Asset Risk Management Dashboard
Calculations Summary

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Abstract

Key calcs used in the Dashboard to compare four maintenance strategies through risk and cost analysis.

1 Core Formulas

1.1 Logistic Curve (S-Curve)

$$f(x) = \frac{1}{1 + e^{-\alpha(x - \text{midpoint})}} \tag{1}$$

Models gradual then rapid changes. Used as foundation for failure rate calculations.

1.2 Likelihood of Failure (LOF)

$$\text{LOF} = \text{min\_lof} + (1 - \text{min\_lof}) \times f(\text{age\_normalized}, \text{lof\_alpha}, 0.7) \tag{2}$$

where $\text{age\_normalized} = t/T$ (normalized asset age, 0 to 1).

1.3 Risk Calculation

$$\text{Risk} = \text{LOF} \times \text{COF} \tag{3}$$

where COF = Replacement Cost (Consequence of Failure).

2 Maintenance Strategy Calculations

2.1 No Fix Strategy

Cost:

$$\text{Baseline} = 0.05 \times \text{replacement\_cost} \times \frac{t}{T} \tag{4}$$

$$\text{Catastrophic} = \text{replacement\_cost} \quad (\text{at} \approx 90\% \text{ lifespan}) \tag{5}$$

$$\text{Total} = \text{Baseline} + \text{Catastrophic} \tag{6}$$

Risk: Continuous S-curve increase, never resets.

$$\text{Risk}(t) = \text{calculate\_lof}(t/T, \alpha, \text{min\_lof}) \times \text{COF} \tag{7}$$

2.2 Fix in Plan (Scheduled Maintenance)

Cost:

$$N_{\text{cycles}} = \left\lfloor \frac{T}{\text{cycle\_length}} \right\rfloor \tag{8}$$

$$C_{\text{cycle}} = 0.15 \times \text{replacement\_cost} \tag{9}$$

$$\text{Baseline} = 0.02 \times \text{replacement\_cost} \times \frac{t}{T} \tag{10}$$

$$\text{Total} = \sum_{i=1}^{N} C_{\text{cycle}} + \text{Baseline} \tag{11}$$

Risk: Cyclic wave pattern within each maintenance cycle.

$$\text{cycle\_pos} = \frac{t \bmod \text{cycle\_length}}{\text{cycle\_length}} \tag{12}$$

$$\text{wave} = \frac{1 - \cos(2\pi \times \text{cycle\_pos})}{2} \tag{13}$$

$$\text{LOF} = \text{min\_lof} + (\text{peak\_lof} - \text{min\_lof}) \times \text{wave} \tag{14}$$

2.3 Fix on Fail (Reactive Maintenance)

Cost:

$$\text{Baseline} = 0.01 \times \text{replacement\_cost} \times \frac{t}{T} \tag{15}$$

$$N_{\text{failures}} = \max\left(3, \left\lfloor 2 + 3 \times \left(\frac{t}{T}\right)^2 \right\rfloor\right) \tag{16}$$

$$C_{\text{repair}} \sim \text{Uniform}(0.3, 0.5) \times \text{replacement\_cost} \tag{17}$$

$$\text{Total} = \text{Baseline} + \sum C_{\text{repair}} \tag{18}$$

Risk: Gradual buildup (S-curve) between failures, spikes to 1.0 at failure, resets after emergency repair.

2.4 Fix on Risk (Optimized Maintenance)

Cost:

$$\text{Baseline} = 0.02 \times \text{replacement\_cost} \times \frac{t}{T} \tag{19}$$

$$C_{\text{intervention}} = 0.20 \times \text{replacement\_cost} \tag{20}$$

$$\text{Interventions} = 4 \text{ at } t_k = (0.3 + 0.15k) \times T \tag{21}$$

$$\text{Total} = \text{Baseline} + \sum C_{\text{intervention}} \tag{22}$$

Risk: Linear growth until threshold, then resets.

$$\text{growth\_rate} = 0.001 \times \alpha \times (1 + 2 \times \text{age\_normalized}) \tag{23}$$

$$\text{If LOF} \geq \text{threshold} : \text{LOF} = 1.5 \times \text{min\_lof} \tag{24}$$

3 Summary Metrics

3.1 Total Cost

$$\text{Total Cost} = C(T) \quad \text{(cumulative cost at end of lifespan)} \tag{25}$$

3.2 Average Risk

$$\text{Average Risk} = \frac{1}{n} \sum_{i=1}^{n} \text{Risk}_i \tag{26}$$

where $n = 500$ (number of time points).

4 Key Parameters

- **Replacement Cost:** Base monetary value for all calculations

- **Risk Alpha:** Controls steepness of failure rate curves

- **Min LOF:** Baseline failure rate (infant mortality, default 5%)

- **Cycle Length:** Maintenance interval for "Fix in Plan" strategy

- **Risk Threshold:** Fraction of COF that triggers intervention (0.1 to 0.9)

- **Cost Curve Alpha:** $= \text{risk\_alpha} \times 0.8$

5 Notes

- All calculations use 500 time points for smooth curves

- Random events use seed=42 for reproducibility

- Costs are cumulative (not incremental)

- Age normalization: $\text{age\_normalized} = t/T$ (0 to 1)