PNNL-SA-141888

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Enterprise Risk Management of Large Facility Projects

Stephen Unwin

Presentation at the NSF 2019 Large Facilities Workshop

April 4, 2019

U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

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Outline

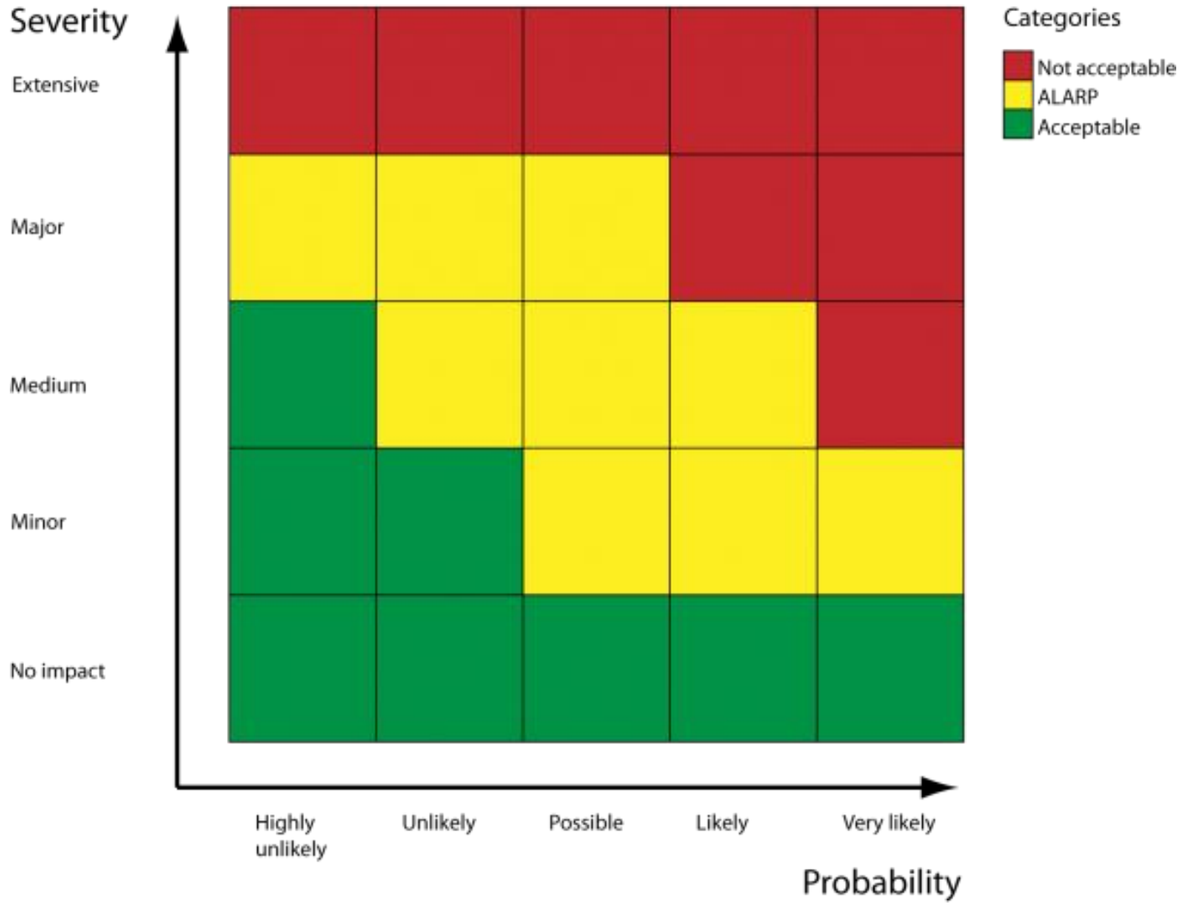
- Enterprise risk management: what and why?
- Why quantify risk (if you can)?
- Defining risks/uncertainties
- Role of Subject Matter Expertise
- Characterizing risks
- Finding the risk drivers
- Risk mitigation/handling
- Risk monitoring/communication
- A few cases studies: what was gained?

Enterprise Risk Management: What and Why

- Managing diverse risks across big programs
  - Diverse types of activities
  - Multiple technical disciplines
  - Numerous facility types
  - Several geographic locations
  - High stakes/visibility
- And managing it
  - Consistently
  - Transparently
  - Defensibly
- By applying
  - A common, uniform risk basis

Why quantify program risk?

- Qualitative risk methods may be best suited prior to detailed project definition



But …

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Why quantify program risk?

- Because it's a robust/scrutable basis for risk management
  - Fully incorporates complex schedule/costing logic
  - Transparent identification of risk drivers
  - Supports a realistic view of timelines and costs
  - Can test/justify/track risk mitigation strategies and performance improvement strategies
  - Quantifies contingency needs
- And because highly visible programs may undergo greater scrutiny
  - Scrutable basis for conveying risks and impacts
  - Provides a robust defense of risk management decisions
  - Describes near-term and out-year probabilistic cash flow
  - Focuses leadership attention to manage threats and pursue opportunities

While a qualitative risk analysis is less resource intensive, a quantitative analysis provides deeper and more defensible insights

Risk/Uncertainty Taxonomy

- Sources of risk:
  - R&D outcomes
  - Low TRL uncertainty
  - Construction
  - Budgetary
  - Performance
  - Vendor availability
  - Compliance
- Impacts of risk:
  - Schedule
  - Cost
  - Reputation
  - Safety
  - Environmental
  - Mission

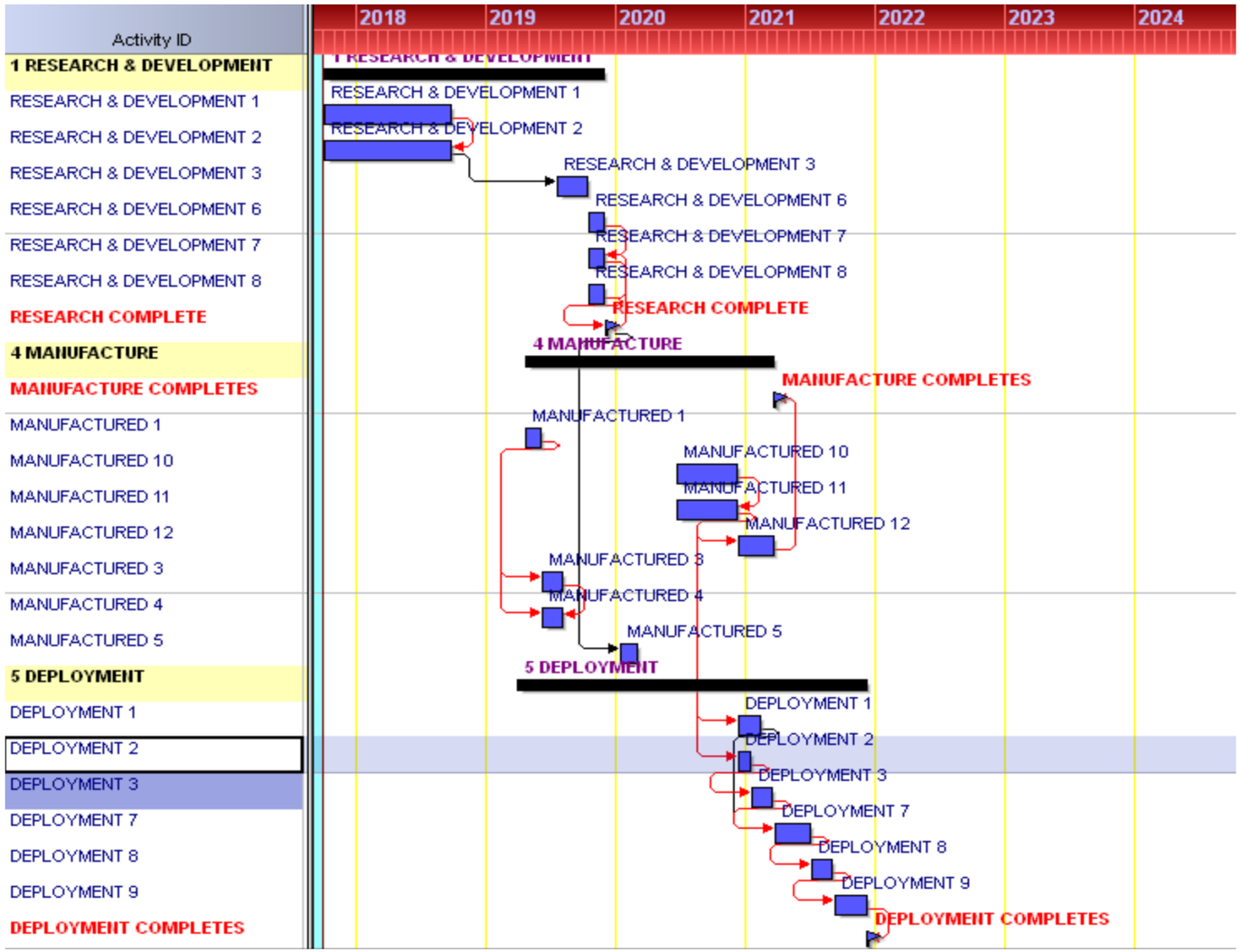
- Some risks outside program purview
  - These risks are not generally quantified
  - Identify and listed as Enabling Assumptions
    - ✓ E.g., adequate budget appropriation
- Program uncertainties also modeled probabilistically
  - While *risks* are linked to episodic events, *uncertainty* defined in terms of imprecision in task cost/duration estimates
- Issues versus risks
  - Issues have no probability element
  - Have occurred or *will* occur and need to be managed

Baseline Schedule

While qualitative/semi-quantitative risk methods can be applied early in conceptual design, a full quantitative study begins generally with a baseline schedule

PNNL experience with complex programs:
> 100,000 tasks

And with the integration & modeling of diverse risks:
> 1,000 risks



Elicitation: Basis for risk identification and characterization

- Identify technical domains/pillars
  - Mirror technical breakdown of baseline schedule or WBS
  - Multiple (3+) subject matter experts (SMEs) participants per pillar
- Identify elicitors, who have
  - Understanding of risk context
  - Ability to manage elicitation pitfalls
    - ✓ Overconfidence
    - ✓ Dominating participants
    - ✓ Self-serving biases
    - ✓ Flawed/incomplete reasoning
    - ✓ Other social dynamics, groupthink
- Elicit risks and handling strategies / mitigative actions
  - Probabilities and impacts

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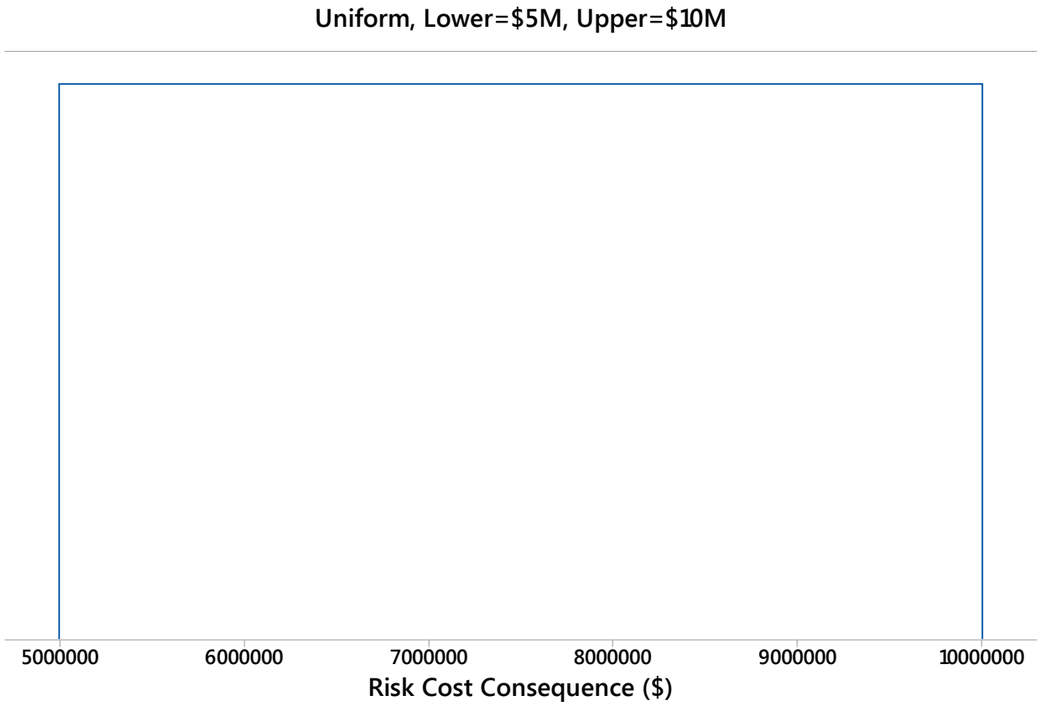
Risk Event Probability Characterization

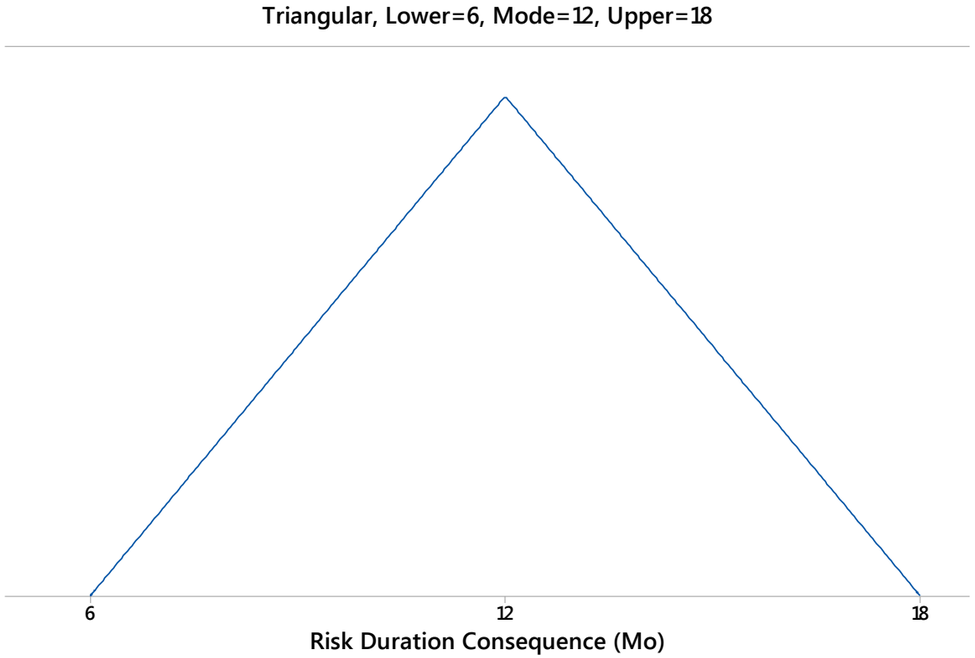
Rating	Description	Interval	Likelihood
Very Very Low	May only occur in exceptional circumstances	0-1%	0.5%
Very Low	May occur in rare circumstances	0-10%	5%
Low	Could only occur some time	11-25%	18%
Moderate Low	Might occur some time	26-50%	33%
Moderate	Might occur some time	26-75%	50%
Moderate High	Might occur some time	50-75%	66%
High	Would probably occur in most circumstances	76-90%	83%
Very High	Is expected to occur in most circumstances	91-100%	95%

Risk Event Consequence Characterization

Probability distribution: Cost uncertainty



Probability distribution: Duration Impact uncertainty



Central Risk Register

Primary Risk

Band: MH | **Range:** 50 - 75% | **(%):** 70

Basis:
The likelihood is high that if improvements are not in place this risk will realize through experimental and developmental campaigns.

Cost

Band: VH | **Range:** 10 - 25 $M | **Shape:** Uniform

Min: 24.5 | **ML:** | **Max:** 36.7 | **Period:** Fixed

Basis:
The following campaigns are likely to get impacted. The main factor accounted to increase cost is rework (due to on-demand labor to meet throughput on time). This cost

Duration

Band: MH | **Range:** 9 - 12 months | **Shape:** Uniform

Min: 6.25 | **ML:** | **Max:** 12.5 | **Period:** Months

Basis:
A successful foil production campaign will take 125 days, or 6.25 Mo (125-days/20-days/mo). This value is the minimum risk impact over current schedule. The maximum risk impact is

Residual Risk

Band: L | **Range:** 11 - 25% | **(%):** 1

Basis:
Any residual risk after mitigation is successfully implemented is related to efforts to perform the fabrication requirements document for the rest of the campaigns to

Cost

Band: L | **Range:** 0.1 - 1 $M | **Shape:** Uniform

Min: 0.5 | **ML:** | **Max:** 1 | **Period:** Fixed

Basis:
Perform the fabrication requirements document for the rest of the campaigns

Duration

Band: ML | **Range:** 3 - 6 months | **Shape:** Uniform

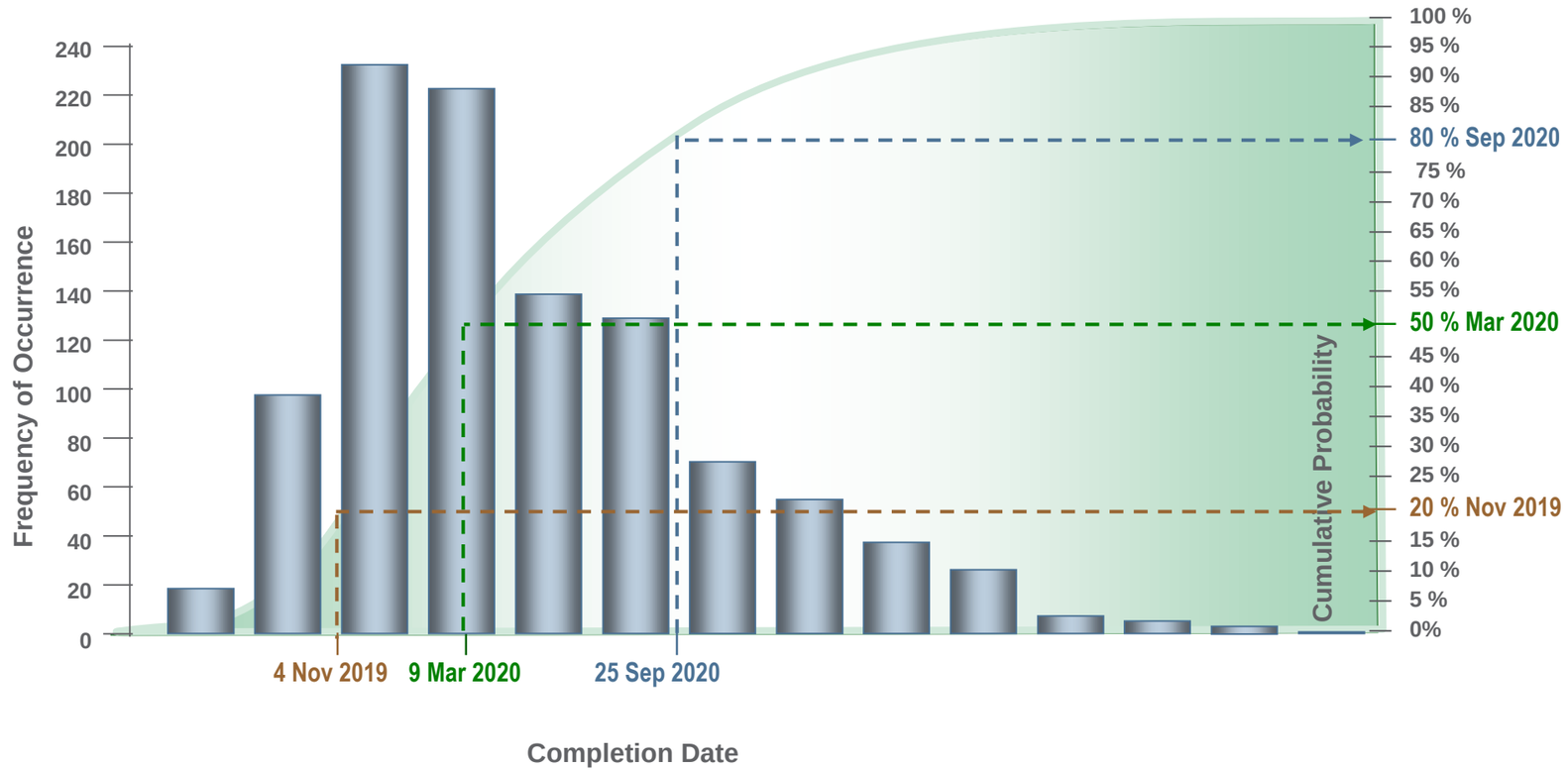
Min: 2 | **ML:** | **Max:** 6 | **Period:** Months

Basis:
Perform the fabrication requirements document for the rest of the campaigns

Can be custom-built or shrink-wrapped

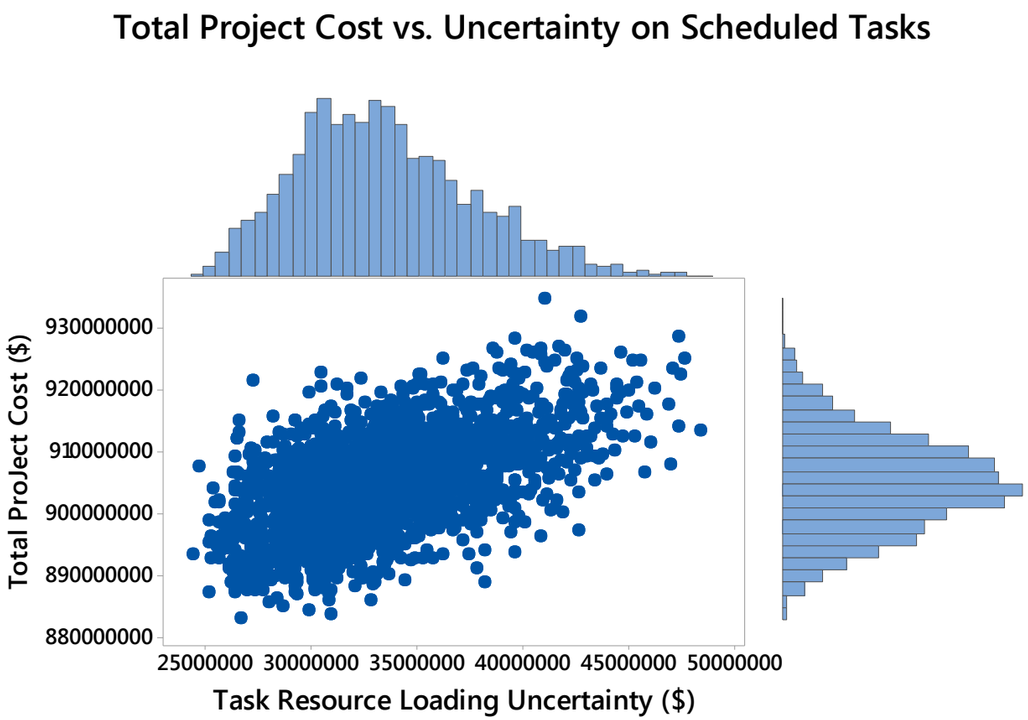
Implementation of Risk Model

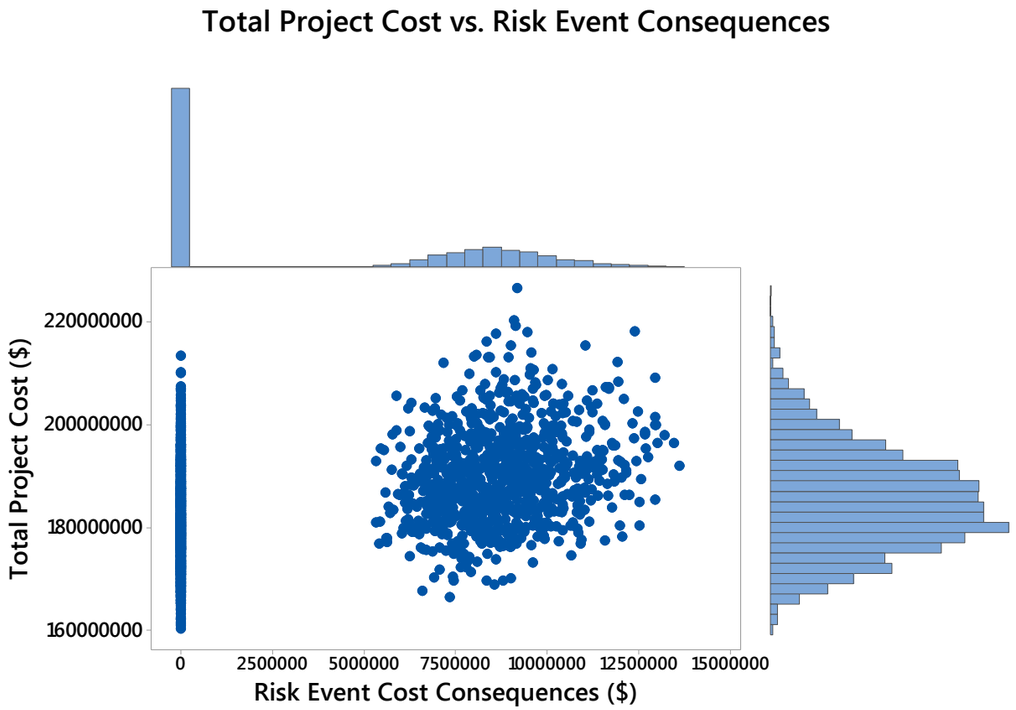
Monte Carlo analysis that integrates the risk register with the baseline costed schedule



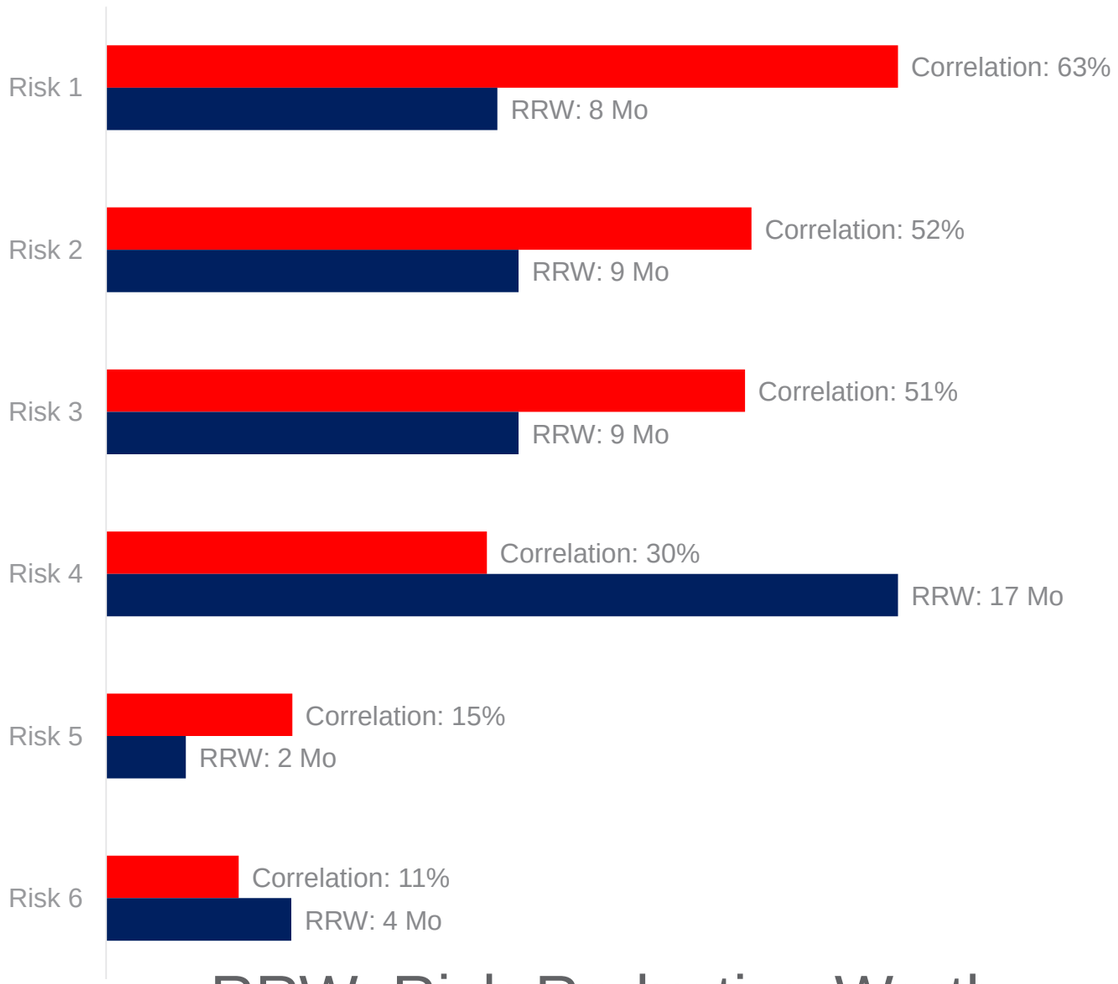
Looking for the Risk-Drivers

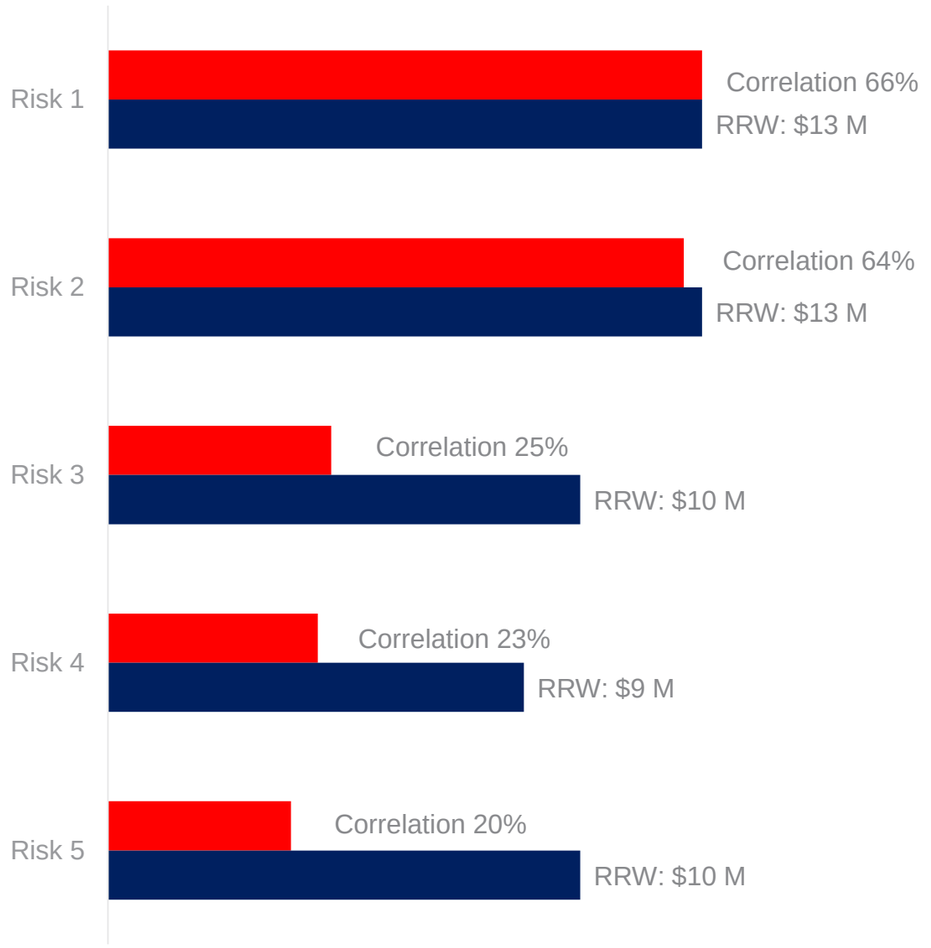
Knowing the risk-drivers is knowing where to direct risk management resources





Importance/Sensitivity Analysis





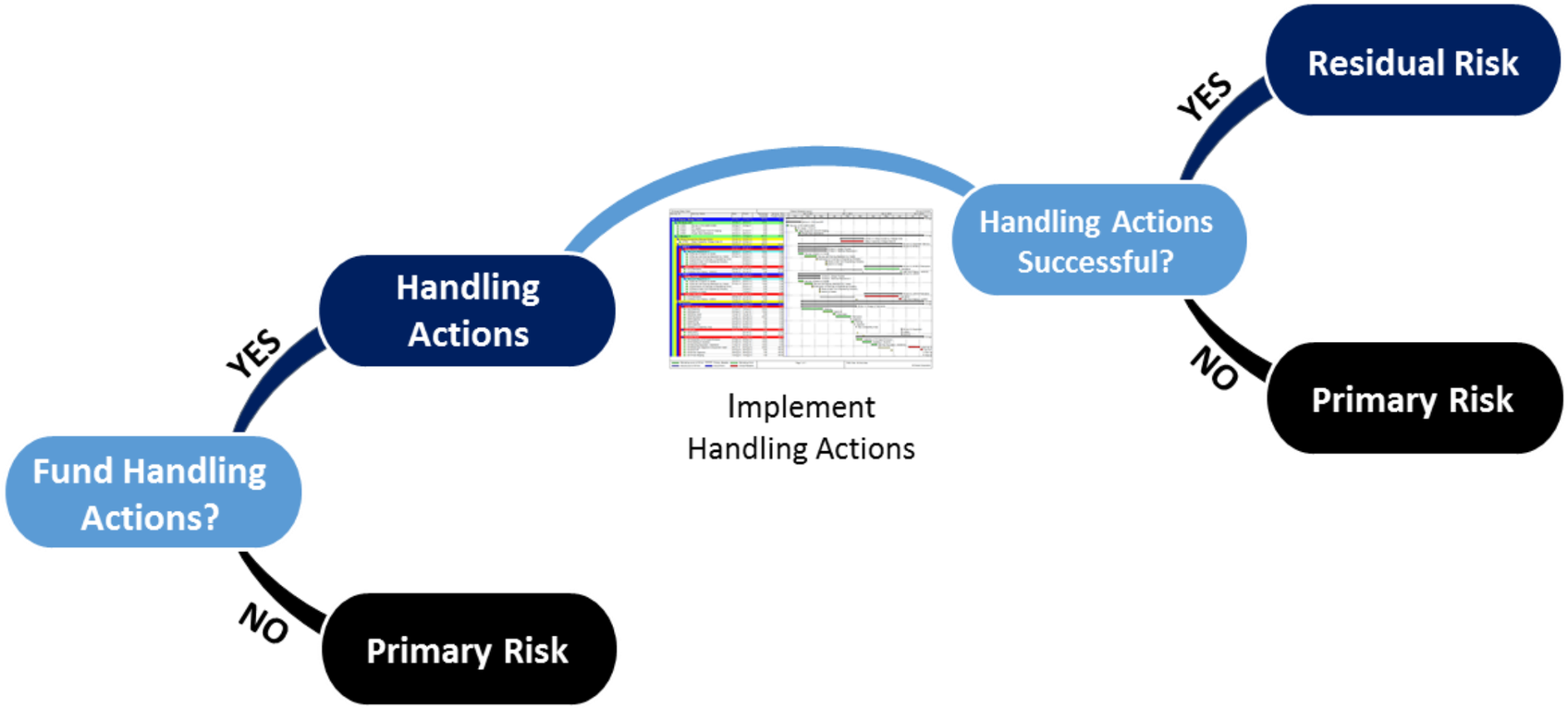
RRW: Risk-Reduction Worth

Correlation RRW

Risk Handling Actions (Mitigations)

Handling options: Accept risk, eliminate it, reduce it, or transfer it.

Risk impact of handling actions and other opportunities for risk reduction can be incorporated into the model



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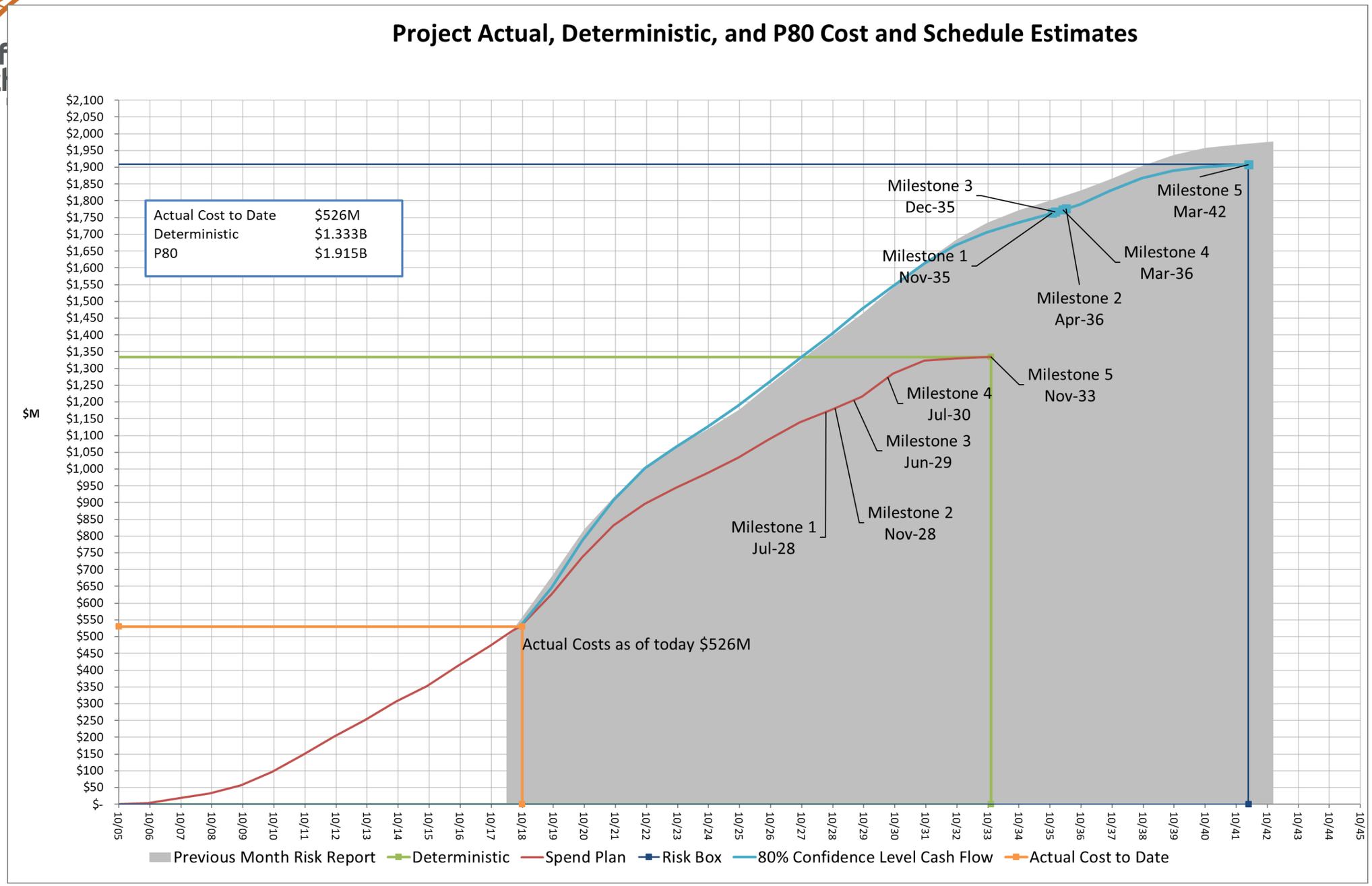
Risk Handling Actions (Mitigations)

Timely reminders for risk mitigation opportunities

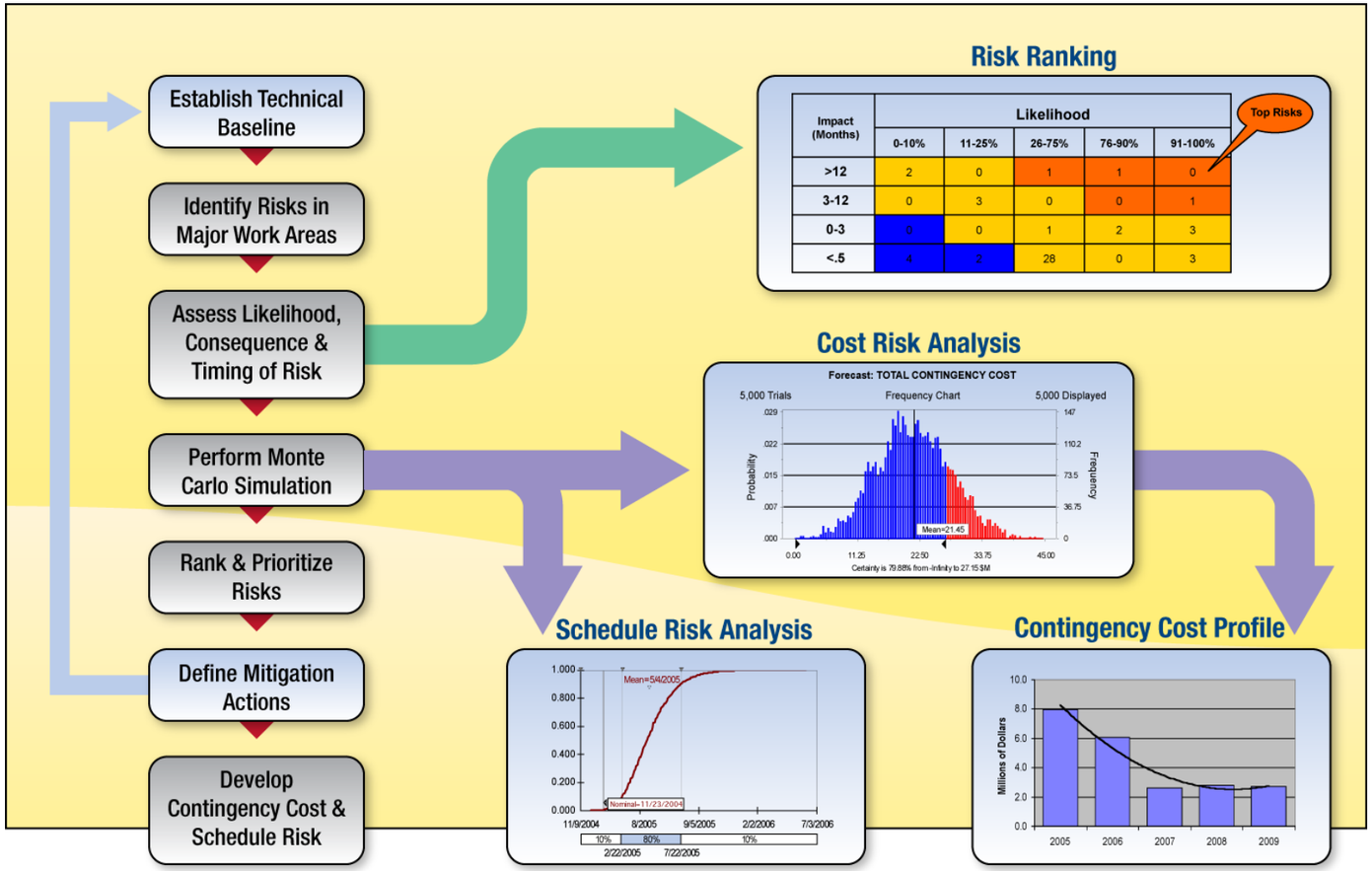
ID	Risk Title	Handling Strategy Description	Handling Action Un-Budgeted Cost					Increase/Decrease in P80	
			FY17	18	19	Othr	Total	Cost Savings ($)	Schedule Reduction (Mo)
ID.1	{A specific identified risk that impacts both cost and schedule}	{Specific Handling strategy for risk ID.1 that, at the P80, has a significant savings to the lifecycle cost and schedule}		$2M			$2M	$7.77M	4.77 Mo, M1 2.73 Mo, M2 3.92 Mo, M3
ID.2	{A specific identified risk that impacts both cost and schedule}	{Specific handling strategy for risk ID.2 that, at the P80, has a significant savings to the lifecycle cost or schedule}	$30K	$30K	$30K	$30K	$120K	$0.5M	1.02 Mo, M1 0.73 Mo, M2 1.16 Mo, M3
ID.3	{A specific identified risk that impacts both cost and schedule}	{Specific handling strategy for risk ID.3 that, at the P80, has no significant impact to the lifecycle cost nor schedule}	$10K	$30K	$10K	$50K	$100K	$-0.1M	5 Mo, M1 2 Mo, M2
ID.4	{A specific identified risk that impacts both cost and schedule}	{Specific handling strategy for risk ID.4 that, at the P80, has a significant impact to the lifecycle schedule}	$10K	$70K	$20K		$100K	$-0.1M	-1.5 Mo, M1 -3 Mo, M2

Risk-Informed versus Baseline Projections



Where a Structured Quantitative Risk Program has been the Solution

- Technically diverse, multidisciplinary programs
- Big, complex, cross-tied programs
- Geographically diverse programs
- Programs in need of scrutability and defensibility
- Programs in trouble



Case Study: Richland Operations

- DOE-EM - Hanford: largest cleanup project in the world
  - 586 miles^2
  - 9 reactors
  - 6 chemicals separations facilities
  - 1,500+ building
  - 2,000+ contaminated soil sites
- $60B, 50+ year project
  - 100,000+ activities, 1,000+ identified risks, 3 prime contractors, dozens of subs
- PNNL started developing/implementing risk methods in 1999
- Genesis of the current risk tool set
  - Now incorporated into some commercial packages
- Risk model basis to inform stakeholders on realistic timelines/budgets

Case Study: US High-Performance Research Reactor Fuel Conversion

- NNSA - conversion of research reactors to low-enriched uranium fuel
  - 5 reactors for conversion
  - Analysis team across 7 states
  - Significant R&D element
  - Diverse technical pillars
    - ✓ New fuel designs, fabrication, testing, transportation, licensing and reactor conversion
- $1B+, 30 year project
  - 8,000+ activities, 700+ identified risks, multiple national labs and contractors
- Transparency has been crucial
  - Basis for responding to Congressional requests

Case Study: PNNL Capability Replacement Lab

- DOE Office of Science - Construction and upgrading of laboratory space affected by DOE cleanup of 300 Area
  - Build Physical Science Lab (Congressional line item)
  - Infrastructure and transition project
  - High-visibility project
- $224M, 4 year project
  - 3,400 activities, 250+ identified risks
- Risk management critical
  - On-schedule DOE approval of critical decision points
  - Facilities delivered on-time, within budget
- Vehicle for significant methodology enhancements

Case Study: Belle II Electronics and Data Acquisition

- DOE Office of Science - Delivery of detector elements to achieve research goals using Japanese (KEK) Belle II electron-positron collider
  - Delivery of multiple instruments, monitors, readout systems
- Smaller project: $15M+, 4 years
  - 2,000+ activities, 50+ identified risks
- High-visibility project for DOE SC High-Energy Physics
  - On Lab Director's performance list
- Comprehensive cost and schedule risk identification and management project

PNNL Mission/Program Risk - Our Lessons Learned

- What's critical to transparency, interpretability and defensibility of risk insights:
  - Capturing the logic of mission success
    - ✓ Integrated budget/schedule risk insights
  - Adhering to best practices elicitation/quantification
  - Use of state-of-the-art quantitative analytical techniques
    - ✓ Creates defensible insights of value to stakeholders:
      - Budget/schedule contingency requirements, risk drivers, risk reduction effectiveness
  - Err on the side of over-communication
    - ✓ Frequent and effective communication with stakeholders
- Strong partnerships with software developers
  - Building-in evolving methodology/capability
  - Most recently: Safran Risk Software