Risk Assessment for Highway Construction

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The "Problem"

It's documented that we often have difficulty delivering large transportation projects as promised

Why?

Many uncertain variables (conditions, events) determine a project's outcome but cannot be predicted in advance

Therefore, we need to:

Identify and account for these variables early on

→ Risk Assessment

Proactively manage potential problems

→ Risk Management

Outline

- Risk Assessment Fundamentals
- Risk Assessment from Planning Through Construction
- Comments on Implementation

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Risk Assessment Fundamentals: Objectives

Help mitigate these problems for transportation projects by:

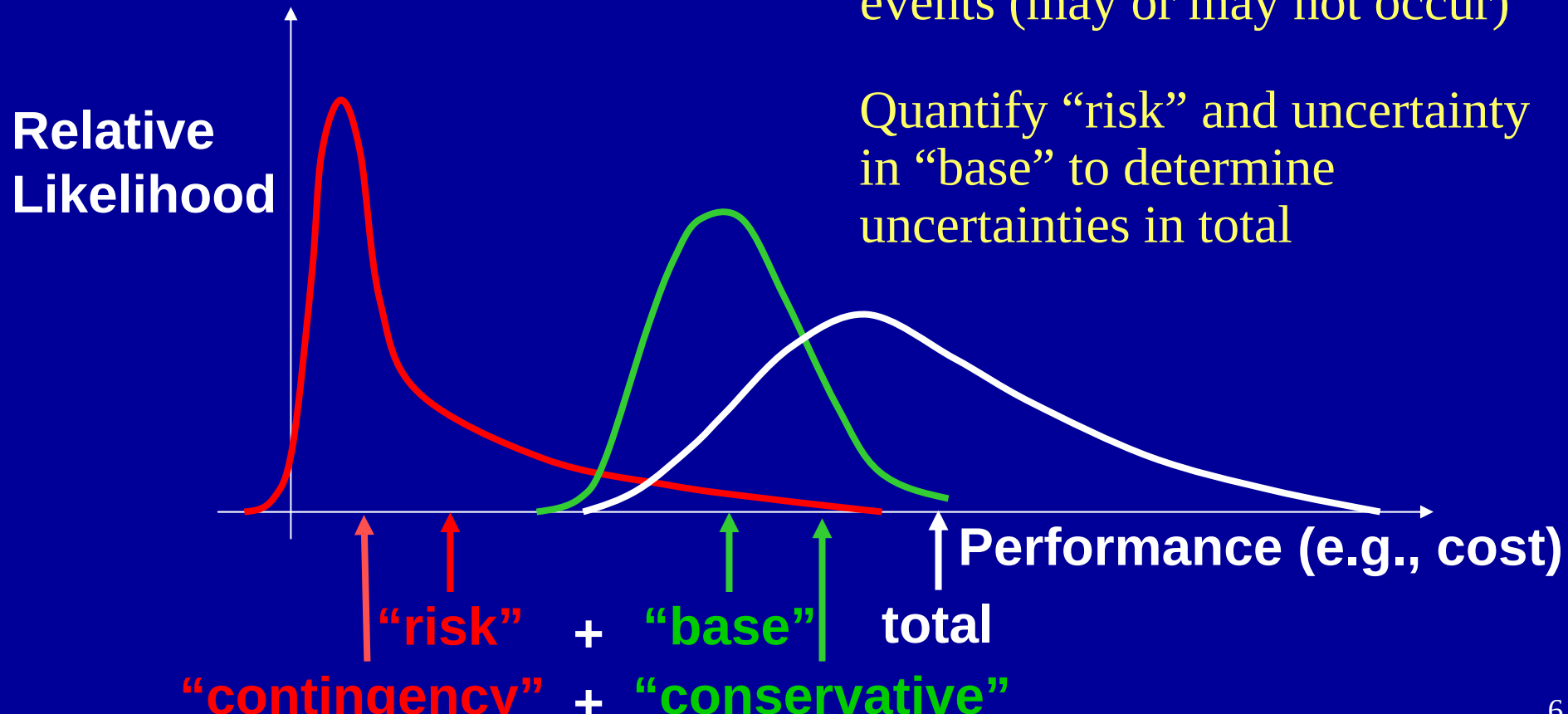
- Identifying and prioritizing critical risks and key opportunities to enable Risk Management and Value Engineering studies
- Quantifying project cost and schedule uncertainty to:
  - increase confidence in cost / schedule estimates
  - establish reasonable budgets / milestones
  - equitably compare alternatives
- Increasing project team understanding and communication, as well as with external stakeholders

Risk Assessment Fundamentals: Traditional vs. Risk-Based

$$Total \approx \text{“}Base\text{”} + \text{“}Risk\text{”}$$

Replace contingency with explicit risk and opportunity events (may or may not occur)

Quantify “risk” and uncertainty in “base” to determine uncertainties in total



Risk Assessment Fundamentals: Key Principles

- Anticipate all possible outcomes
- Take a comprehensive look at the entire project – many large risks occur before construction
- Before discussing “risk”, first define “baseline” scope, strategy, and cost and schedule estimates
- Balance the project team’s perspective with independent subject-matter expertise
- Stay focused on the key issues – not details
- Follow up – monitor and update (risks change and are ultimately resolved as project develops)
- Develop and maintain documentation (Risk Register, Risk Management Plan / Implementation Program)

Risk Assessment Fundamentals: Key Steps in Risk Assessment

1. Structure the project for the risk assessment
2. Review and de-bias the cost and schedule estimates
3. Develop the "baseline" cost and schedule (i.e., without risk or opportunity) – cost-loaded schedule
4. Quantify uncertainty in the baseline cost / schedule
5. Develop a "Risk Register" – a comprehensive, non-overlapping list of risks and opportunities relative to baseline, and how they affect cost-loaded schedule
6. Assess / prioritize the risks (ratings or values)
7. Quantify uncertainty in cost and schedule (or other)
8. Identify and evaluate risk-management strategies – develop / implement a Risk Management Plan
9. Monitor / update

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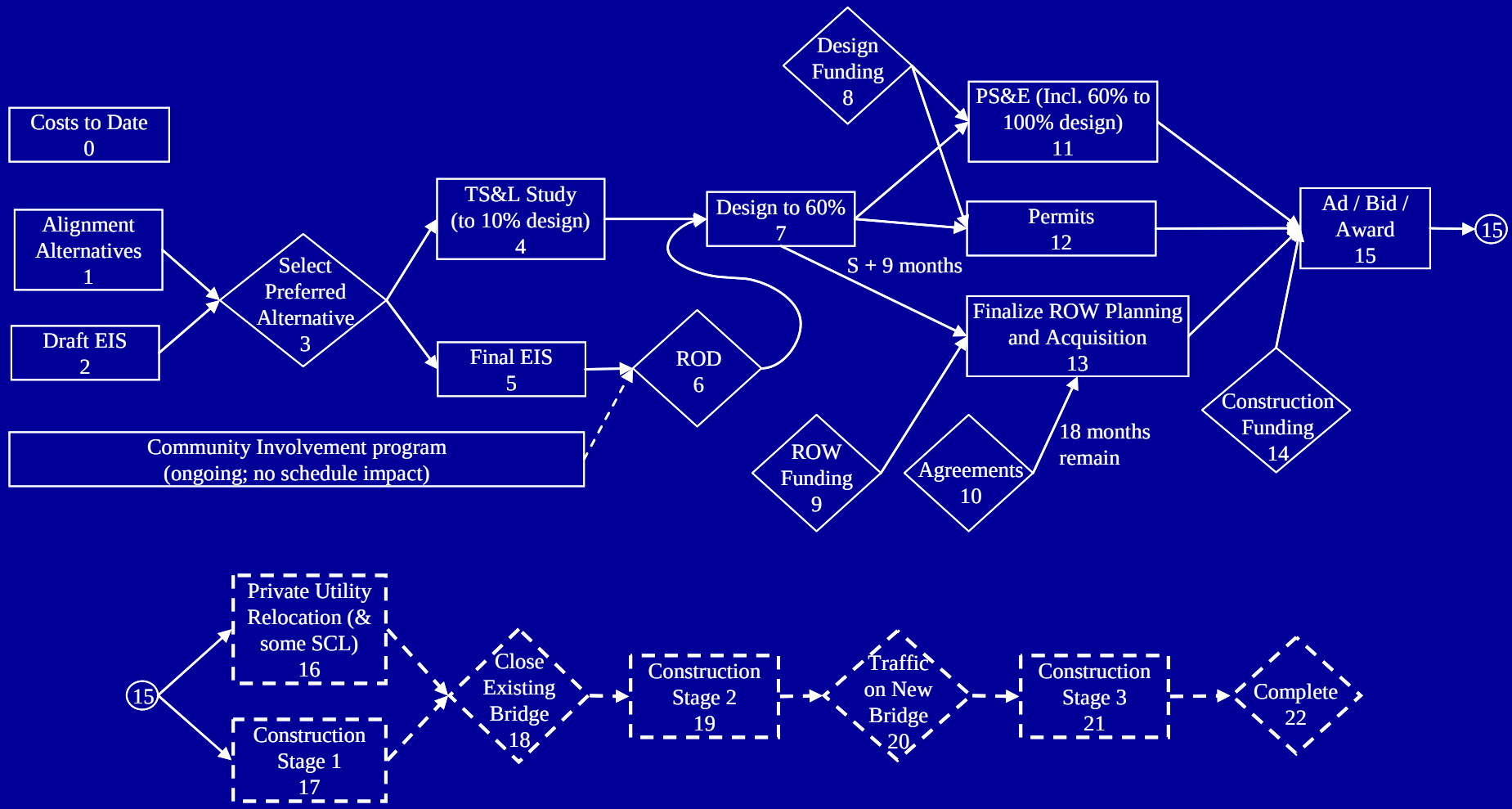
Structuring for Risk Assessment: Defining the "model"

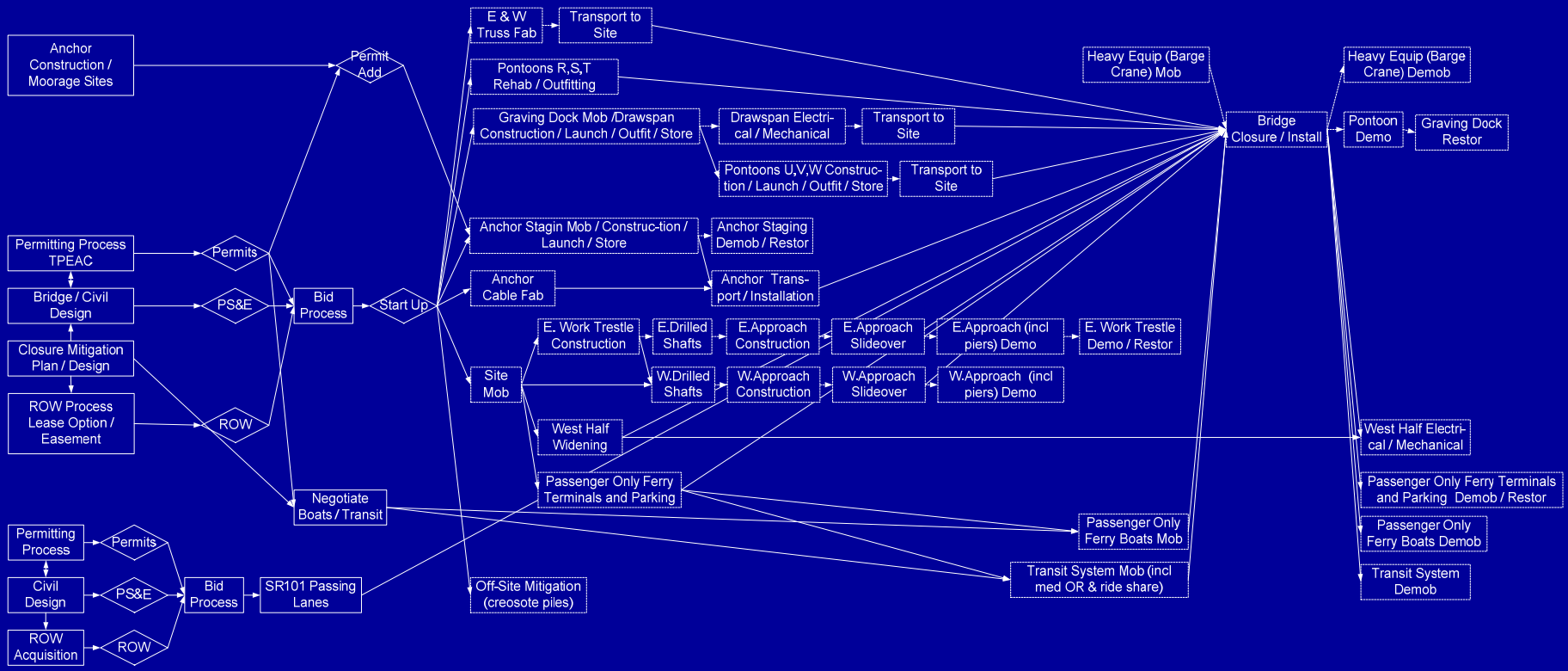
- Structuring involves defining key project scope, strategy and other assumptions as the basis for the risk assessment model
- For "bottom up" risk assessment, a "flow chart" (sequence of major project activities) forms the basis for integrated cost and schedule analysis
- Level of detail in the model is flexible and depends on level of project development
  - Projects early in development: more detail in pre-construction activities and sequencing
  - Projects later in development: more detail in construction activities and sequencing

Example flow chart for bridge project early in design



Solid lines = preconstruction; dashed lines = construction

Example flow chart for bridge project nearing advertisement/letting



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Integrated Cost/Schedule Model

- Simplified schedule logic (scope / strategy)
  - Comprehensive and non-overlapping set of all activities from "now" through completion
  - All activity precedence requirements
  - Decision points
- Debiased / uncertain base durations / lags → uncertain base schedule (critical path)
- Debiased / uncertain summary cost estimate (w/o contingency or escalation) allocated to activities → uncertain unescalated base cost
- Uncertain risk events affect unescalated cost and/or duration of specific activities → uncertain total schedule and escalated cost

Risks by Project Phase

- Projects face different risks in each phase of development – some are resolved early
- Projects early in development tend to face larger schedule risks (which might affect critical path and have significant cost impacts), many from environmental and policy issues

Example issues for projects early in development:

- Identifying and evaluating project alternatives
- Selecting a preferred project alternative, including clarifying purpose and need, and concept (i.e., transit versus highway; establishing project alignment)
- Funding, financing and programming (e.g., funded all at once versus phased)
- Environmental impacts and issues (including selecting an appropriate form of environmental documentation)
- Governance and stakeholder participation

Risks by Project Phase

- Projects later in development face issues related to selected alternative, such as right-of-way acquisition and finalizing design
  - Preliminary design (includes potential Value Engineering opportunities):
    - Agreements with stakeholders
    - Early or advance right-of-way planning and/or acquisition
    - Refined scope
    - Project delivery strategy (including contracting method, contract size, and estimated cost and schedule)
    - Configuration of major project components (e.g., interchange design)
    - Structural design (e.g., bridge type, size, and location)
    - Other civil/roadway design elements
  - Final design (by owner or contractor, depending on delivery method):
    - Environmental permitting
    - Utility coordination, agreements, and early relocation
    - Final right-of-way
    - Construction staging

Risks by Project Phase

- Projects in design have already resolved many of these issues; remaining issues usually relate to procurement and construction

Contract procurement and Construction:

- Contract-related issues (e.g., size, allocation of risk, other terms and conditions)
- Insurance
- Bonding
- Finalizing construction staging/phasing
- Construction means and methods
- Sources for potential delays or other construction difficulties/problems
- Disputes and claims

Example Risks by Project Phase – Two Similar Projects for RAs done at different phases

Project #1 in Conceptual Phase	Project #2 nearing Ad/Letting
Cost Risks (in decreasing order of significance)	
Uncertainty in the design for the tunnel ($240 million)	Lack of competition in the contracting market at the time of project advertisement/bid
Lack of competition in the contracting market at the time of project advertisement/bid ($200 million)	Other general change orders during construction
Uncertainty in the limits of roadway expansion, or additional lanes are required ($125 million)	Pontoon disposition after construction
Uncertainty in the scope for local improvements ($95 million)	Detour route closed (e.g., by landslide), causing delay in bridge closure
Issues completing civil contract procurements ($80 million)	Additional electrical power source required during construction

Example Risks by Project Phase – Two Similar Projects for RAs done at different phases

Project #1 in Conceptual Phase	Project #2 nearing Ad/Letting
Schedule Risks (in decreasing order of significance)	
Delay in selecting preferred alternative for the project (24 months)	Changed environmental / ecological conditions in the field (relative to what was assumed in design)
Delays completing stakeholder agreements for Tier 1 EIS (8 months)	Lack of competition in the contracting market at bid time (need to re-bid)
Staging and phasing of construction (6 months)	Detour route closed (e.g., by landslide), causing delay in bridge closure
Challenges to Tier 2 NEPA determinations (3 months for each project segment)	Difficulty obtaining permits for graving dock and/or trestle / shaft construction
Challenge to Tier 1 ROD (2 months)	Significant marine construction difficulties

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Comments on Implementation

- Risk Assessment can be an effective tool, but it must be implemented appropriately to produce meaningful results
- If done correctly, studies show that Risk Management reduces 90% of problems and reduces total project cost by 5% on average
- General comments based on observations from nearly 200 transportation risk assessments
- Applicable to risk assessments for projects at any phase of development

Comments on Implementation

1. Avoid constraining the risk assessment with too many exclusions or assumptions
   - Can produce misleading (biased) results
   - Results won't "stand the test of time"
   - Too easy to forget the constraints on the results

   Instead, consider documenting and including all major uncertainties, even if it's via separate "what if" model scenarios

   For example, using specified but artificially low annual escalation rates, ignoring uncertainty, lead to significant cost underestimates and related funding problems

Comments on Implementation

2. Answer the right questions
   - Find out what the owner wants to know, and address those questions
   - Determine if there's anything else the owner *should* know, and address those issues
   - Make sure the owner understands the results and how to use them

This may seem obvious, but results from many risk assessments are never used because the owner doesn't know how to use them

Comments on Implementation

3. Subjective assessment of risk-based inputs is almost always required because *relevant* "objective" data rarely exist, but avoid common pitfalls related to subjective assessments, including:
   - Poor or ambiguous definitions
   - Unspecified assumptions
   - Uncorrected individual or team biases, whether intentional or not (*very important; biases can be very hard to identify and correct!* See next slide on construction market conditions)
   - Lack of credibility (i.e., use experts)

Comments on Implementation

For example, uncertainty in "construction market conditions" at time of bid:

- Major risk for many projects in last few years
- Appears to be consistently underestimated, even when evidence from similar, recent projects is available
  - Many teams believe "it won't happen to them" and/or
  - That they know how contractors bid, so they underestimate the uncertainty…
  - But it is difficult to predict how the low-bid contractor will bid (strategy for that bid, how market trends are perceived and incorporated, etc.)
- Example:
  - Tunnel project: even after initial bids came in 20% higher than Engineer's Estimate, team assessed -5% to +10% market-risk cost range for re-bid; actual was *another* +20% and 6-month delay

Comments on Implementation

4. Ensure that probabilistic analyses are properly structured and conducted
   - Either train your internal risk analysts, or use qualified external risk analysts (*you wouldn't have a geotech design a bridge, would you?*)
   - Work at an appropriate level of detail – too much detail leads to inefficiency & potential errors, too little detail leads to potential assessment errors
   - Consider checking complex models with simpler models (e.g., top-down vs. bottom-up)
   - Include significant dependencies and correlations among variables (integrated cost-schedule model)

Summary

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