A Quantitative Method for Risk Tracking and EAC Management Through The Project Lifecycle

David Grodzki

Weapons Infrastructure Project Engineer

Lawrence Livermore National Laboratory

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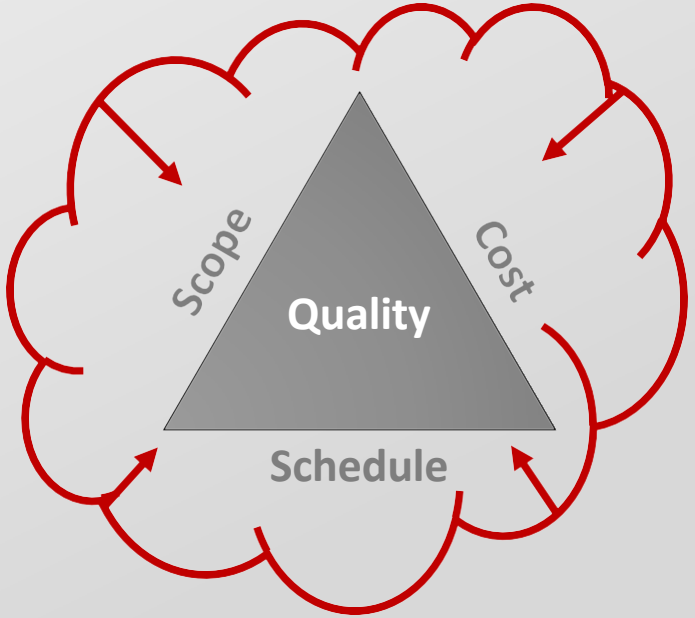
Presenter Background

- Rose-Hulman Institute of Technology, B.S. Mech. Eng.
- (7) years experience in test, design, applications
  - Mercury Marine (Fond du Lac, WI)
  - Grundfos (Indianapolis, IN)
- (6) years at Rolls-Royce (Indianapolis, IN)
  - Project Engineer, F-35B Structures & Transmissions
  - IPT Lead, Trent 1000-TEN Compressor Structures
  - Project Lead, Hybrid-Electric Propulsion
- (2) years at Pratt & Whitney (West Palm Beach, FL)
  - IPT Lead, PW1100G Mechanical Systems & Externals
  - Project Engineer: F135 High Pressure Compressor
- Currently: Weapons Infrastructure Project Engineer at LLNL
  - PE for (2) new material characterization facilities, ALM, HE&E & SNM processing equipment

David Grodzki
CECOP 2022

Risk Management: Principles & Practices



- Forms the core of successful project management & execution
  - Risk can be thought of as the external "pressure" applied to the project management triangle
- Well-planned projects account for key risk mitigation
  - Structure project Verification & Validation (V&V) around key risk items
  - Inform all stakeholders, understand consequences
  - How much / where should risk be taken to avoid erosion of key characteristics (KPIs)?
  - Ensure mitigations are defined, achievable, costed, resourced
- Successful projects manage risk in an iterative fashion to avoid surprises
  - Registers, waterfalls, etc. are not the only tools for managing risk! Utilize V&V, FMECA, EVMS, schedule to execute mitigation plans, trade margin, and optimize design through project conduct
  - Be prepared to adjust resources & project priorities dynamically as risks manifest

LLNL WI Tools for Managing Risk

- Risk Assessment Forms efficiently capture key information
  - What is the basis of the risk?
  - What is the consequence? (Probability / Impact scoring)
  - What funding sources will be impacted if risk comes to fruition?
  - What funding sources provision for mitigations?
  - Document plan to close, status, and action owners
- Do not excel at tracking risk impact & closure
  - Not purely numerical
  - Not time phased
  - Do not aggregate subsystem risks to full-system level
  - Not aligned to project schedule or Estimate At Complete (EAC)

Non-Nuclear Capabilities Modernization Office (NA-194)
Risk Assessment Form (RAF)

General Information				
Risk ID	Title	Type	Status	Risk Owner

Background Information

Risk Description	
If this risk event occurs...	
...then there will be this technical consequence	
...which impacts the Project in this way	

Trigger Date	Trigger Event

Programs (LEPs, ALTs, legacy, etc.) Impacted	

Current Risk Evaluation (Pre-Mitigation)	
Probability of Occurrence (%)	Basis of Estimate
Schedule Impact (weeks)	
Cost Impact ($M)	
Funding Source	
Mission Impact	
Primary Risk Level	

Risk Handling			
Risk Handling Strategy			
Mitigation/Recovery Plan		Mitigation/Recovery Cost ($M):	
Mitigation/Recovery Plan Approval Date		Mitigation/Recovery Funding Source	
Mitigation/Recovery Plan Status (and date):			

Residual Risk Evaluation (Post-Mitigation)	
Residual Probability of Occurrence (%)	Basis of Estimate
Residual Schedule Impact (weeks)	
Residual Cost Impact ($M)	
Funding Source	
Residual Mission Impact	
Residual Risk Level	

Risk Closure	
Retirement Date/Milestone	Criteria for closure
Closed Risk Review Date:	

An Example (NA-194) Risk Assessment Form

LLNL WI Tools for Managing Risk

- Risk Registers provide for additional tracking of multiple project risk items to inform system margin
  - Provides for evaluation of multiple risks to common criteria
  - Tracks progress of mitigation closure
  - Can accommodate quantitative & numerical ranking
  - Provides for risk trades between Integrated Product Teams (IPTs)
- Provide Program Manager (PM) with good overall visibility into key project risks, but frequently do not inform ongoing execution strategy!
  - Not directly tied to project EAC, schedule
  - Not robust in individual risk phased mitigation tracking & residual risk maturity

Id	Risk Description	Probability (%)	L/M/H	Impact (Delays in days)	EMV (P*I) (Days)
Project A Risk Register (Partial) - Mar 2011				Total EMV (delay in days) = 43	
1	Delays in completing the Data Model	40%	M	15	6
2	Impact is very large because of new data model	10%	L	10	1
3	Sharing of tables gets minimized to keep the impact low	30%	M	10	3
4	Data migration is not final until end of Nov 11	50%	M	15	7.5
5	Conversion of Group1 programs gets delayed	50%	M	15	7.5
6	Batch Cycle becomes longer	40%	M	5	2
7	Project X - taking the resources away from this project	80%	H	15	12
8	Other new product - Taking resources away	80%	M	5	4
Project A Risk Register (Partial) - May 2011				Total EMV (delay in days) = 46.5	
1	Delays in completing the Data Model	30%	L	10	3
2	Impact is very large because of new data model	10%	L	10	1
3	Sharing of tables gets minimized to keep the impact low	20%	L	5	1
4	Data migration is not final until end of Nov 11	50%	M	15	7.5
5	Conversion of G1 programs gets delayed	60%	M	15	9
6	Batch Cycle becomes longer	40%	M	5	2
7	Project X - taking the resources away from this project	80%	H	15	12
8	Project Y Implementation of Base Layer gets delayed	10%	L	10	1
9	Datawarehouse can't handle new data by end of Dec 11	50%	M	20	10
10	Other new product - Taking resources away	80%	M	5	4
Project A Risk Register (Partial) - Jul 2011				Total EMV (delay in days) = 33	
1	Delays in completing the Data Model	0%		10	0
2	Impact is very large because of new data model	0%		10	0
3	Sharing of tables gets minimized to keep the impact low	0%		5	0
4	Data migration is not final until end of Nov 11	30%	L	10	3
5	Conversion of G1 programs gets delayed	50%	M	10	5
6	Batch Cycle becomes longer	40%	M	5	2
7	Project X - taking the resources away from this project	80%	H	15	12
8	Project Y Implementation of Base Layer gets delayed	10%	L	10	1
9	Datawarehouse can't handle new data by end of Dec 11	50%	M	20	10
10	Other new product - Taking resources away	80%	M	5	4
Project A Risk Register (Partial) - Sep 2011				Total EMV (delay in days) = 25.1	
1	Delays in completing the Data Model	0%		0	0
2	Impact is very large because of new data model	0%		0	0
3	Sharing of tables gets minimized to keep the impact low	0%		0	0
4	Data migration is not final until end of Nov 11	5%	L	2	0.1
5	Conversion of G1 programs gets delayed	15%	L	10	1.5
6	Batch Cycle becomes longer	30%	L	15	4.5
7	Project X - taking the resources away from this project	50%	H	10	5
8	Project Y Implementation of Base Layer gets delayed	10%	L	10	1
9	Datawarehouse can't handle new data by end of Dec 11	50%	M	20	10
10	Other new product - Taking resources away	30%	L	10	3
Project A Risk Register (Partial) - Dec 2011				Total EMV (delay in days) = 22.5	
1	Delays in completing the Data Model	0%		0	0
2	Auto Impact is very large because of new data model	0%		0	0
3	Sharing of tables gets minimized to keep the auto impact low	0%		0	0
4	Data migration is not final until end of Nov 11	0%		2	0
5	Conversion of G1programs gets delayed	0%		10	0
6	Batch Cycle becomes longer	30%	L	15	4.5
7	Project X - taking the resources away from this project	0%		0	0
8	Project Y Implementation of Base Layer gets delayed	0%		0	0
9	Datawarehouse can't handle new data by end of Dec 11	50%	M	20	10
10	Other new product - Taking resources away	30%	L	10	3
11	Legacy System Changes not completed by end of Dec 11	50%	M	10	5
Project A Risk Register (Partial) - Feb 2012				Total EMV (delay in days) = 3	
1	Delays in completing the Data Model	0%		0	0
2	Auto Impact is very large because of new data model	0%		0	0
3	Sharing of tables gets minimized to keep the auto impact low	0%		0	0
4	Data migration is not final until end of Nov 11	0%		2	0
5	Conversion of G1programs gets delayed	0%		10	0
6	Batch Cycle becomes longer	10%	L	5	0.5
7	Project X - taking the resources away from this project	0%		0	0
8	Project Y Implementation of Base Layer gets delayed	0%		0	0
9	Datawarehouse can't handle new data by end of Jan 12	0%		10	0
10	Other new product - Taking resources away	0%		10	0
11	Legacy System Changes not completed by end of Jan 12	25%	M	10	2.5
12	Issues with coordination just after the code freeze is lifted	0%		5	0
13	Datawarehouse cycle becomes longer	20%	L	1	0.2

An example project risk register

https://www.pmi.org/learning/library/project-risk-management-success-tool-6078

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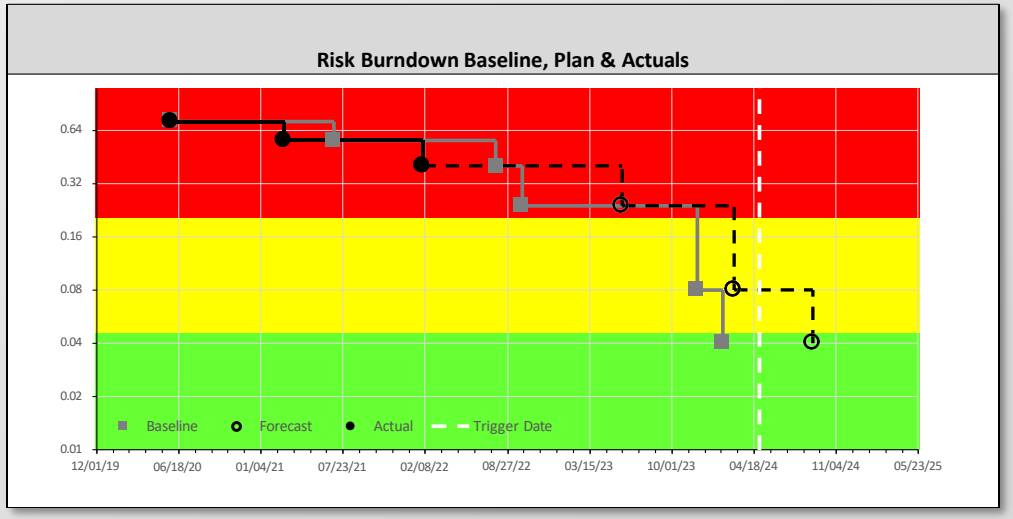
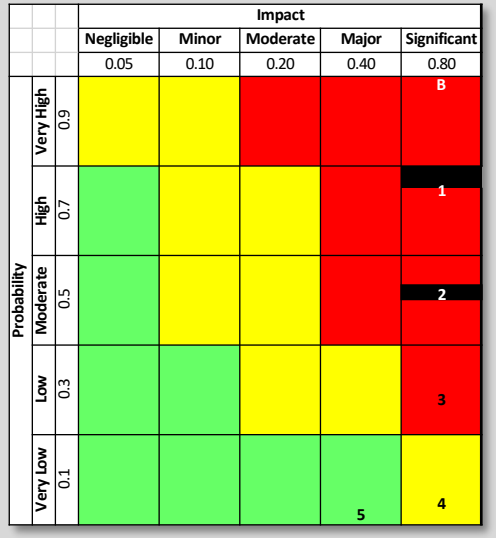
LLNL WI Tools for Managing Risk

- Risk "waterfall" tools provide for phased mitigation tracking through risk closure
  - Provide PM with visibility into original, current, and future risk status
  - Provide for additional (phased) mitigation tracking
  - Demonstrate progress to committed closure plans
- Typically, single-risk focused, and again, do not inform overall program risk trades or execution strategies
  - Not directly tied to project EAC, schedule, resources, funding
  - Individual risk owners may not be aware of larger program trades
  - Not robust for tracking overall risk impact to system margins
  - Manual input from individual closure plans to program risk register



A risk waterfall tool

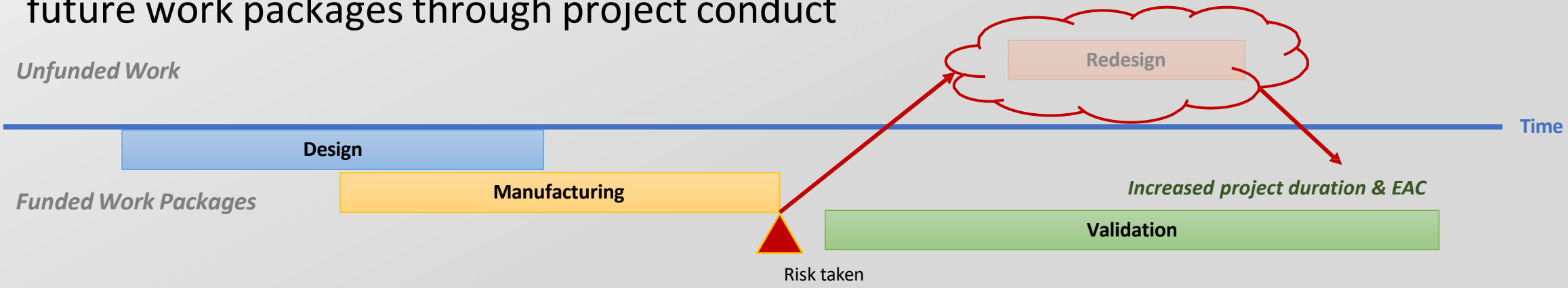


Common Methodologies for Ongoing Risk Management

- Talented lead systems engineers track technical KPIs and associated uncertainty through the development process for infrastructure & development programs
  - Examples: Weight, thrust, power, range, reliability, cooling / heating margin
  - At any point in development, can provide current weight, margin to max weight, uncertainty, what components are driving most uncertainty, etc.
- Project managers similarly have robust means of tracking project risk
  - Risks are presented at design reviews, etc. and mitigation plans are agreed
  - Mitigations are funded according to program appetite for risk
  - Management Reserve (MR) is allocated by PM to account for project risks
  - Risks are regularly statused through development, and obviously directly inform EV
  - **However, the risk process is frequently not precisely aligned to project schedule & cost**
  - There is no direct tie to schedule, EAC, or future resource demands as a result of evolving risk

Problem Statement

- Every "risk" taken during the course of a project represents a notional future work package, transferred, with some probability & impact, to the future project team
  - These work packages are not always planned for or resourced ("surprise" demand signals)
  - Agreed Management Reserve (MR) provides a "buffer", but not detail on how that buffer will be consumed, or how / when project staffing or deliverables will be impacted
  - Consequences: project delay due to staffing or funding, re-prioritization, knowledge gaps, etc.
- It would be preferable to be able to forecast, in real time, the demands of these future work packages through project conduct



Proposed Solution

- An integrated, excel-based tool developed & deployed by LLNL WI
  Goal: meet or exceed commercial tool (i.e. ARM) ability to predict risk impacts over time
  - Program-wide definition of common risk thresholds
  - Granular risk burndown & mitigation statusing for detailed risk management by technical staff
  - Aggregation into IPT and program-level risk register for PM personnel
  - Cost & schedule impact projections, as a function of time, which directly inform project EAC
- This approach provides immediate benefit to project & technical staff as well as to management allocating MR and resources
  - Project & technical leads can constantly evaluate & “run out” impacts (performance, staffing, budget) as an integral part of project EAC reporting & system design
    - What was / is / will be our risk level for system X?
    - Can we trade that risk level with another, healthier system?
    - How should we allocate funding, staffing, or program priority given a known future risk?

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Risk Thresholds Overview

- Probability and impact scoring per DOD Risk Management guidelines
- Thresholds can be agreed and modified per program criteria
- Provides for capture of cost, schedule, technical risk drivers
- Framework accommodates both risk & opportunity scoring

Project Opportunity & Risk: Probability & Impact Thresholds

		Negligible	Minor	Moderate	Major	Significant
Risk	Cost Impact ($k)	$0 to <$100k	$100k to <$1M	$1M to <$5M	$5M to < $10M	>$10M
	Schedule Impact (days)	Activity Delay <3mo Critical Path Impact <1mo	Activity Delay 3-6mo OR Critical Path Impact 1-3mo	Activity Delay 6-12mo OR Critical Path Impact 3-6mo	Activity Delay 1-2yr OR Critical Path Impact 6-12mo	Activity Delay >2y OR Critical Path Impact >1y
	Performance Shortfall	Negligible; Impact accommodated within existing margins	Minor; Impact accommodated by modifications within WBS	Moderate; Require modification to subsystem margins	Major; Require modification to system margins	Severe; Require modification to System KPIs
		Negligible	**Minor**	**Moderate**	**Major**	**Significant**
Opportunity	Cost Impact ($k)	$0 to <$100k	$100k to <$1M	$1M to <$5M	$5M to < $10M	>$10M
	Schedule Impact (days)	Activity Improve <3mo Critical Path Improve <1mo	Activity Improve 3-6mo OR Critical Path Improve 1-3mo	Activity Improve 6-12mo OR Critical Path Improve 3-6mo	Activity Improve 1-2yr OR Critical Path Improve 6-12mo	Activity Improve >2y OR Critical Path Improve >1y
	Performance Opportunity	Negligible; No significant change in performance margin	Minor; Opportunity for margin reallocation within WBS	Moderate; Opportunity for margin reallocation within subsystem	Large; Capability should be reallocated at system level	Very Large; Capability no longer required at system level

		Opportunity / Risk Impact				
		Negligible	**Minor**	**Moderate**	**Major**	**Significant**
		0.05	0.10	0.20	0.40	0.80
Risk Probability	**Very High**	0.05	0.09	0.18	0.36	0.72
	0.90					
	High	0.04	0.07	0.14	0.28	0.56
	0.70					
	Moderate	0.03	0.05	0.10	0.20	0.40
	0.50					
	Low	0.02	0.03	0.06	0.12	0.24
	0.30					
	Very Low	0.01	0.01	0.02	0.04	0.08
	0.10					
Opportunity Probability	**Very Low**	-0.01	-0.01	-0.02	-0.04	-0.08
	0.10					
	Low	-0.02	-0.03	-0.06	-0.12	-0.24
	0.30					
	Moderate	-0.03	-0.05	-0.10	-0.20	-0.40
	0.50					
	High	-0.04	-0.07	-0.14	-0.28	-0.56
	0.70					
	Very High	-0.05	-0.09	-0.18	-0.36	-0.72
	0.90					

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Risk Waterfall Overview

- Captures phased mitigation plans
- Tracks plans to baseline
- Accounts for closure funding required
- Visual & numeric representation of risk waterfall & risk cubes

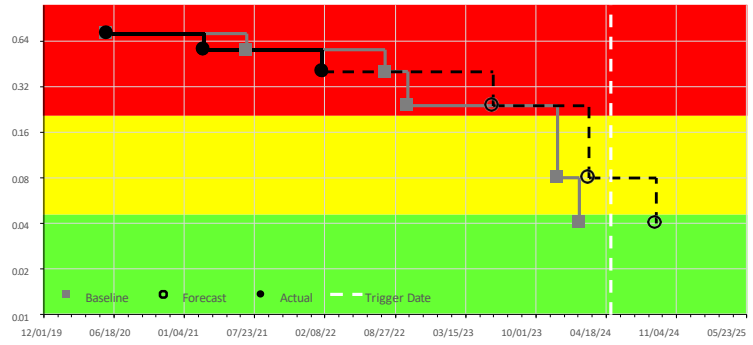
Hypothetical Example

Risk Title:	High R-Ratio Load Testing Capability	Subsystem:	Housing	IPT:	Frame	Owner:	Project Engineer	Type	Threat	Stragegy:	Mitigate	Status Date	06/24/22	Trigger Date	04/30/24	Risk ID:	H01

Risk / Opportunity Description, BOE, and Alt. Strategy

Risk Description:	The maximum force provisioned by current dynamic testing equipment may not be sufficient to physically demonstrate all required certification tests for the new component.
Precipitating Action (IF):	IF the new component design can not be validated for high R Ratio fatigue by any institutional capability
Consequence (THEN):	THEN additional hydraulic power modifications to existing load frames, or a supplemental new-design test frame, or component redesign may be required
Alternate Strategy (ALT):	ALTERNATIVELY new design component requiring elevated force will not be qualified, resulting in reuse of legacy design with major shortfalls to KPIs
Risk Impact BOE:	Assume $1M for new test system and/or component redesign, with 1yr lead time. Assume $1M for other design & test modifications. Assume $5M LCC impact if HS material is needed.

Risk Burndown Baseline, Plan & Actuals



Probability	Impact: Negligible 0.05	Minor 0.10	Moderate 0.20	Major 0.40	Significant 0.80
Very High 0.9					B
High 0.7					1
Moderate 0.5					
Low 0.3					3
Very Low 0.1				5	4

ID	Mitigation	Mitigation Description, BOE & Success Criteria	Residual Cost Impact ($k)	Residual Schedule Impact (d)	Residual Technical Impact	Pr	Ir	Sr	Baseline	Forecast	Actual	Schedule Status	Technical Status	Funding Status	Funding Req'd ($k)	Status	FMEA Sig.	Notes
B	Initial State	Baseline Risk Assessment	$ 7,000	600	Significant	0.9	0.8	0.72	05/30/20	05/30/20	05/30/20	On Track	On Track	On Track	$ -	Complete	X	Baseline risk curve showhn at PDR. Assume all mitigations will be necessary
1	Component Design	Complete design of component	$ 6,700	550	Significant	0.7	0.8	0.56	06/30/21	03/01/21	03/01/21	On Track	On Track	On Track	$ -	Complete		Component design completed on 1 March 23
2	Subscale Test	Design subscale test	$ 6,500	400	Significant	0.5	0.8	0.40	07/30/22	02/02/22	02/02/22	On Track	On Track	On Track	$ -	Complete		Subscale test completed late to plan on 2 Feb 24, still shows increased test capacity will be required
3	Additional Power	Purchase new Hydraulic pump Assume ROM $100k cost for upgraded hyd. Capacity	$ 6,450	365	Significant	0.3	0.8	0.24	10/01/22	06/01/23		On Track	On Track	At Risk	$ 100	In Process		Currently evaluating whether pumps of sufficient capacity are avilable
4	New Frame	Purchase dedicated test frame for new component & execute dedicated component test program.	$ 5,250	30	Minor	0.1	0.8	0.08	12/01/23	03/01/24		At Risk	On Track	Off Plan	$ 1,100	Deferred	X	Updated quote received confirming $800k cost for new load frame & furance. Will require $300k and 3mo to complete test. Funding has not been allocated.
5	High Strength Material	If full-scale validation at full-load reveals a design shortfall, then use of alt. material may be required. Assume 3mo and $250k to incorporate.	$ 5,000	0	Minor	0.1	0.4	0.04	02/02/24	09/08/24		On Track	On Track	At Risk	$ 250	In Process		If HS material is needed, planned cost savings will not be realized. Transfer cost risk to Sustainment IPT

Opportunity Tracking

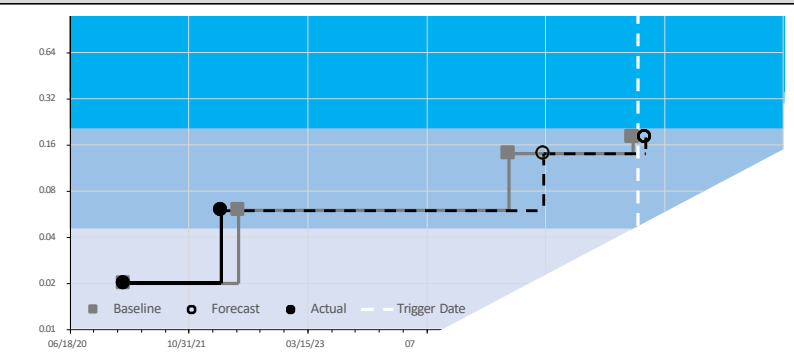
Hypothetical Example

- Inverse of risk waterfall for project opportunities
- Tracks likelihood and costs to realize identified savings
- Provides mgmt. with insight into additional MR
- Feeds risk register

Risk Title:	Reuse of Existing Thermal Protection System	Subsystem:	Vehicle	IPT:	Thermals	Owner:	Project Engineer	Type	Opportunity	Stragegy:	Mitigate	Status Date	07/01/22	Trigger Date	01/01/27	Risk ID:	V01

Risk / Opportunity Description, BOE, and Alt. Strategy	
Risk Description:	Existing thermal protection system may be able to be reused negating need for modern, expensive housing.
Precipitating Action (IF):	IF the proposed flight envelope does not result in increased thermal loading that existing legacy design can accommodate
Consequence (THEN):	THEN new thermal protection system may not be necessary.
Alternate Strategy (ALT):	Parallel design of new, increased capability thermal protection system.
Risk Impact BOE:	Assume $1M design cost for new TPS and $.5M life cycle production cost based on program of record. Assume savings of 6mo of schedule to implement new design.

Risk Burndown Baseline, Plan & Actuals



Impact		
Negligible	Minor	Moderate
0.05	0.10	0.

Very High 0.9

ID	Mitigation	Mitigation Description, BOE & Success Criteria	Residual Cost Impact ($k)	Residual Schedule Impact (d)	Residual Technical Impact
B	Initial State	Baseline Opportunity Assessment	$ (1,500)	-180	
1	Flight Envelope Confirmed	Confirm flight envelope and heating loads	$ (1		
2	Thermal Testing Complete	Complete dedicated thermal testing on legacy component. Requires funding for supple test not in V&V plan			
3	Flight Test Complete	Complete flight test with le demonstrating no ne system			
4					
5					

Interlinked Risk Register

- Obtains detail from program risk scoring criteria & individual risk worksheets
- Reports current and residual cost, schedule, & technical impacts
  - Based on actual mitigation closure status for each subsystem risk
  - Reports over-target status / trigger dates
  - Aggregates risks by IPT & program, quantifies impacts

Project Risk Register

Risk ID	Risk Title	Type	Risk Description (IF/THEN)	Cost Impact ($k)	Schedule Impact (d)	Technical Impact	Pc	Ic	Sc	IPT	Owner	Date Raised	Status	Disposition	Current Mitigation Strategy	Trigger Date	Pr	Ir	Sr	Status Date	Schedule Status	Technical Status	Funding Status	In Project Plan?	Funding Req'd ($k)	Basis of Risk & Trigger Date
H01	High R-Ratio Load Testing Capability	Threat	IF the new component design can not be validated for high R Ratio fatigue by any institutional capability THEN additional hydraulic power modifications to existing load frames, or a supplemental new-design test frame, or component redesign may be required	$ 6,450	365	Significant	0.50	0.80	0.40	Frame	Project Engineer	05/30/20	Open	Mitigate	Purchase new Hydraulic pump Assume ROM $100k cost for upgraded hyd. Capacity	04/30/24	0.10	0.80	0.08	6/24/22	At Risk	On Track	Off Plan	Yes	$ 350	Assume $1M for new test system and/or component redesign, with 1yr lead time. Assume $1M for other design & test modifications. Assume $5M LCC impact if HS material is needed.
H02	Dynamic Response of Housing	Threat	IF the dynamic response of the housing and/or interfacing components is not sufficiently removed from all modes in the operating range THEN the housing may exhibit insufficient margin to HCF stresses, requiring redesign.	$ 625	450	Significant	0.50	0.80	0.40	Frame	Project Engineer	01/15/21	Open	Mitigate	Obtain final point masses and interface agreement from all interfacing hardware and rerun FEM with finalized ICD values from all impacting IPTs	01/15/23	0.10	0.80	0.08	6/24/22	At Risk	On Track	Off Plan	Yes	$ -	Assume $500k part cost, $125k labor cost and 15 months (3mo redesign, 1yr fabrication) to procure new housing, with optional $600k test (if req'd)
C01	New Material Availability for Thrust Links	Threat	IF the proposed additively manufactured material considered for use in the thrust links does not have the requisite strength, or is not adequately characterized THEN the components may need to be redesigned with conventional forming & machining means to enable certification.	$ 5,000	365	Significant	0.30	0.80	0.24	Forging	Project Enginer	05/30/20	Open	Mitigate	Acquire & characterize larger HIP furnace & fixturing to improve finished part uniformity	06/15/23	0.10	0.80	0.08	6/24/22	On Track	Off Plan	Off Plan	Yes	$ 1,100	Assume $1.5M and 9mo to complete characterization of ALM material; Assume $600k/1yr design/qual effort for alt design and $500/ea/10k units cost impact if ALM part is not feasible
E01	Externals Integration with Fuselage	Threat	IF fuselage design impacts existing cooling manifold designs THEN redesign of completed components may be required.	$ 3,000	180	Moderate	0.70	0.20	0.14	Externals	Project Engineer	01/15/22	Open	Mitigate	Complete CDR for cooling manifolds to demonstrate compliance with KOZs	07/01/25	0.30	0.20	0.06	6/24/22	On Track	On Track	On Track	Yes	$ -	Assume 6mo and $3M to redesign (12) main cooling manifolds
V01	Reuse of Existing Thermal Protection System	Opportunity	IF the proposed flight envelope does not result in increased thermal loading that existing legacy design can accommodate THEN new thermal protection system may not be necessary.	$ (1,500)	-180	Moderate	0.70	0.20	-0.14	Thermals	Project Engineer	01/30/21	Open	Mitigate	Complete dedicated thermal testing on legacy component. Requires funding for supplemental test not in V&V plan	01/01/27	0.30	0.20	-0.06	7/1/22	On Track	On Track	Off Plan	Yes	$ 100	Assume $1M design cost for new TPS and $.5M life cycle production cost based on program of record. Assume savings of 6mo of schedule to implement new design.

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Cost & Schedule Variance Projections

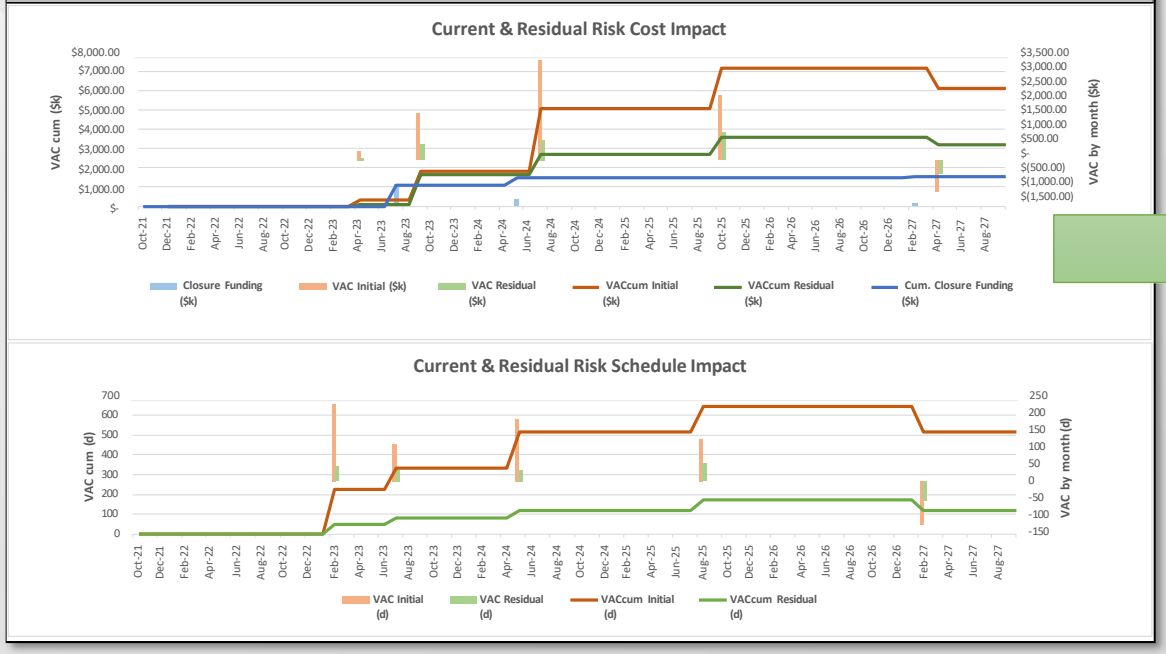
- Run-out projections can directly inform project staffing & resource profiles

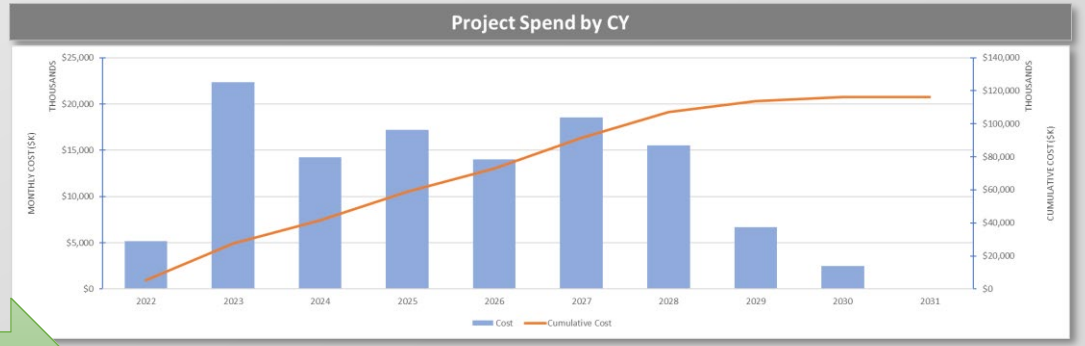
Project Risk Report

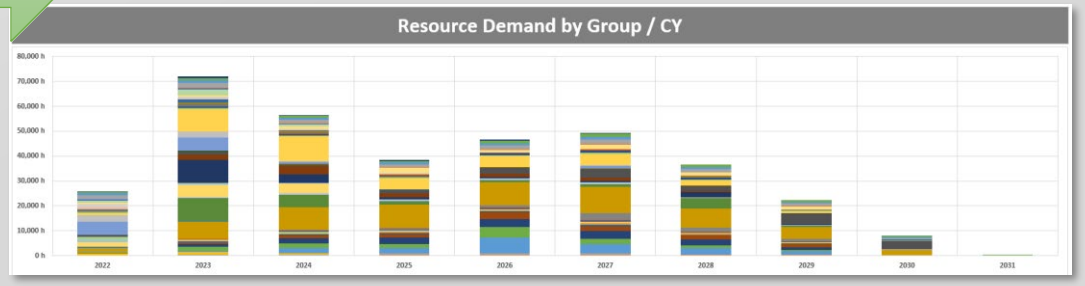
Risk Count & Severity Index

Accepted & Mitigated Risks	5	Trigger Dates Overdue	0
Unapproved Risks	0	Original Average Severity Index	0.21
Retired Risks	0	Status Date Average Severity Index	0.05

Original & Mitigated Potential Exposure







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Program Benefits

- Allows for capture of all customer-required risk information
- Supports a regular risk review cadence for managed IPTs
- Allows instantaneous visibility into detailed risk mitigation plans
- Provides ability to aggregate risk levels by subsystem & roll up to system level
- Supports risk-transfer and margin trades between IPTs
- Continually informs project EAC, schedule, and resourcing
- Assists with variance reporting & explanations
- Provides management with visibility into future staffing needs & MR consumption
- Supports responsible program conduct, reduces “surprise” demand signals

Tool Maturity & Future Improvements

- Approach utilized on multiple development programs (prior career) across defense and commercial aerospace portfolios
  - Leveraged multiple home-grown and commercial tools; long-time desire to combine functions
- Tool developed throughout conduct of multiple efforts at LLNL
  - Utilized for infrastructure as well as programmatic equipment efforts
    - (2) material characterization facilities, new AM facility, DAQ equipment expansion for HE&E
  - Informed estimation and baselining process for a large new SNM processing facility at NNSS
- Future Improvements
  - Implementation of a commercial tool set for added robustness / ease of use
  - Monte Carlo analysis for probabilistic severity ranking
  - Direct allocation of resource skill codes & hours to project mitigation staffing needs
  - Direct tie-in with institutional scheduling and EV tools

Questions?

Thank you very much for your attention!