Portfolio Analysis Made Effective and Simple

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7/23/2024

Agenda

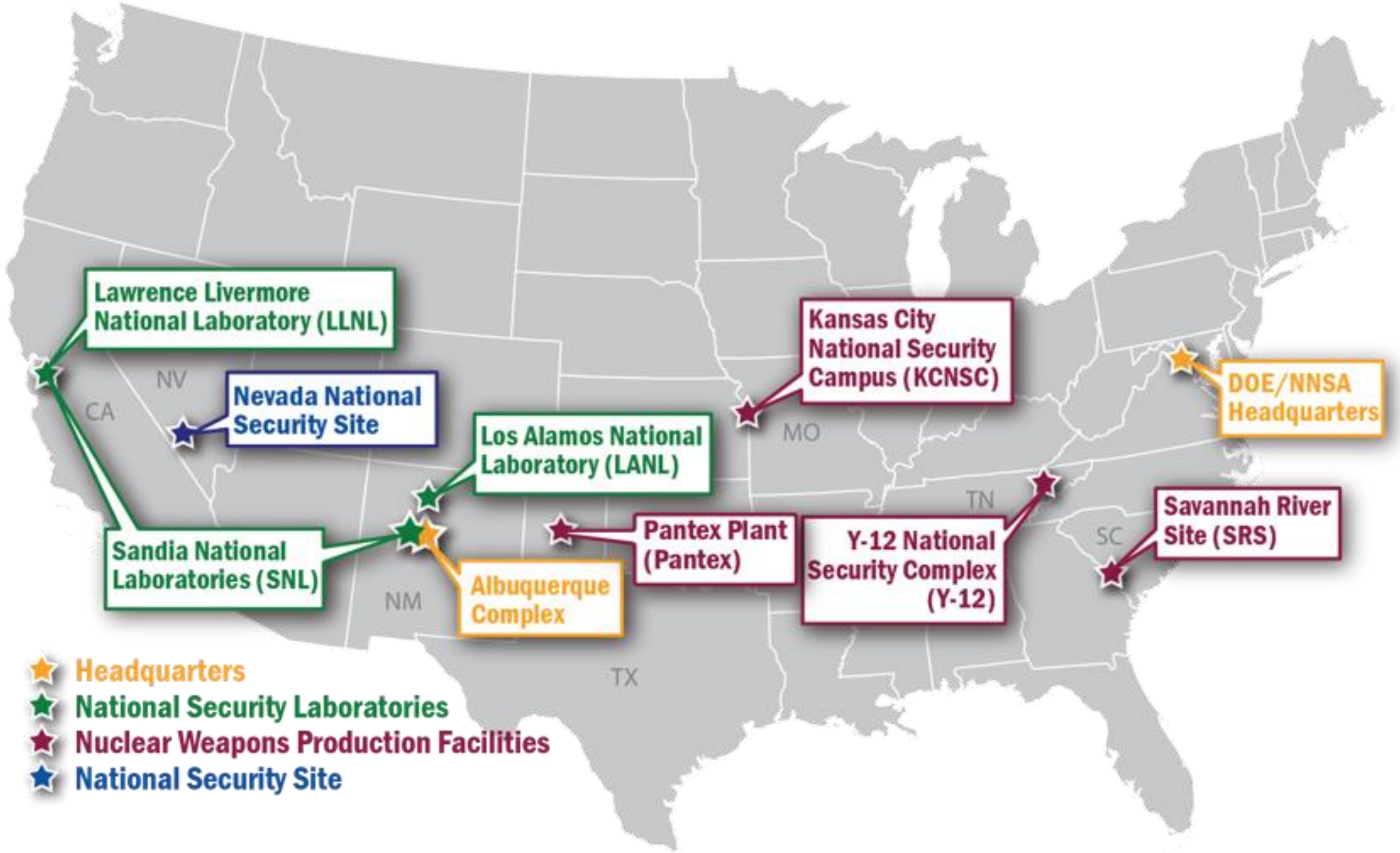
1) Overview / Background
2) High-level Process Overview
3) Methodology Deep-Dive
4) Next Steps & Future Applications

Overview / Background

BLUF

- NNSA is undertaking efforts to improve Planning, Programming, Budgeting, and Execution (PPBE) outcomes by developing new processes, methods, and tools
  - Application to-date has been on large infrastructure investments, which is a large portion of the overall NNSA infrastructure budget
- NNSA's Office of Programming, Analysis, and Evaluation (PA&E) - in coordination with other NNSA partners - has been developing a flexible, generalizable, and analytically rigorous process to improve portfolio analysis capabilities for NNSA
- Presentation will cover these processes, methods, and tools – highlighting their **impact on NNSA** and **applicability to other organizations**
- The methods and processes being presented today are **actively influencing and shaping** NNSA's long-term, multi-billion dollar infrastructure plans

NNSA Overview



Organizational Headwinds

- **Resource Constraints:** Increased demand on government agencies and inflation erosion in budget purchasing power
  - Has led to unprecedented resource constraints
- **Uncertain Future:** Increasingly complex and rapidly changing geopolitical and socioeconomic landscape
  - Makes flexibility and adaptability in resource allocation a necessity to mission success
  - **Examples:** Rise in superpower competition; Covid; increased conflicts across the globe
- **Competing Priorities:** Government organizations have priorities that directly conflict
  - Leads to difficult, and at times paralyzing, decision-making circumstances

Portfolio Analysis Overview

1. Foundational Scope Analysis, Data Collection, and Data Normalization

Critical to ensuring that subsequent analysis is defensible

2. Sub-Portfolio Analysis

Enables organizations to effectively compare-and-contrast priorities *within and across portfolios*

3. Portfolio Level Analysis

Considers interdependencies between portfolios, and evaluates decision-making more holistically

1. *Portfolio analysis is a series of interconnected analyses that are all dependent upon the quality of the previous analysis.*
2. *A single mistake early in the process causes a ripple effect that will carry throughout all downstream analyses.*
3. *It is essential to provide expertise in **all** aspects of the process.*

Step 1: Foundational Analysis

Critical to ensuring that subsequent analysis is defensible

Data Aggregation & Normalization

PARS	Repository for DOE Capital Assets Project Documents ***Project, cost, schedule, scope, technical accomplishment data, PM Assessment, EVM*****;** Used to determine schedule and cost variance, etc. Updated regularly.
G2	Program management system for various program offices; *Database of line-item & MC project data; scope, cost, schedule, etc*
CPDS	Detailed budgetary documents *appropriations, obligations, costs, by year and type.* Updated yearly
FormEx	FYNSP budget data for developing scenarios
MAP	NNSA real property assets *Name, age, location, complex, etc*

Multiple datasets were combined and cleaned to support analysis

Cost & Schedule Estimating

Cost Estimates: Two CERs to produce estimates for TEC and OPC

$$TEC = a * GSF^b * HC^c * EC^d$$

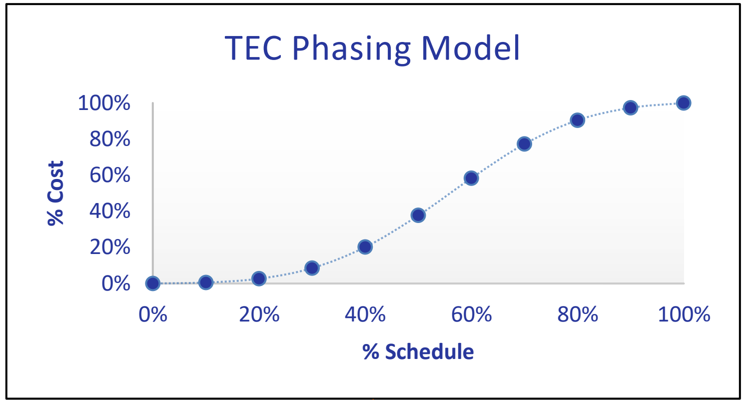
$$OPC\%\ of\ TEC = a * GSF^b * HC^c * EC^d$$

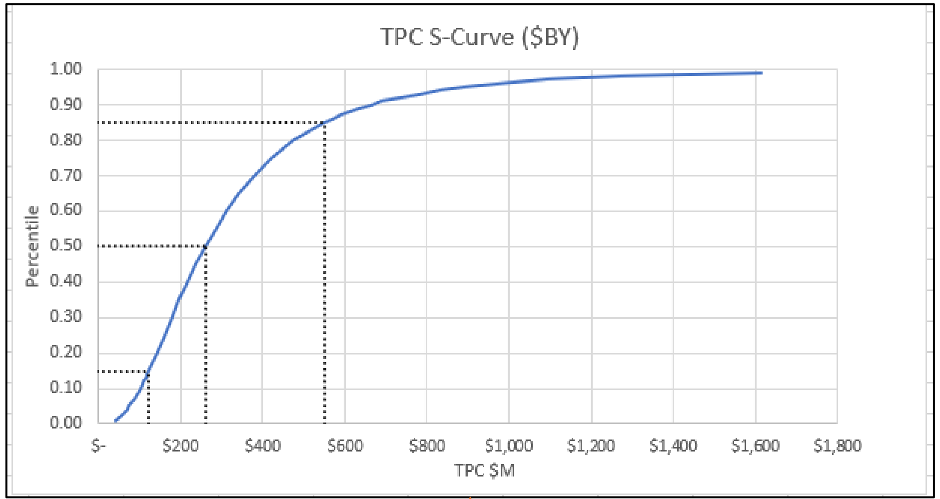
Schedule Estimates: An SER to produce an estimate for project duration with key milestone dates

$$Duration\ (Days) = 31.70 * TPC^{0.23} * 1.40^{Nuclear}$$

Phasing Estimates: Two PERs to estimate year-by-year cost profiles for TEC and OPC

Visualizations: Produces visualizations depicting estimated project cost and schedule





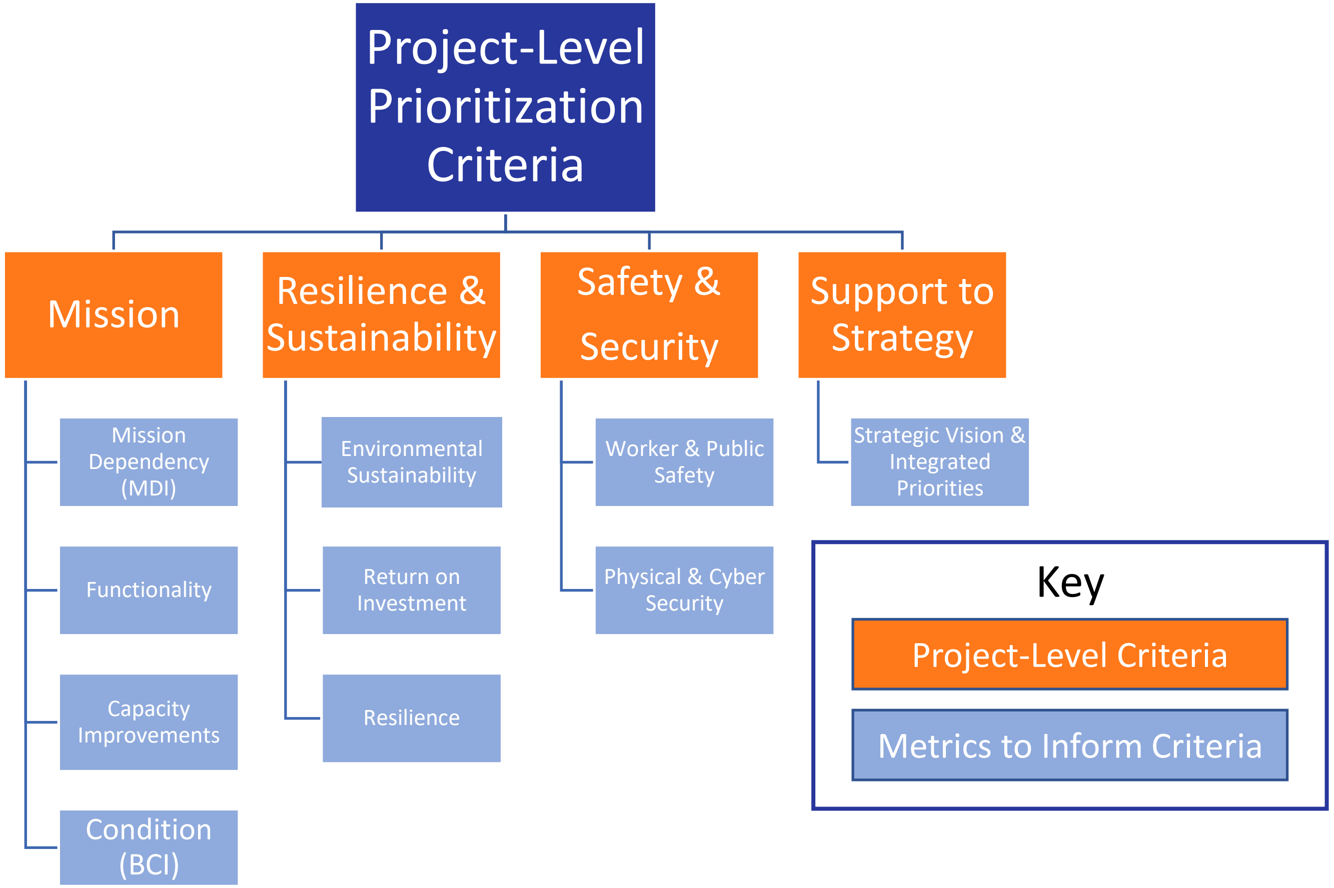
GSF = Gross Square Footage
TPC = Total Project Cost
HC = Hazard Category
EC = Equipment Complexity
TEC = Total Estimated Cost
OPC = Other Project Costs
CER = Cost Estimating Relationship
PER = Phasing Estimating Relationship
SER = Schedule Estimating Relationship

Step 2: Sub-Portfolio Analysis

Enables organizations to effectively compare-and-contrast priorities *within and across portfolios*

Criteria Identification & Definition

- Project proposals prioritized using a **standardized set of evaluative criteria**
- Developed methods for scoring each project on 1 – 100 scale *for each criteria*
- Criteria weights developed to reflect **relative importance of each criteria**
    - Weights calculated by soliciting input from NNSA Stakeholders, Labs, Plants, and Sites
- Prioritized list of proposals used to **inform portfolio-level decision-making**
- Standardized prioritization process ensures **effective cross-communication**



Specific criteria should be custom based on organizational objectives

Sub-Portfolio Prioritization

Step 1:
Score each project on prioritization criteria. Higher scores mean higher performance on that criteria

Project Name	Mission Need Score	Capacity Improvements Score
Project A	100	80
Project B	66	75
Project C	50	50
Project D	10	90
Project E	25	15

Step 2:
Assign weights to each metric to determine relative importance. Higher weights represent relatively more important criteria

Weight 1: Mission Need	Weight 2: Capacity Improvements
60%	40%

$$Project\ Score = (W_1 * Score_1) + (W_2 * Score_2)$$

Step 3:
Combine project scores and metric weights to calculate project score. Higher scores represent relatively more important projects

Project Score (60/40)
92
70
50
42
21

$$Project\ Rank = Project\ Score\ Ranked\ Highest\ to\ Lowest$$

Project Rank
1
2
3
4
5

Model specification should be custom based on organizational objectives

Step 3: Portfolio-Level Analysis

Considers interdependencies between portfolios, and evaluates decision-making more holistically

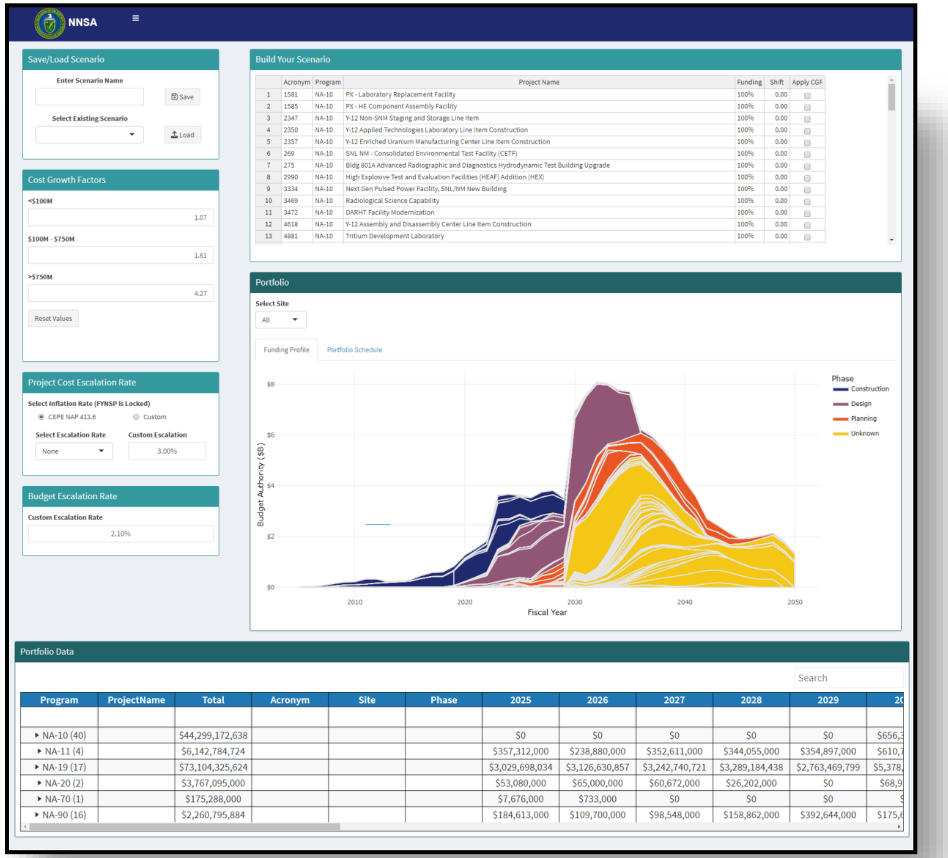
Loading Data into Portfolio Analysis Model

Project ID	Project Name	Site	Mission Need Date	Project Rank	Project Score	Project Start Date	Project End Date	Inflation Code	Project Type	Total Project Cost (BY$21)	2010	2011	2012	2013	2014	2015
1	Build Facility 1	PA	2035	5	86	2030	2035	0	Proposed	$ 29,477,172	$ -	$ -	$ -	$ -	$ -	$ -
2	Modify Capability 2	WA	2042	28	55	2034	2042	0	Proposed	$ 64,050,000	$ -	$ -	$ -	$ -	$ -	$ -
3	Replace Facility 3	FL	2029	32	45	2024	2029	0	Proposed	$ 40,104,436	$ -	$ -	$ -	$ -	$ -	$ -
4	Build Capability 4	WA	2040	4	87	2035	2040	3	Proposed	$ 32,730,557	$ -	$ -	$ -	$ -	$ -	$ -
5	Replace Facility 5	PA	2032	9	76	2030	2032	0	Proposed	$ 3,000,000	$ -	$ -	$ -	$ -	$ -	$ -
6	Repair Capacity 6	WA	2036	7	78	2029	2036	0	Proposed	$ 50,000,000	$ -	$ -	$ -	$ -	$ -	$ -
7	Modify Capability 7	WA	2025	30	53	2023	2025	0	Ongoing	$ 1,356,000	$ -	$ -	$ -	$ -	$ -	$ -
8	Build Facility 8	FL	2034	18	65	2030	2034	0	Proposed	$ 33,192,901	$ -	$ -	$ -	$ -	$ -	$ -
9	Build Capacity 9	PA	2033	26	58	2030	2033	3	Proposed	$ 12,978,000	$ -	$ -	$ -	$ -	$ -	$ -
10	Build Capability 10	FL	2041	16	67	2035	2041	0	Proposed	$ 112,000,006	$ -	$ -	$ -	$ -	$ -	$ -
11	Replace Capability 1	VA	2029	24	58	2022	2029	3	Ongoing	$ 283,125,000	$ -	$ -	$ -	$ -	$ -	$ -
12	Repair Facility 12	WA	2050	24	58	2047	2050	2	Proposed	$ 71,344,381	$ -	$ -	$ -	$ -	$ -	$ -
13	Build Capability 13	VA	2028	6	82	2023	2028	2	Proposed	$ 59,780,283	$ -	$ -	$ -	$ -	$ -	$ -
14	Build Capacity 14	WA	2031	19	64	2025	2031	2	Proposed	$ 62,543,816	$ -	$ -	$ -	$ -	$ -	$ -
15	Repair Capacity 15	WA	2040	1	95	2025	2040	0	Proposed	$ 124,823,827	$ -	$ -	$ -	$ -	$ -	$ -
16	Build Capability 16	VA	2031	36	35	2024	2031	2	Proposed	$ 50,000,000	$ -	$ -	$ -	$ -	$ -	$ -
17	Repair Capacity 17	PA	2038	34	42	2027	2038	1	Proposed	$ 21,504,677	$ -	$ -	$ -	$ -	$ -	$ -
18	Replace Capability 1	WA	2033	38	26	2025	2033	1	Proposed	$ 3,528,490	$ -	$ -	$ -	$ -	$ -	$ -
19	Replace Capability 1	PA	2036	34	42	2027	2036	1	Proposed	$ 54,000,000	$ -	$ -	$ -	$ -	$ -	$ -
20	Modify Capability 20	WA	2031	31	47	2024	2031	0	Proposed	$ 29,092,300	$ -	$ -	$ -	$ -	$ -	$ -
21	Repair Facility 21	FL	2050	36	35	2043	2050	0	Proposed	$ 132,027,034	$ -	$ -	$ -	$ -	$ -	$ -
22	Modify Capability 22	PA	2048	22	59	2030	2048	1	Proposed	$ 76,521,002	$ -	$ -	$ -	$ -	$ -	$ -
23	Repair Capacity 23	FL	2050	29	54	2040	2050	0	Proposed	$ 147,527,034	$ -	$ -	$ -	$ -	$ -	$ -
24	Repair Capacity 24	WA	2042	26	58	2025	2042	1	Proposed	$ 28,557,148	$ -	$ -	$ -	$ -	$ -	$ -
25	Modify Capacity 25	VA	2031	8	77	2024	2031	1	Proposed	$ 106,789,217	$ -	$ -	$ -	$ -	$ -	$ -
26	Build Facility 26	FL	2035	17	65	2027	2035	1	Proposed	$ 36,377,582	$ -	$ -	$ -	$ -	$ -	$ -
27	Modify Capacity 27	VA	2050	13	70	2037	2050	0	Proposed	$ 26,190,051	$ -	$ -	$ -	$ -	$ -	$ -
28	Modify Capability 28	FL	2032	20	63	2028	2032	1	Proposed	$ 4,451,685	$ -	$ -	$ -	$ -	$ -	$ -
29	Build Facility 29	PA	2032	40	22	2024	2032	1	Proposed	$ 58,969,853	$ -	$ -	$ -	$ -	$ -	$ -
30	Repair Facility 30	VA	2038	12	71	2026	2038	2	Proposed	$ 173,121,462	$ -	$ -	$ -	$ -	$ -	$ -
31	Build Facility 31	PA	2013	2	89	2010	2013	3	Historic	$ 23,205,000	$ 5,000,000	$ 5,500,000	$ 6,050,000	$ 6,655,000	$ -	$ -
32	Repair Capability 32	FL	2019	21	63	2011	2019	3	Historic	$ 32,146,830	$ -	$ 3,000,000	$ 3,300,000	$ 3,630,000	$ 3,993,000	$ 4,392,300
33	Modify Capability 33	PA	2021	14	69	2012	2021	3	Historic	$ 32,183,791	$ -	$ -	$ 4,503,221	$ 200,000	$ 1,200,000	$ 461,000
34	Repair Capability 34	VA	2021	32	45	2015	2021	2	Historic	$ 47,932,008	$ -	$ -	$ -	$ -	$ -	$ 1,345,443
35	Modify Capability 35	VA	2022	22	59	2016	2022	0	Historic	$ 76,704,213	$ -	$ -	$ -	$ -	$ -	$ -
36	Build Facility 36	PA	2021	39	25	2015	2021	2	Historic	$ 93,150,926	$ -	$ -	$ -	$ -	$ -	$ 281,000
37	Build Facility 37	WA	2021	11	72	2017	2021	1	Historic	$ 32,830,000	$ -	$ -	$ -	$ -	$ -	$ -
38	Replace Capability 3	PA	2018	9	76	2010	2018	3	Historic	$ 259,971,163	$ 47,404,631	$ 37,106,810	$ 21,932,825	$ 21,114,800	$ 20,181,246	$ 19,428,212
39	Modify Capacity 39	VA	2013	14	69	2010	2013	1	Historic	$ 33,822,000	$ 5,000,000	$ 11,805,000	$ 11,017,000	$ 6,000,000	$ -	$ -
40	Repair Capacity 40	VA	2016	3	88	2012	2016	3	Historic	$ 114,256,407	$ -	$ -	$ 10,871,000	$ 20,369,510	$ 32,809,468	$ 32,706,430

Typical minimum dataset required to perform portfolio analysis

R Shiny Simulation and Analysis Model

- **Key Functionality:**
  - **Consolidation:** Data cleaning, analysis & visualization in one place
  - **Server-Based:** Easily accessible by anyone with the link
  - **Speed:** Fast calculation speeds mean more analysis extensions are possible
- **Current Analysis Capabilities:**
  - Develop core plan-of-record based on *traceable, defensible assumptions*
  - Evaluate portfolio performance on key affordability, executability, and schedule risk statistics
  - Compare scenarios against each other
  - Deep-dive on specific projects
  - Save & export scenarios
- **Current Modeling Capabilities:**
  - Filter by site / program
  - Adjust escalation rates for *future* projects
  - Apply cost growth factors tailored to project size and stage
  - Modify project schedules

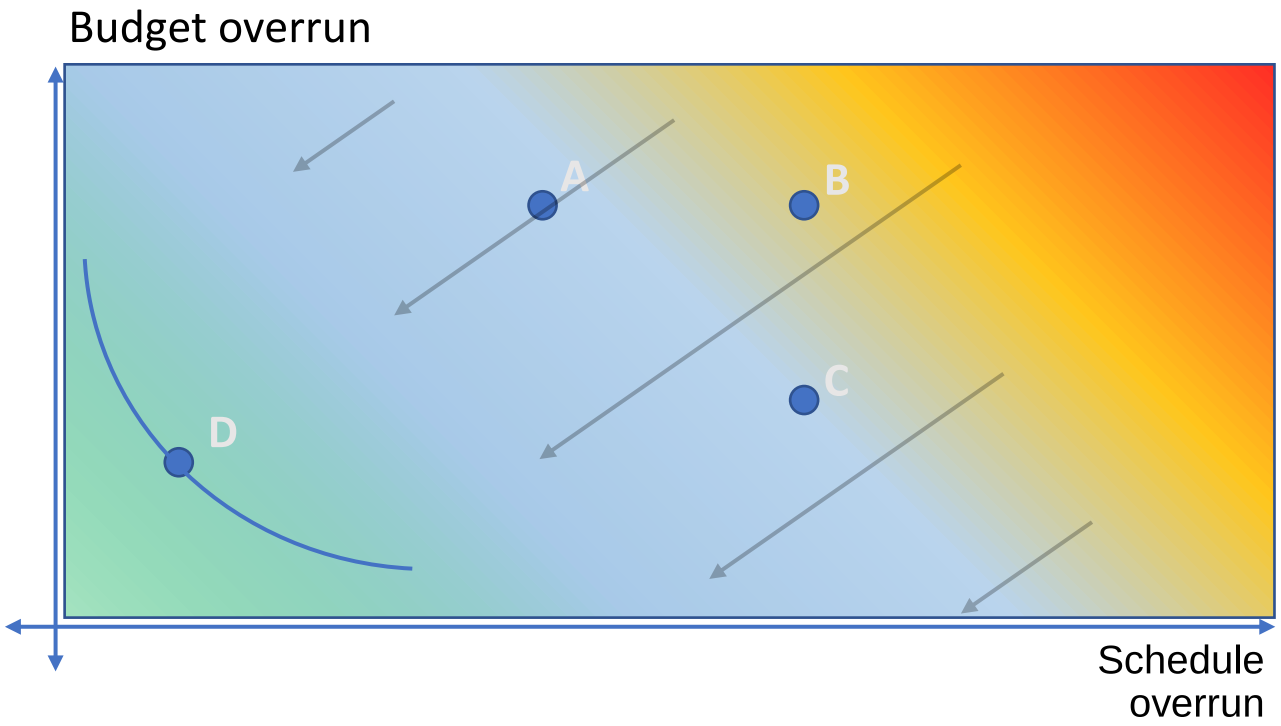


Key Concept: Pareto Efficiency

- Thousands of portfolio alternatives sorted categorically based on *efficiency*
  - *Efficient* portfolios *exist when* one portfolio statistic cannot be improved without making the other portfolio statistic worse
    - "I cannot reduce budget overruns anymore without sacrificing schedule"
    - "I cannot reduce cumulative schedule overrun without further violating the budget constraint"
- Inefficient portfolios eliminated from consideration
  - Inefficient portfolios, by definition, always have an alternative portfolio that is *strictly better*
- All efficient portfolio alternatives outlined; respective pros & cons of each alternative outlined for decision-maker
  - Providing a suite of portfolio alternatives gives decision-makers *actionable options*

Key Concept: Pareto Efficiency

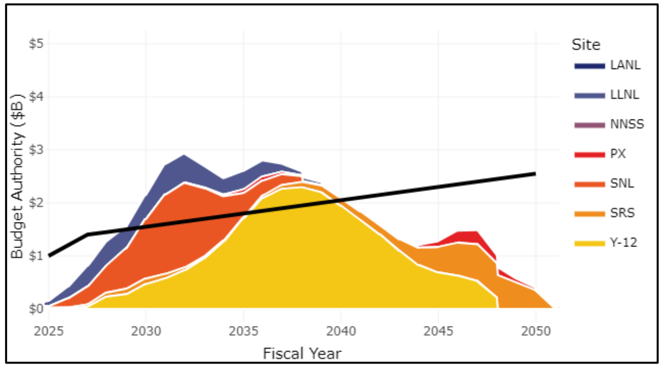
- Portfolio A > B
- Portfolio C > B
- A vs. C preference dependent upon stakeholder priorities
  - Schedule overrun (A) < Schedule overrun (B)
  - Budget overrun (A) > Schedule overrun (B)
- Portfolio D > A, B, & C
  - Portfolio D is better than Portfolios A, B, & C because it reduces both cost and schedule overrun greater than each of those portfolios
  - Portfolio D is *pareto efficient*



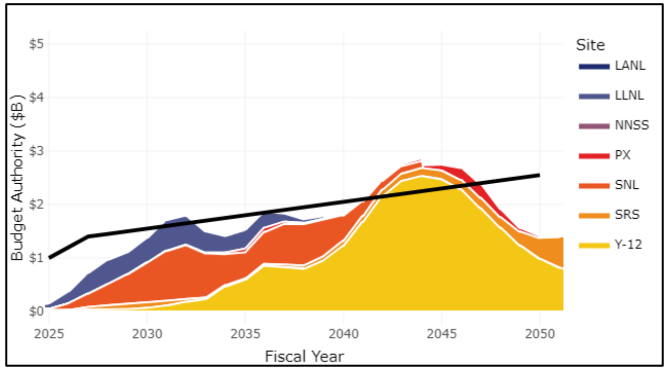
Portfolio-Level Results Example

Statistic Category	Portfolio Statistic	Baseline Portfolio	Portfolio A	Portfolio B
-	Portfolio Optimization Target	None	Affordability	Executability
Schedule	Average Mission Need Delta (Years)	5.36	6.4	7.08
Affordability	Cumulative Budget Constraint Overrun	267.67%	63.85%	98.84%
Affordability	Maximum One-Year Violation	43.08%	11.82%	17.63%
Executability	Max Projects Ratio	2.73	2.47	2.2
Executability	Portfolio Variability Statistic (VS)	34.20%	34.22%	15.02%
Executability	Portfolio Ramp-up-Rate (RuR)	-1.06%	-1.06%	-1.04%

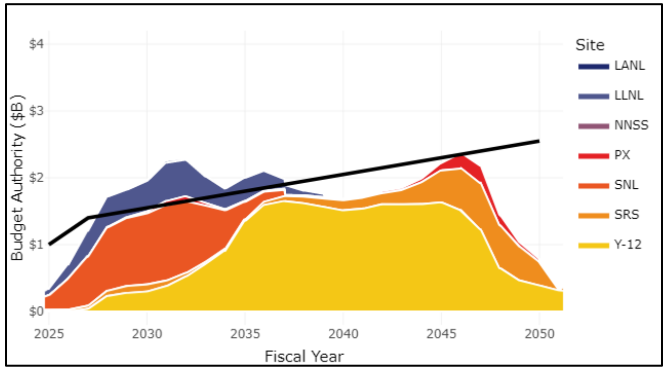
Baseline Portfolio



Portfolio A – Affordability Optimized



Portfolio B – Executability Optimized



Portfolio Analysis Model allows NNSA to simulate thousands of portfolio alternatives and their corresponding tradeoffs

Future Applications / Conclusion

- Examples in presentation highlight portfolio analysis process within NNSA infrastructure portfolio
- Generalized processes, methods, and tools are likely applicable to other organizations with similar challenges
  - Resource constraints; uncertainty; competing priorities; ambiguity

Key Benefits:

1. **Analytically Rigorous:** Develop budget-constrained portfolios based on project cost, schedule, and priorities to *reduce affordability risks* & *minimize deviations from priorities*
2. **Efficient:** Identify & perform *efficient* portfolio tradeoffs between competing assets by analyzing thousands of portfolio alternatives
3. **Customizable:** Allows for custom constraints & optimization parameters that enables user to easily "optimize" on a specific characteristic
4. **Universally Applicable:** Analytical concepts can be applied to many different organizations

How can these methods and concepts be applied to **your organization?**

Questions?

Backup

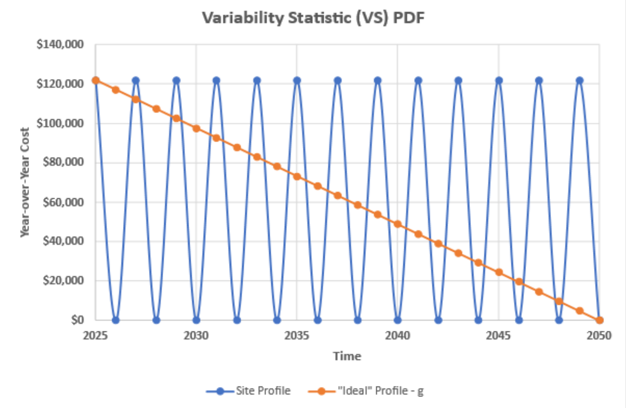
Executability Analysis Methodology

The Ramp-up-Rate – Variability Matrix (RVM) Approach to Executability

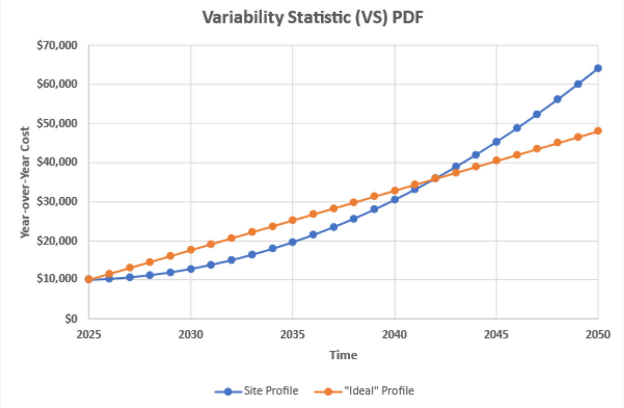
- **Principal 1:** The *Year-over-Year* **rate of change** (i.e. the "Ramp-Up Rate") of a portfolio is a useful indicator of executability
  - If the Ramp-up-Rate (RuR) is above or below certain thresholds, this is a red flag for executability
- **Principal 2:** The *Year-over-Year* **variability** (i.e. volatility) of funding of a portfolio is a useful indicator of executability
  - Higher volatility indicates less consistent and predictable funding, potentially harming execution likelihood
- These two principles, evaluated jointly, can paint a high-level picture on whether a particular portfolio of projects is executable
- Subsequent slides outline the approach to performing RVM analysis, and provide illustrative examples

Executability Examples Summarized

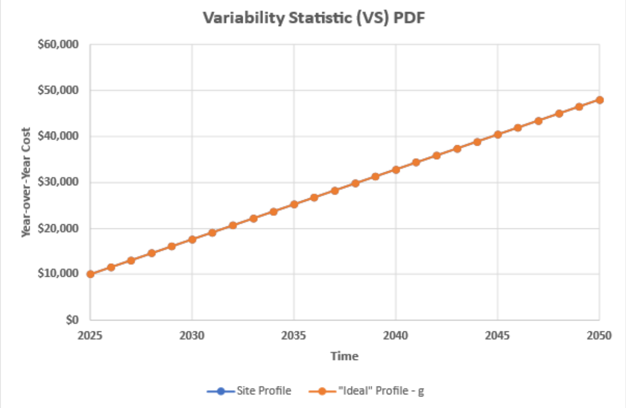
Variability Statistic (VS)	98.46%	Ramp-up-Rate (RuR)	-4.00%



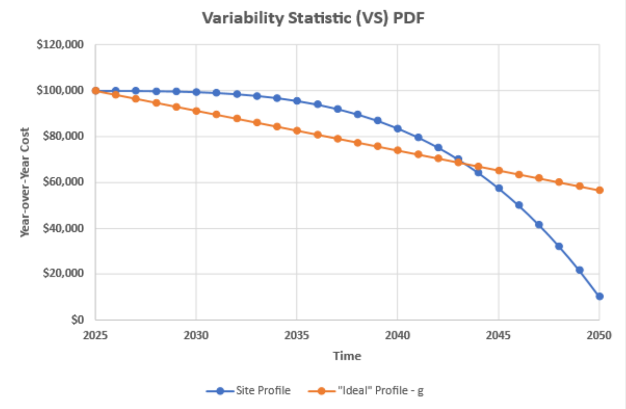
Variability Statistic (VS)	17.41%	Ramp-up-Rate (RuR)	15.20%



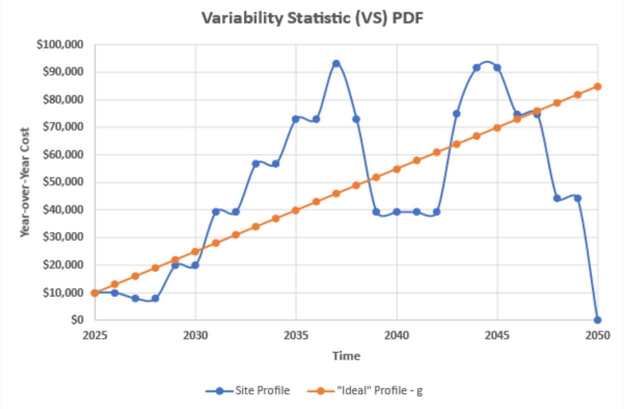
Variability Statistic (VS)	0.00%	Ramp-up-Rate (RuR)	15.20%



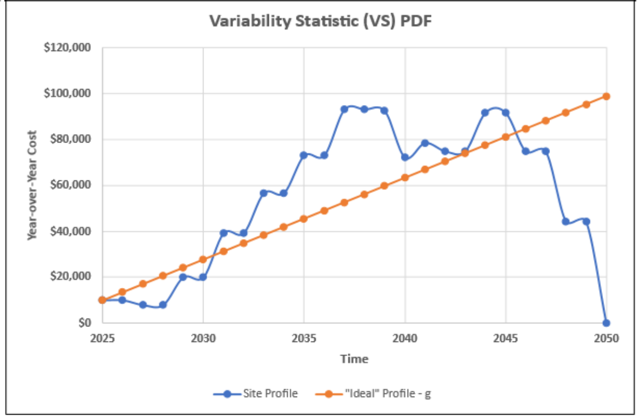
Variability Statistic (VS)	15.29%	Ramp-up-Rate (RuR)	-1.73%



Variability Statistic (VS)	42.12%	Ramp-up-Rate (RuR)	29.98%



Variability Statistic (VS)	37.01%	Ramp-up-Rate (RuR)	35.56%



Portfolio Key (For Next Slide)		
A	B	C
D	E	F

RVM Example

- Specific portfolios mapped into matrix below
- Color coding system meant to highlight potentially problematic portfolio scenarios *for each site*
- Colors are primarily meant to draw attention to executability risks – not make a judgement on actual executability

RuR	{-50% -31%}	{-10% -30%}	0%	{10% 30%}	{31% 50%}
Direction	Negative		Flat	Positive	
Slope	Extreme	Moderate	Stagnant	Moderate	Extreme
Theoretical Rank	5	4	2	1	3

VS Range	Variability Description	Rank
VS > 40%	Extreme	5
30% > VS > 40%	Moderately High	4
20% > VS > 30%	Moderate	3
10% > VS > 20%	Moderately low	2
VS < 10%	Low	1

			Ramp-Up Rate (RuR)				
			Extreme Negative	**Moderate Negative**	**Extreme Positive**	**Stagnant**	**Moderate Positive**
		Rank	**5**	**4**	**3**	**2**	**1**
Variability Statistic (VS)	**VS > 40%**	**5**		A			E
	30% > VS > 40%	**4**			F		
	20% > VS > 30%	**3**					
	10% > VS > 20%	**2**		D			B
	VS < 10%	**1**					C

Project Cost Escalation Methodology

Methods used to escalate project costs based on individual project scope

Escalation Methodology Overview

- **Data Sources:**
  - **CEPE NAP 413.6** – for future construction projects & LEPs
  - **ENR CCI** – for historic construction projects
  - **CPI-U** – for historic LEPs
- Escalation is custom based on each project's individual scope:
  - **Project Type:** Nuclear Construction, Non-Nuclear Construction, LEP
  - **Escalation Percentile:** 5th, 10th….95th
  - **Project Location:** SNL, LANL, LLNL, etc.
- Default escalation logic built into system if project scope information

ENR CCI / CPI-U Escalation Index			NAP 413.6 Escalation Index				413.6 Index Extrapolation		
….	2021	2022	2023	2024	….	2038	2039	…..	2050
Invariant to Project Scope			Dependent Upon Project Scope						

Escalation Code Syntax

- Three pieces of information used to develop each unique index
- **Construction Type:**
  - 1 = Nuclear
  - 2 = Non-Nuclear
  - 3 = LEP
- **Inflation Rate:**
  - 5^{th},…95^{th}
- **Site:**
  - LANL, LLNL, etc.
- Unique combination of three pieces of information constitute a unique escalation code, which can be applied to a project / program with those same unique characteristics
- Default code (code number 000) can be used as a default if pieces of information above are unknown
  - 000 is simply ENR CCI, BY$22

Example Code			
Construction Type Code	Inflation Rate	Site	Unique Code
1	95th	LANL	Nuclear95thLANL

Quantification Methodology

Existing Data Mapping Analysis

Reviewed 352 variables from FIMS, MAP and G2 for relevance to study

Deep-dives performed on 33 variables identified as relevant based on definition and level of completeness

16 variables identified for use as **direct or indirect metric quantifiers**

Variables from FIMS, MAP, and G2 mapped to 10 project-level **metrics**

Approaches used to determine most appropriate quantification method for each project criteria (using existing data, leveraging data call, etc.)

Project Description Review

Review of 82 **previous Line-Item project** descriptions

Gauged **ability to quantify** each criteria

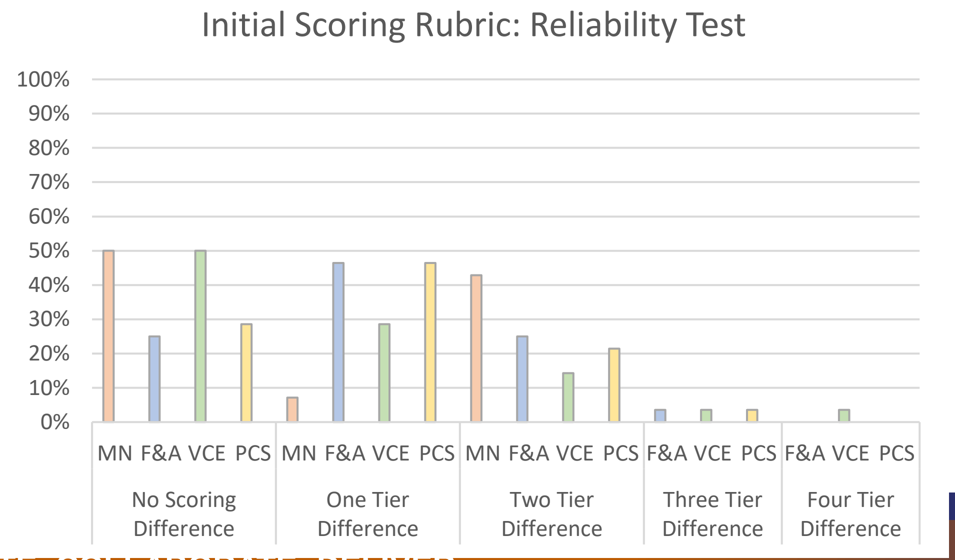
Aided in **developing questions** for data call

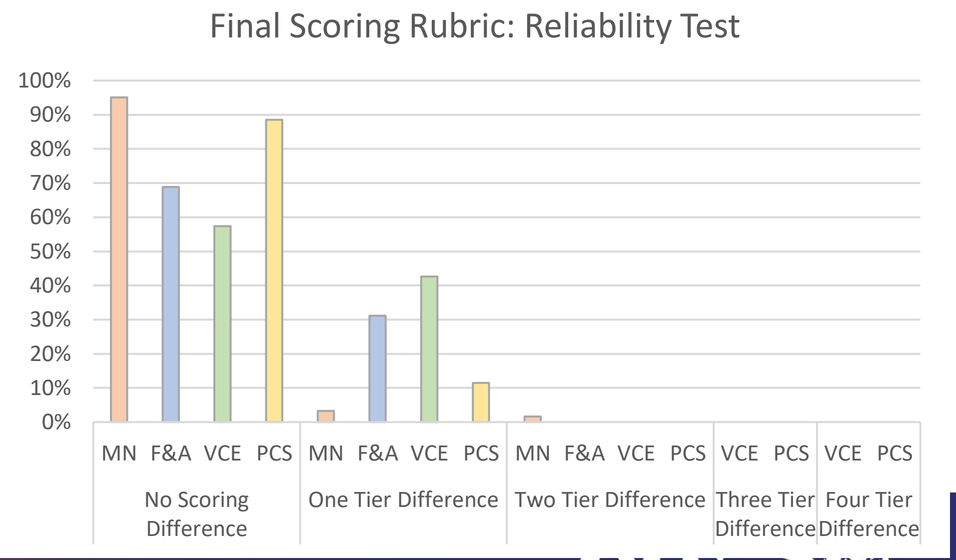
- **Quantitative Metrics:** Project-level criteria scored using existing numeric data derived from a formula
  - Replaceability & Impact (MDI)
  - Environmental Sustainability (Parametric)
  - Economic Cost Reduction (Parametric)
  - Worker & Public Safety (ERI)
  - Condition (BCI)
- **Qualitative Metrics**: Project-level criteria scored using subjective evaluation formed from project descriptions & data call inputs

  Note: The rubrics used for evaluation **should** be Operational, Reliable, Relevant, and Justifiable.
  - Mission Priority
  - Flexibility & Alternatives
  - Mission Versatility, Capability & Efficiency
  - Physical & Cyber Security
  - Capacity Improvements

Scoring Rubric: Reliability Test

- **Purpose:** To determine whether a qualitative scale is reliable, such that any number of independent analysts evaluating the same project on the same rubric come to the same conclusion
- Three analysts independently score subset of projects on pre-defined qualitative scoring rubric
- Results for each project compared between analysts
- **No Scoring Difference:** All analysts scored project in same tier
  - Best outcome & indicates reliability of scale
- **X Tier Difference:** Analysts disagreed on appropriate tier to place project
  - Higher magnitude indicates larger disagreement & need to reconsider qualitative scale definitions
- Distribution of scoring comparisons developed to gauge general reliability of scale

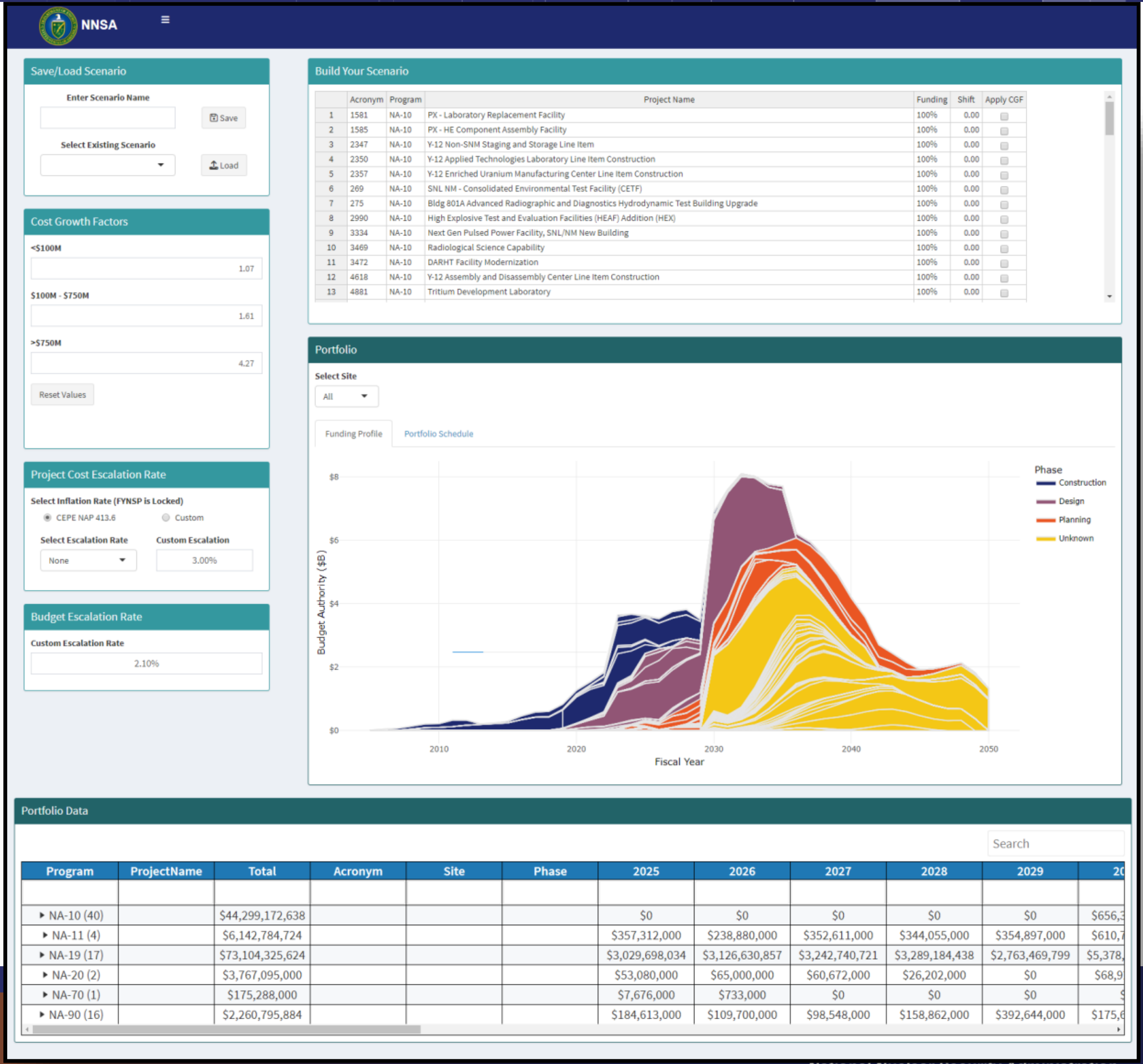




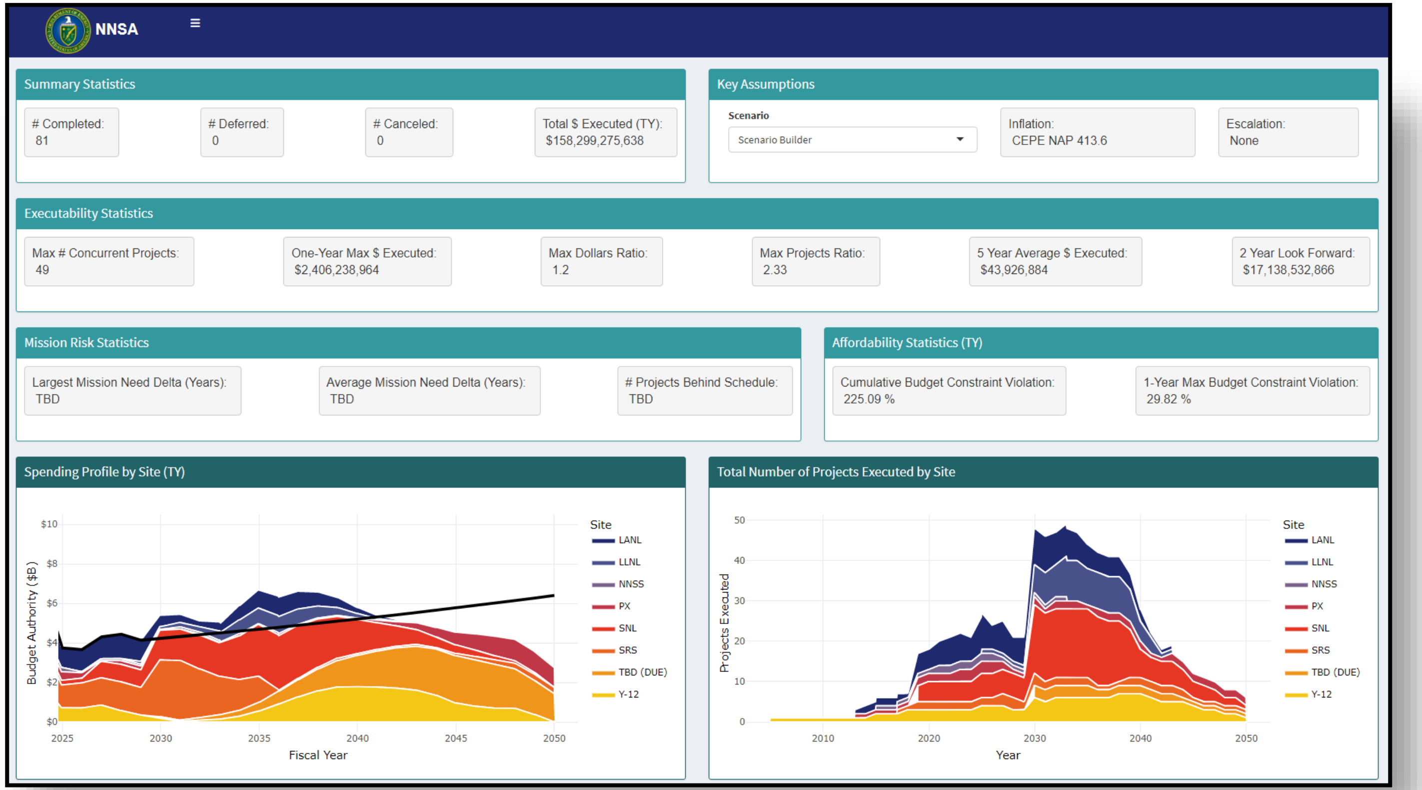
Portfolio Analysis Model Visuals

Scenario Builder

- Build custom scenarios by toggling key portfolio parameters such as:
  - Escalation rates for *future* projects
  - Apply cost growth factors tailored to project size and stage
  - Modify project schedules & cost profiles
  - Dynamic base-year and then-year cost adjustments
- Scenarios stored in a central repository where other users can instantly download & view that scenario's unique parameters



Portfolio Summary

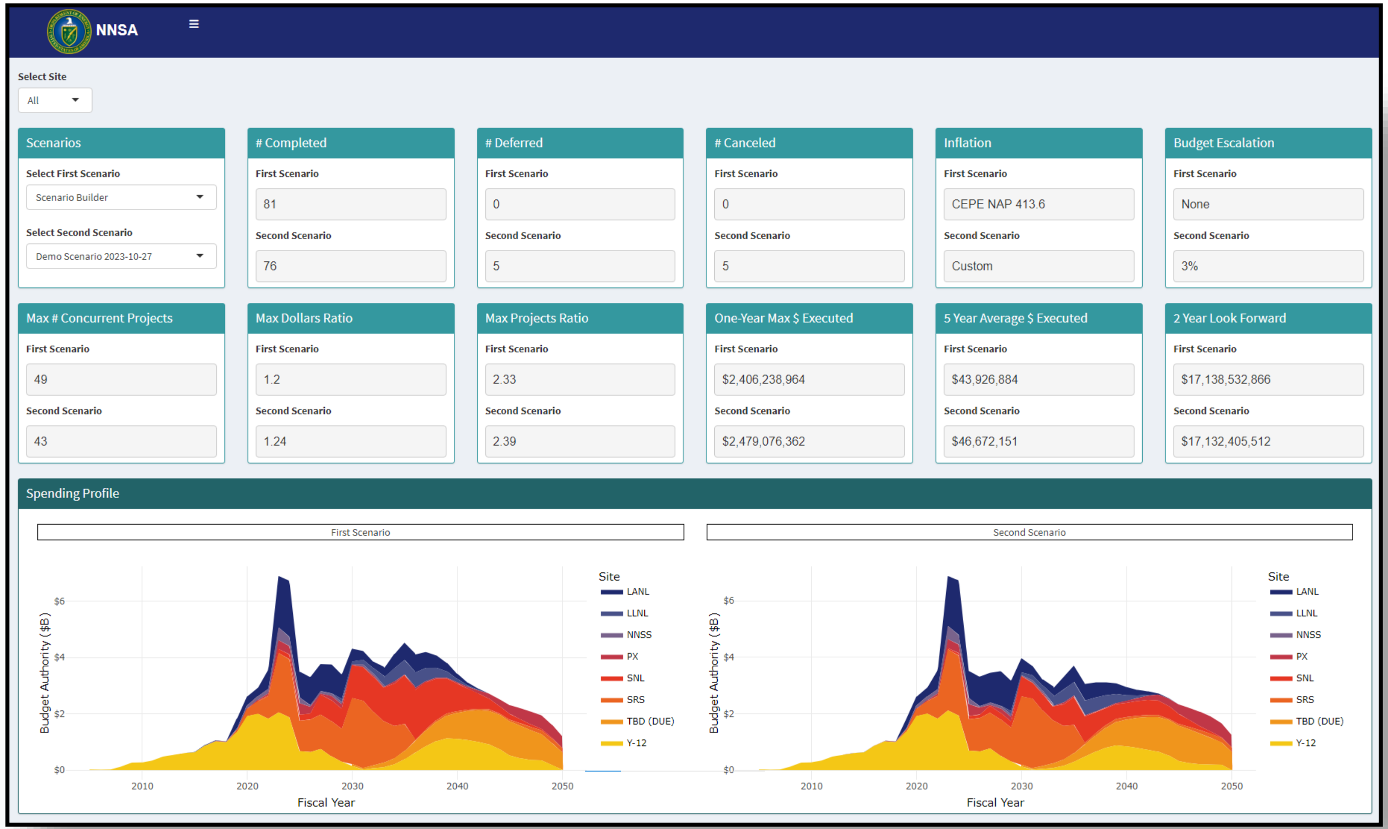


Scenario Comparison

- Compare-and-contrast performance between two different portfolio scenarios to understand the high-level tradeoffs between each
- Summarizes key differences in assumptions and parameters to understand what is driving difference in portfolio performance

Executability Deep-Dive

- Deep-dive into executability for a specific scenario to *inform discussion* on high-level executability risks
- Current executability statistics serve as high-level risk indicators, **not authoritative** evaluations of executability
- More in-depth executability analysis approaches are being explored & developed to better understand & analyze executability
    - Details available upon request



Project-Specific Deep-Dive

- Deep-dive into the specific characteristics of an individual project.
- Users can compare implications for *a specific project across multiple scenarios*
- Meant to summarize key project characteristics such as:
  - Project scope
  - Relative priority (from prioritization model)
  - Project cost & schedule
  - Anticipated location
  - Funding profile