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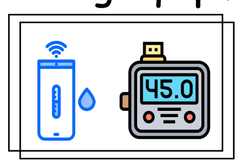
Optimizing monitoring equipment investments for an asset portfolio with multiple failure modes

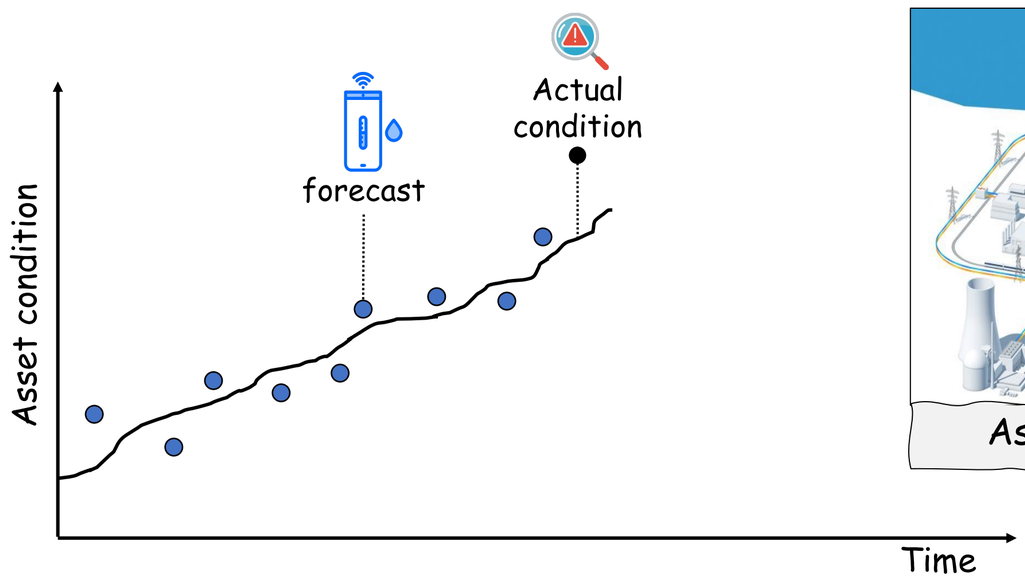
The challenge

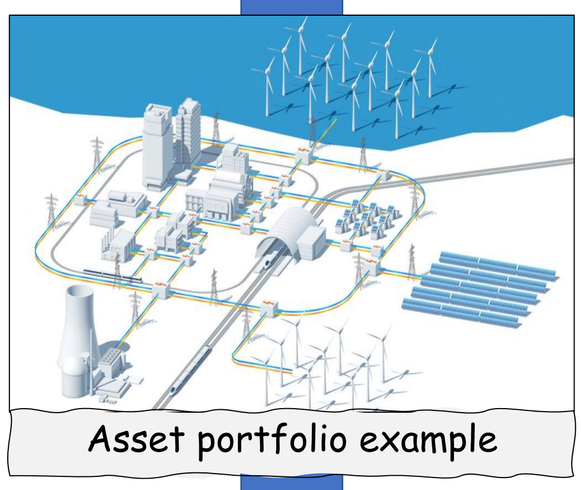
Which monitoring equipment to install?

✓ More accurate prediction
✗ More expensive



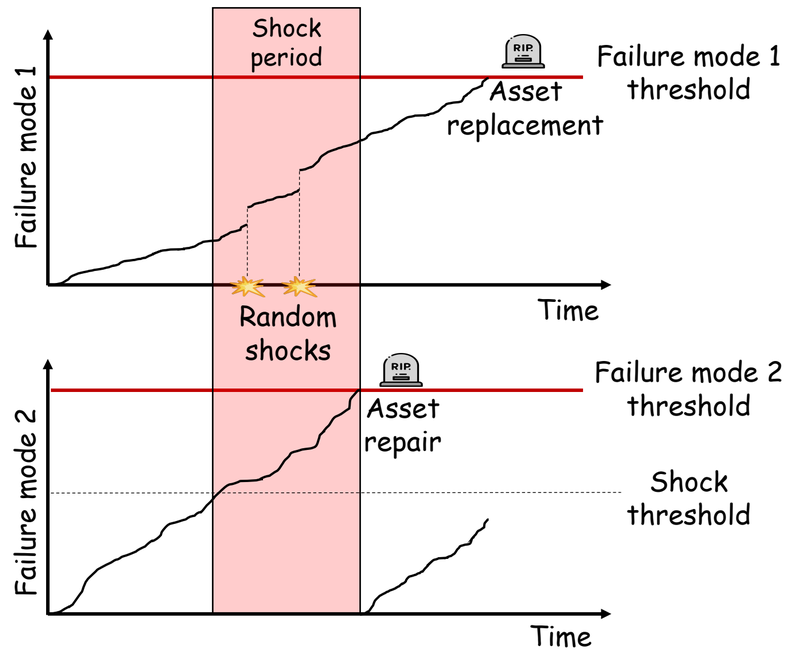
✗ Less accurate prediction
✓ Less expensive





Asset portfolio example

How to model the effect of failure mode 2 on failure mode 1?



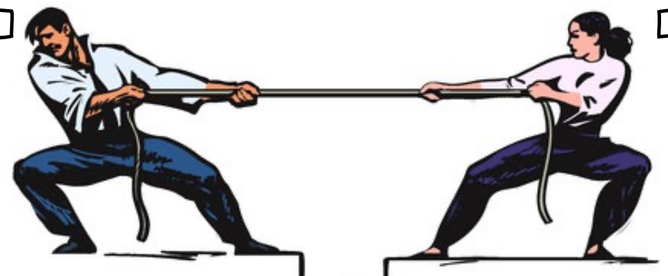
The monitoring equipment accuracy depends on the failure mode

The monitoring equipment has heterogeneous accuracy and costs

An asset failure increases the degradation of nearby assets

The short-term condition influences the long-term condition

Main decisions and constraints



- ⚠ The asset must be replaced whenever the asset failure mode 1 reaches the failure threshold;
- ⚠ The asset must be repaired whenever the asset failure mode 2 reaches the failure threshold;
- ⚠ The failure mode 1 degradation increases whenever the failure mode 2 condition is above a certain level;
- ⚠ The monitoring equipment is not perfect (forecast accuracy);

- ✓ Select the type of monitoring equipment to install for a given asset;
- ✓ Optimize the monitoring accuracy and costs trade-off;
- ✓ Design the best maintenance policy for the scheduling of operation and maintenance interventions;
- ✓ Select the maintenance policy to apply for each asset of the portfolio

Proposed approach

"Continuous degradation with competing failure modes subjected to random shocks"

"Mathematical model to estimate each asset remaining useful life (RUL)"

"Continuous imperfect inspection for continuous degradation units"

"Power transformers portfolio real-world case study"

Contributions

Integration of competing soft failure modes with continuous imperfect inspection monitoring

Novel mathematical formulation for the tackled problem

Obtained relevant managerial insights from a real-word case study