CRIMS[1] Simplified Relative Risk Weighting (RRW) Process Concepts and Guidelines

FOR THE

PRICE Systems Symposium

by

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[1]Cost-Risk Identification and Management System

TOPICS

- CRIMS Overview
- Cost Estimating Cost-Risk
- The Simplified RRW Process: What it does; How Simplified RRW Works; RRW Guidance; Why RRW Works; Most Likely Cost/Risk Equivalence
- Simplified RRW 4-Step Approach
- Combining Cost Estimating Cost-Risk and Technical Cost-Risk

CRIMS

- Identify cost-risk with the *Relative Risk Weighting* Process (RRW)
  - Use Weighted Risk Category, Scaled Matrix with Engineering Input to Develop *Technical* Cost-Risk Distributions at WBS Element Level
  - Combine RRW Distributions with *Cost Estimating* Cost-Risk Distributions Using Monte Carlo Simulations
- Track cost-risk with the *Risk Feedback Management Strategy* (RFMS)
  - IBR and Earned Value; TPMs, Technical Interchanges
- Store cost-risk data in the *Cost Risk Database*
  - Actual Cost Results Compared to Expectations
  - Calibration Factor Development for Cost Proposal Evaluation

Cost Estimating Cost-Risk

- Much of the end-of-contract cost impact due to risk-driven forces has already been captured by the cost estimate itself
  - The cost estimate is a projection from end-of-contract costs (‘actuals’), already containing end-of-contract, risk-driven cost growth
  - Risk-driven cost growth on the proposed WBS element is likely to be similiar to, but not exactly like, that experienced in the past

What RRW Does

- The RRW captures the *incremental* technical cost-risk in a WBS element over-and-above, and under-or-below, that technical cost-risk already captured by the cost estimate
- The risk-driven cost embedded in the cost estimate is adjusted for the unique technical characteristics of the proposed WBS element
- This *incremental* or ‘marginal’ cost-risk exists due to the planned WBS element's characteristics not present in any previous instances of like-WBS elements that are in the database underlying the cost model

How Simplified RRW Works

- Relates the worst and best case possibilities to a most likely possibility in terms of riskiness
- Scenarios should be explicitly described for each case: Pessimistic, Optimistic and Most Likely
- The worst case scenario, the ‘Pessimistic Profile’, reflects everything that could go wrong actually going wrong, and reflects pessimistic assumptions about achieving the desired specifications

How Simplified RRW Does It (cont)

- The best case scenario, the ‘Optimistic Profile’, reflects getting lucky on all the things that could go wrong and, as credibly as possibly, assumes that achieving difficult specifications will be relatively easy
- The most likely case scenario, the ‘Most Likely Profile’, reflects the achievement of the desired specifications without everything either going all right or all wrong and assumes that some of the specifications will be harder than the initial expectations while others will be easier

Rate WBS Profiles

_____	TECH	DES/ENG	COMPLEXITY	SCHEDULE	**TOTAL**
Pessimistic Profile	High	VH	VH	HIGH	‘SCORE’
Most Likely Profile	MOD	MOD	MOD	MOD	‘SCORE’
Optimistic Profile	LOW	ML	MOD	MOD	‘SCORE’

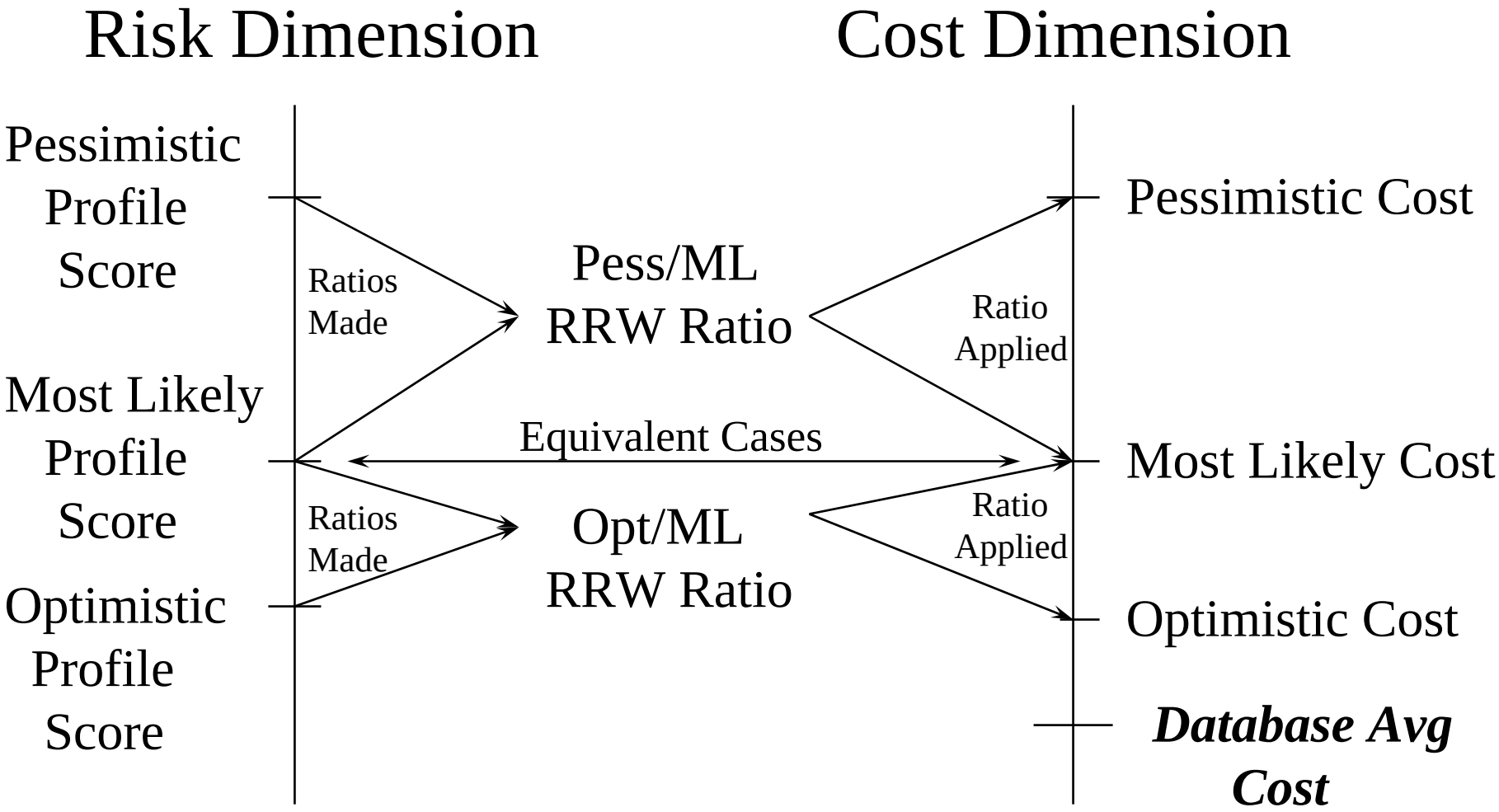
RRW Guidelines

- All profiles are assessed per the CARD or some other technical description of the proposed WBS element
- The Pessimistic Profile should be assessed first, followed by the Optimistic Profile, and then the Most Likely Profile
- By assessing the Pessimistic and Optimistic profiles first, the upper and lower bounds are identified, allowing a middle case, the Most Likely case, to be credibly positioned between them

Most Likely Cost/Risk Equivalence

- The Most Likely case is the only profile estimated for cost (from the CARD specifications)
- The Most Likely case is also rated with respect to risk
  - The RRW captures the Most Likely Profile in the risk dimension with a risk ‘score’ from the weighted risk category matrix
- The Most Likely profile is the ‘common denominator’ between risk and cost, allowing worst and best *cost* cases to be derived through worst and best *technical risk* cases through RRW-derived ratio-factors

Why RRW Works



Note: The Most Likely Cost is actually not a point but a distribution of point costs, to which RRW ratios are applied during the simulation

Simplified RRW 4-Step Approach

- STEP 1: Choose Risk Categories and Assign Weights of Relative Importance
- STEP 2: Assign Values for Rating Intensities in Each Risk Category Rating Scale
- STEP 3: Using Scale Values, Rate the WBS's Three Profiles Against Risk Categories
- STEP 4: Develop the Cost-Risk Factors (Ratios) between Pessimistic/Most Likely and Optimistic/Most Likely Risk Scores to apply to the Most Likely cost estimate

Weight Risk Categories: A Spacecraft WBS Example

- Example: A New Spacecraft Has to be Evaluated for Cost-Risk
- ***Step 1:*** Work with engineers to assign weights, that sum to 1.0, to each example risk category:
  - TECHNOLOGY 0.35
  - DES/ENG 0.25
  - COMPLEXITY 0.2
  - SCHEDULE 0.2

    1.0

Develop Rating Scale Values: A Spacecraft WBS Example (cont)

- ***Step 2:*** Work with Engineers to assign weights to rating intensities for each scale by risk category:

	TECH	DES/ENG	COMPLEXITY	SCHEDULE
Very Low	0.8	0.7	0.9	0.6
Low	1	1	1	1
Mod Low	2	2.5	2	1.5
Moderate	3	3.5	2.7	2.2
Mod High	4	4.5	4	3.8
High	5	6	5.5	5.3
Very High	6.5	7.5	6	6.3

Rate WBS Profiles and Add Products: A Spacecraft WBS Example (cont)

Step 3:	TECH (0.35)	DES/ENG (0.25)	COMPLEXITY (0.2)	SCHEDULE (0.2)	**TOTAL RISK SCORE**
Pessimistic Profile	High (5)	VH *(7.5)*	VH *(6)*	HIGH *(5.3)*	***5.9***
Most Likely Profile	MOD (3)	MOD *(3.5)*	MOD *(2.7)*	MOD *(2.2)*	***2.9***
Optimistic Profile	LOW (*1*)	ML *(2.5)*	MOD *(2.7)*	MOD *(2.2)*	***2.0***

ML Profile Calc: (0.35)(3) + (0.25)(3.5) + (0.2)(2.7) + (0.2)(2.2) = 2.9

Develop Ratio-Factors: A Spacecraft WBS Example (cont)

Step 4: Build Pessimistic/Most Likely Profile and Optimistic/Most Likely Profile Ratios

Pess/ML = 5.9/2.9 = 2.0

Opt/ML = 2.0/2.9 = 0.7

Factors are applied to the Most Likely cost for low and high of distribution

RRW Matrix Summary

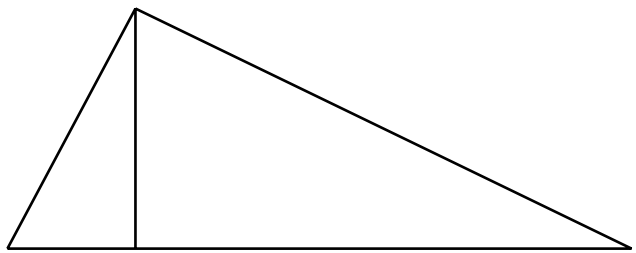
A Spacecraft WBS Example (cont)

	TECHNLGY	DES/ENG	COMPLEXITY	SCHEDULE		TOTAL
WBS ELEMENT PROFILES	**0.35**	**0.25**	**0.2**	**0.2**		**1.0**
1. PESSIMISTIC PROFILE	**HIGH**	**VERY HIGH**	**VERY HIGH**		**HIGH**	**5.9**
2. MOST LIKELY PROFILE	**MOD**	**MOD**	**MOD**	**MOD**		**2.9**
3. OPTIMISTIC PROFILE	**LOW**	**MOD LOW**	**MOD**	**MOD**		**2.0**

$$\frac{\text{OPTIMISTIC “SCORE”}}{\text{MOST LIKELY “SCORE”}} = \frac{5.9}{2.9} = 2.0 = \text{LOW END RISK FACTOR FOR } \textbf{S/C}$$

$$\frac{\text{PESSIMISTIC “SCORE”}}{\text{MOST LIKELY “SCORE”}} = \frac{2.0}{2.9} = 0.7 = \text{HIGH END RISK FACTOR FOR } \textbf{S/C}$$

THESE FACTORS ARE THEN APPLIED TO THE RPE TO OBTAIN THE “LOW AND HIGH END” COSTS



0.7 * MLC MLC 2.0 * MLC

(“LOW END” COST) (“HIGH END” COST)

WBS#	Risk Item	CRIMS (L)	CRIMS (H)
1000	HOSV	0.67	2.40
1000	HOSV	0.54	2.19
1100	SV IAT&C	0.57	1.47
1130	SV Design Integration	0.56	1.62
1210	GEO P/L IAT&C	0.64	1.67
1210	GEO P/L IAT&C	0.53	1.79
123X	GEO P/L Pointing and Control Assy	0.68	2.19
1240	GEO P/L Focal Plane Assembly	0.80	1.89
1250	GEO P/L Thermal Control System	0.66	1.75
1260	GEO P/L Signal Processing Assy.	0.63	1.55
1260	GEO P/L Signal Processing Assy.	0.55	1.66
1310	S/C IAT&C	1.00	1.46
1310	S/C IAT&C	0.53	1.50
1320	S/C Structures & Mechanisms	0.71	1.47
1360	S/C Flight Software Subsystem	0.64	1.64
1380	Communications Subsystem	1.00	1.00
1410	HEO P/L IAT&C	0.66	1.27
143X	HEO P/L Pointing and Control Assy.	0.69	1.24
1450	HEO P/L Thermal Control System	0.66	2.43
1460	HEO P/L Signal Processing Assy.	0.63	1.55
1460	HEO P/L Signal Processing Assy.	0.64	1.64
3120	Ground Segment Sys. Eng.	1.00	1.00
3130	Ground Segment I&T	0.89	2.64
3130	Ground Segment I&T	0.71	1.27
3210	MCS IAT&C	0.56	1.73
3210	MCS IAT&C	0.54	1.69
3220	MCS Equipment	0.72	2.05
3240	MCS Mission Processing Software	0.85	1.53
3250	MCS Mission Mgmt. Software	0.73	2.41
3260	MCS Service and Infrastructure S/W	0.81	1.65
3400	Survivable MCS	0.54	1.76
3500	RGS	0.64	2.06
3500	RGS	0.64	2.06
3510	RGS IAT&C	0.56	1.73
3510	RGS IAT&C	0.54	1.69
3600	RT	0.54	1.88
3610	RT IAT&C	0.57	1.54
3610	RT IAT&C	0.66	1.37
4130	SOS Reqmts Analysis, Alloc. & Veri	0.69	1.35
4140	System & Mission Afford. / Util.	0.69	1.35
4150	SOS System Design, Dev., & Integ.	0.88	1.24
4190	SOS Launch System Integration	0.71	1.47
5100	System Test DT&E	0.58	1.59
5100	System Test DT&E	0.58	1.59
5200	System Test IOT&E and Certif. Sup	0.54	1.22
5300	System Testbed	0.58	1.59
5300	System Testbed	0.58	1.59

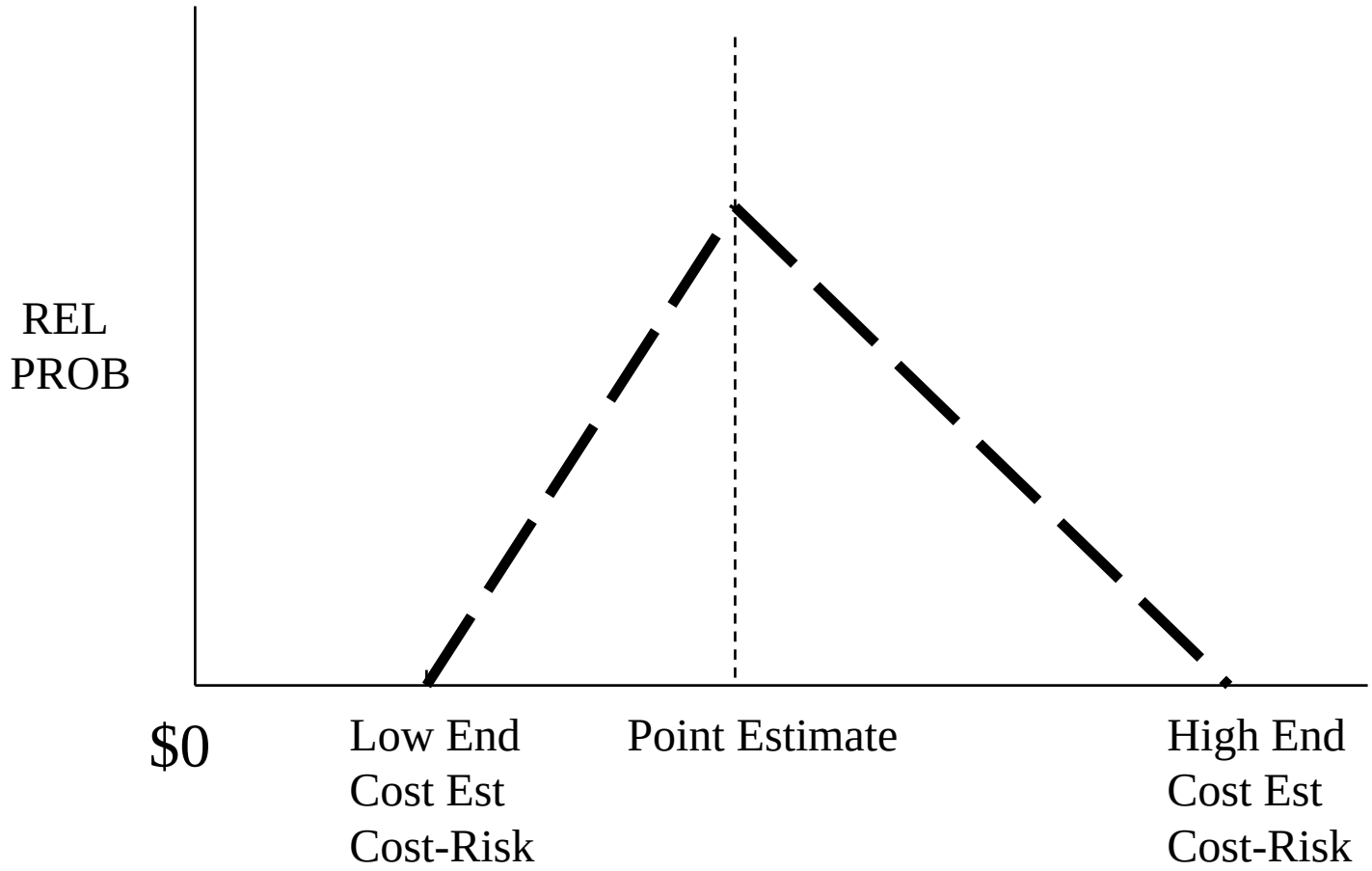
Combining Cost Estimating and Technical Cost-Risk Distributions

Cost Estimating Cost-Risk

- Use the cost estimating cost-risk distribution, from cost model, as the underlying distribution to start with
- The example (next slide) shows a triangular distribution, but it could have another shape
- This distribution will be modified during the monte carlo simulation by the technical cost-risk distribution results from the RRW process

Cost Estimating Cost-Risk

(Due Only to Costing Method Uncertainty)

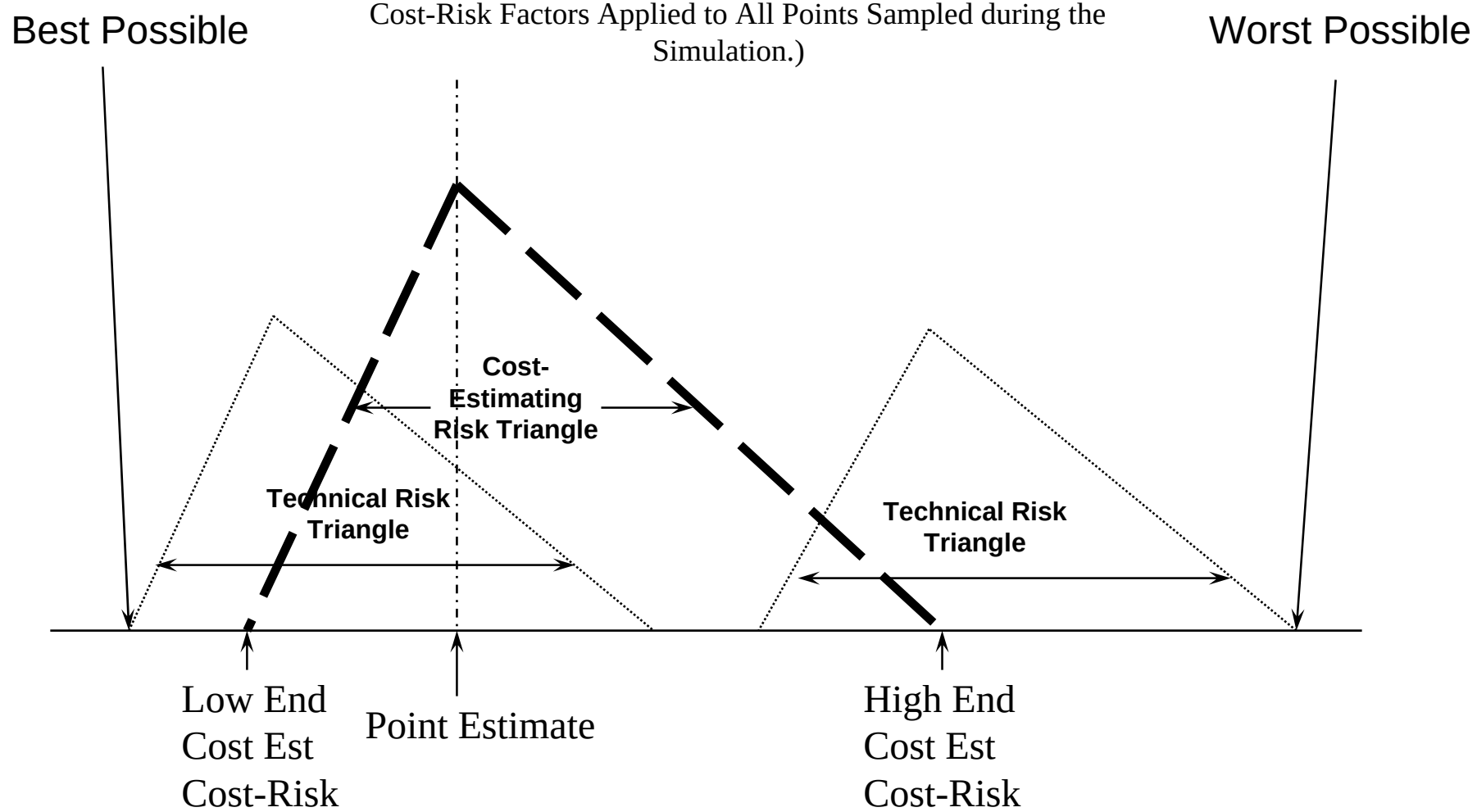


Technical Cost-Risk on Cost Estimating Risk

- With every iteration of the monte carlo simulation, each draw is multiplied by the RRW ratio-factors
- Each draw is therefore treated as a possible ‘most likely’ cost, to which is applied the incremental effects of the technical cost-risk impact

Technical Cost-Risk on Cost Estimating Risk

(Two Random Draws Illustrated at Low End and High End only. Actual Simulation Would Involve 1,000-10,000 Iterations and Cost-Risk Factors Applied to All Points Sampled during the Simulation.)

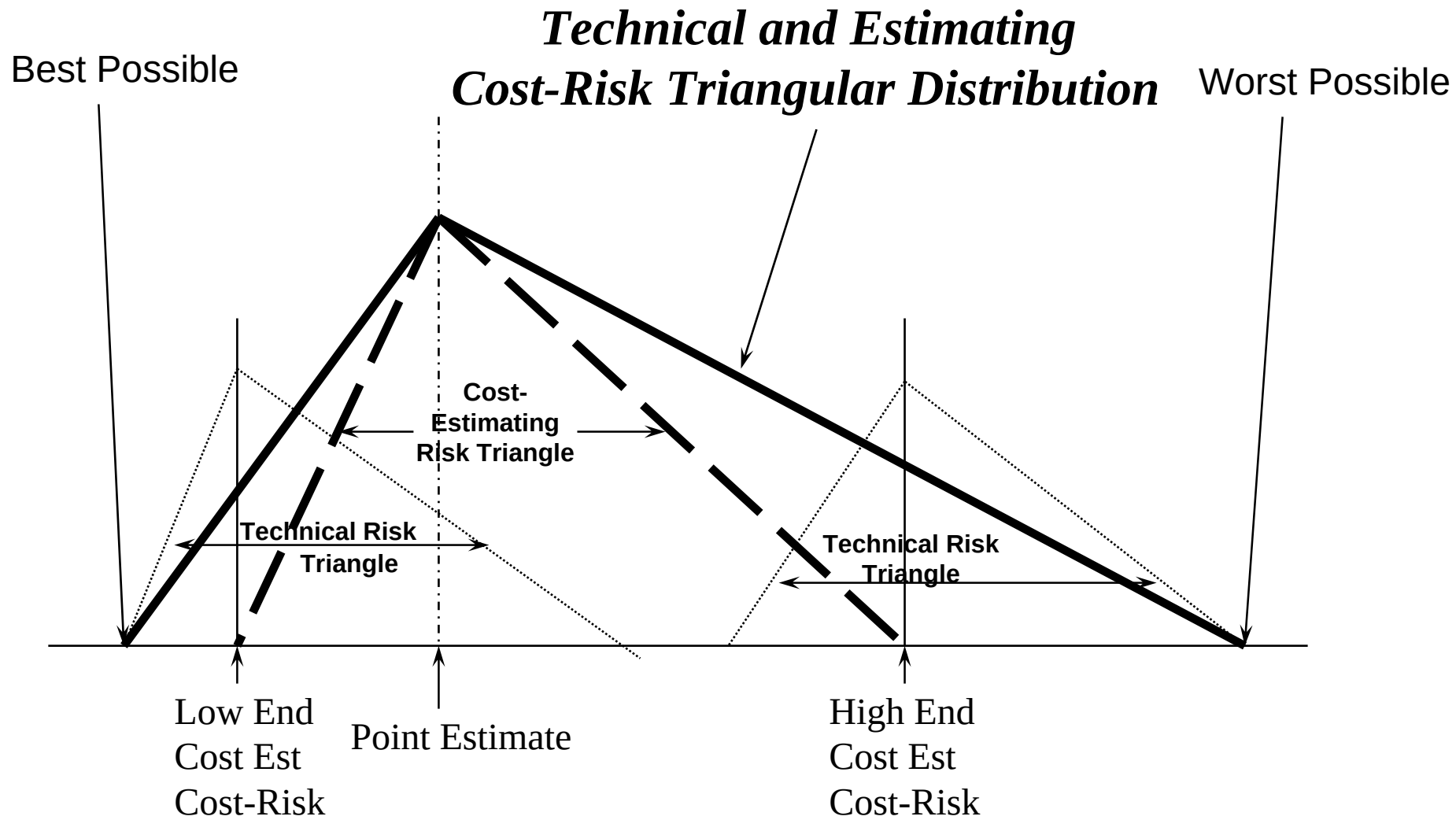


Total Cost-Risk Distribution

- The resulting distribution includes both technical and cost estimating cost-risk effects
- The cost estimating cost-risk distribution's variance has been increased by the contribution due to incremental technical cost-risk

Total Cost-Risk Distribution

(Total Cost-Risk = Cost Estimating Cost-Risk Plus Technical Cost-Risk)

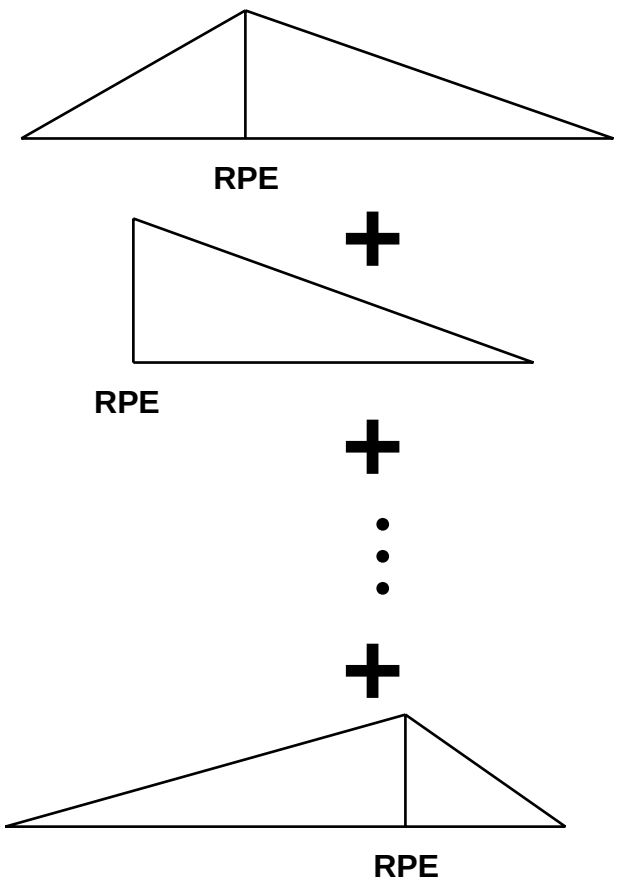


SUM WBS COST DISTRIBUTIONS

- Each WBS element's total cost-risk distribution is combined in the monte carlo simulation and summed
- The resulting total program cost-risk distribution is then used to identify the confidence level/cost level with which the decision maker is comfortable

SUM WBS COST DISTRIBUTIONS

WBS COST DISTRIBUTIONS:



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SUMMARY COST DISTRIBUTION: