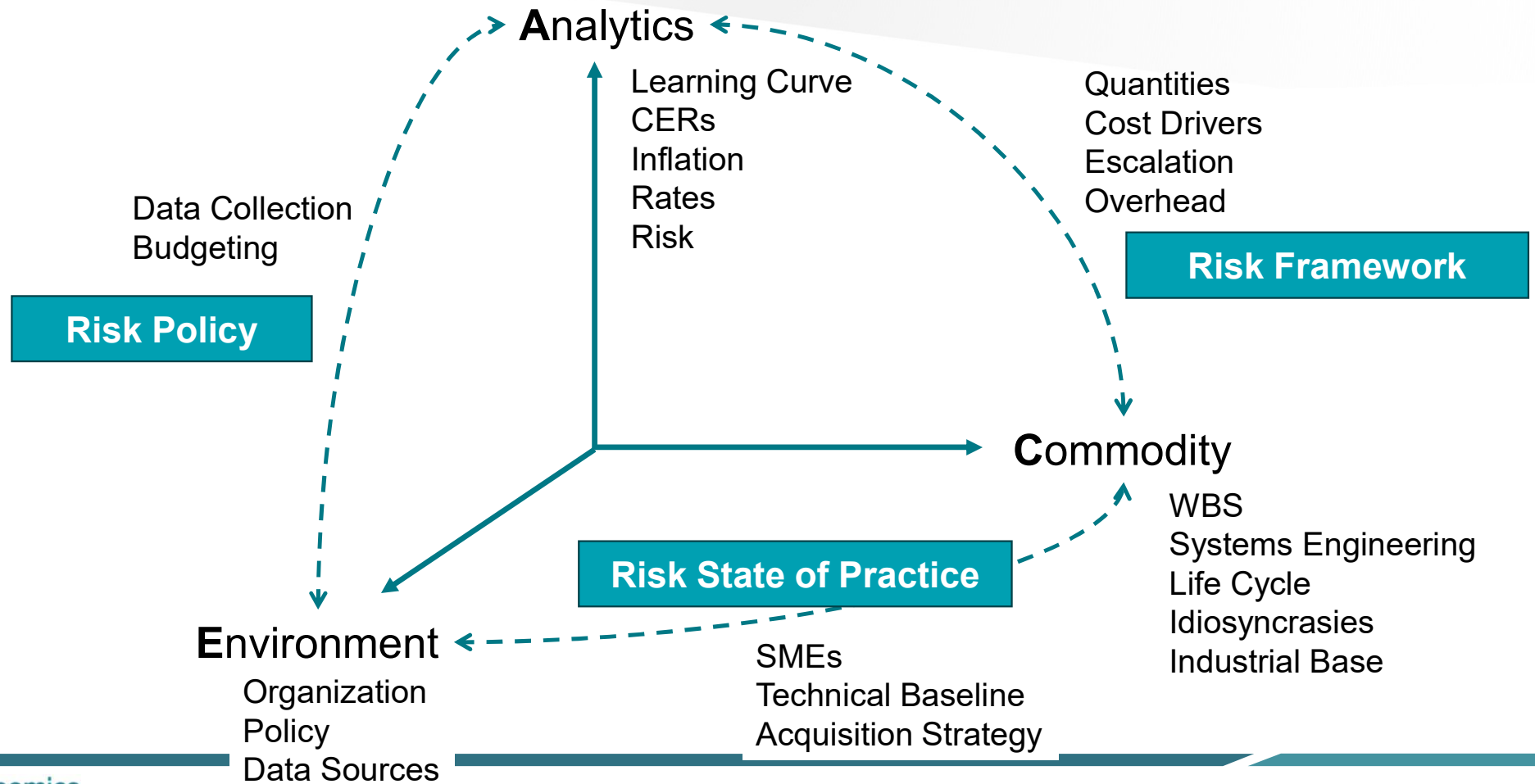
Engineers / Deterministic / RM	Statisticians / Stochastic / RA
Risk Cube / Risk Register	S-Curve / Probability Distributions
DoD RIO 5-step process	GAO 12-step process
Variability is to be controlled (Lean Six Sigma)	Variability is to be expected (Stuff Happens)
Framing Assumptions and Conditional Estimates	Ground Rules and Assumptions (GR&A) and Unconditional Estimates
Root Cause Analysis (RCA)	Cost and Schedule Growth Analysis
Inputs Risk	Outputs Risk

IMPACT / CONSEQUEN Cost		Rare < 20%	Unlikely > 20% < 40%	Possible > 41% < 60%	Likely > 60% < 80%	Almost Certain > 81%
		A	B	C	D	E
>= \$100M	5 Severe	5A				
\$25M to <\$100M	4 Major	4A				
\$5M to <\$25M	3 Moderate	3A				
\$1M to <\$5M	2 Minor	2A				
<\$1M	1 Insignificant	1A				



Strengths and Weaknesses to both RM and RA

The ACE Construct



Risk Current State of Practice



- Survey of organizations based on personal experience in those environments
- State of practice for both RM and RA
- Stated policy

Area of RA and RM Maturity	DoD	DOE	DHS	IC	Canada
RM Process	4.0	4.0	4.0	4.0	4.0
Risk Cube Application	4.0	4.0	4.0	3.0	3.0
Cost Risk Uncertainty Analysis (CRUA)	4.0	4.0	3.0	3.0	2.0
Schedule Risk Analysis (SRA)	3.0	4.0	2.0	2.0	2.0
Integrated Cost Schedule and Risk Analysis (ICSRA)	2.0	4.0	1.0	1.0	2.0
Budgets based on risk adjusted estimates	3.0	4.0	4.0	4.0	2.0
Acquisition based on risk adjusted position	4.0	4.0	4.0	4.0	4.0
Acquisition level (ACAT) determined by risk adjusted estimates	3.0	3.0	4.0	3.0	NA
Acquisition Affordability Determination	2.0	2.0	4.0	3.0	3.0
Management Reserve and Contingency established through risk adjusted estimates	2.0	4.0	2.0	2.0	3.0
Formal Risk Policy Established and Maintained	3.0	4.0	4.0	3.0	0.0
Risk Management Guidance Established and Maintained	4.0	4.0	4.0	4.0	4.0
Cost Risk Uncertainty Analysis Guidance	4.0	4.0	3.0	4.0	2.0
Schedule Risk Analysis Guidance Documented	2.0	4.0	0.0	1.0	2.0
Training Available	4.0	4.0	4.0	4.0	4.0

4.0	Policy is well defined and integrated with related financial management policy; it covers acquisition by milestone, and has both practices and guidance for RA and RM throughout the project lifecycle.
3.0	Policy is well defined and agency tailored; it covers acquisition by milestone and includes some RA and RM techniques and tactics but lacks clarity and direction as to the proper application of the policy.
2.0	Policy is defined or required for use within the Agency; it may cover acquisition by milestone, it slanted to an singular RA or RM view but not both
1.0	Policy is ill defined (leveraged from outside agency) regarding acquisition by milestone
0.0	Policy or practice is non-existent
NA	Measure not applicable for this organization

RM Notional Example

- **Assumptions:** ground rules for which risks are to be considered
- **Risk Register:** the structure of the table itself, what data and metadata are included
- **Risk Viewer:** a means to view the detailed data and metadata for an individual risk without having to scroll down the rows (individual RIOs) and across the columns (data fields) of the table
- **Risk Cube:** The display of risks on a 5x5 square-of-squares (not really a cube!)
- **RIOs:** The contents of the Risk Register (Risks, Issues, and Opportunities)

Title
Integration Risk

Project: **PMO XYZ**

RIO Type: **Risk**

Priority Level: **Medium**

Probability: **Medium** | Impact: **High**

Escalation Data: **10/31/2024**

Unique ID: **XYZ-139**

POC(s): **Genevieve Desjardins – XYZ GOV**
Ernest Thayer – XYZ GOV

Risk Owner: **Dave Davidson – XYZ CTR**

Risk Statement
***IF* subsystem interfaces are not well-documented, *THEN* integration may be delayed, incurring rework and additional cost.**

Mitigation: **XYZ Systems Engineering is working to identify and document all subsystem interfaces and other dependencies.**

RM Notional Example – Risk Cube

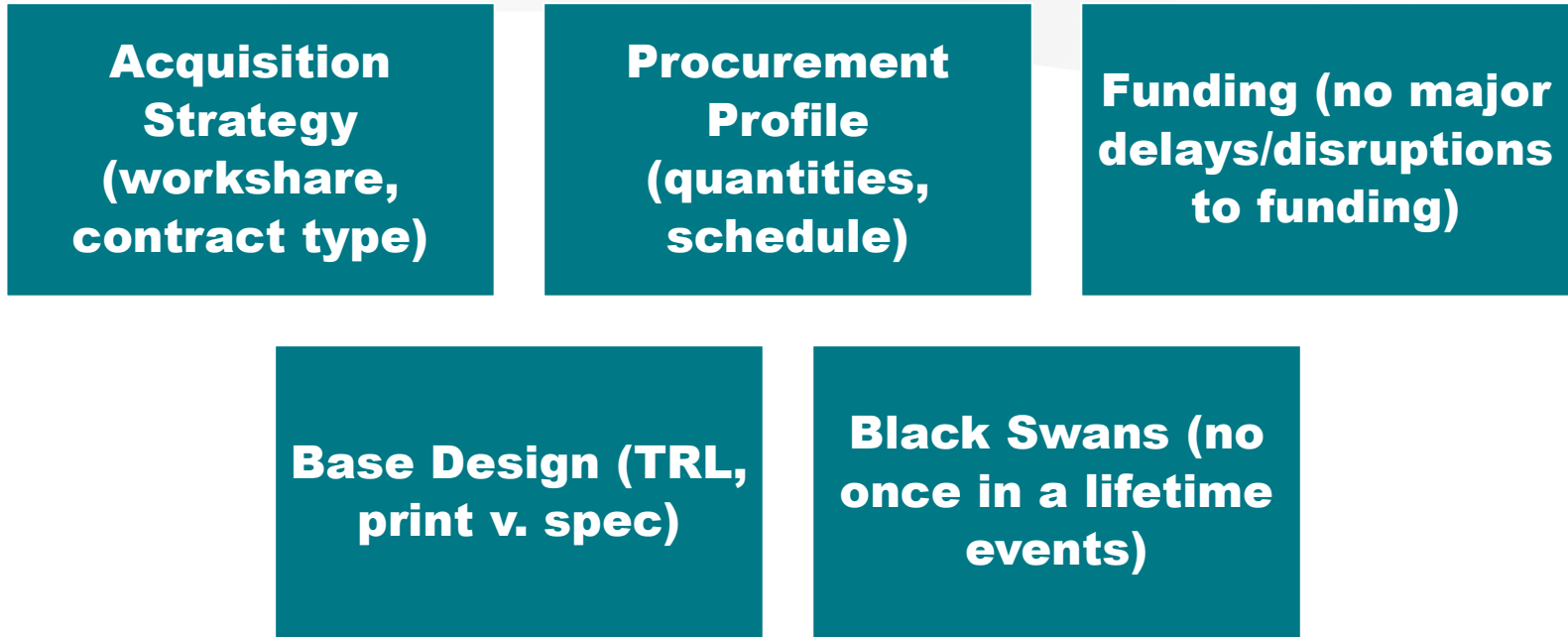
IMPACT / CONSEQUENCE				Rare < 20%	Unlikely > 20% < 40%	Possible > 41% < 60%	Likely > 60% < 80%	Almost Certain > 81%
Cost	Schedule	Technical		A	B	C	D	E
>= \$100M	> 52 weeks	Platform- lose a major capability	5 Severe	5A	5B	5C	5D	5E
\$25M to <\$100M	26 to 52 weeks	Platform - degradation of a major capability	4 Major	4A	4B	4C	4D	4E
\$5M to <\$25M	12 to 26 weeks	Platform - loss or degradation of a system	3 Moderate	3A	3B	3C	3D	3E
\$1M to <\$5M	4 to 12 weeks	Subsystem - experience a reduction in technical/expected performance	2 Minor	2A	2B	2C	2D	2E
<\$1M	< 4 weeks	No significant reduction	1 Insignificant	1A	1B	1C	1D	3E

Severity	Very High
	High
	Significant
	Moderate
	Low

The Program Manager's Serenity Prayer:

*Grant me the serenity to accept the risks I cannot mitigate;
the courage to mitigate the risks I can; and the wisdom to know the difference.*

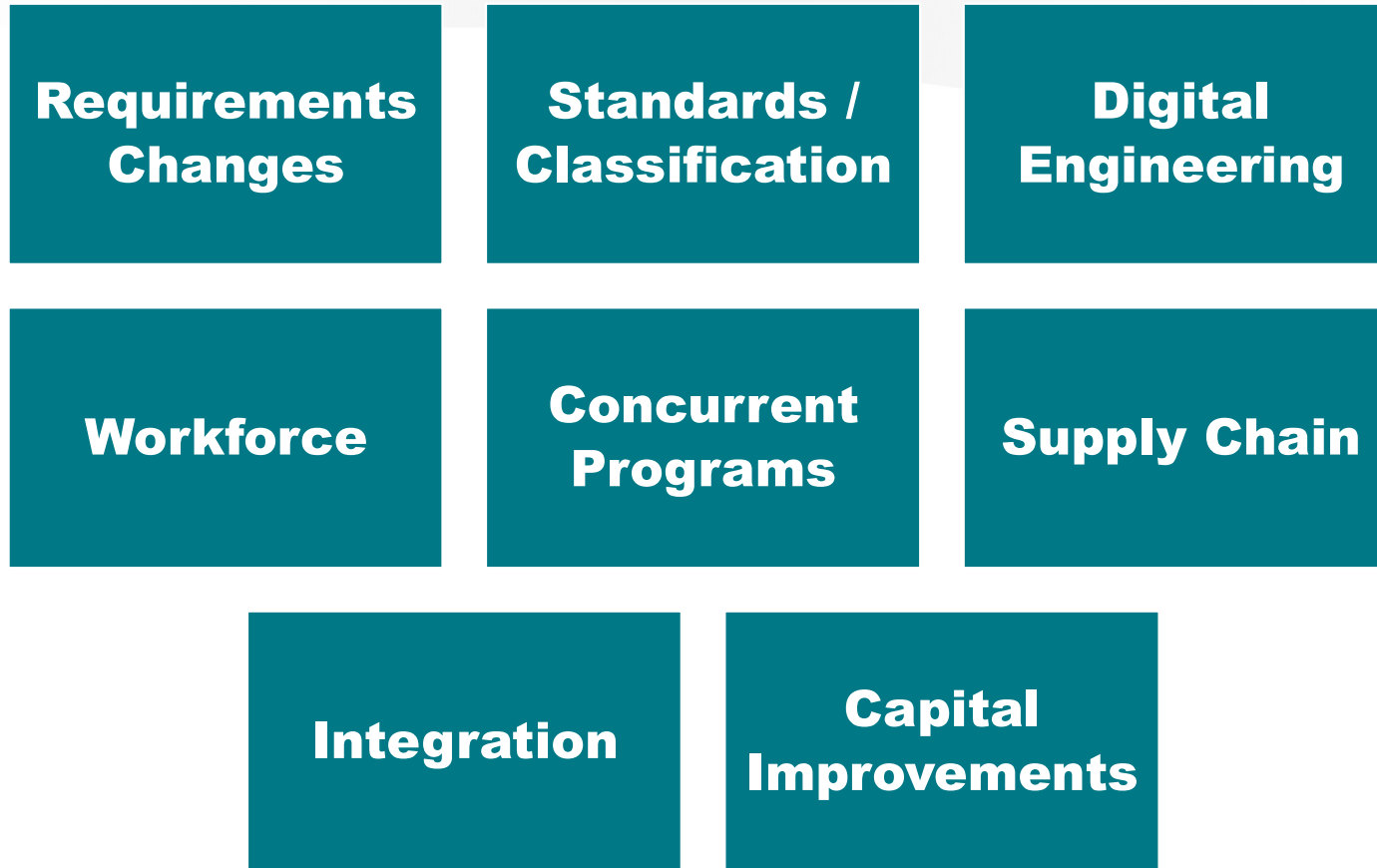
Risk Framework – Framing Assumptions



Area	Subarea	Shipbuilding	CapAx	SW/IT
Acquisition Strategy	Competition	Ship type and IB;	Open Competition vs.. Limited	Generally competitive.
		program swaps	Specialized Competition or Sole Source	No impact on cost.



Risk Framework – Discrete Risks



1



Risk Framework – Uncertainties

1



Risk Framework – Unifying RM and RA

1

Reboot the S-curve

- Framing Assumptions
 - Program-level assumptions upon which cost and schedule estimates fundamentally rest
 - Any substantive violation triggers re-estimation
 - The aspects we have the most (program decisions) and least (*force majeure*) control over
- Discrete Risks
 - Adverse events that *might* happen, impacting cost and/or schedule
 - Tracked in nested Contractor, Program, and Enterprise Risk Registers
 - Generally not included in bids and point estimates
- Uncertainties
 - Parametric cost estimate inputs that naturally vary over a significant range
 - Not a matter of *whether* they will happen, only a question of *how much* the impact will be
 - Should be included in all estimates, with net effect dependent on point estimate
 - If optimistic (aggressive), net *risk*; if pessimistic (conservative), net *opportunity*

Shift (and spread) the S-curve

Spread (and shift) the S-curve

Risk Cube per Mathematica (via ChatGPT)

mathematica Copy Edit

CONSEQUENCE (Impact)

	1	2	3	4	5	
5	M	H	H	C	C	← Almost Certain
4	M	M	H	H	C	← Likely
3	L	M	M	H	H	← Possible
2	L	L	M	M	H	← Unlikely
1	L	L	L	M	M	← Rare

1 2 3 4 5
(Negligible → Catastrophic)

Key:

- **L (Low Risk)** = Green 🟢 (Monitor)
- **M (Moderate Risk)** = Yellow 🟡 (Manage)
- **H (High Risk)** = Orange 🟠 (Mitigate)
- **C (Critical Risk)** = Red 🔴 (Immediate Action)

Would you like a more detailed version or a graphic representation? 😊

Adjectival
Ratings

Four-level
Severity Scale

Accessed 17 Feb 2025

Risk Register – Deficiencies and Remedies

2

- “Junk Math” is indulging the irresistible urge to manipulate or combine numbers in ways that have no meaning or are dangerously misleading based on what those numbers represent
- Examples:
 - Cost/Sked/Tech score conflation
 - If Cost = 4, Sked = 2, Tech = 3, then the product is 24, the sum is 9, the average is 3, the max is 4...
 - Impact/Likelihood products
 - Pf = 5, Cf = 4, and Pf = 4, Cf = 5 both give a product of 20, but most Risk Cube implementations are not symmetric in this way
 - Numbering the 5 x 5 Risk Cube in a (somewhat arbitrary) 1 to 25 sequence
- RA brings the proper analytical tools to “do math” with RM inputs
 - Spoiler alert: We’ll likely have to “fix” those inputs first...

Risk Viewer – Deficiencies and Remedies

- Data Integrity
- No “Junk Math”
- Clear Risk and Mitigation Status
- Pre- and Post-Mitigation Assessments

Temperature Scale for Risk Scores

Risk ID	Risk Type		Status		Raised By		Category		Risk Name		Risk Statement
2	Threat		Accepted		Original Estimating Risk Log		Certification / Standards		Certification		There is a risk that Industry will be instructed to comply with Standards or agreements/ understandings that are different from those specified in the Development Contract. Caused by: The government mandating adherence to different, more stringent standards.
	Prime Score		Integrator Score		Design Agent Score		Support Lead Score		Overall Score		
	Impact	Probability	Impact	Probability	Impact	Probability	Impact	Probability	Impact	Probability	
	1	1	2	3	3	5	1	1	3	5	
	Prime Mitigated Score		Integrator Mitigated Score		Design Agent Mitigated Score		Support Lead Mitigated Score		Overall Mitigated Score		
	N/A	N/A	N/A	N/A	1	2	N/A	N/A	1	2	
	Prime Mitigation Strategy		Integrator Mitigation Strategy		Design Agent Mitigation Strategy		Support Lead Mitigation Strategy		Final Mitigation Strategy		
	N/A		N/A		Ensure contractual terms and scopes of work are aligned to the Development Contract standards with no deviation therefore allowing the design and the build to continue on the same standards as designed. Any new standards introduced would be treated as a contractual change.		N/A		N/A		

Risk Cube – Deficiencies and Remedies

Square #	Impact Score	Likelihood Score	Midpoint Probability	Midpoint Cost	Expected Value Cost	Cost Rank	Severity (alleged)
1A	1	A	0.10	\$ 0.5	\$ 0.050	1	Low
1B	1	B	0.30	\$ 0.5	\$ 0.150	2	Low
1C	1	C	0.50	\$ 0.5	\$ 0.250	3	Low
2A	2	A	0.10	\$ 3.0	\$ 0.300	4	Low
1D	1	D	0.70	\$ 0.5	\$ 0.350	5	Moderate
1E	1	E	0.90	\$ 0.5	\$ 0.450	6	Moderate
2B	2	B	0.30	\$ 3.0	\$ 0.900	7	Low
3A	3	A	0.10	\$ 15.0	\$ 1.500	8.5	Low
2C	2	C	0.50	\$ 3.0	\$ 1.500	8.5	Moderate
2D	2	D	0.70	\$ 3.0	\$ 2.100	10	Moderate
2E	2	E	0.90	\$ 3.0	\$ 2.700	11	Significant
3B	3	B	0.30	\$ 15.0	\$ 4.500	12	Moderate
4A	4	A	0.10	\$ 62.5	\$ 6.250	13	Moderate
3C	3	C	0.50	\$ 15.0	\$ 7.500	14	Significant
3D	3	D	0.70	\$ 15.0	\$ 10.500	15	Significant
3E	3	E	0.90	\$ 15.0	\$ 13.500	16	High
5A	5	A	0.10	\$ 150.0	\$ 15.000	17	Significant
4B	4	B	0.30	\$ 62.5	\$ 18.750	18	Significant
4C	4	C	0.50	\$ 62.5	\$ 31.250	19	High
4D	4	D	0.70	\$ 62.5	\$ 43.750	20	High
5B	5	B	0.30	\$ 150.0	\$ 45.000	21	High
4E	4	E	0.90	\$ 62.5	\$ 56.250	22	Very High
5C	5	C	0.50	\$ 150.0	\$ 75.000	23	High
5D	5	D	0.70	\$ 150.0	\$ 105.000	24	Very High
5E	5	E	0.90	\$ 150.0	\$ 135.000	25	Very High

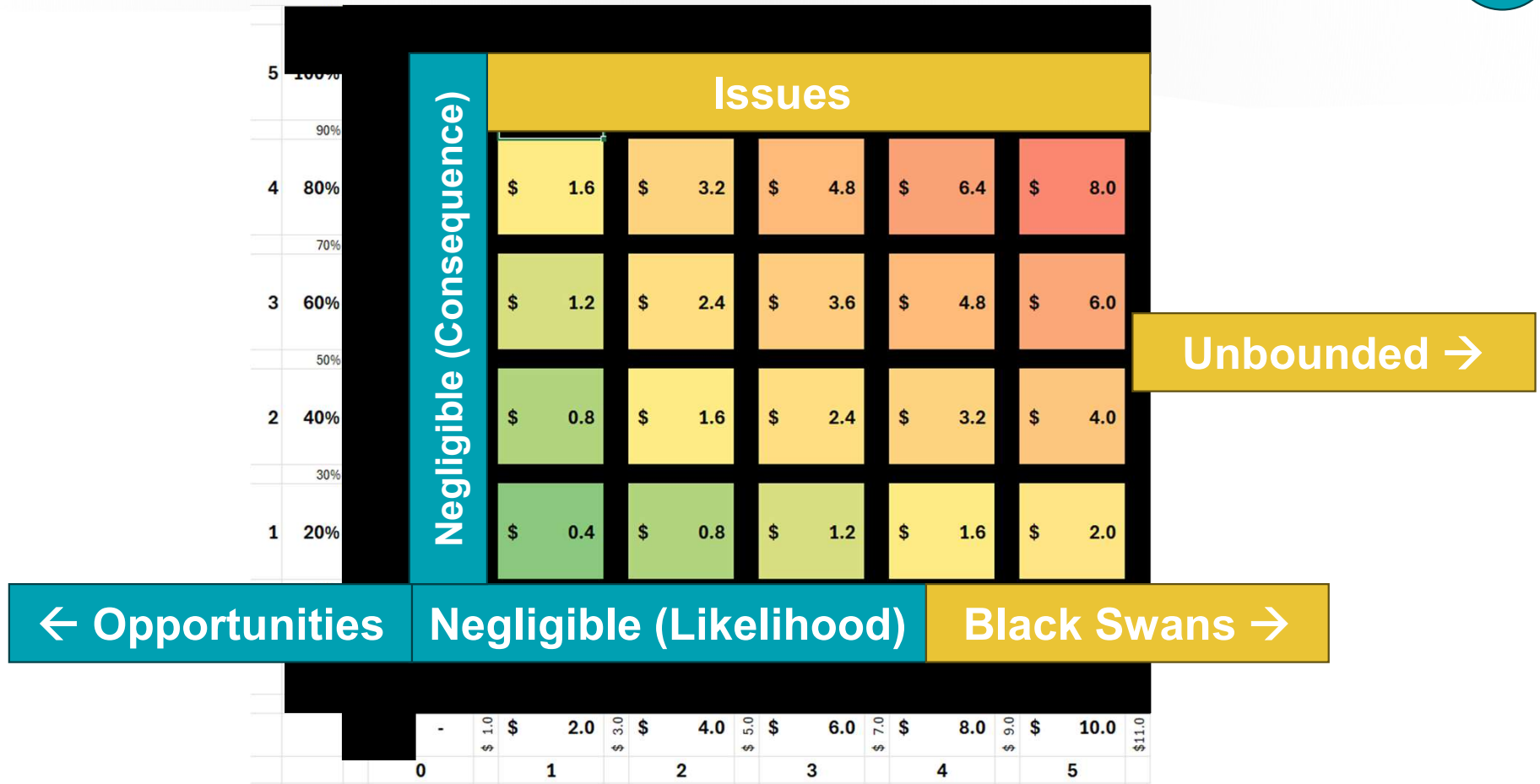
Severity ratings are inconsistent with expected values

Centered Risk Cube

2

		110%										
5	100%		\$ 2.0	\$ 4.0	\$ 6.0	\$ 8.0	\$ 10.0					
		90%										
4	80%		\$ 1.6	\$ 3.2	\$ 4.8	\$ 6.4	\$ 8.0					
		70%										
3	60%		\$ 1.2	\$ 2.4	\$ 3.6	\$ 4.8	\$ 6.0					
		50%										
2	40%		\$ 0.8	\$ 1.6	\$ 2.4	\$ 3.2	\$ 4.0					
		30%										
1	20%		\$ 0.4	\$ 0.8	\$ 1.2	\$ 1.6	\$ 2.0					
		10%										
0	0%											
		-10%										
			\$ (1.0)	\$ 1.0	\$ 3.0	\$ 5.0	\$ 7.0	\$ 9.0	\$ 11.0			
			\$ -	\$ 2.0	\$ 4.0	\$ 6.0	\$ 8.0	\$ 10.0				
			0	1	2	3	4	5				

Centered Risk Cube Boundaries



Centered Risk Cube (Extended)

2

		\$ (1.0)	\$ 1.0	\$ 3.0	\$ 5.0	\$ 7.0	\$ 9.0	\$ 11.0	\$ 13.0	\$ 15.0	\$ 17.0	\$ 19.0	\$ 21.0
5	100%		\$ 2.0	\$ 4.0	\$ 6.0	\$ 8.0	\$ 10.0	\$ 12.0	\$ 14.0	\$ 16.0	\$ 18.0	\$ 20.0	
4	80%		\$ 1.6	\$ 3.2	\$ 4.8	\$ 6.4	\$ 8.0	\$ 9.6	\$ 11.2	\$ 12.8	\$ 14.4	\$ 16.0	
3	60%		\$ 1.2	\$ 2.4	\$ 3.6	\$ 4.8	\$ 6.0	\$ 7.2	\$ 8.4	\$ 9.6	\$ 10.8	\$ 12.0	
2	40%		\$ 0.8	\$ 1.6	\$ 2.4	\$ 3.2	\$ 4.0	\$ 4.8	\$ 5.6	\$ 6.4	\$ 7.2	\$ 8.0	
1	20%		\$ 0.4	\$ 0.8	\$ 1.2	\$ 1.6	\$ 2.0	\$ 2.4	\$ 2.8	\$ 3.2	\$ 3.6	\$ 4.0	
0	0%												

Unbounded →

Centered Risk Cube (Icosatiles)



24	100%	\$ 0.5	\$ 1.0	\$ 1.5	\$ 2.0	\$ 2.5	\$ 3.0	\$ 3.5	\$ 4.0	\$ 4.5	\$ 5.0	\$ 5.5	\$ 6.0	\$ 6.5	\$ 7.0	\$ 7.5	\$ 8.0	\$ 8.5	\$ 9.0	\$ 9.5	\$ 10.0
19	95%	\$ 0.5	\$ 1.0	\$ 1.4	\$ 1.9	\$ 2.4	\$ 2.9	\$ 3.3	\$ 3.8	\$ 4.3	\$ 4.8	\$ 5.2	\$ 5.7	\$ 6.2	\$ 6.7	\$ 7.1	\$ 7.6	\$ 8.1	\$ 8.6	\$ 9.0	\$ 9.5
18	90%	\$ 0.5	\$ 0.9	\$ 1.4	\$ 1.8	\$ 2.3	\$ 2.7	\$ 3.2	\$ 3.6	\$ 4.1	\$ 4.5	\$ 5.0	\$ 5.4	\$ 5.9	\$ 6.3	\$ 6.8	\$ 7.2	\$ 7.7	\$ 8.1	\$ 8.6	\$ 9.0
17	85%	\$ 0.4	\$ 0.9	\$ 1.3	\$ 1.7	\$ 2.1	\$ 2.6	\$ 3.0	\$ 3.4	\$ 3.8	\$ 4.3	\$ 4.7	\$ 5.1	\$ 5.5	\$ 6.0	\$ 6.4	\$ 6.8	\$ 7.2	\$ 7.7	\$ 8.1	\$ 8.5
16	80%	\$ 0.4	\$ 0.8	\$ 1.2	\$ 1.6	\$ 2.0	\$ 2.4	\$ 2.8	\$ 3.2	\$ 3.6	\$ 4.0	\$ 4.4	\$ 4.8	\$ 5.2	\$ 5.6	\$ 6.0	\$ 6.4	\$ 6.8	\$ 7.2	\$ 7.6	\$ 8.0
15	75%	\$ 0.4	\$ 0.8	\$ 1.1	\$ 1.5	\$ 1.9	\$ 2.3	\$ 2.7	\$ 3.1	\$ 3.5	\$ 3.9	\$ 4.3	\$ 4.7	\$ 5.1	\$ 5.5	\$ 5.9	\$ 6.3	\$ 6.7	\$ 7.1	\$ 7.5	
14	70%	\$ 0.4	\$ 0.7	\$ 1.1	\$ 1.4	\$ 1.8	\$ 2.1	\$ 2.5	\$ 2.8	\$ 3.2	\$ 3.5	\$ 3.9	\$ 4.2	\$ 4.6	\$ 4.9	\$ 5.3	\$ 5.6	\$ 6.0	\$ 6.3	\$ 6.7	\$ 7.0
13	65%	\$ 0.3	\$ 0.7	\$ 1.0	\$ 1.3	\$ 1.6	\$ 2.0	\$ 2.3	\$ 2.6	\$ 2.9	\$ 3.3	\$ 3.6	\$ 3.9	\$ 4.2	\$ 4.6	\$ 4.9	\$ 5.2	\$ 5.5	\$ 5.9	\$ 6.2	\$ 6.5
12	60%	\$ 0.3	\$ 0.6	\$ 0.9	\$ 1.2	\$ 1.5	\$ 1.8	\$ 2.1	\$ 2.4	\$ 2.7	\$ 3.0	\$ 3.3	\$ 3.6	\$ 3.9	\$ 4.2	\$ 4.5	\$ 4.8	\$ 5.1	\$ 5.4	\$ 5.7	\$ 6.0
11	55%	\$ 0.3	\$ 0.6	\$ 0.8	\$ 1.1	\$ 1.4	\$ 1.7	\$ 1.9	\$ 2.2	\$ 2.5	\$ 2.8	\$ 3.0	\$ 3.3	\$ 3.6	\$ 3.9	\$ 4.1	\$ 4.4	\$ 4.7	\$ 5.0	\$ 5.2	\$ 5.5
10	50%	\$ 0.3	\$ 0.5	\$ 0.8	\$ 1.0	\$ 1.3	\$ 1.5	\$ 1.8	\$ 2.0	\$ 2.3	\$ 2.5	\$ 2.8	\$ 3.0	\$ 3.3	\$ 3.5	\$ 3.8	\$ 4.0	\$ 4.3	\$ 4.5	\$ 4.8	\$ 5.0
9	45%	\$ 0.2	\$ 0.5	\$ 0.7	\$ 0.9	\$ 1.1	\$ 1.4	\$ 1.6	\$ 1.8	\$ 2.0	\$ 2.3	\$ 2.5	\$ 2.7	\$ 2.9	\$ 3.2	\$ 3.4	\$ 3.6	\$ 3.8	\$ 4.1	\$ 4.3	\$ 4.5
8	40%	\$ 0.2	\$ 0.4	\$ 0.6	\$ 0.8	\$ 1.0	\$ 1.2	\$ 1.4	\$ 1.6	\$ 1.8	\$ 2.0	\$ 2.2	\$ 2.4	\$ 2.6	\$ 2.8	\$ 3.0	\$ 3.2	\$ 3.4	\$ 3.6	\$ 3.8	\$ 4.0
7	35%	\$ 0.2	\$ 0.4	\$ 0.5	\$ 0.7	\$ 0.9	\$ 1.1	\$ 1.2	\$ 1.4	\$ 1.6	\$ 1.8	\$ 1.9	\$ 2.1	\$ 2.3	\$ 2.5	\$ 2.6	\$ 2.8	\$ 3.0	\$ 3.2	\$ 3.3	\$ 3.5
6	30%	\$ 0.2	\$ 0.3	\$ 0.5	\$ 0.6	\$ 0.8	\$ 0.9	\$ 1.1	\$ 1.2	\$ 1.4	\$ 1.5	\$ 1.7	\$ 1.8	\$ 2.0	\$ 2.1	\$ 2.3	\$ 2.4	\$ 2.6	\$ 2.7	\$ 2.9	\$ 3.0
5	25%	\$ 0.1	\$ 0.3	\$ 0.4	\$ 0.5	\$ 0.6	\$ 0.8	\$ 0.9	\$ 1.0	\$ 1.1	\$ 1.3	\$ 1.4	\$ 1.5	\$ 1.6	\$ 1.8	\$ 1.9	\$ 2.0	\$ 2.1	\$ 2.3	\$ 2.4	\$ 2.5
4	20%	\$ 0.1	\$ 0.2	\$ 0.3	\$ 0.4	\$ 0.5	\$ 0.6	\$ 0.7	\$ 0.8	\$ 0.9	\$ 1.0	\$ 1.1	\$ 1.2	\$ 1.3	\$ 1.4	\$ 1.5	\$ 1.6	\$ 1.7	\$ 1.8	\$ 1.9	\$ 2.0
3	15%	\$ 0.1	\$ 0.2	\$ 0.2	\$ 0.3	\$ 0.4	\$ 0.5	\$ 0.5	\$ 0.6	\$ 0.7	\$ 0.8	\$ 0.8	\$ 0.9	\$ 1.0	\$ 1.1	\$ 1.1	\$ 1.2	\$ 1.3	\$ 1.4	\$ 1.4	\$ 1.5
2	10%	\$ 0.1	\$ 0.1	\$ 0.2	\$ 0.2	\$ 0.3	\$ 0.3	\$ 0.4	\$ 0.4	\$ 0.5	\$ 0.5	\$ 0.6	\$ 0.6	\$ 0.7	\$ 0.7	\$ 0.8	\$ 0.8	\$ 0.9	\$ 0.9	\$ 1.0	\$ 1.0
1	5%	\$ 0.0	\$ 0.1	\$ 0.1	\$ 0.1	\$ 0.1	\$ 0.2	\$ 0.2	\$ 0.2	\$ 0.2	\$ 0.3	\$ 0.3	\$ 0.3	\$ 0.3	\$ 0.4	\$ 0.4	\$ 0.4	\$ 0.4	\$ 0.5	\$ 0.5	\$ 0.5
0	0%																				

Centered Risk Cube with Opportunities

2

		<u>Windfalls</u>						<u>Issues</u>					
		\$ (10.0)	\$ (8.0)	\$ (6.0)	\$ (4.0)	\$ (2.0)	\$ -	\$ 2.0	\$ 4.0	\$ 6.0	\$ 8.0	\$ 10.0	
5	100%	\$ (10.0)	\$ (8.0)	\$ (6.0)	\$ (4.0)	\$ (2.0)	\$ -	\$ 2.0	\$ 4.0	\$ 6.0	\$ 8.0	\$ 10.0	
4	80%	\$ (8.0)	\$ (6.4)	\$ (4.8)	\$ (3.2)	\$ (1.6)	\$ -	\$ 1.6	\$ 3.2	\$ 4.8	\$ 6.4	\$ 8.0	
3	60%	\$ (6.0)	\$ (4.8)	\$ (3.6)	\$ (2.4)	\$ (1.2)	\$ -	\$ 1.2	\$ 2.4	\$ 3.6	\$ 4.8	\$ 6.0	
2	40%	\$ (4.0)	\$ (3.2)	\$ (2.4)	\$ (1.6)	\$ (0.8)	\$ -	\$ 0.8	\$ 1.6	\$ 2.4	\$ 3.2	\$ 4.0	
1	20%	\$ (2.0)	\$ (1.6)	\$ (1.2)	\$ (0.8)	\$ (0.4)	\$ -	\$ 0.4	\$ 0.8	\$ 1.2	\$ 1.6	\$ 2.0	
0	0%	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
		\$ (11.0)	\$ (9.0)	\$ (7.0)	\$ (5.0)	\$ (3.0)	\$ (1.0)	\$ 1.0	\$ 3.0	\$ 5.0	\$ 7.0	\$ 9.0	\$ 11.0
		-5	-4	-3	-2	-1	0	1	2	3	4	5	

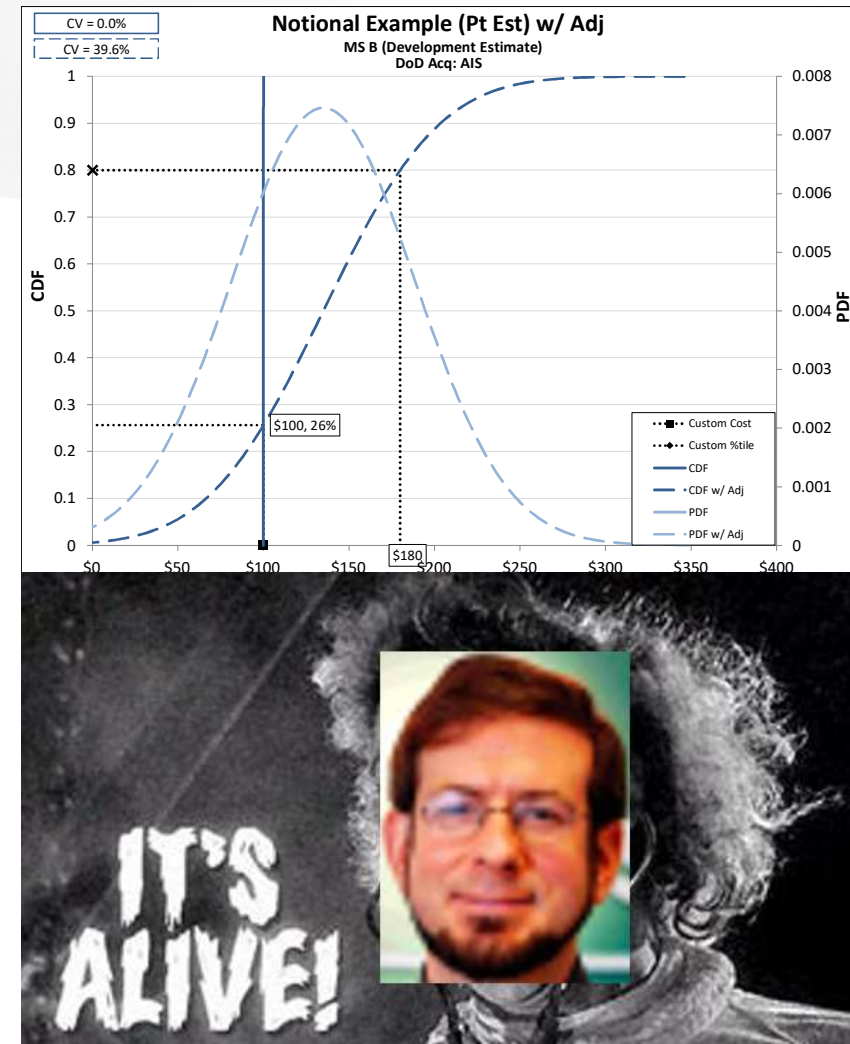
Opportunities

Risks

Negligible Gains

Risk Analysis Visualization

- The S-curve is the touchstone graphic for RA
 - The NCCA S-Curve Tool remains a versatile means of generating, annotating, and comparing S-curves
- As RM and RA become better integrated, producing “live” S-curves may require implementing cost estimates as a data pipeline
 - Another variant of the proposed Continuous Estimating / Continuous Analysis (CE/CA)
 - Companion to the Continuous Integration / Continuous Deployment (CI/CD) of DevSecOps



Risk Model Integration

- Calibrating Risk Cube (RM only)
 - Ignore Uncertainties
 - Unfactored Risk (max)
 - Factored Risk (mean only)
 - Monte Carlo (stair step distribution)
- Enhanced Scenario-Based Method (eSBM) (RA only)
 - Parametric drivers
 - Discrete Risks omitted or *Prego* ("It's in there!")
- Risk Framework (RM and RA in conjunction)
 - Deconflict Discrete Risks and Uncertainties
 - Mutually Exclusive and Exhaustive ("no gaps or overlaps")
 - Compare with Historical Benchmarks (and tease out *unknown unknowns*)

Unifying RM and RA – Best of Both Worlds

- Adopt the Risk Framework 1
 - Improves RM by focusing the five-step process on the Discrete Risks where it is most effective
 - Improves RA by guiding the deconfliction of discrete and continuous risks, both of which are quantified in the Living Risk Model
- Adopt the Centered Risk Cube 2
 - Improves RM by accurately depicting RIOs on a unifying graphic with minimal (but crucial) changes to what most RM practitioners are used to
 - Improves RA by ensuring that the Pf and Cf quantification of RIOs is as accurate as possible
- Maintain a Living Risk Model 3
 - Improves RM by replacing the junk math to which Risk Registers so often fall prey with a means of continually updating the cost estimate
 - Improves RA by keeping input risks to that model, especially the discrete risks that “live” in the Risk Register, continually up to date

The Living Risk Model is the Unifying Solution for Effective RM/RA

RM and RA – Stronger Together



Epilogue – Alternate Titles

- “Everything You Know Is Wrong: How Current Risk Management Practices Mislead (And What to Do About It)”
- “The Risk Management Cube is Neither Risk, Nor Management, Nor a Cube ... Discuss!”
- “The (Cube) Root of All Evil: How 25 Little Squares Ruined Risk (And How to Fix It)”
- “Beyond Calibration: How the Risk Cube Can Better Serve Risk Management and Analysis”
- “Risk Management vs. Risk Analysis: Bridging the Great Divide”
- “Blame It On RIO: How to See Beyond the Risk Cube”
- “Fence Posts and Fence Rails: Why Your Risk Cube Should Be Ratio, Not Ordinal”
- “Getting the Risk Crew Together: Risk, Opportunity, Windfall, Issues, and Negligible Gains (ROWING) Management”

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Annie Oakleying the Risk Cube ***Back-Up***

Triangular Heat Maps

		Low/High	0%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%		
Triangular means	Triangular Standard Deviations	0%	0%	2%	3%	5%	7%	8%	10%	12%	13%	15%	17%	18%	20%	22%	23%	25%	27%	28%	30%	32%	33%		
		5%	2%	0%	2%	2%	5%	7%	8%	10%	12%	13%	15%	17%	18%	20%	22%	23%	25%	27%	28%	30%	32%	33%	
		Low/High	0%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%		
		0%	0%	1%	2%	4%	5%	6%	7%	8%	9%	11%	12%	13%	14%	15%	16%	18%	19%	20%	21%	22%	24%		
		5%	1%	2%	2%	4%	5%	7%	8%	9%	10%	11%	12%	14%	15%	16%	17%	18%	19%	20%	21%	22%	24%		
		Low/High	0%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%		
		0%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	13%	14%	15%	16%	16%	17%	18%	18%	19%
		-5%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	12%	13%	14%	15%	16%	16%	17%	18%	18%	19%	20%
		-10%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	12%	13%	14%	15%	16%	16%	17%	18%	19%	19%	20%	21%
		-15%	4%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%	16%	17%	17%	18%	19%	19%	20%	20%	21%	22%
-20%	5%	6%	6%	7%	8%	9%	10%	11%	12%	13%	14%	14%	15%	16%	17%	17%	18%	19%	19%	20%	20%	21%	22%		
-25%	6%	7%	8%	9%	9%	10%	11%	12%	13%	14%	15%	16%	17%	17%	18%	19%	19%	20%	20%	21%	22%	23%	24%		
-30%	8%	8%	9%	10%	11%	11%	12%	13%	14%	15%	16%	17%	18%	18%	19%	20%	20%	21%	21%	22%	23%	24%	25%		
-35%	9%	10%	11%	11%	12%	13%	14%	14%	15%	16%	17%	17%	18%	19%	20%	20%	21%	22%	22%	23%	24%	24%	25%		
-40%	11%	11%	12%	13%	13%	14%	15%	16%	16%	17%	18%	18%	19%	20%	20%	21%	22%	22%	23%	23%	24%	24%	25%		
-45%	12%	13%	14%	14%	15%	16%	16%	17%	18%	18%	19%	20%	20%	21%	22%	22%	23%	24%	24%	25%	26%	26%	27%		
-50%	14%	15%	15%	16%	16%	17%	18%	18%	19%	20%	20%	21%	22%	22%	23%	24%	24%	25%	26%	26%	27%	27%	28%		
-55%	16%	16%	17%	17%	18%	19%	19%	20%	20%	21%	22%	22%	23%	24%	24%	25%	26%	26%	27%	27%	28%	29%	29%		
-60%	18%	18%	19%	19%	20%	20%	21%	21%	22%	23%	23%	24%	24%	25%	26%	26%	27%	27%	28%	28%	29%	29%	30%		
-65%	20%	20%	20%	21%	21%	22%	22%	23%	24%	24%	25%	25%	26%	27%	27%	28%	28%	29%	29%	30%	30%	31%	31%		
-70%	22%	22%	22%	23%	23%	24%	24%	25%	25%	26%	26%	27%	27%	28%	29%	29%	30%	30%	31%	31%	32%	32%	33%		
-75%	24%	24%	24%	25%	25%	25%	26%	26%	27%	27%	28%	29%	29%	30%	30%	31%	31%	32%	32%	33%	33%	34%	34%		
-80%	26%	26%	26%	27%	27%	27%	28%	28%	29%	29%	30%	30%	31%	31%	32%	32%	33%	33%	34%	34%	35%	35%	36%		
-85%	28%	28%	28%	29%	29%	29%	30%	30%	31%	31%	32%	32%	32%	33%	33%	33%	34%	34%	35%	35%	36%	36%	37%		
-90%	30%	30%	31%	31%	31%	32%	32%	32%	33%	33%	33%	34%	34%	35%	35%	36%	36%	37%	37%	38%	38%	39%	39%		
-95%	33%	33%	33%	33%	33%	34%	34%	34%	35%	35%	35%	36%	36%	37%	37%	37%	38%	38%	39%	39%	40%	40%	41%		
-100%	35%	35%	35%	36%	36%	36%	36%	36%	37%	37%	37%	38%	38%	38%	39%	39%	40%	40%	40%	41%	41%	41%	42%		

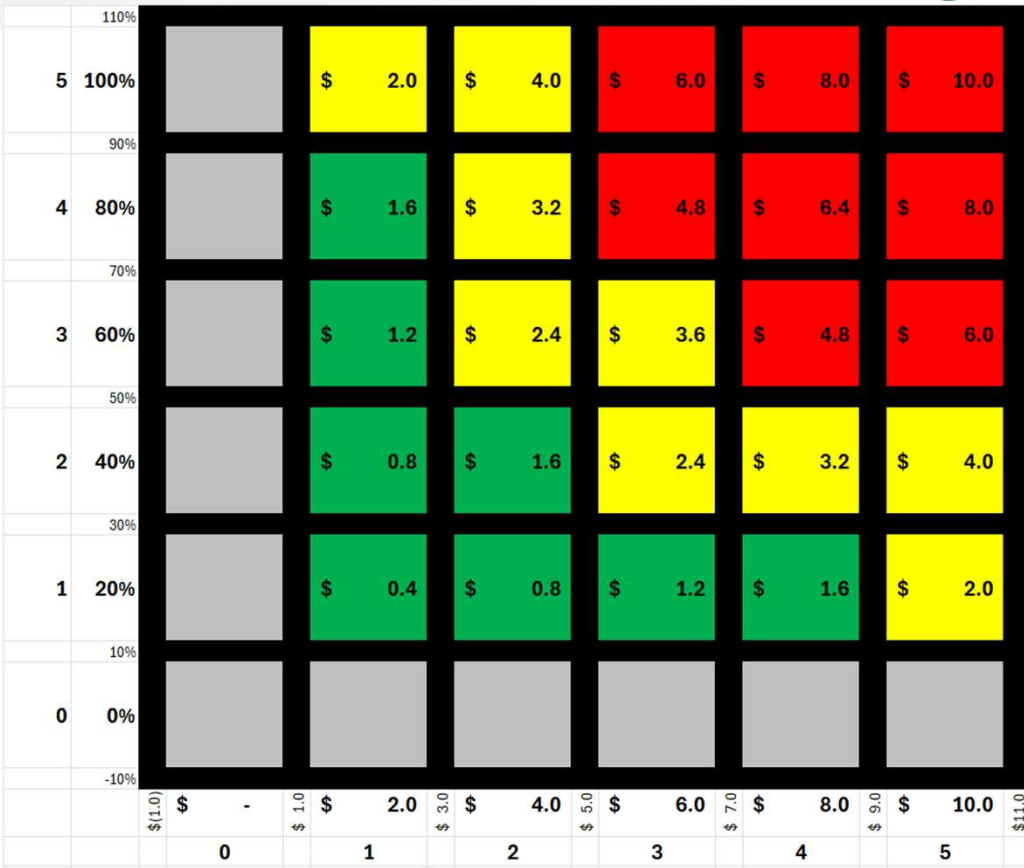
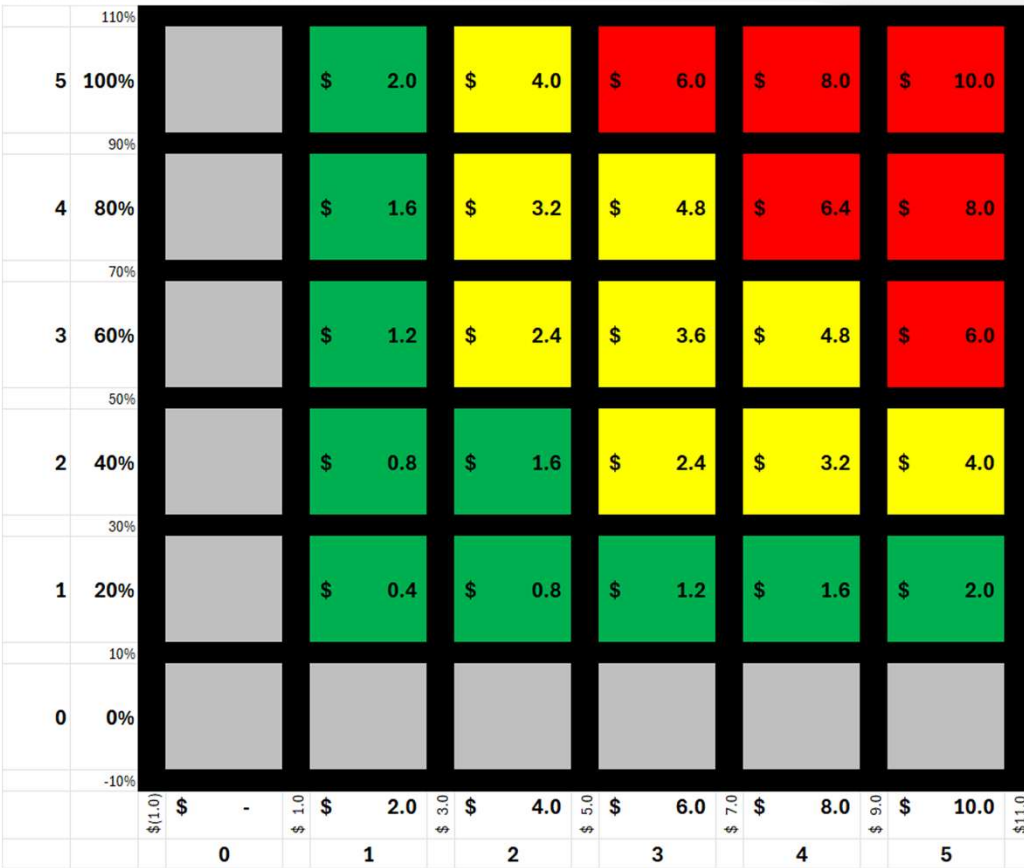
Bernoulli Heat Maps

Cf/Pf	0%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%	
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ 500,000.00	\$ -	\$ 25	\$ 50	\$ 75	\$ 100	\$ 125	\$ 150	\$ 175	\$ 200	\$ 225	\$ 250	\$ 275	\$ 300	\$ 325	\$ 350	\$ 375	\$ 400	\$ 425	\$ 450	\$ 475	\$ 500	
\$ 1,000,000.00	\$ -	\$ 50	\$ 100	\$ 150	\$ 200	\$ 250	\$ 300	\$ 350	\$ 400	\$ 450	\$ 500	\$ 550	\$ 600	\$ 650	\$ 700	\$ 750	\$ 800	\$ 850	\$ 900	\$ 950	\$ 1,000	
\$ 1,500,000.00	\$ -	\$ 75	\$ 150	\$ 225	\$ 300	\$ 375	\$ 450	\$ 525	\$ 600	\$ 675	\$ 750	\$ 825	\$ 900	\$ 975	\$ 1,050	\$ 1,125	\$ 1,200	\$ 1,275	\$ 1,350	\$ 1,425	\$ 1,500	
Cf/Pf	0%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%	
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
\$ 500,000.00	\$ -	\$ 109	\$ 150	\$ 179	\$ 200	\$ 217	\$ 229	\$ 238	\$ 245	\$ 249	\$ 250	\$ 249	\$ 245	\$ 238	\$ 229	\$ 217	\$ 200	\$ 179	\$ 150	\$ 109	\$ -	
\$ 1,000,000.00	\$ -	\$ 218	\$ 300	\$ 357	\$ 400	\$ 433	\$ 458	\$ 477	\$ 490	\$ 497	\$ 500	\$ 497	\$ 490	\$ 477	\$ 458	\$ 433	\$ 400	\$ 357	\$ 300	\$ 218	\$ -	
\$ 1,500,000.00	\$ -	\$ 327	\$ 450	\$ 536	\$ 600	\$ 650	\$ 687	\$ 715	\$ 735	\$ 746	\$ 750	\$ 746	\$ 735	\$ 715	\$ 687	\$ 650	\$ 600	\$ 536	\$ 450	\$ 327	\$ -	
Cf/Pf	0%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%	
\$ -																						
\$ 500,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 1,000,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 1,500,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 2,000,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 2,500,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 3,000,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 3,500,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 4,000,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 4,500,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 5,000,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 5,500,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 6,000,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 6,500,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 7,000,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 7,500,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 8,000,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 8,500,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 9,000,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 9,500,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	
\$ 10,000,000.00		436%	300%	238%	200%	173%	153%	136%	122%	111%	100%	90%	82%	73%	65%	58%	50%	42%	33%	23%	0%	

(Scaled) Bernoulli CVs

Centered Risk Cube with Tricolor Shading

2



Which One Is Right? ... Both!

Figure C-1: Likelihood Ratings per ChatGPT

Assigning **Likelihood** and **Consequence** ratings for your **Risk Cube** depends on the context of your risk assessment, such as business, engineering, cybersecurity, or project management. Here's a general approach:

1. Likelihood Rating (Probability of Occurrence)

Likelihood assesses how often a risk might occur. Use a **5-point scale** (or adjust as needed):

Rating	Description	Example
1 - Rare	Unlikely to happen; highly improbable	Less than once in 10 years
2 - Unlikely	Could happen, but not common	Once every 5–10 years
3 - Possible	Might occur occasionally	Once every 1–5 years
4 - Likely	Expected to happen regularly	Annually or more frequently
5 - Almost Certain	Will almost certainly happen	Multiple times per year

Accessed 17 Feb 2025

Figure C-2: Consequence Ratings per ChatGPT

2. Consequence Rating (Impact Severity)

Consequence measures the impact if the risk occurs. Again, a 5-point scale is common:

Rating	Description	Example (Business Context)
1 - Insignificant	Minimal impact, no disruption	Minor financial loss, no reputation damage
2 - Minor	Some impact, but manageable	Small delays, slight cost increase
3 - Moderate	Noticeable impact, needs response	Operational disruption, moderate financial loss
4 - Major	Significant impact	Project failure, major financial or reputational damage
5 - Catastrophic	Severe impact, potential crisis	Business shutdown, legal violations, fatalities

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Figure C-3: Conflated Risk Scores per ChatGPT

3. Risk Score & Cube Mapping

Once Likelihood and Consequence are assigned, multiply them to get the Risk Score (e.g., $3 \times 4 = 12$).

Then, map it to your Risk Cube:

- Low Risk (1–5) → Acceptable, minimal action needed
- Medium Risk (6–10) → Monitor and manage
- High Risk (11–15) → Requires mitigation
- Critical Risk (16–25) → Immediate action needed

Would you like a visual example of the Risk Cube? 😊

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Figure C-4: Notional Risk per ChatGPT

Risk Title: Project Deadline Overrun

Risk Description:

There is a risk that the project may not meet its planned deadline due to unforeseen delays in software development and testing. This could result from resource constraints, technical complexities, or dependencies on third-party vendors.

Likelihood Rating: 3 – Possible

Based on historical data, similar projects have experienced moderate delays due to unforeseen coding challenges and integration issues.

Consequence Rating: 4 – Major

Failure to meet the deadline could lead to significant financial penalties, reputational damage, and loss of client trust. Additionally, project delays may impact downstream deliverables in related initiatives.

Risk Score: $3 \times 4 = 12$ (High Risk)

Mitigation Plan:

1. Implement an **agile sprint review** every two weeks to monitor progress.
2. Assign a **contingency buffer** of two additional weeks in the timeline.
3. Secure additional **developer resources** to avoid bottlenecks.
4. Escalate potential delays in **weekly risk review meetings** for early intervention.

Accessed 17 Feb 2025