SYSTEMS PLANNING AND ANALYSIS, INC.

Managing Schedule Risk Expectations During Program Execution

Patrick Malone
pmalone@spa.com

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Agenda

- Introduction
- GAO Schedule Emphasis
- Attaining Required Knowledge
- Traditional Risk Management
- Schedule and Risk Integration
- Examples
- Benefits
- Future Work

"You'd be surprised the headaches you can avoid by addressing these four simple questions before beginning a project."

Introduction

- **Schedules are integral to project management**
- **Risk management supports successful execution**
- **Historical Issues**
  - Success driven schedules
  - Rule-based risk management
- **Schedule and risk integration**
  - Adds realism
  - Supports sensitivity analysis
- **Benefits**
  - Effective schedules
  - Provides executable execution alternatives
  - Supports project success

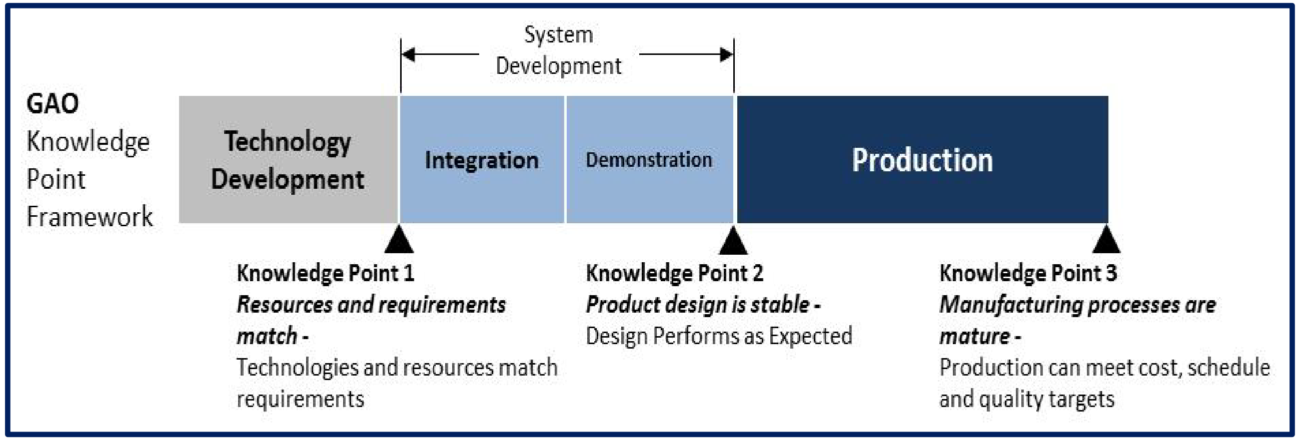
GAO Emphasis

- **19th Annual GAO Assessment of DoD Weapon Programs (published 2021)**
  - Emphasis – “Deliver solutions and capability to the end user in a timely manner”

- **Findings:**
  - “…programs have acquisition approaches that still result in cost and schedule challenges”
  - Cost growth 54%
  - Schedule delay 40% to 38 months

- **Some Causes:**
  - Starting Engineering and Manufacturing Development prior to attaining required knowledge
    - From Technology Development
    - Other Maturity programs

Attaining Required Knowledge Guidelines

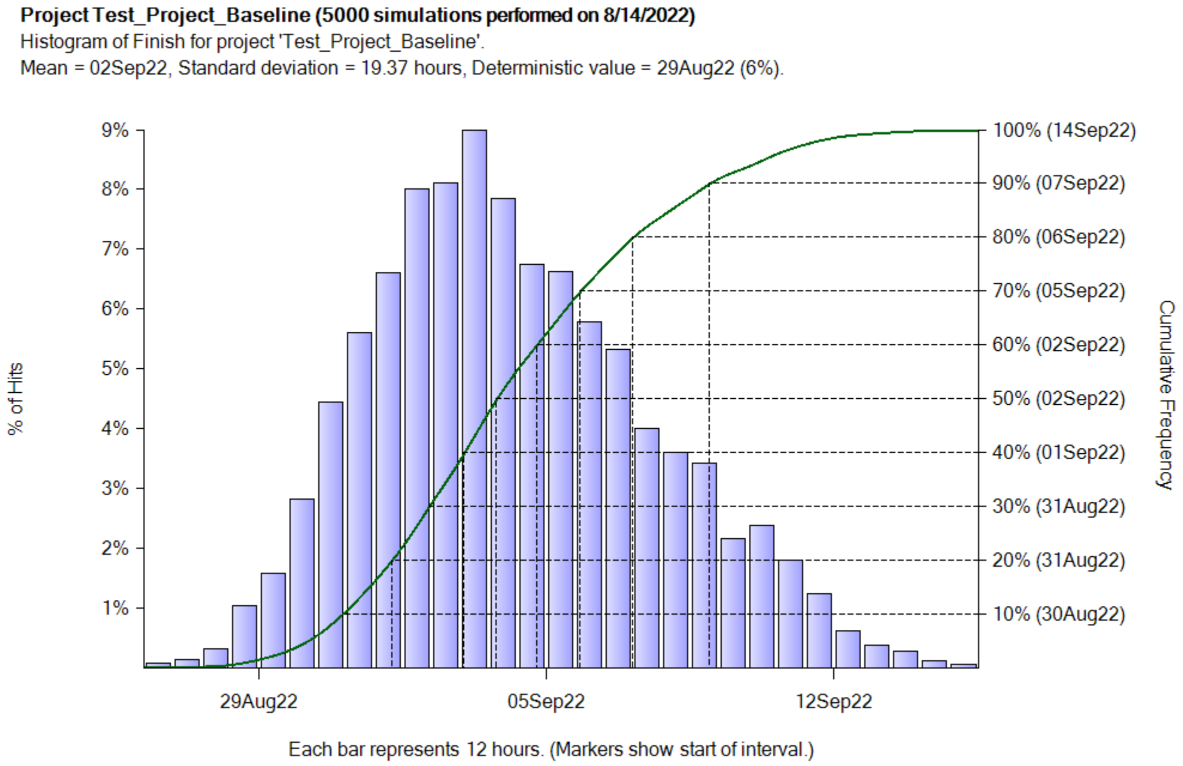


- **Knowledge point 1:** Resources and requirements match.
- Achieving a **high level of technology maturity** by the start of system development is one of several important indicators of whether this match has been made.
- This means that the **technologies needed to meet essential product requirements have been demonstrated** to work in a relevant environment.
- The developer should complete a series of systems engineering reviews culminating in a preliminary design of the product that shows the design is feasible.
- **Constraining the development phase of a program to 5 or 6 years is also recommended because it aligns with DOD's budget planning process** and fosters the negotiation of trade-offs in requirements and technologies.

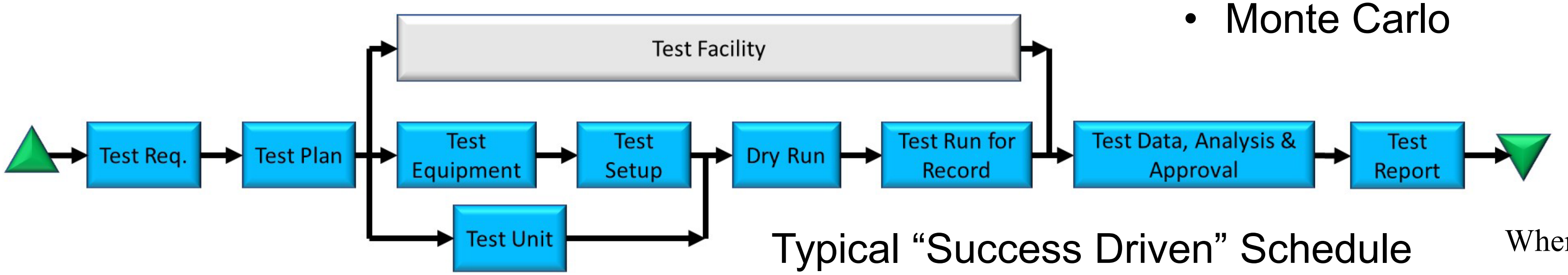
- **Knowledge point 2:** Product design is stable.
- This point occurs when a **program determines that a product's design will meet customer requirements, as well as cost, schedule, and reliability targets.**
- A best practice is to achieve design stability at the system-level critical design review, usually held midway through system development.
- Completion of at least **90 percent of engineering drawings** at this point provides tangible evidence that the product's design is stable, and a **prototype demonstration** shows that the design is capable of meeting performance requirements.
- Programs can also **improve the stability of their design by conducting reliability growth testing** and completing failure modes and effects analyses so fixes can be incorporated before production begins.
- At this point, programs should also **begin preparing for production** by identifying manufacturing risks, key product characteristics, and critical manufacturing processes.

- **Knowledge point 3:** Manufacturing processes are mature.
- This point is achieved when it has been **demonstrated that the developer can manufacture the product within cost, schedule, and quality targets.**
- A best practice is to ensure that all **critical manufacturing processes are in statistical control**—that is, they are repeatable, sustainable, and capable of consistently producing parts within the product's quality tolerances and standards—at the start of production.
- Demonstrating critical process on a pilot production line is an important initial step in this effort.
- In addition, production and postproduction costs are minimized when a fully integrated, capable production-representative prototype is demonstrated to show that the system will work as intended in a reliable manner before committing to production.

Traditional Risk Management



- **Risk and Uncertainty**
  - Risk – is the chance of loss or injury
  - Uncertainty – is the indefiniteness of the outcome of a situation
- **Schedule Risk Assessment**
  - Actually quantitative uncertainty assessment
  - Used on “success driven” schedules
  - Methods
    - Average durations $\text{Duration} = (OD + MLD + PD)/3$
    - Pert Method $\text{Duration} = (OD + 4*MLD + PD)/6$
    - Monte Carlo



Typical “Success Driven” Schedule

Where:

OD = Optimistic Duration
MLD = Most Likely Duration
PD = Pessimistic Duration

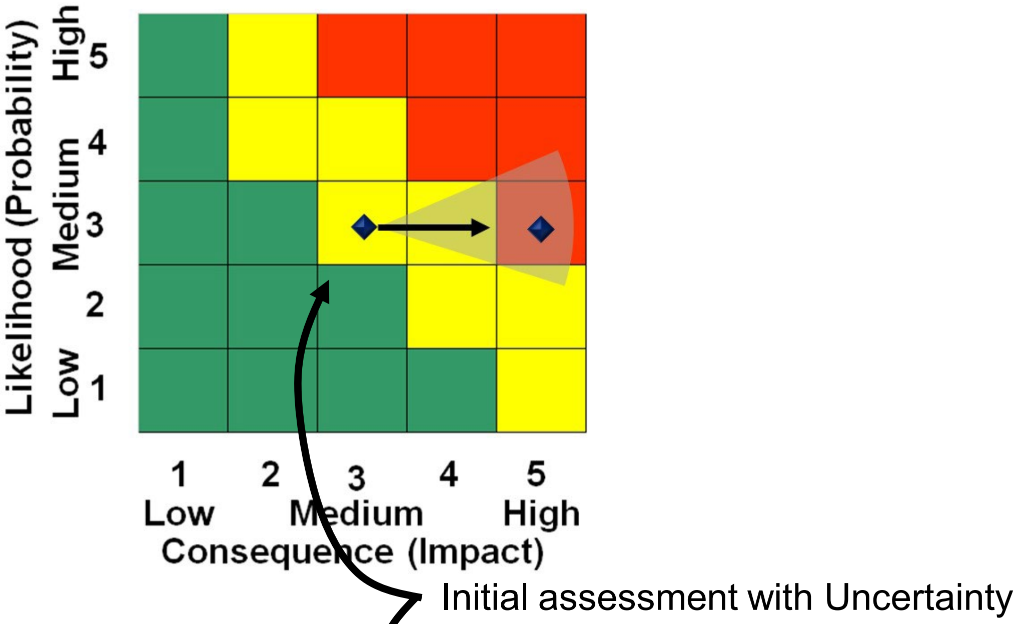
Traditional Risk Management

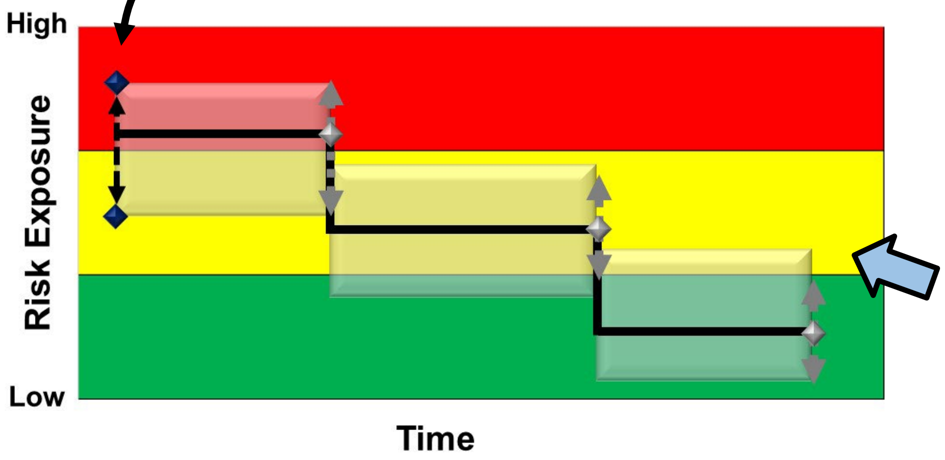
- **Common Risk evaluation**
  - Historical performance
  - Expert Opinion
  - Delphi (Group assessment)
  - Rule-based
- **Less Common Risk Evaluation**
  - Experimental
  - Simulations
- **Pitfalls**
  - Rule-based ties probability and impact together
  - If probability is less than 50%, not likely a risk

		Impact (Consequence)		
Rating	Probability Range	Performance	Schedule	Cost
Low	5% - 20%	Minimal performance impact	Insignificant schedule slippage	Insignificant cost increase
Low-Medium	21% - 40%	Minor performance impact, slight degradation in performance	Overall project slippage <5%	<5% cost increase
Medium	41% - 60%	Moderate performance degradation, partial failure of one element	Overall project slippage 5 - 10%	5 - 10% cost increase
Medium-High	61% - 80%	Significant performance degradation, partial or full failure of one element, partial failure of others	Overall project slippage 10 - 20%	10 - 20% cost increase
High	81% - 99%	Severe performance degradation or failure of key elements	Overall project slippage >20%	>20% cost increase

Common Rule-based "lookup" table

Risk Management

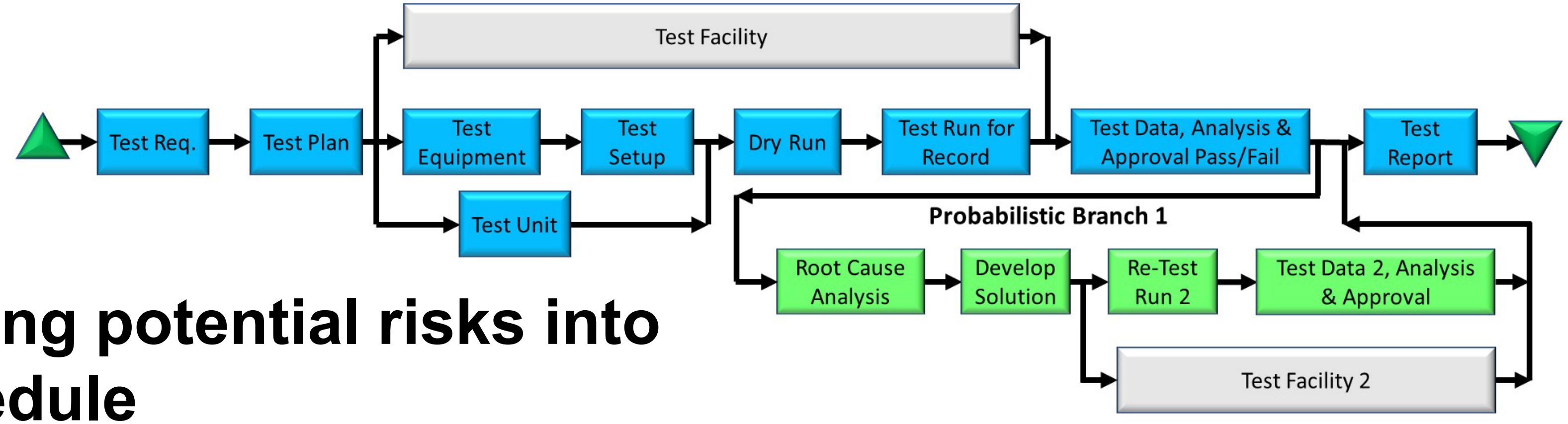




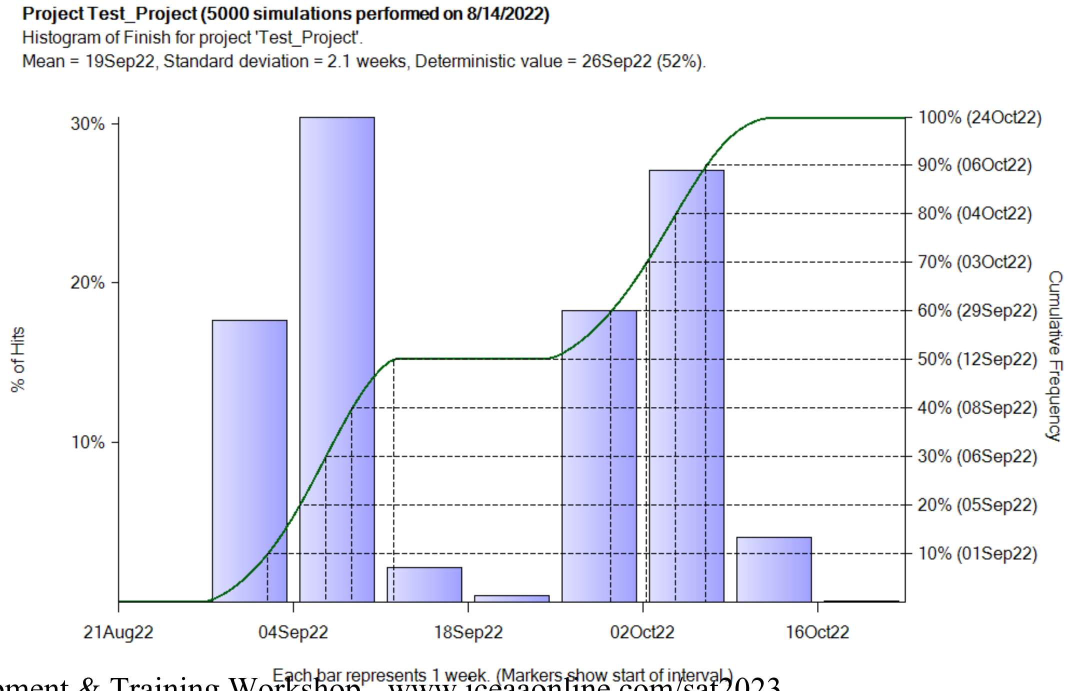
Burndown Steps
To support
schedule and
cost impacts

- **Department of Defense**
  - Mature processes
  - Utilize Risk Cubes and Burndown plans
- **NASA**
  - Historical Continuous Risk Management
  - Risk-Informed Decision Making
- **Industry**
  - Rule-based approach
  - Experimental

Schedule and Risk Integration

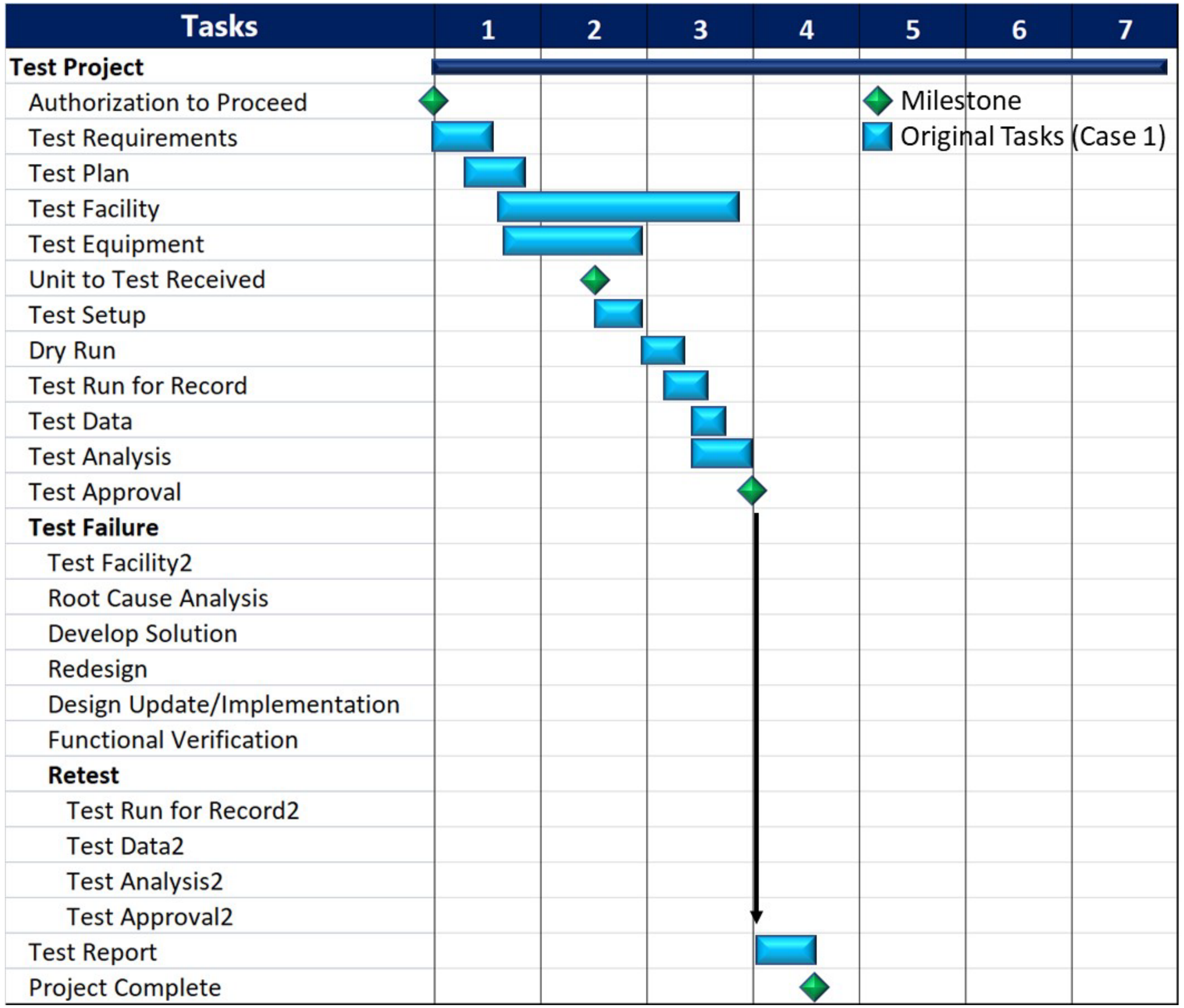


- **Integrating potential risks into the schedule**
  - Branching is an effective simulation method
  - Adds realism
- **Results show a “bi-modal” distribution if a failure occurs**
  - Adds significant delay to project (4 Oct from deterministic 29 Aug) completion
  - Other factors are impact to program critical path and cost growth beyond forecast estimate



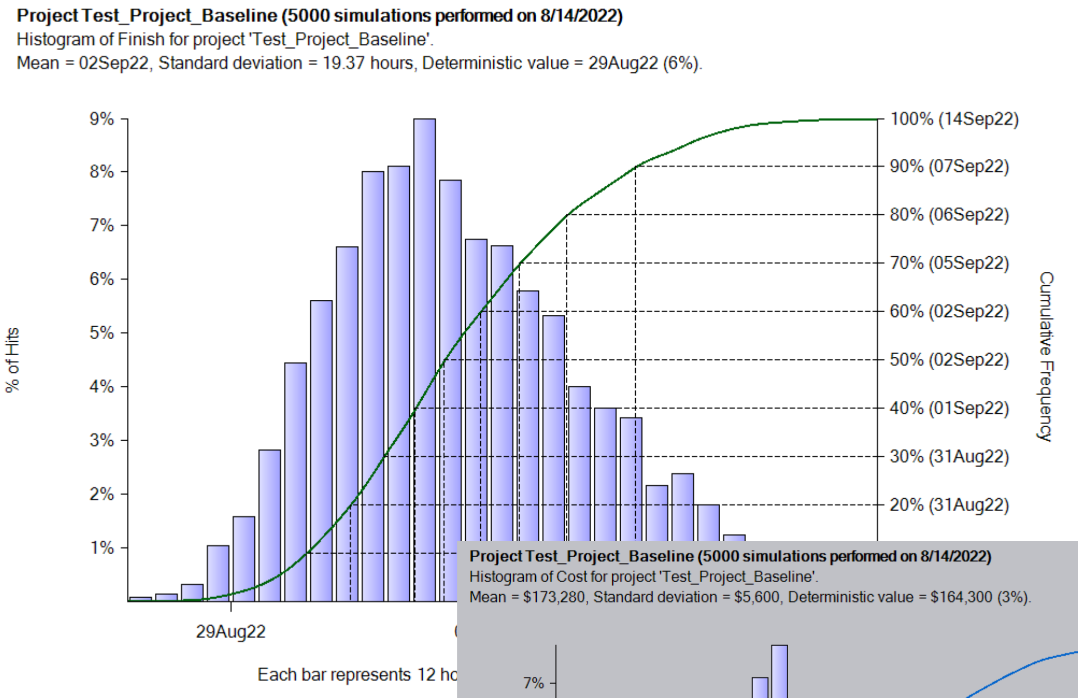
Example – The Project

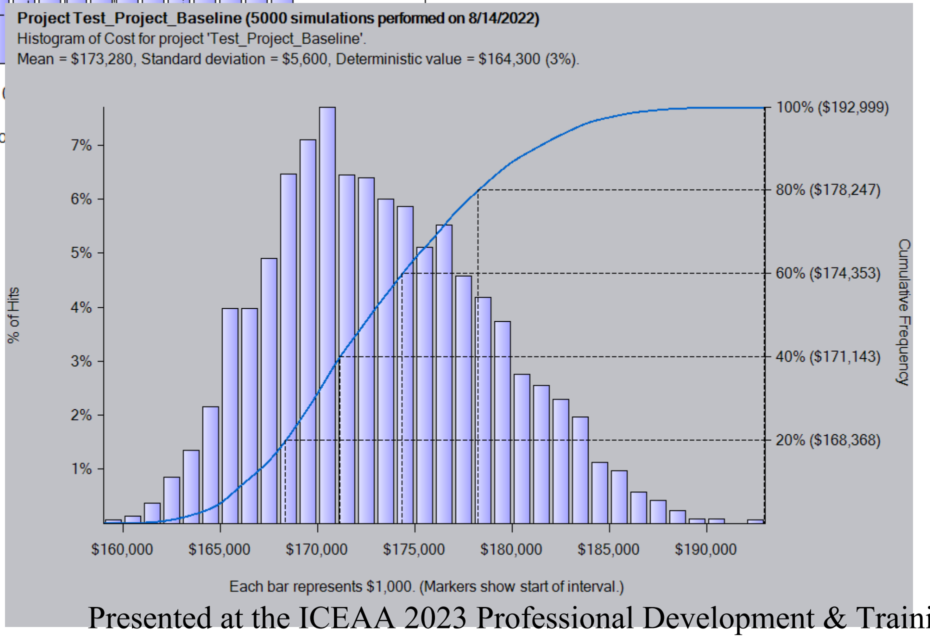
- This example illustrates the test of a sub-system (test unit).
- An outside test facility that has specialized equipment and tools to evaluate the unit will be used.
- The test requirements will be finalized as part of the project.
- Test equipment set up and a dry run will be conducted.
- The unit will be shipped to the facility.
- Following arrival of the unit the test will be run for record.
- When complete, test data will be reviewed along with any analysis to support a test approval decision.
- The last task is to publish a test report.



Typical success driven detailed task schedule

Example – Success Project





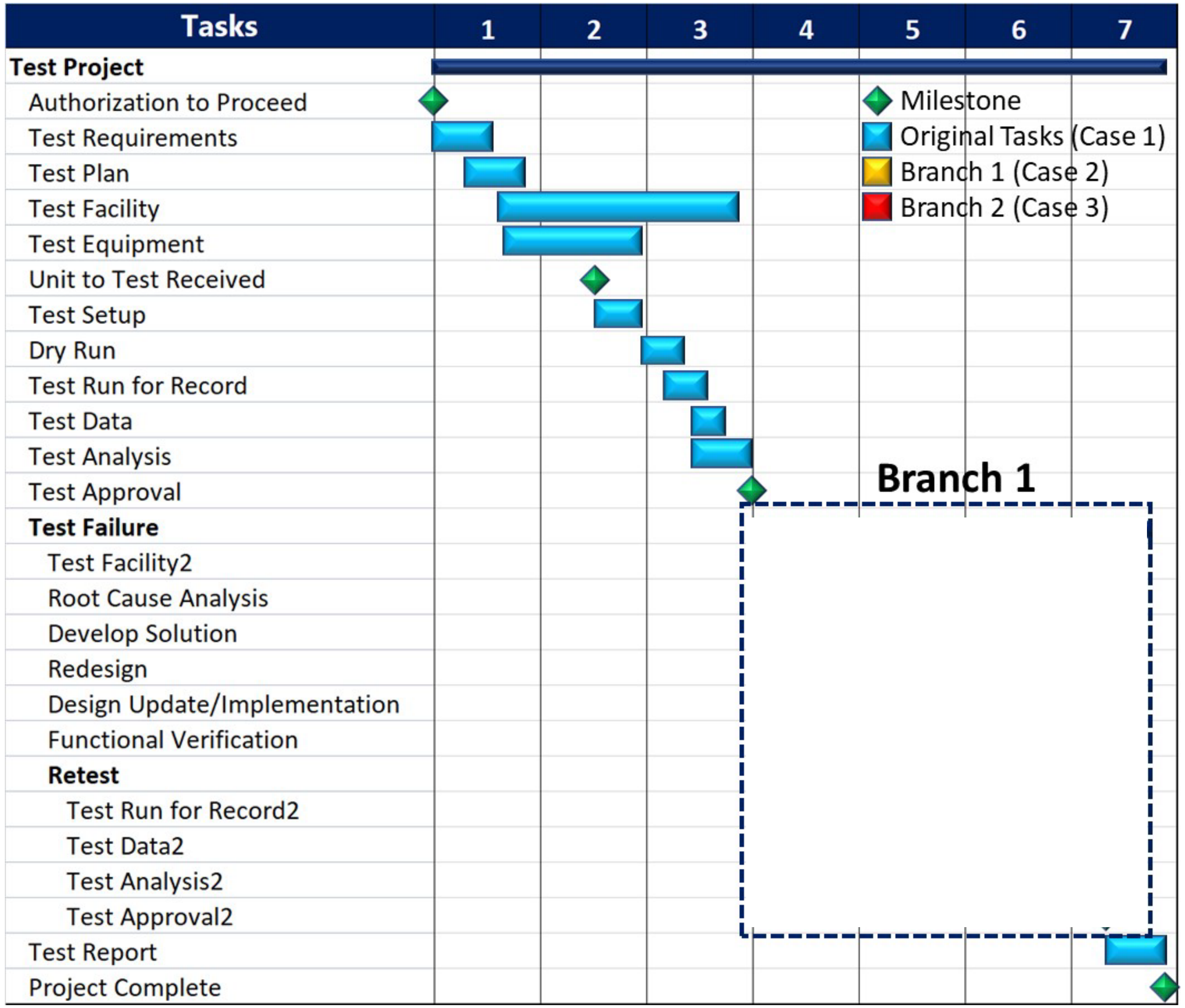
- **Baseline duration – 46 Days**
- **Target Completion – 29 Aug 2022**
- **Baseline Cost - $164.3K**

- **Schedule Risk**
  - Mean 02 Sept 2022
  - 80% Confidence 06 Sept 2022

- **Cost Risk**
  - Mean $173.3K
  - 80% Confidence $178.3K

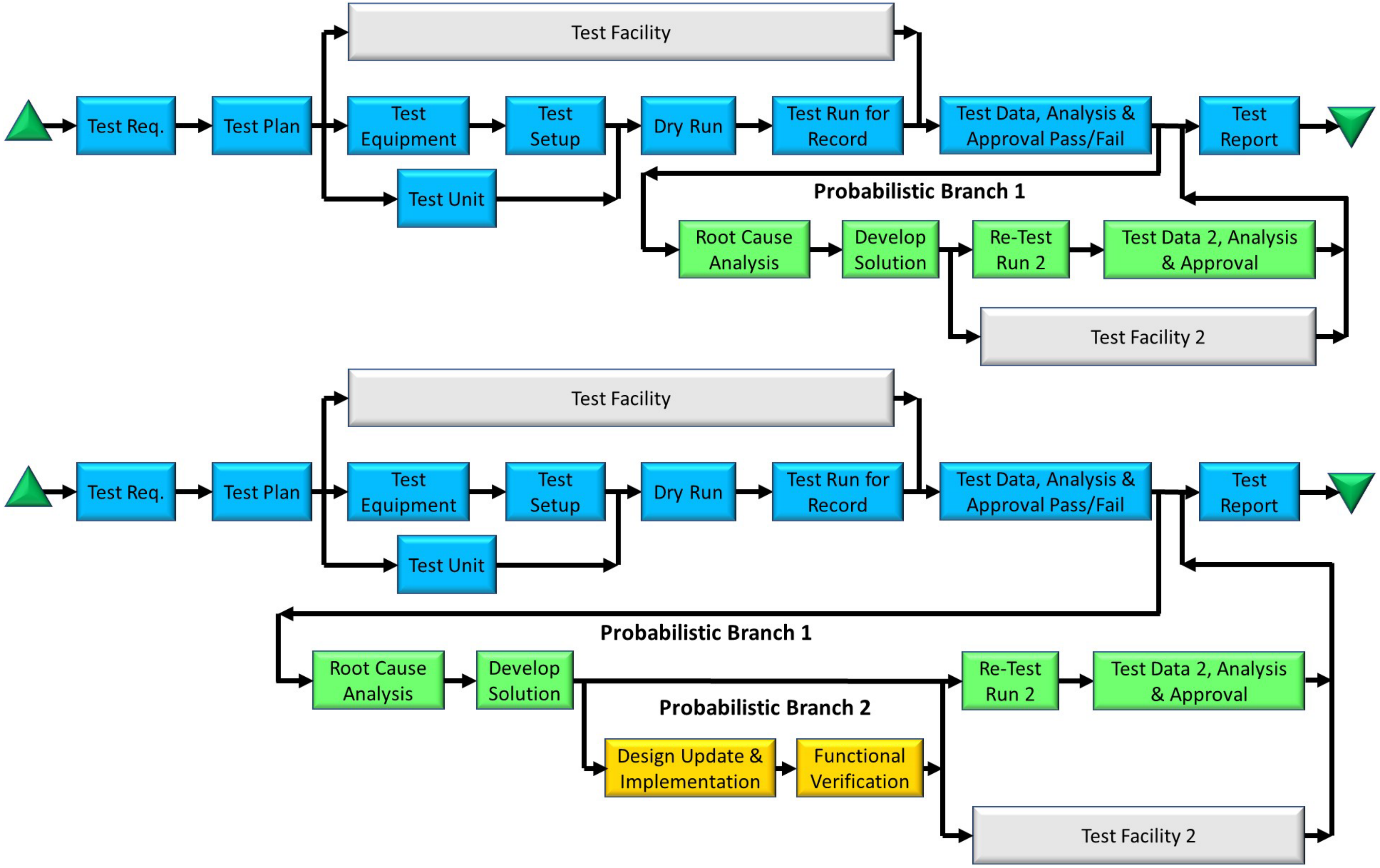
Example – Adding Realism

- **Conducting a "what-if" includes:**
  - A *test failure* possibility
    - Without additional information it is a "coin toss" or 50% probability
  - After a root cause analysis
  - A possible *design update*
    - Nested within the first branch
    - Also a 50% probability
  - Two Cases
    - One branch for test failure
    - Second Nested branch if test failure
    - Impacts of each



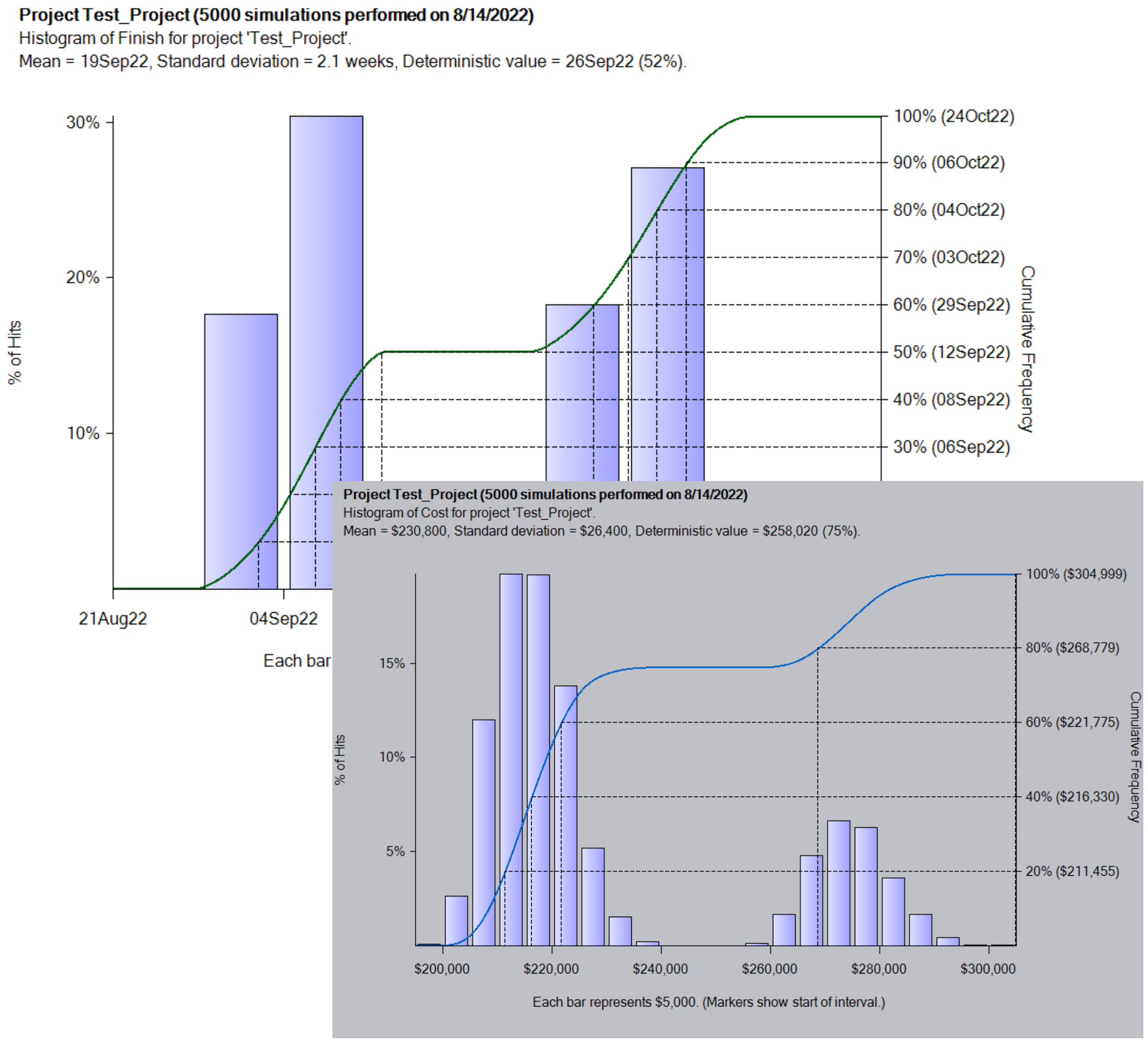
Adding realism with branching

Example – The Network



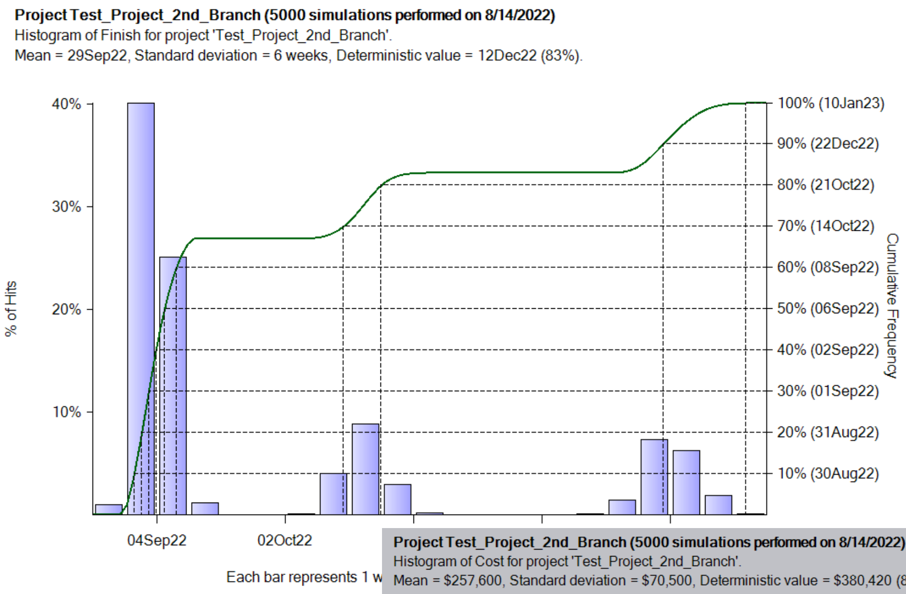
- **Case 2 – 1 Branch**
  - – 4 Additional Steps
  - – Additional Test Facility TIme
- **Case 3 – 2 Branches**
  - – Nested Redesign
  - – 2 Additional Steps

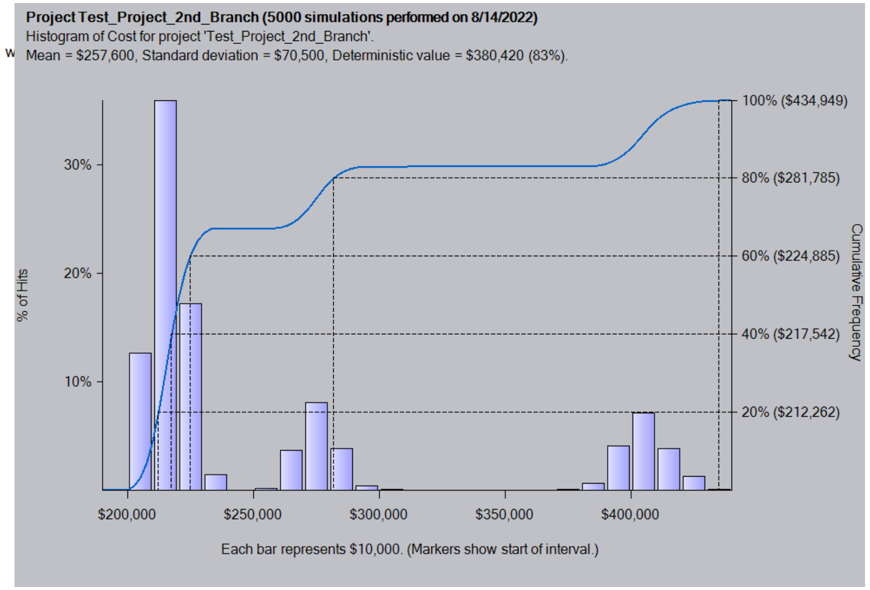
Example - Results 1 Branch



- **Baseline**
  - Schedule 29 Aug 2022
  - Cost $164.3K
- **Case 2 – 1 Branch – Bimodal**
  - Schedule
    - Mean 19 Sept 2022
    - 80% Confidence 04 Oct 2022
  - Cost
    - Mean $230.8K
    - 80% Confidence $268.8K

Example - Results 2 Branches

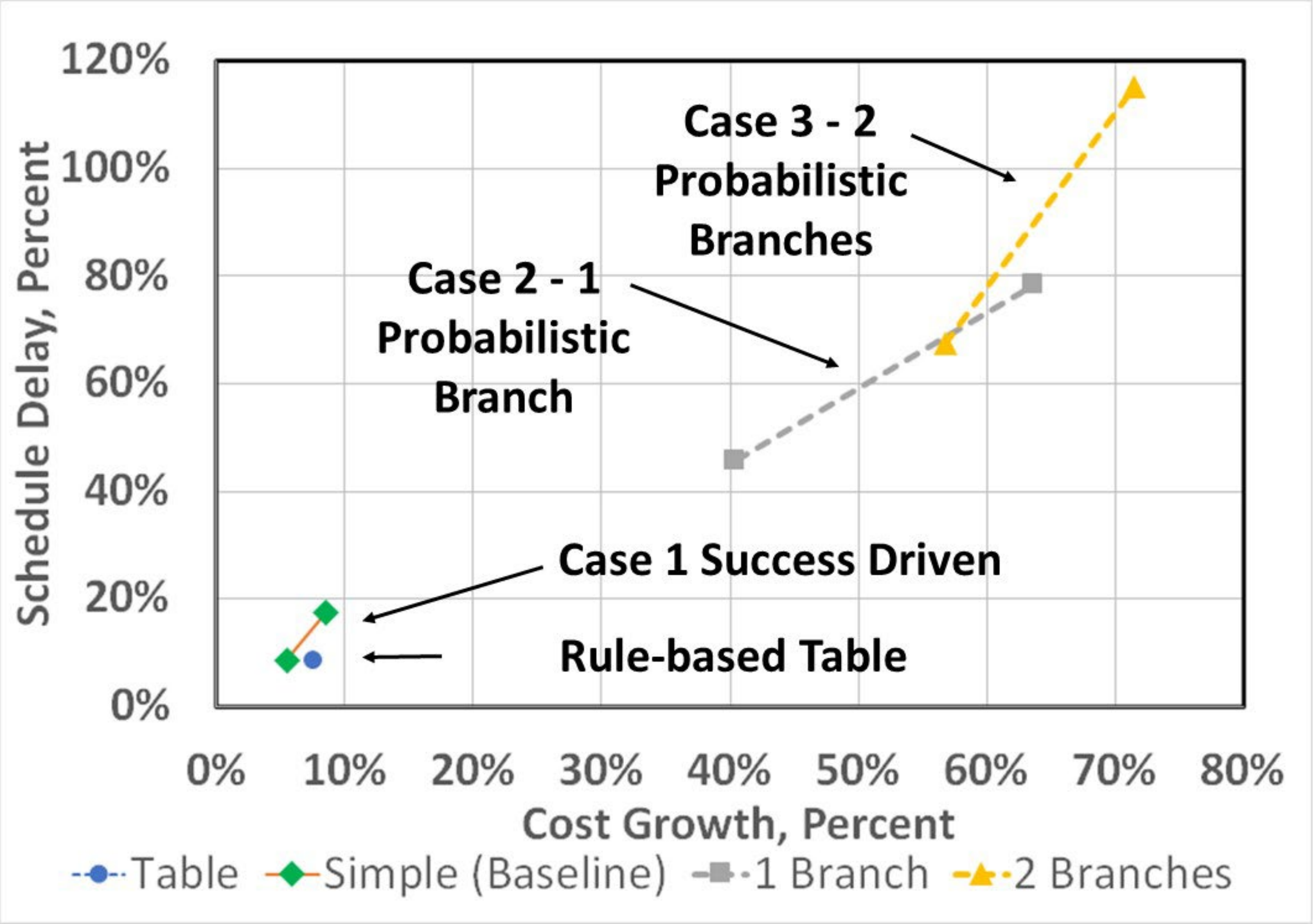




- **Baseline**
  - Schedule 29 Aug 2022
  - Cost $164.3K
- **Case 3 – 2 Branches – Trimodal**
  - Schedule
    - Mean 29 Sept 2022
    - 80% Confidence 12 Dec 2022
  - Cost
    - Mean $257.6K
    - 80% Confidence $281.8K

Example - Summary

- **Rule-Based Risk analysis**
  - Common method to initiate process
  - May fall short of actual risks
- **Simulations**
  - Success Driven Solution
    - Mainly an uncertainty analysis
    - May not capture possible realism
  - Added realism with branching
    - Provides more likely outcomes
    - Helps plan time to complete
    - Supports contingency funds planning

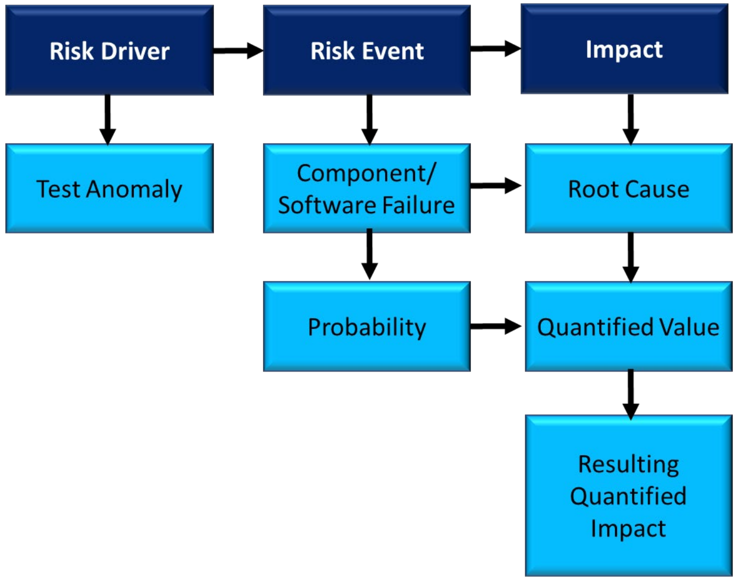


Benefits

			Schedule Delay, Percent			
		Cost	Table	Simple (Baseline)	1 Branch	2 Branches
Baseline w/Risk Factor	Table	8%	9%			
Baseline Case 1	Mean	5%		9%		
Baseline Case 1	80%	8%		17%		
Case 2, 1 Branch	Mean	40%			46%	
Case 2, 1 Branch	80%	64%			78%	
Case 3, 2 Branches	Mean	57%				67%
Case 3, 2 Branches	80%	72%				115%

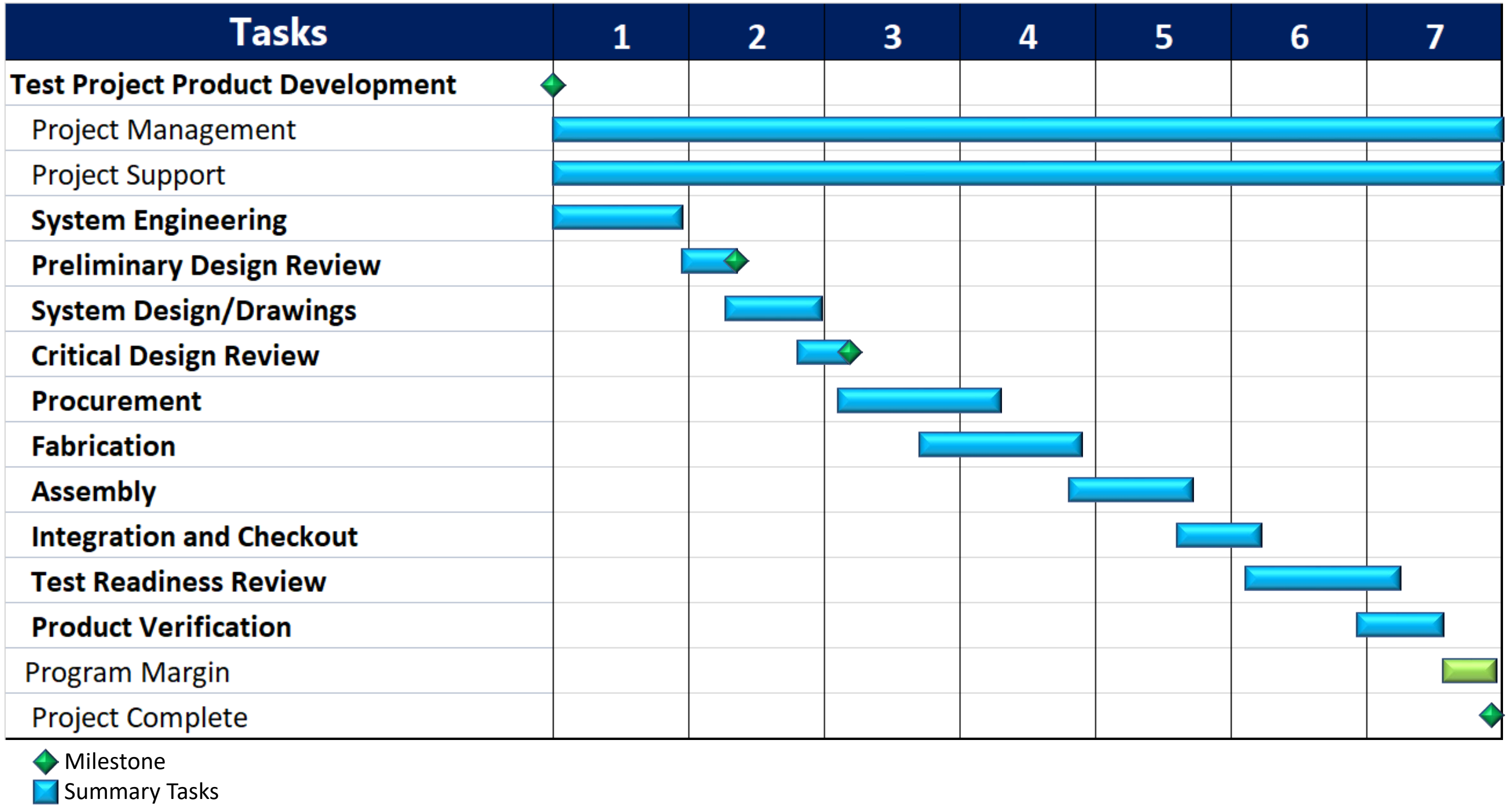
Task Name	Remaining Duration	Percent Critical	Percent Critical (Sensitivity)	Sensitivity Index	Sensitivity Index 50.0	Optimistic Mean Finish of Project	Pessimistic Mean Finish of Project	2022 Aug 28, Sep 04, 11	Early Finish Histogram	Schedule Sensitivity Bar Basis
Test Facility	30 days	100%	79%	83%		Wed 8/31/22	Tue 9/13/22		Graph	Estimat...
Test Equipment	20 days	21%	21%	15%		Fri 9/2/22	Wed 9/7/22		Graph	Estimat...
Test Report	5 days	100%	100%	18%		Thu 9/1/22	Mon 9/5/22		Graph	Estimat...
Test Plan	5 days	100%	100%	18%		Thu 9/1/22	Mon 9/5/22		Graph	Estimat...
Test Requirements	5 days	100%	100%	18%		Thu 9/1/22	Mon 9/5/22		Graph	Estimat...
Test Setup	5 days	21%	21%	4%		Fri 9/2/22	Mon 9/5/22		Graph	Estimat...
Test Analysis	4 days	21%	21%	3%		Fri 9/2/22	Mon 9/5/22		Graph	Estimat...
Dry Run	3 days	21%	21%	2%		Fri 9/2/22	Fri 9/2/22		Graph	Estimat...
Test Approval	1 day	100%	100%	4%		Fri 9/2/22	Fri 9/2/22		Graph	Estimat...
Test Data	2 days	21%	21%	2%		Fri 9/2/22	Fri 9/2/22		Graph	Estimat...
Test Run for Record	2 days	21%	21%	2%		Fri 9/2/22	Fri 9/2/22		Graph	Estimat...
Unit to Test Received	1 day	21%	21%	1%		Fri 9/2/22	Fri 9/2/22		Graph	Estimat...

- **Rule-based method is a starting point to risk management**
- **Simulations with Success driven schedules model uncertainty**
- **Adding branching or existence of risk**
  - Supports deadline realism
  - Helps plan for funding contingency
  - Shows drivers to focus effort for mitigation, avoidance, transfer, etc.
- **Implementing a repeatable process supports consistency**



Project Example

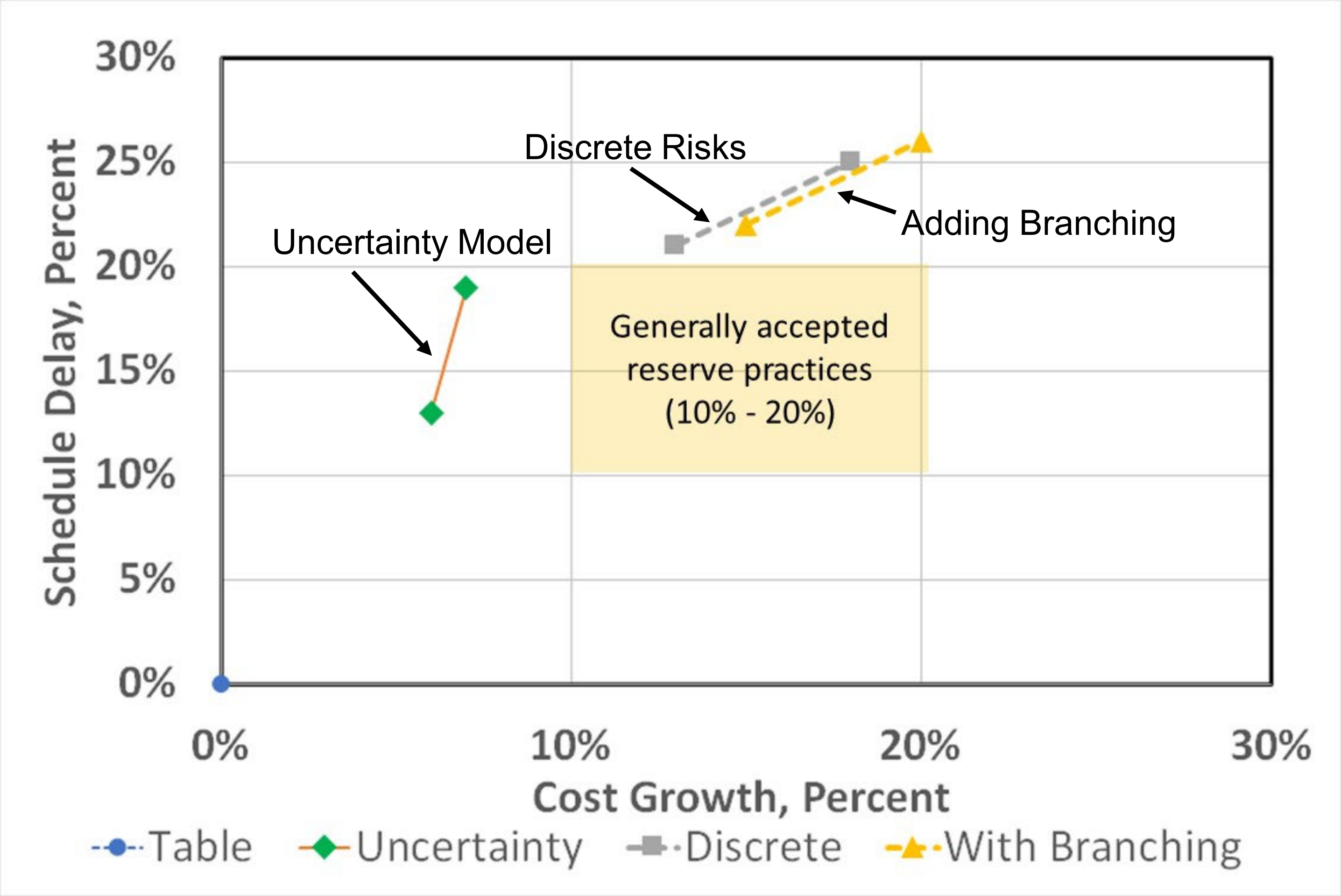
- **Integrate multiple risk simulations**
  - Demonstrates overall impact and planning
  - Supports contingency planning
    - Deadlines
    - Cost
- **Simulations**
  - Existence of Risks
  - Branching
  - Supports margin development
    - Schedule
    - Cost



Project Results

- **Baseline**
  - Schedule 10 July 2026 (619d)
  - Cost $4.908M
- **Case 1 – Uncertainty**
  - Schedule
    - Mean 4 Sep 2026 (699d)
    - 80% Confidence 23 Sep 2026 (737d)
  - Cost
    - Mean $5.192M
    - 80% Confidence $5.270M
- **Case 2 – Discrete Risks**
  - Schedule
    - Mean 5 Jan 2027 (751d)
    - 80% Confidence 5 Feb 2027 (774d)
  - Cost
    - Mean $5.532M
    - 80% Confidence $5.769M
- **Case 3 –Discrete Risks and Branching**
  - Schedule
    - Mean 5 Feb 2027 (757d)
    - 80% Confidence 16 Mar 2027 (781d)
  - Cost
    - Mean $5.626M
    - 80% Confidence $5.866M

Project Results



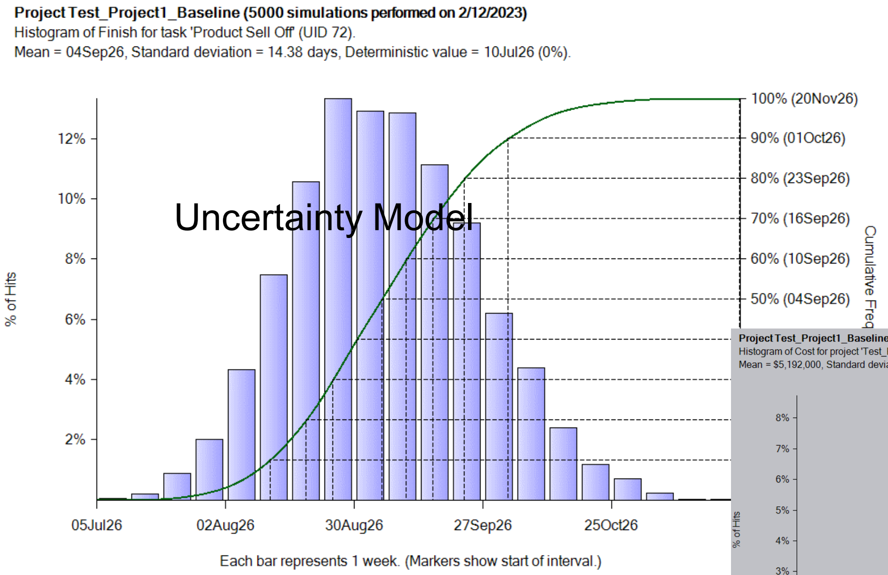
- **Generally accepted practices**
  – Often under forecast impacts
- **Modeling uncertainty**
  – Is likely an optimistic solution
- **Adding discrete risks**
  – Adds realism
- **Adding branching**
  – Adds more realism

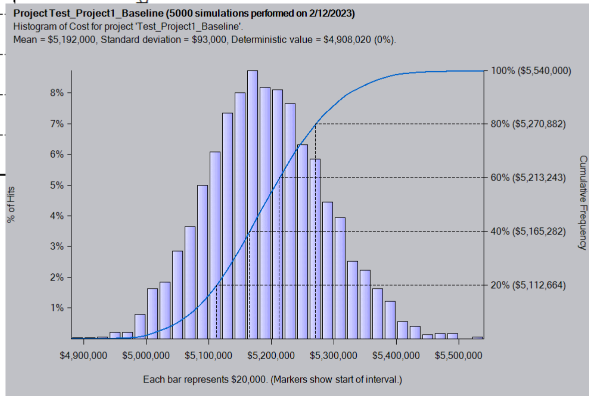
Project Results (cont.)

- **Small project shows impact to a limited scope**
  - Suitable for investigating focus area
- **Project modeling**
  - Uncertainty modeling is a starting point
  - Adding risks and branching adds realism

Sub-Project of short duration (Schedule Delay, Percent) / **Project Results** (Schedule Delay, Percent)

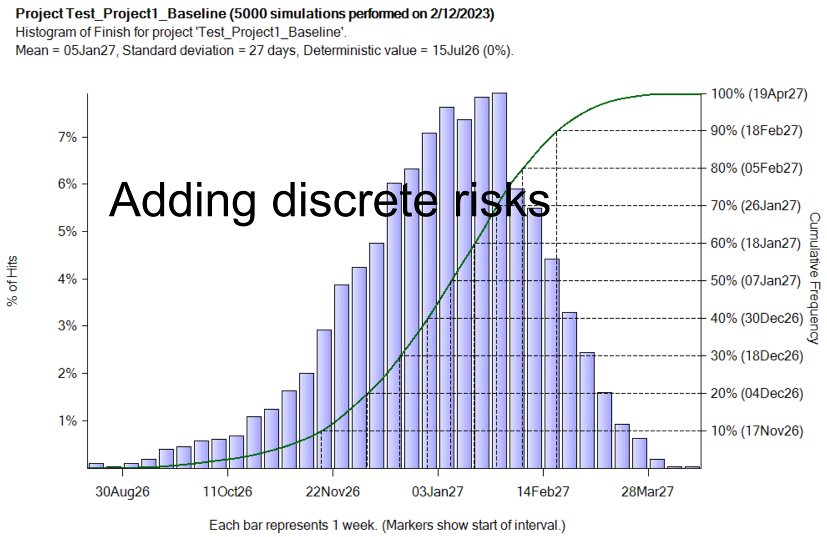
		Cost	Table	Simple (Baseline)	1 Branch	2 Branches		Cost	Table	Uncertainty	Discrete	With Branching
Baseline w/Risk Factor	Table	8%	9%				Baseline	0%	0%			
Baseline Case 1	Mean	5%		9%			Mean	6%		13%		
Baseline Case 1	80%	8%		17%			80%	7%		19%		
Case 2, 1 Branch	Mean	40%			46%		Mean	13%			21%	
Case 2, 1 Branch	80%	64%			78%		80%	18%			25%	
Case 3, 2 Branches	Mean	57%				67%	Mean	15%				22%
Case 3, 2 Branches	80%	72%				115%	80%	20%				26%

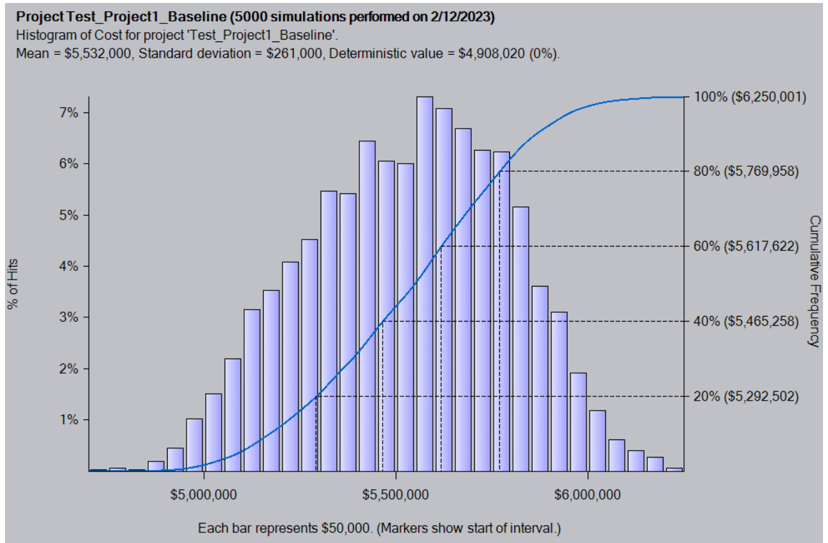


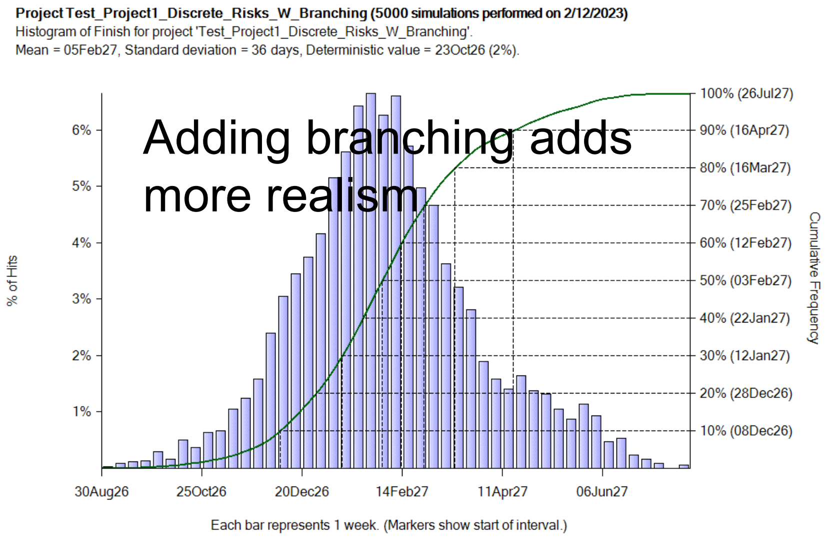


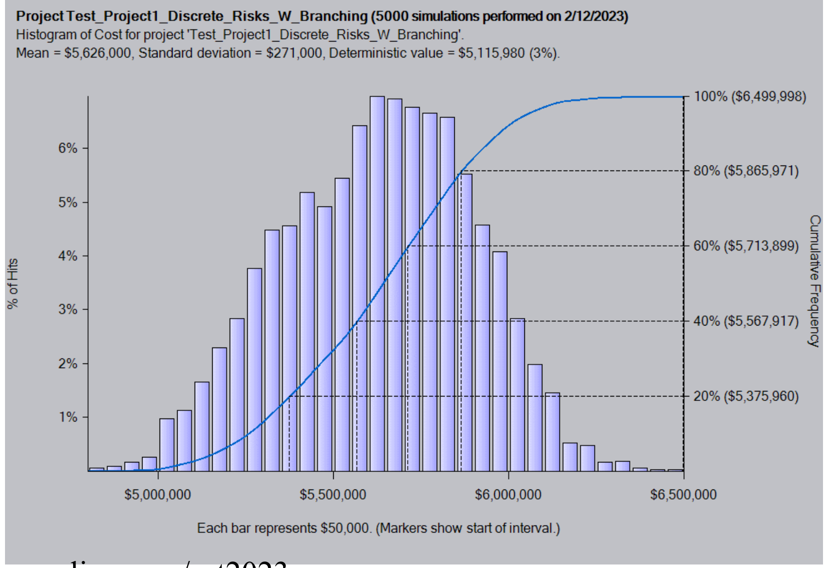
Project Results (cont.)

- **Including discrete risks enhanced realism**
- **Adding branching adds additional realism to modeling actual program execution**
- **Allows for:**
  - Contingency planning
  - Assessing realistic schedule margins at various levels
  - Developing adequate management reserves.









Future Work

- Evaluate historical scenarios across a myriad of risk types
- Apply advanced methods
  - Machine Learning and
  - Artificial Intelligence
- Broaden trade space
- Reduces time to obtain recommendations
- Enhances contingency planning early in the process
  - Schedule Durations and Margins (GAO 5 -6 year program duration)
  - Cost reserves (avoid Nunn-McCurdy breach)
- Develop set of guidelines for simulations and modeling techniques

- **Questions**

Patrick Malone
Systems Planning and Analysis, Inc.
Space and Intelligence Division
pmalone@spa.com