A Process for Translating Project Risks into Cost Risk

Presented at The 19th Annual SCEA Conference
June 2008

David Graham, Robert Kellogg, Bob Bitten, Randy Persinger, Debra Emmons

Agenda

- Background
- Approach Overview
- 5x5 Cost Risk Process
- Scenario-based Estimate Process
- Benefits/Limitations of Approach & Next Steps
- Summary

Background

- Space system development projects have processes for identifying and managing risks
  - DoD: Risk Management Guide for DoD Acquisition, Sixth Edition, August 2006
  - NASA: Risk Management Procedural Requirements, NPR 8000.4
  - Most have common attributes – Identification, Classification, Mitigation, etc..
- Requires classification of likelihood and consequences for each risk
  - Typically displayed as a risk matrix showing likelihood vs. consequence
  - Classification is typically subjectively binned into discrete levels of risk
- Cost estimating requirements for many agencies are evolving towards probabilistic estimates
  - Cost-risk probabilistic "S-curves" have been required by DoD and are now required by NASA for major projects
- Difficulty has been in tying project management identified risks to cost risk results
  - Cost estimate are typically unrelated to project risk management results

Proposed process provides a connection between Project Risk & Cost Risk

Overview of Process

- Technical experts review candidate design approach
  - Identify Design and Cost Drivers
  - Identify Technical challenges
- Risks are quantified in terms of likelihood and consequences
  - Likelihood of Occurrence expressed in percent likelihood
    - Choose from Remote = 10%; Unlikely = 30%; Likely = 50%; Very Likely = 70%; Near Certainty = 90%
  - Quantifying “Consequence”
    - Method 1
      - Assess potential schedule delays associated with risk
      - Translate schedule delay into cost based on anticipated burn rate for applicable WBS element(s) for a given phase (i.e. design, development, integration & test)
      - Burn rate differs if element is on critical path or not (assesses “marching army” cost)
    - Method 2
      - Assess impact as a percent of estimated base cost for applicable WBS element(s) for given phase
- Results reviewed by panel of technical and cost experts
  - Some risks can be “rolled-up” to eliminate double-booking and to account for highly correlated risks
  - Consensus achieved on Likelihood and Consequence values
- Risks summarized and translated into cost-risk analysis for use in cost estimates

Probabilistic Cost Estimate Approach

Communication Satellite Cost Risk Assessment Example

Baseline Estimate

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Identify Threats

- PM/SE/MA
- Spacecraft Bus
- Comm. Payload
- Ground System
- Launch Vehicle

Translate to Schedule/Cost Risk

Consequence	1	2	3	4	5
5	M	H	H	H	H
4	L	M	H	H	H
3	L	M	M	H	H
2	L	L	M	M	H
1	L	L	L	L	M

Likelihood

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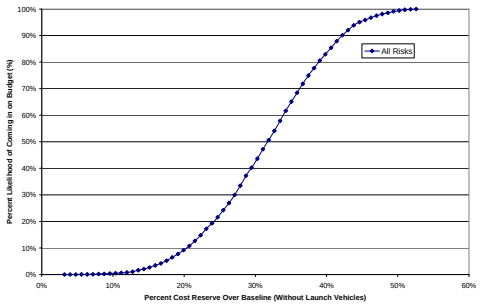
Final Cost Distribution



5x5 Risk Matrix Identification Summary

Definitions From Risk Management Guide for DoD Acquisition

- Consequence[1]
  - 1 Minimal or no impact
  - 2 Additional resources < 5%
  - 3 Additional resources = 5-7%
  - 4 Additional resources = 7-10%
  - 5 Additional resources > 10%
  - OPP (opportunities) Potential cost savings (added to matrix)

- Level Likelihood of Occurrence[2]
  - 1 Remote (10%)
  - 2 Unlikely (30%)
  - 3 Likely (50%)
  - 4 Highly likely (70%)
  - 5 Near certainty (90%)

Consequence	1	2	3	4	5
5	2	1	1	1	1
4	0	0	0	1	2
3	0	0	0	0	0
2	1	3	3	7	2
1	0	1	0	0	0
OPP	0	1	3	0	0

Likelihood

Total Risks =	30
High =	9
Medium =	12
Low =	5
Opportunities =	4

Different organizations may use different definitions, but most require quantification of likelihoods and consequences

1) Percent additional resources taken as percent of major WBS element (i.e. Spacecraft, Payload, etc.)
2) As taken from "Risk Management Guide for DoD Acquisition", Sixth Edition, August 2006., pg. 12

Example Risk List

Risk	Likelihood	Conseq. (FY07$M)	Risk Level
GS1	3	$ 4	Medium
GS2	4	$ 4	Medium
GS3	2	$ 3	Low
GS4	4	$ 8	High
GS5	5	$ 6	High
GS6	4	$ 4	Medium
GS7	1	$ 10	Medium
SC1	5	$ 15	High
SC2	4	$ 20	High
SC3	1	$ 5	Low
SC4	3	$ 35	High
SC5	2	$ 5	Low
SC6	3	$ (10)	Opportunity
SC7	2	$ (15)	Opportunity

Risk	Likelihood	Conseq. (FY07$M)	Risk Level
PL1	4	$ 10	Medium
PL2	3	$ 15	Medium
PL3	2	$ 5	Low
PL4	5	$ 30	High
PL5	4	$ 20	Medium
PL6	3	$ (25)	Opportunity
PM1	4	$ 25	Medium
PM2	4	$ 10	Medium
PM3	3	$ 15	Medium
PM4	4	$ 20	Medium
PM5	5	$ 50	High
PM6	2	$ 25	Low
PM7	1	$ 30	Medium
PM8	2	$ 20	High
PM9	3	$ (50)	Opportunity
LV1	5	$ 20	Low

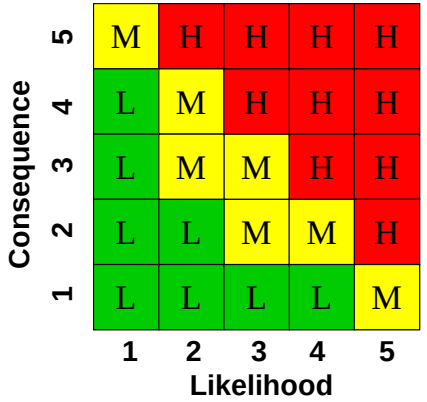
All projects should have risks that can be quantified in this manner

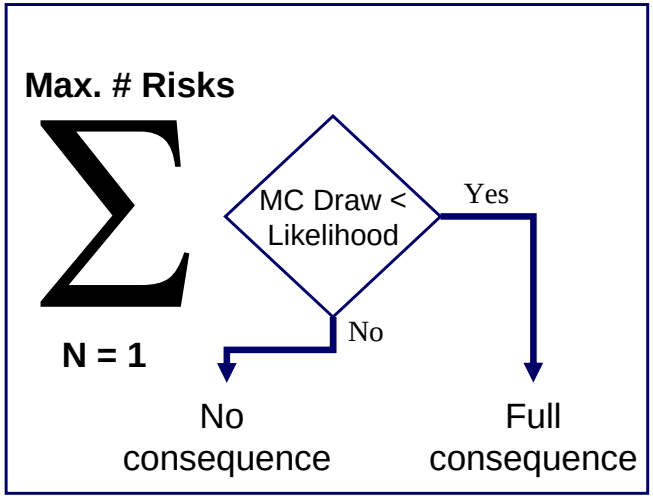
5x5 Matrix Cost Risk Conversion Process Overview

Identify Discrete Risks
Risk #1
Risk #2
Risk #3
…

Estimate Consequence
- WBS, Months delay, Phase of Delay
- WBS % Increase in NRE, RE or both
- Convert both to $

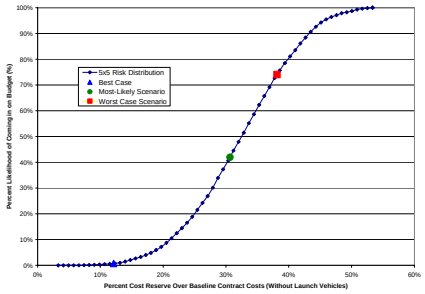
Estimate Likelihood
- Remote, Unlikely, Likely, Very Likely, Near Certainty





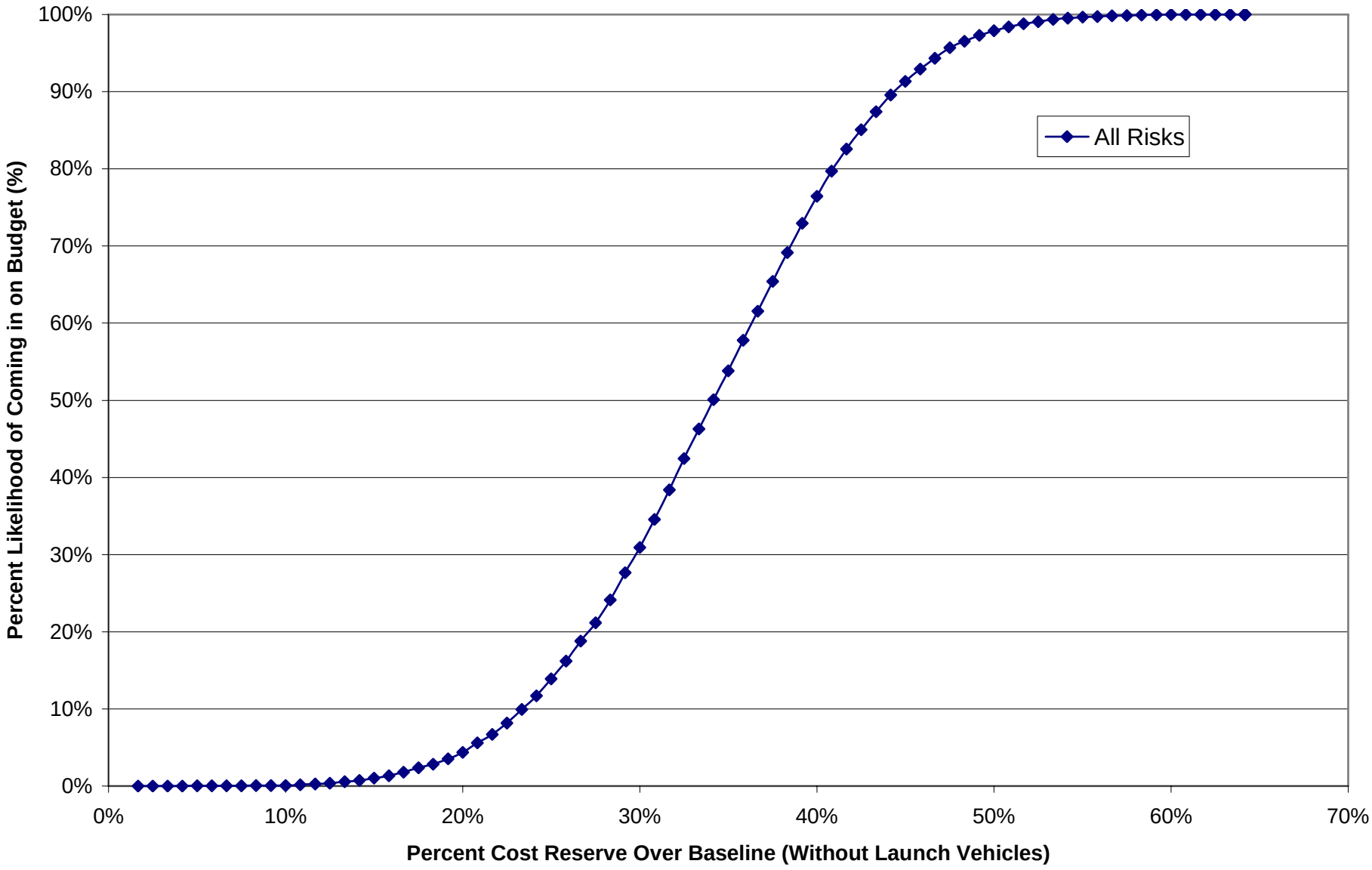
Run 10,000 iterations

Develop Cumulative Distribution



Process run in Excel to allowing for direct traceability to risk and baseline estimate

Results Based on Full Risk List as Percent of Baseline Development Costs

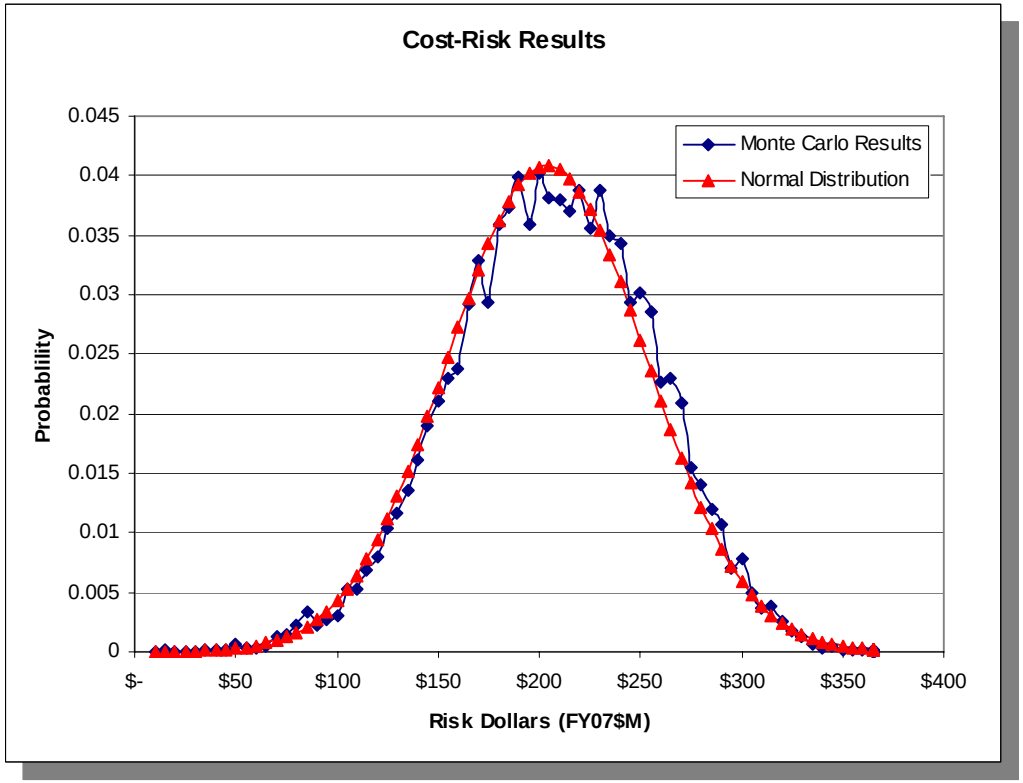


Discrete Cost Risk Can Then be Added to Model Specific Cost Risk to Provide A Complete Cost Risk Picture

- Model Specific Considerations
  - Cost risk should measure uncertainty about a baseline estimate
    - Different estimate methods should have different error bounds
- Understand basis of estimate
  - Cost Estimating Relationship (CER)
  - Database
  - Range of input values
- Range of possible answers
  - Assuming CER is built on a comprehensive, representative database past projects would have experienced a comparable set of problems
    - If range of input values is appropriate, then no need to add anything from the discrete list
  - If database of projects is not representative or unknown, then problems are not representative and it is unclear if some of the cost of problems were “normalized out” of the cost data, so be conservative
    - Add all of the risks from the discrete list
  - Correct answer is almost certainly in the middle
- Analyze discrete risks
  - Identify whether each risk is ‘in’ or ‘out’ of the baseline S-curve from each model
  - Run Monte Carlo, in which the only discrete risks not already covered by model are included
  - Add result to the ‘regular’ S-curve to get a combined S-curve

Adding Results To Other S-Curves

- Distribution from this analysis is close to normal
- Can be treated as an “extra” WBS element in standard analysis tools
- The Monte Carlo results can be described by the following parameters
  - Mean: $204M
  - Median: $204M
  - Standard Deviation: $49M



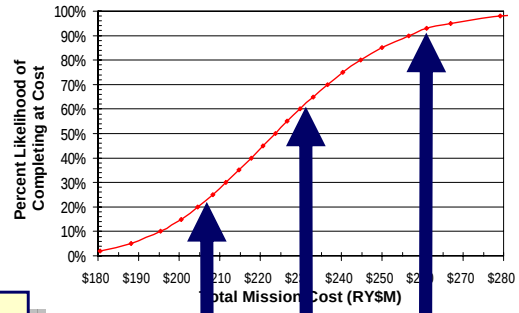
Discrete Risks List Can Also Be Used to Develop Scenario Based Estimate Approach

List of Threats From Cost Risk Assessment

Define best, nominal and worst case Scenarios

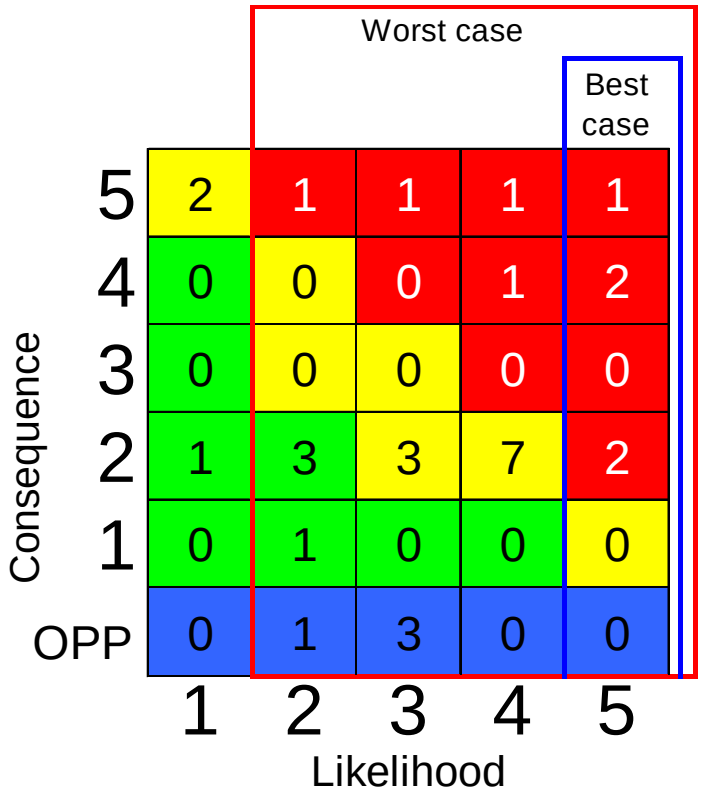
Baseline Cost Estimate + Estimate Cost Deltas = Best, Nominal, Worst Case Cost

Final Cost Distribution

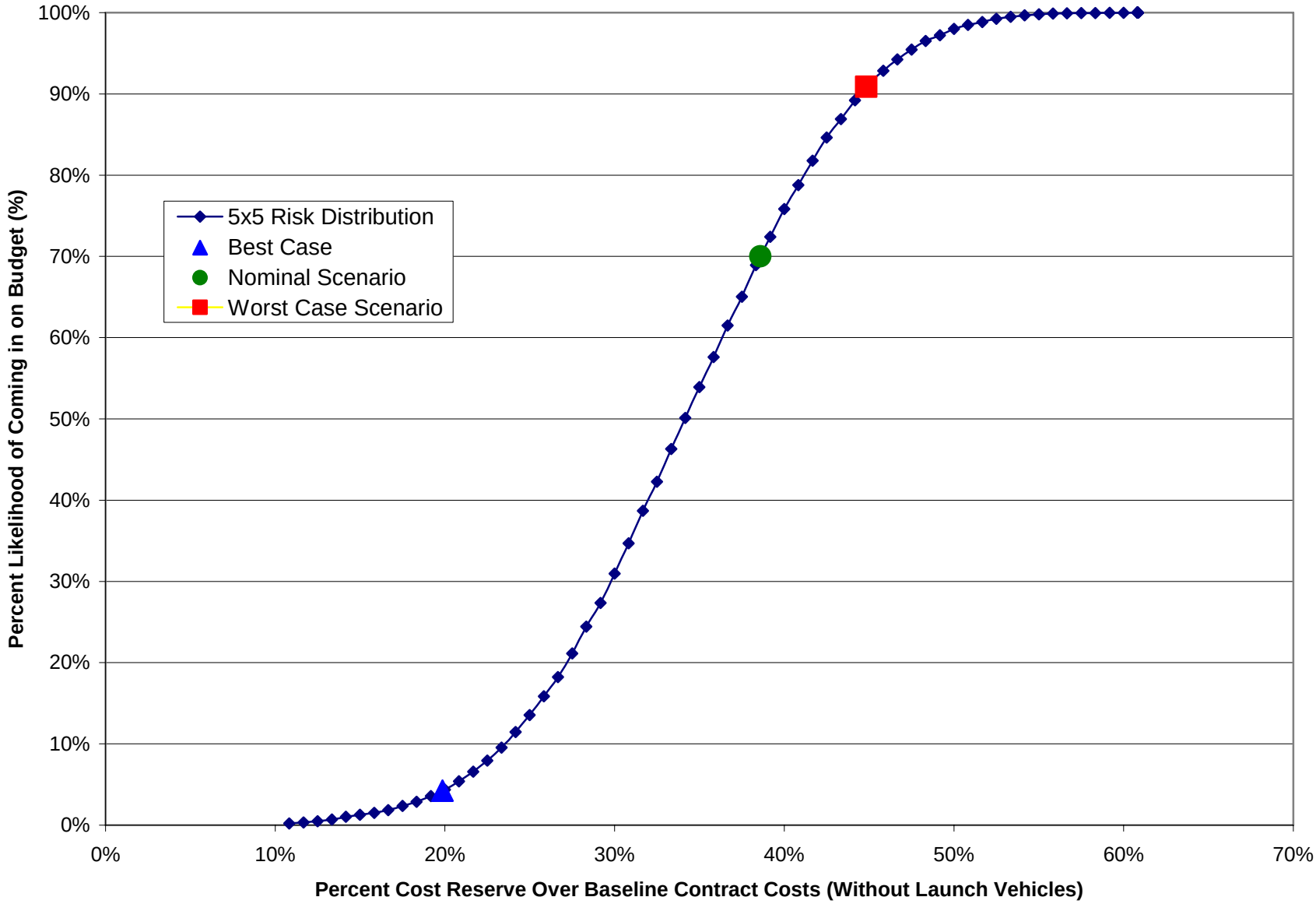


Scenario Based Risk Assessment

- Started with database (5x5 matrix) of risks, likelihoods and consequences
- Nominal Scenario defined as 70th percentile estimate from probabilistic analysis of risks
- Best Case Scenario defined by sum of consequence values for only risks with likelihood greater than or equal to 0.9 (Near Certainty)
- Worst Case Scenario defined by sum of consequence values for all risks with likelihood greater than or equal to 0.3 (Somewhat unlikely)
- Scenario analysis uses average of contractor-specific risks



Scenario Based Results Plotted on S-Curve from Probabilistic Analysis



Benefits/Limitations of Approach & Next Steps

- Benefits
  - Involves Technical Experts (e.g. Standing Review Board (SRB), Independent Assessment Team (IAT), etc.) directly in cost risk process
  - Provides SRB/IAT ownership of risks and buy-in to cost-risk process
  - Provides traceability of risks to S-curve distribution, determination of proper reserve levels and scenario based estimates
- Limitations
  - Approach may not account for unknown unknowns depending on thoroughness and foresight of review team
  - Likelihood and consequence of risks based primarily on expert opinion
- Next Steps
  - Review historical projects to determine cost/schedule growth attributed to unknown unknowns at time of CSR, PDR, CDR, ARR, etc.

Summary

- Approach developed to translate traditional 5x5 risk matrix inputs into cost risk distribution
- Project risks identified and quantified
  - Technical experts identify and provide ownership for discrete risks
  - Consequence in $ based on translation of schedule delay into cost or as a percent cost increase
  - Likelihood estimate as probability of occurrence
- Tool developed to translate quantified risks into cost risk distribution
  - Monte Carlo draws on discrete risks provides distribution of possible outcomes
- Scenario Based Estimate is directly traceable to discrete risk list
  - Risks grouped into best case, most-likely, and worst case and combined for range of scenario based estimate
- Additional work required to account for contribution of unknown unknowns