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National Nuclear Security Administration

The Nuclear Option

Avoiding Critical Delays with Advanced Constraints Analysis

ICEAA Professional Development & Training Workshop

Minneapolis, Minnesota
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Technomics/NNSA Papers at ICEAA

Stretching Purchasing Power through Improved Escalation Methods

Updating escalation methodology for programmatic equipment across the Nuclear Security Enterprise (NSE)

Portfolio Analysis Made Effective and Simple

Documents a flexible and repeatable process for analyzing projects across a portfolio to assist decision makers.

The Nuclear Option: Avoiding Critical Delays with Advanced Constraints Analysis

Documents the methodology used to analyze how funding constraints impact construction project schedules and phasing

All this work directly impacts the NNSA by increasing their data and modeling capabilities for making funding decisions across portfolios in a resource constrained environment

The Nuclear Option: Avoiding Critical Delays with Advanced Constraints Analysis

The constrained phasing model is a **data-driven**, **predictive** methodology built on historic construction project data. This model can help prevent costly schedule overruns, positively impacting the missions of the NNSA.

This paper will offer the framework for developing this model within **other government agencies** using their unique capital acquisition data, likely impacting the success of high priority government projects across the U.S.

Hannah Lee

Hannah comes from a multidisciplinary research background and holds degrees in both Biochemistry and Pharmaceutical Science. As a researcher, Hannah gained extensive experience in project design and project management, statistics, and data visualization. She has published her research in high-impact journals and has presented findings at multiple conferences and events. **At Technomics, Hannah develops models and tools for NNSA's Office of Management and Budget.**

Agenda

- Introduction
- Constrained Phasing Model
- Methodology
- Example Use Case
- Impacts & Limitations
- Non-NNSA Development

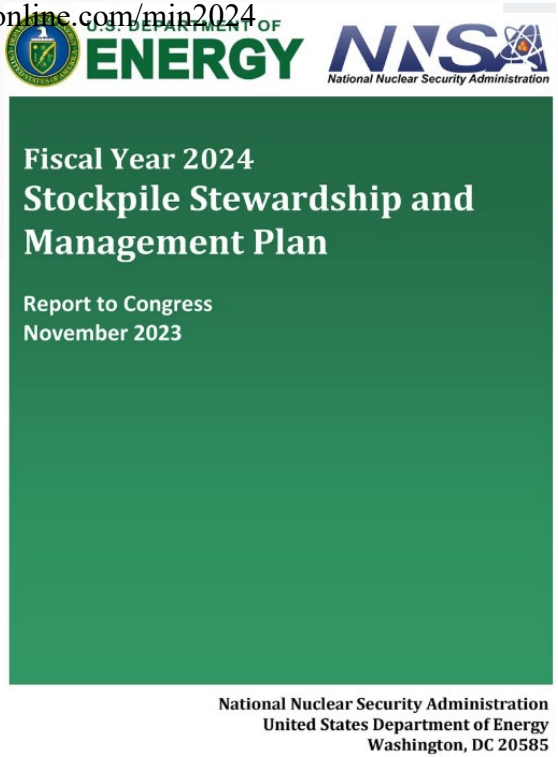
Introduction - NNSA

The **National Nuclear Security Administration** (NNSA) is a semi-autonomous agency within the U.S. Department of Energy

The NNSA enhances national security through four major missions: Maintaining the Stockpile, Nonproliferation, Counterterrorism and Counterproliferation, and Powering the Nuclear Navy

Office of Programming, Analysis, and Evaluation (**PA&E**) is part of the NNSA Office of Management and Budget

PA&E develops **models and tools** to support Programming, Planning, Budgeting and Evaluation (PPBE) and capital acquisition processes, and to help ***inform decision-making at the highest levels***



As of Fiscal Year 2024, DOE/NNSA has over 5,500 facilities with an **average age of 47 years**

Much of the NNSA infrastructure needs **complete replacement or modernization** making the capital acquisition process a top priority

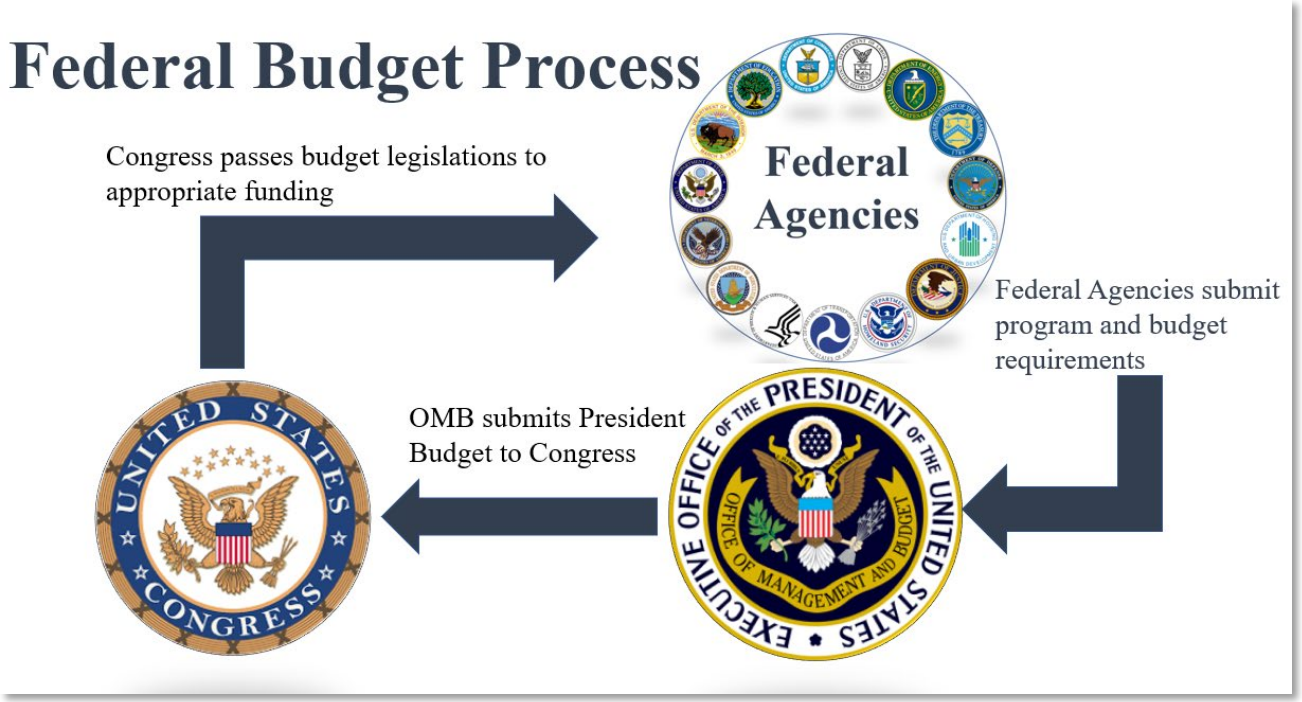
Introduction – What are we trying to solve?

Government agencies request and receive funding the same way: through the **Federal Budget Process**

This involves a great deal of data collection, portfolio analysis, prioritization, and inter-office collaboration

What happens to projects when an agency receives less funding than expected?

The effect of these funding shortfalls may be severe, potentially forcing projects into suboptimal execution plans that produce costly schedule slips with **drastic mission implications**



Introduction – Unconstrained Phasing

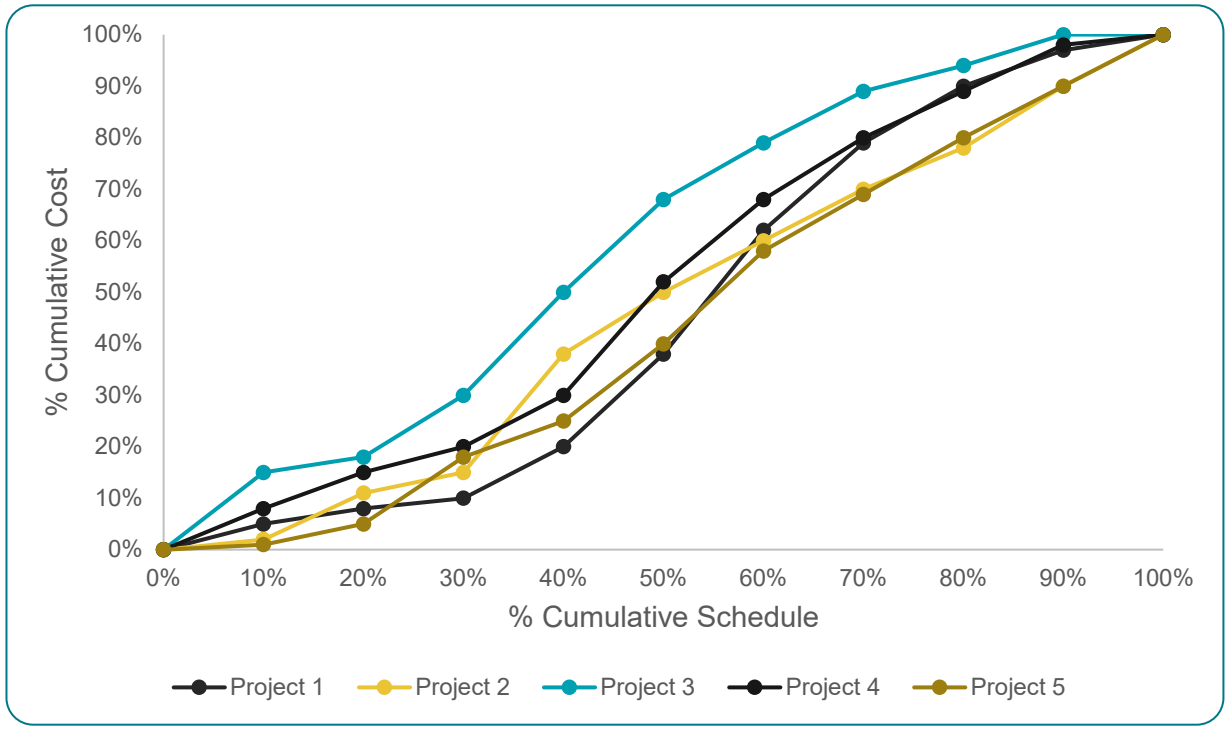
What is the "right" way to phase costs for a construction project?

Develop a **Phasing Estimating Relationship** (PER) using previously completed projects

- Weibull
- Rayleigh
- Log normal

Need information including:

- Total project cost
- Project start date
- Project end date
- Project type
- Who is executing this project



Any project that executes as the PER predicts would be considered *unconstrained* in this context

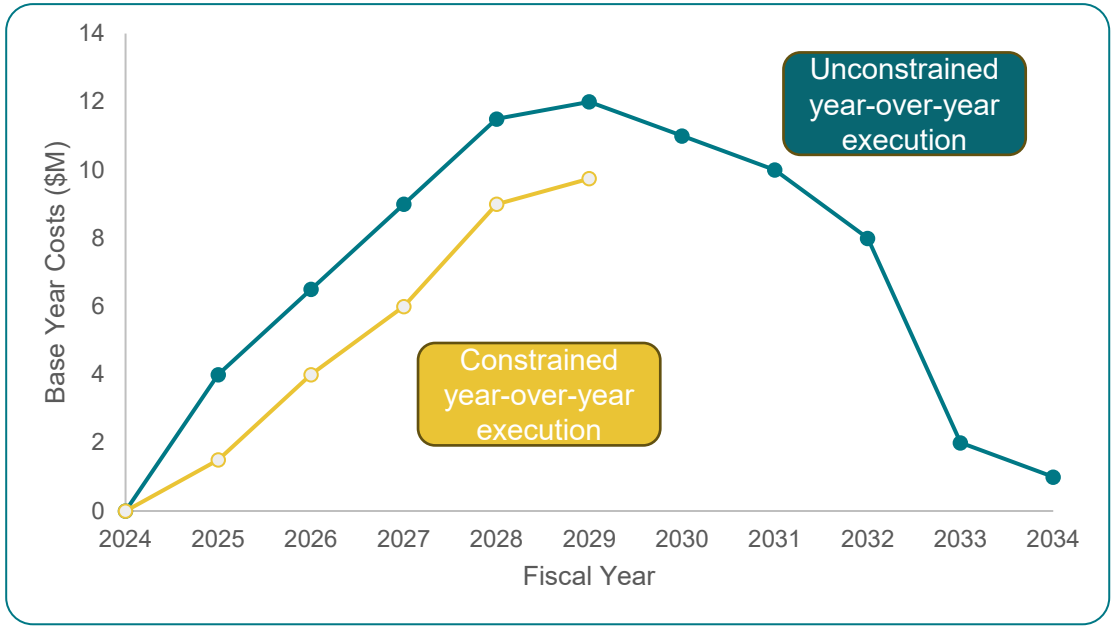
Introduction – Constrained Phasing

It is more likely that projects are required to execute under some amount of **funding constraint** within the NNSA

Common constraints include:

- Five-year funding plan
- Topline
- Project Holds
- Early Optimism

Status Quo involves manually forcing execution profiles under budget lines; this is time consuming and does not have predictive or data-driven capabilities



Constrained Phasing Model

Data-driven tools have not been readily available to address these funding constraints. A **comprehensive model** is required to predict schedule changes, re-phase costs after overcoming constraints, and mitigate additional, negative implications on project timelines.

The model seeks to answer questions like:

What happens if funds cannot be executed ideally for this project?
Will this project finish on time if the funding is cut in half?
How will funding cuts impact project schedule?
How can I recover from constraints and re-phase costs ideally again?

Has not been used for other constraint types: commodity, manpower, etc. Only **funding constraints**

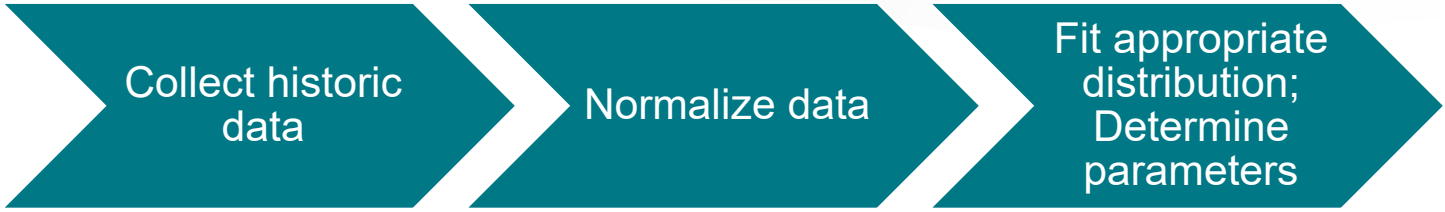
Methodology – PER Development

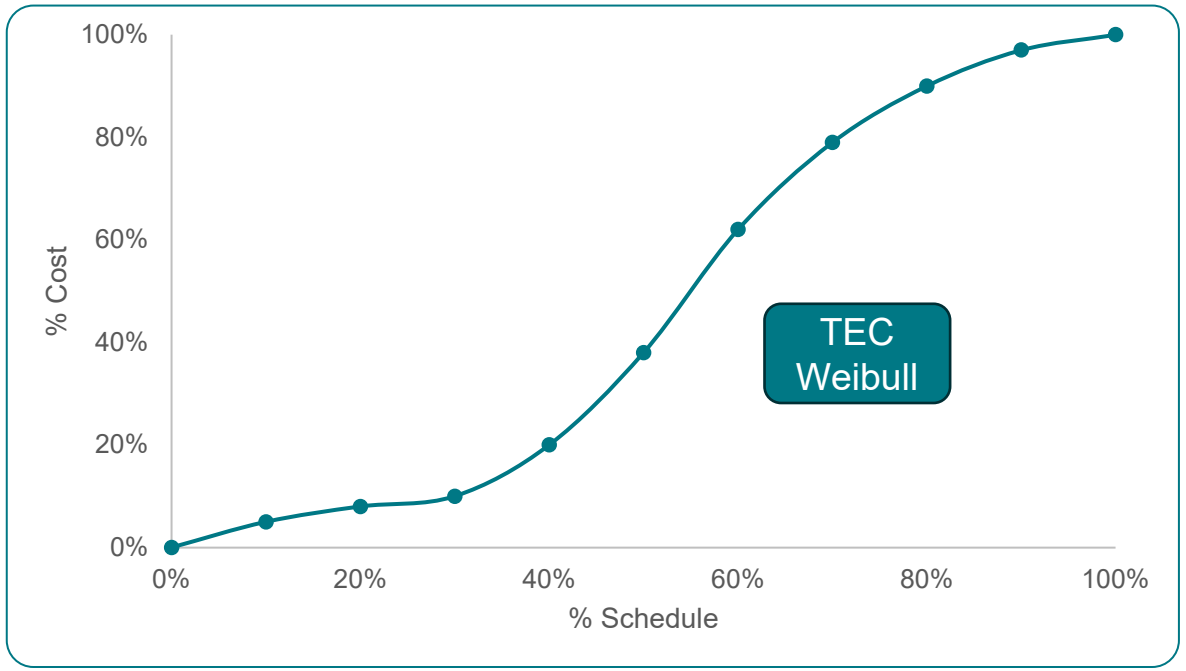
The Cost, Schedule, Phasing Estimating Relationship- Construction (**CSPER-C**) model was developed by PA&E in 2018

3 PERs were developed using complete, historic capital acquisition project data

- Total Estimated Cost (TEC):
  - **Weibull** distribution
- Other Project Cost (OPC):
  - Nuclear Facility: **Exponential**
  - Non-Nuclear Facility: **Exponential decay**

These PERs are used in the **constrained phasing model**





Methodology – Functionality Development

The model answers **3 major questions**:

Is the year-over-year execution plan executable?

Can the project meet its Mission Need date with the given execution plan? If not, what would the new project end date be?

How can costs be re-phased after facing constraints?

Methodology – Executability (Question 1)

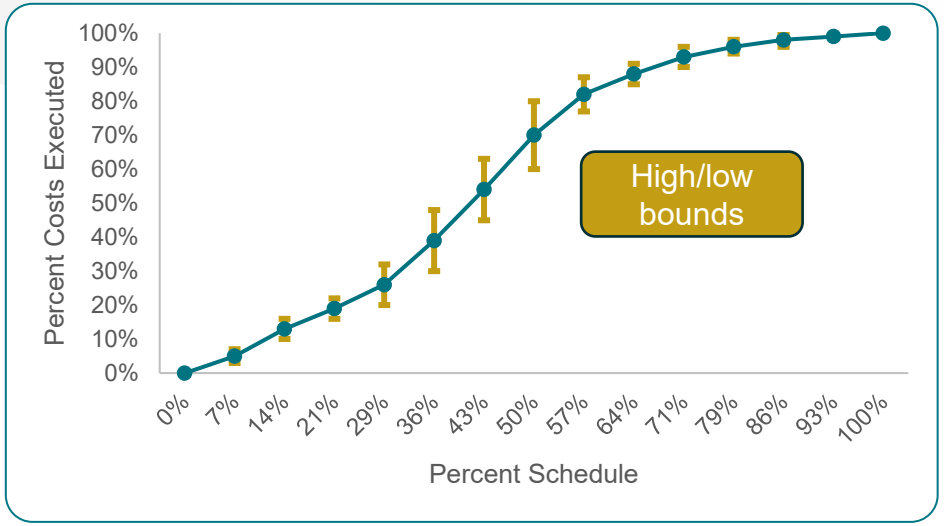
Used historic data to set executability bounds

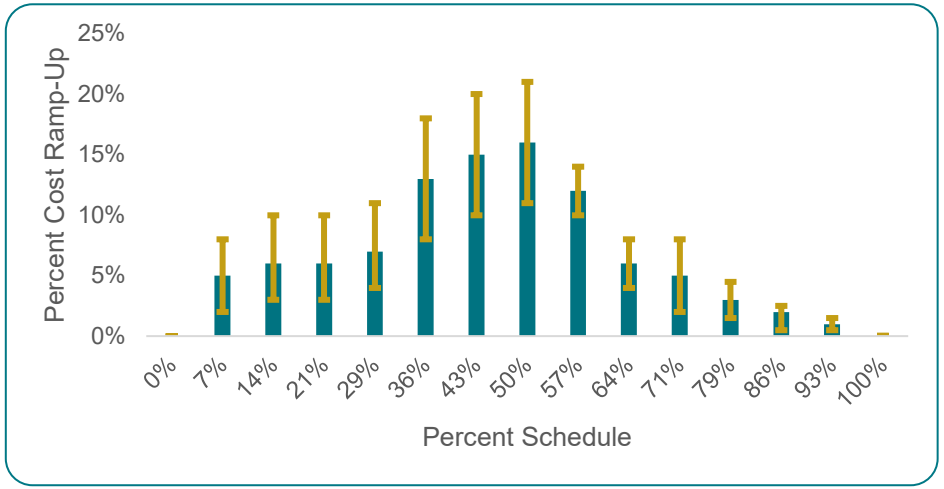
Projects were **normalized from 0-100%** for both project cost and schedule

Every 7% (longest project was 14 years)

Standard deviations were calculated at every 7% schedule

At 50% project schedule, a project can execute anywhere from 60-80% of their costs and be within bounds





Is the year-over-year execution plan executable?

Methodology – Project End Date (Question 2)

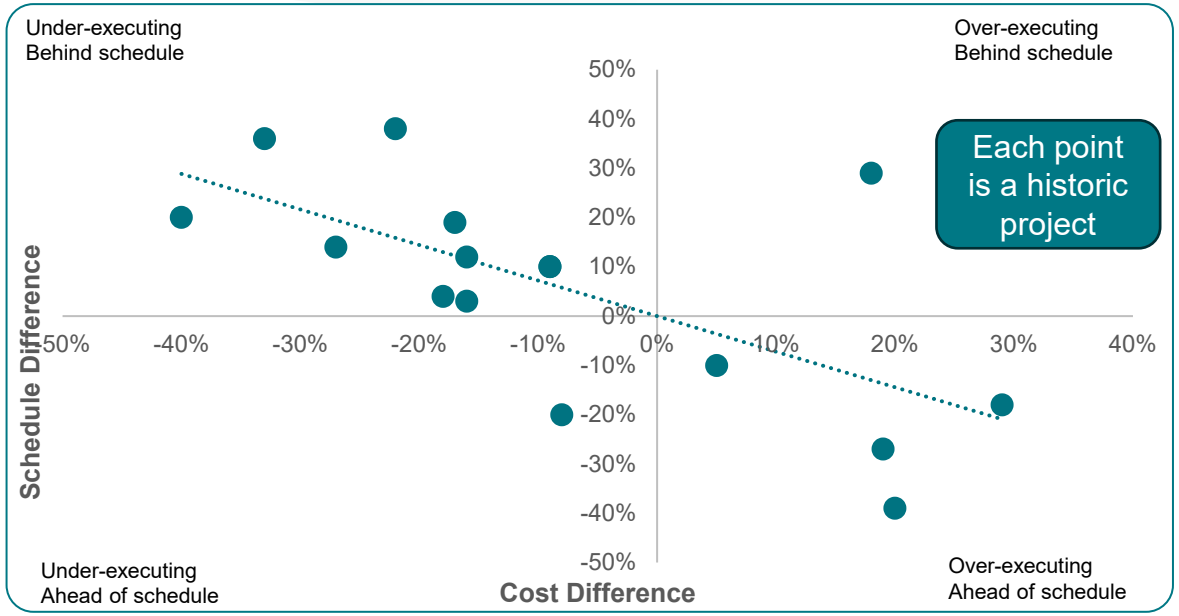
The **quad chart** was developed to offer a predictive solution within the constrained phasing model

A quad chart exists for **every 7 percent schedule**

Data used to build each quad chart:
- Estimated project duration
- Actual project duration
- Estimated project cost execution
- Actual project execution

Difference = Actual – Estimated

Quad Chart at 50% Schedule



The **cost difference** is used as "**x**" in the linear trendline equation

The **schedule difference** is "**y**" and used to adjust the new project end date

Can the project meet its *Mission Need date* with the given execution plan?

Methodology – Re-phasing (Question 3)

If we determine a project falls outside our executability bounds and is estimated to slip schedule, we must offer a **viable plan to re-phase costs.**

The difference between the last FY with a constraint and the first FY without a constraint, must be re-phased **proportionately to the PER**

FY	Constrained Cumulative Costs	Model Cumulative Costs	Re-Phased Cumulative Costs
2024	1.0 M	1.0 M	1.0 M
2025	3.0 M	4.0 M	3.0 M
2026	4.0 M	8.0 M	4.0 M
2027		18.0 M	16.0 M
2028		27.0 M	22.0 M
2029		31.0 M	27.0 M
2030		32.0 M	30.0 M
2031			32.0 M

Constrained FYs

Re-phased FYs

$4M under

New end date

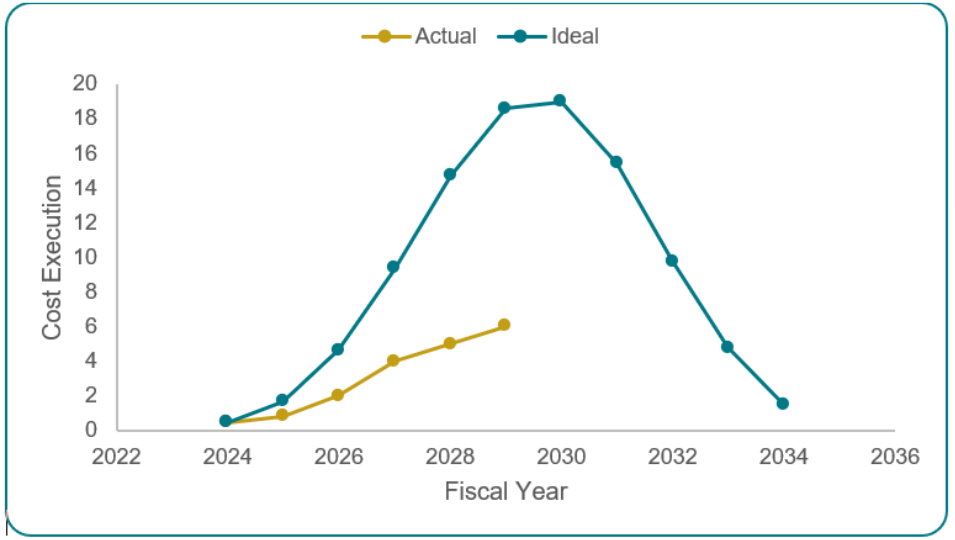
How can we re-phase costs after facing constraints?

Example Use Case - Inputs

Project CON is a new construction project starting in 2024 with a projected end date of 2034

The model needs the following **inputs** for analysis:

- Project start: **FY 2023 Q1**
- Construction start: **FY 2024 Q1**
- Project end: **FY 2034 Q4**
- Base Year: **2024**
- Standard deviation: **1.0**
- Total Project Cost: **$100 M**
  - OPC: **$10 M**
  - TEC: **$90 M**
- Estimated Executed Plan



FY	TEC ($M)
2023	0.0
2024	0.5
2025	0.8
2026	2.0
2027	4.0
2028	5.0
2029	6.0

Execution plan

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*Only years with constraints are added to the model.

Example Use Case – Executability Check

Project CON is a new construction project starting in 2024 with a projected end date of 2034

Four fiscal years did **not** pass the executability check

1. 2026: Ramp-up is **too low** from 2026 to 2027
2. 2027: Ramp-up is **too low** from 2027 to 2028
3. 2028: Ramp-up is **too low** from 2028 to 2029
4. 2029: Cost value is **too low**; Ramp-up is **too high** from 2029-2030*

		CUMULATIVE CONSTRAINT TESTS	
FY	**TEC ($M)**	**Value**	**Ramp-Up**
2023	0.0	✓ 1 σ	✓ 1 σ
2024	0.5	✓ 1 σ	✓ 1 σ
2025	0.8	✓ 1 σ	✓ 1 σ
2026	2.0	✓ 1 σ	✗ 1 σ LOW
2027	4.0	✓ 1 σ	✗ 1 σ LOW
2028	5.0	✓ 1 σ	✗ 1 σ LOW
2029	6.0	✗ 1 σ LOW	✗ 1 σ HIGH

*Only years with constraints are added to the model. 2030 and beyond is assumed to be PER-developed (ideal values)

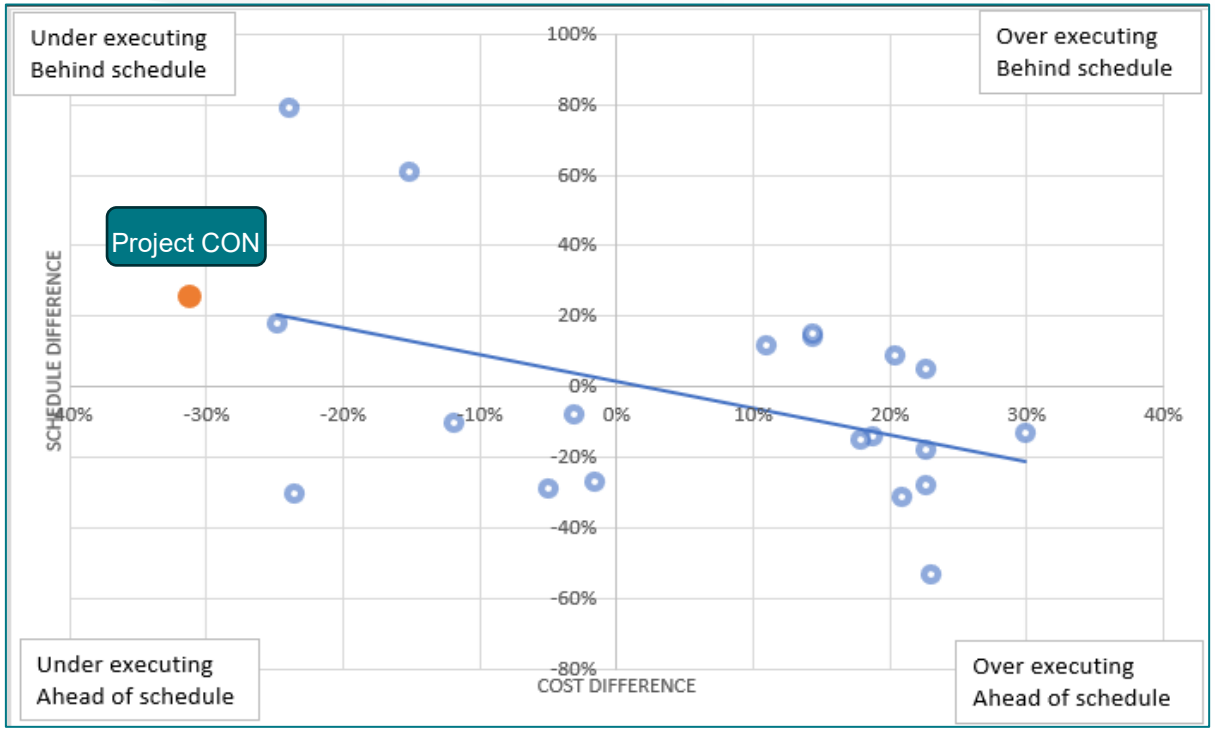
Example Use Case – Quad Chart

Project CON is a new construction project starting in 2024 with a projected end date of 2034

Based on the execution plan, the cost difference is used to determine the schedule difference (schedule slip) from the linear trendline on the quad chart

The schedule difference is estimated to be ~ 2.5 years

This pushes the estimated end date from **Q4 2034** to **Q2 2037**



Previous End Date	
Q04	2034
New Estimated End Date	
Q02	2037

Example Use Case – Re-Phasing

Project CON is a new construction project starting in 2024 with a projected end date of 2034

Previous End Date	
Q04	2034
New Estimated End Date	
Q02	2037

Using the new project end date, the remaining costs are **re-phased**

The re-phased costs are plugged back into model to confirm they are **executable**

All costs pass the executability tests; the generated execution plan is viable

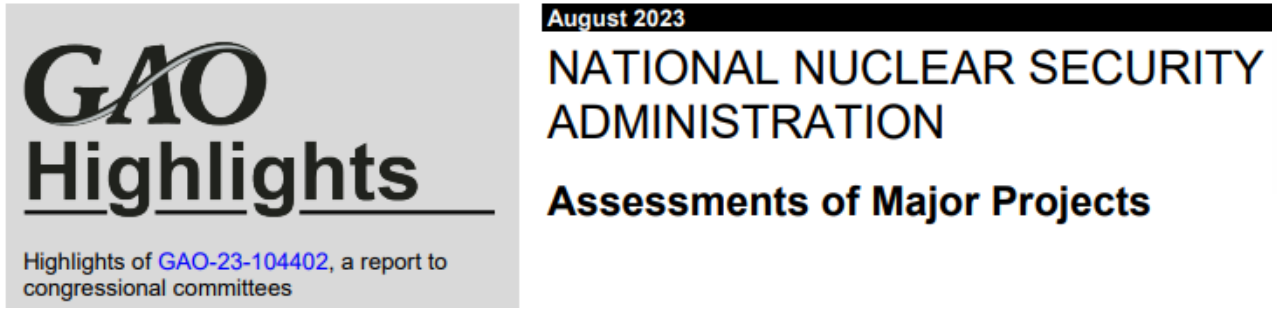
Re-phased Costs

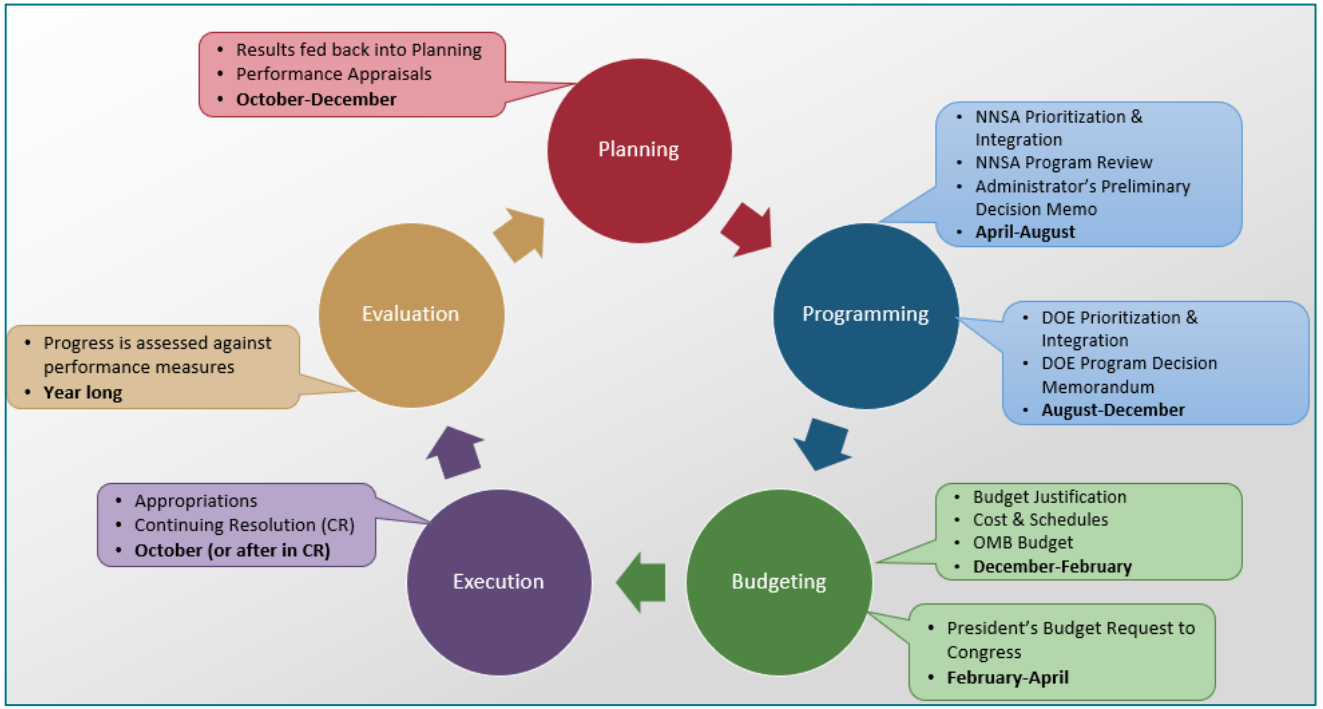
FY	TEC ($M)	CUMULATIVE CONSTRAINT TESTS Value	Ramp-Up
2023	0	✓ 1 σ	✓ 1 σ
2024	0.5	✓ 1 σ	✓ 1 σ
2025	0.8	✓ 1 σ	✓ 1 σ
2026	2	✓ 1 σ	✓ 1 σ
2027	4	✓ 1 σ	✓ 1 σ
2028	5	✓ 1 σ	✓ 1 σ
2029	6	✓ 1 σ	✓ 1 σ
2030	16.3	✓ 1 σ	✓ 1 σ
2031	17.3	✓ 1 σ	✓ 1 σ
2032	16.4	✓ 1 σ	✓ 1 σ
2033	13.4	✓ 1 σ	✓ 1 σ
2034	9.3	✓ 1 σ	✓ 1 σ
2035	5.5	✓ 1 σ	✓ 1 σ
2036	2.7	✓ 1 σ	✓ 1 σ
2037	0.7	✓ 1 σ	

Impacts

The constrained phasing model will positively impact the **PPBE** and **capital acquisition** processes, thereby impacting decision makers at the highest levels of the NNSA

Implementing the constrained phasing model into project planning will provide data-driven solutions for the "**what ifs**" of schedule risk. The model will allow analysts and leadership to **compare side by side execution plans** of our most mission-critical projects





Limitations

There are a few **limitations** to the constrained phasing model:

Assuming one-year "catch up" to ideal execution	No commodity- or manpower-based constraints	Limited historical project data	Ability to execute "different" than history
• Ability to select catch up would allow for more flexibility in executability analysis & re-phasing	• How could **resource constraints** impact cost and schedule phasing?	• More robust data set would improve executability and quad chart analyses	• Possible that projects **can** execute costs in a way that has not historically been achieved

These are being addressed in future iterations of the model

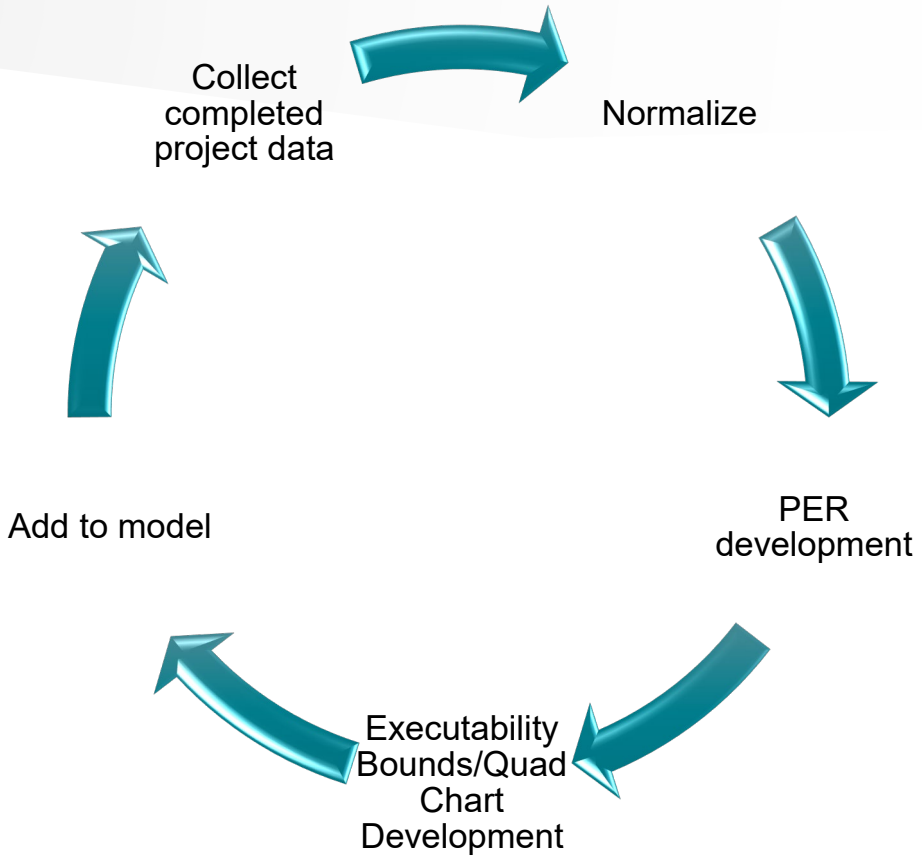
Future Analysis

The model will be **continuously updated** and improved upon as more NNSA construction projects reach their end

This will **strengthen the accuracy** of the PER, executability bounds, and quad chart. And will **widen the scope** of projects that can be analyzed by the model

Executability analysis on **manpower-** and **commodity-based** constraints will be a major focus of the next model iteration

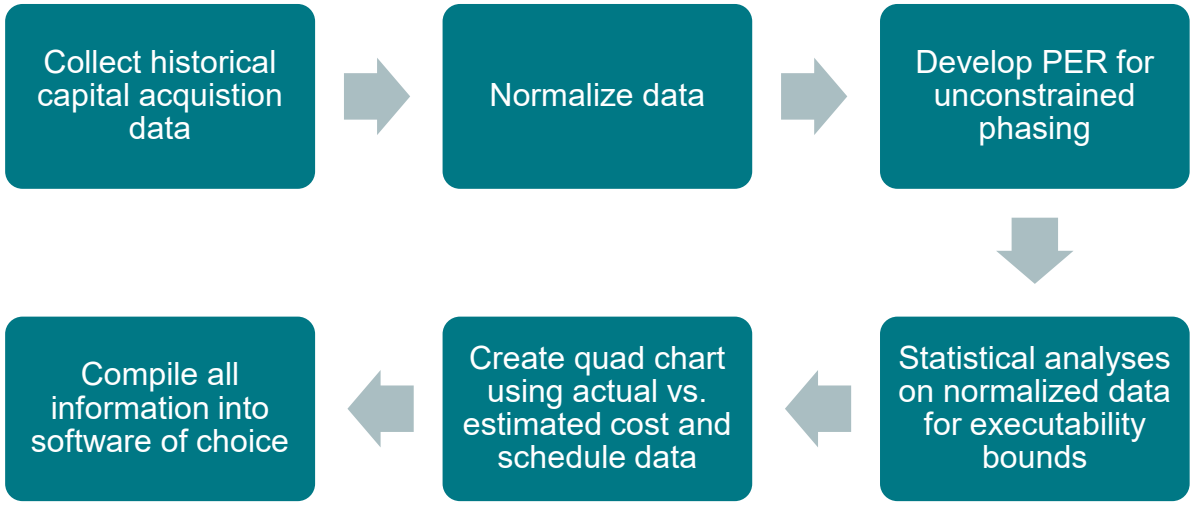
All **limitations** discussed previously are being addressed as well



Non-NNSA Applicability

The framework for the constrained phasing model can be applied to construction project data within **any government agency**

With a robust data set, the functionality within the constrained phasing model can be leveraged to inform decision making within any agency and become a useful tool for any PPBE process. This can **save time, money, and resources** for many types of mission-critical capital acquisition projects



Summary

As the NNSA faces a pivotal time for national security, **models and tools influencing mission-critical decisions** becomes high priority

The constrained phasing model is a **data-driven**, **predictive** methodology built on **historic** construction project data

This model can **prevent costly schedule overruns**, positively impacting the overall missions of the NNSA

PRESS RELEASE

President's Fiscal Year 2025 budget for NNSA advances ongoing modernization, strengthens response to deteriorating global environment

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Thank You