∴ Gabe ∴
GabeL@virginia.edu
https://gabriel-vzh2vs.github.io/SYS3062-Website/
UVA's Systems and Information Engineering

Feburary 10th, 2026

SYS 3062: Project 1

Project 1: Project Planning

Project Overview: The Challenge

The Client: Bygg & Bo

You are a consultant tasked with estimating the budget for a modest renovation of the Seattle harbor district.

The Problem:

- Previous projects were plagued by cost overruns.
- They cannot provide fixed costs, only estimates.
- They fear every risk occurring simultaneously.

Three Layers of Risk

1. **Estimation Uncertainty:** (Standard variability in tasks).
2. **Discrete Risk Events:** (Specific disasters like strikes).
3. **Market Correlation:** (Commodity prices affecting multiple tasks).

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Phase 1: Base Task Estimation

The project manager has broken the work into tasks with specific probability distributions.

Task	Description	Distribution	Parameters (kUSD)
A	Site Survey	Uniform	$a = 40, b = 80$
B	Demolition	Triangular	$L = 100, M = 150, H = 300$
C	Concrete	Normal	$\mu = 300, \sigma = 40$
D	Electrical	Triangular	$L = 80, M = 110, H = 160$
E	Plumbing	Uniform	$a = 90, b = 210$
F	HVAC	Normal	$\mu = 200, \sigma = 30$
G	Interior	Triangular	$L = 70, M = 90, H = 120$

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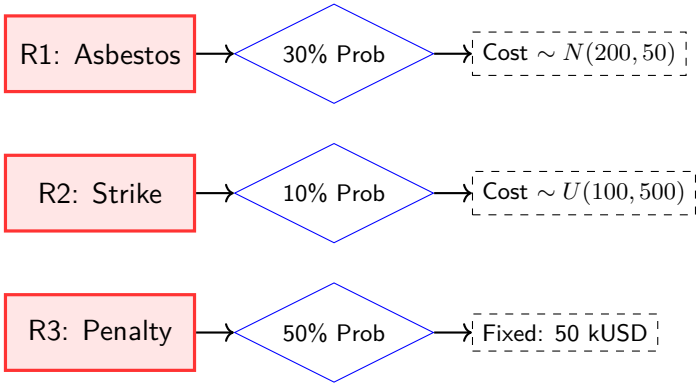
Phase 2: The Risk Register

Unlike standard tasks, these are Discrete Events. They might happen, or they might not.



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Part 2: Required Analysis

Based on your simulation, you must formulate conclusions on the following key risk areas:

Risk Metrics

- **Value-at-Risk (VaR):** Determine potential losses using Confidence Intervals, $\alpha = 0.95$.
- **Variance Contribution:** Which specific stocks are contributing the most to the total portfolio volatility?
- **Normality:** How does Sample Size affect the assumption of Normality?

Scenario Insights

- **Extreme Events:** What are the risks of "tail events" (Skew/Kurtosis)?
- **Sensitivity:** What are the effects of changing the portfolio composition (weights) on the overall variance?

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Phase 3: Modeling Market Correlation

Tasks C (Concrete) and F (HVAC) are sensitive to global commodity prices. If one goes up, the other likely goes up.

The Market Factor Model

We use a shared Standard Normal variable, M, to induce correlation ($\rho = 0.7$).

$$M \sim N(0, 1)$$

The cost for Task C (and similarly F) becomes:

$$\text{Cost}_C = \mu_C + \sigma_C \left[\underbrace{\rho \cdot M}_{\text{Systemic Risk}} + \underbrace{\sqrt{1-\rho^2} \cdot Z_C}_{\text{Idiosyncratic Risk}} \right]$$

This ensures that when the "Market" (M) is high, both Concrete and HVAC costs rise together.

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Key Deliverables & Metrics

You must run the simulation ($N = 10,000$) and compute the following:

1. **"The Perfect Storm" Probability:**
   - What is the chance that **Asbestos occurs** AND Total Cost $> \$1,800k$?
2. **Impact of Correlation:**
   - Compare σ_{total} of the Correlated Model vs. an Independent Model.
   - *Hypothesis: Correlation increases the spread (risk).*
3. **Tail Risk Metrics:**
   - **VaR (95%):** The budget required to be 95% safe.
   - **CVaR (95%):** The average cost if that 95% threshold is breached.

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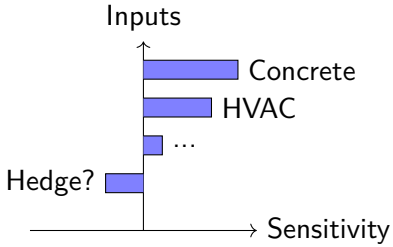
Required Visualizations

1. Overlay Histogram

- Plot "Scenario A" (Correlated) and "Scenario B" (Independent) on the same graph.
- Visualizes how correlation "flattens the curve" and extends the tail.

2. Tornado Chart

- A sensitivity analysis.
- Rank inputs (Task C, Risk R1, etc.) by their correlation with Total Cost.
- Tells the client: *"Which risk matters most?"*



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Why Use HTA Standards for Engineering?

The Source Material

We are adopting the *"Guidance for the Conduct and Reporting of Modeling and Simulation Studies in the Context of Health Technology Assessment"*. For the writing standards of the project report.

How do we implement this in Project 1 (Bygg & Bo):

- **High Uncertainty:** Like medical trials, your construction project has unknown outcomes (Asbestos, Strikes).
- **High Stakes:** Decision-makers need to know the *quality* of the evidence.
- **Transparency:** If your budget model is a "black box," the client will not trust it.

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How to Build Conceptualization & Structure

Guideline: Explicitly state the decision problem, the model's scope, and the rationale for the chosen modeling technique.

Application to Project 1

Do not just start with code. Your report must define:

- **The Problem:** The client fears cost overruns and specific "tail risks" (Perfect Storm).
- **The Approach:** Why Monte Carlo? (Because we need to aggregate complex distributions and discrete risk events).
- **Scope:** We are modeling *direct costs* and *specific risk events*, but excluding external factors like inflation or regulatory changes (unless represented in the distributions).

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Data Transparency

Guideline: Report all data sources clearly. Assess the "risk of bias" in the evidence and justify the choice of distributions.

Application to Project 1

You must document the Input Parameters clearly:

- **Source:** "Project Manager Estimates" (Subjective Expert Opinion).
- **Distributions:** Justify why Task B is *Triangular* (we know the mode/bounds) vs. Task C which is *Normal* (historical data exists).
- **Correlation:** Explicitly state the assumption of $\rho = 0.7$ between Concrete and HVAC. Why is it not 1.0? Why is it not 0?

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Guideline: Verify internal consistency (debugging) and "Face Validity" (does it make sense to experts?). Compare results against alternative scenarios.

Application to Project 1

Show that your model behaves logically:

- **Scenario Comparison:** You are required to run "Correlated" vs. "Independent" scenarios.
- **Validation Check:** Does the Correlated scenario actually produce a wider standard deviation? (It should). If it doesn't, your model is flawed.
- **Sanity Check:** Is the mean Total Cost roughly the sum of the mean Task costs? (A simple check to ensure no double-counting).

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Guideline: Communicate uncertainty fully. Do not report point estimates without confidence intervals. Interpret the "Tail Risks".

Application to Project 1

Bad Reporting: "The project will cost $1,500k."

Good Reporting (HTA Style):

- **Base Case:** Mean cost is $1,500k.
- **Uncertainty:** "There is a 5% chance costs exceed $1,800k (VaR)."
- **Extreme Events:** "The 'Perfect Storm' scenario (Asbestos + High Cost) has a 0.46% likelihood."
- **Visuals:** Use the Overlay Histogram to *show* the spread, not just describe it.

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Guideline: Discuss the limitations of the model. Conclusions are conditional upon the assumptions made.

Application to Project 1

Be honest about what the model **cannot** do:

- **Assumption Risk:** "We assumed a Gaussian Copula for correlation. Real markets might exhibit 'tail dependence' (crashing harder together)."
- **Data Quality:** "Results are highly sensitive to the Project Managers' 3-point estimates. If they were overly optimistic, our VaR is underestimated."
- **Recommendation:** Suggest that the client focuses on Task C (via Tornado Chart) as the highest driver of variance.

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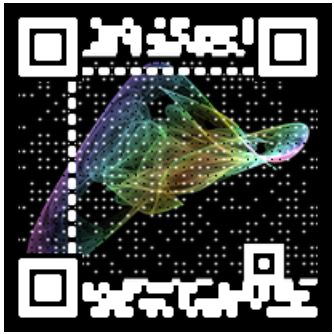
Feedback Form

Throughout the course, I may ask for your feedback on:

- **Course Materials**
- **Lecture & Lab**
- **Assignments**



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Action Items

Thank you for attending this lab!

And now, you need to do the following tasks:

- **Do** Project 1,
- **Attend** Office Hours
- **Read** Prelab 4.

Let's get this project done!

GabeL@virginia.edu