Reliability engineering decision making in the digital age

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We have more data than ever.

- All of it is available at any moment, in any place
- Our assets ‘talk to us’

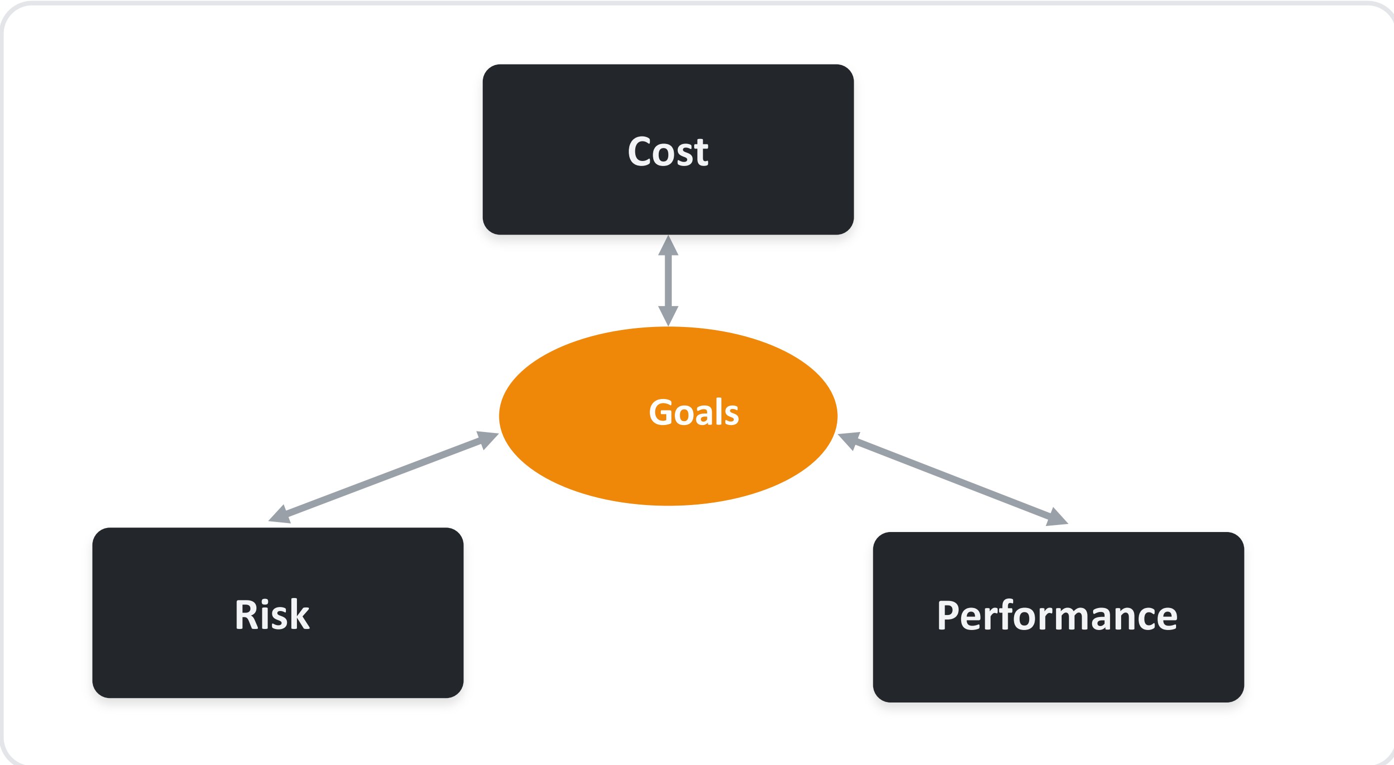
BUT…

Does that, by itself, let us make better decisions?

WHAT IS A 'GOOD DECISION'?

A good decision is a trade-off

Within limited resources



Run this loop more than once

1 Understand the business problem → 2 Understand the failure behaviour → 3 Collect the relevant data → 4 Build a decision model → 5 Decide on sound advice

REPEAT

Pin down the 'right' problem

The 'right' problem

- Relevant to hitting (or missing) business targets
- Quantifiable
- Type of decision: optimal maintenance? OPEX? CAPEX?

Value

Performance Uptime, warranty period

Cost Cost/benefit, opportunity costs

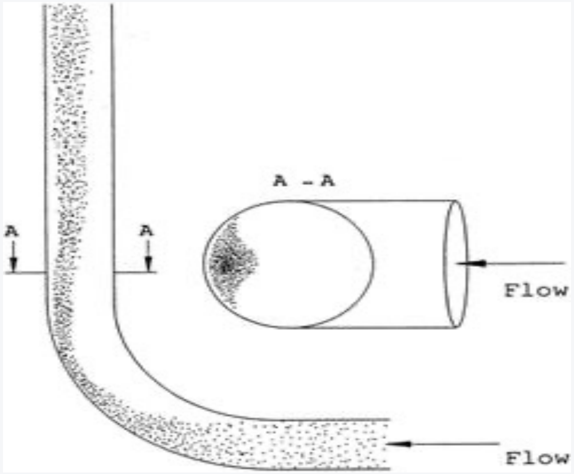
Risk 'What if', short and long term

Case: shifting market conditions for power plants

- Fuel price moved against the long-term expectation
- Result: assets get used differently than they were designed for
- Impact: what does this do to the life cycle?

Which data do we need to collect?

Pulverised coal transport: erosion & corrosion

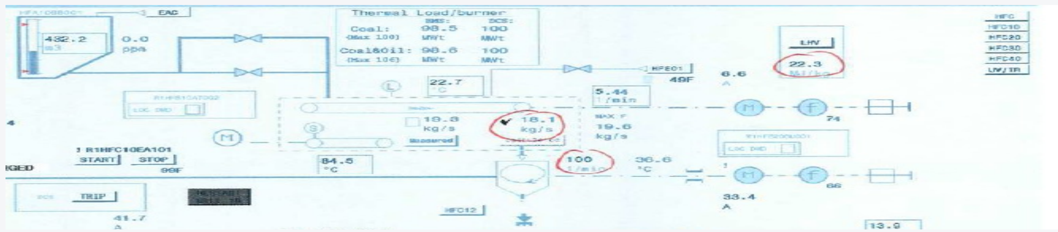


Wall thinning in the bend

Erosion wear rises sharply with velocity

$$W = K_{Erosion} \cdot \mu \cdot v^{3,5}$$

Reference condition from heat balance & process data



The right data from the right sources

- Expert opinion
- ERP / CMMS: maintenance records & failures
- Condition monitoring & process data
- OEM data: O&M manuals, service reports & modelling

"Bringing the right data to the table by bringing the right people together."

What a model adds

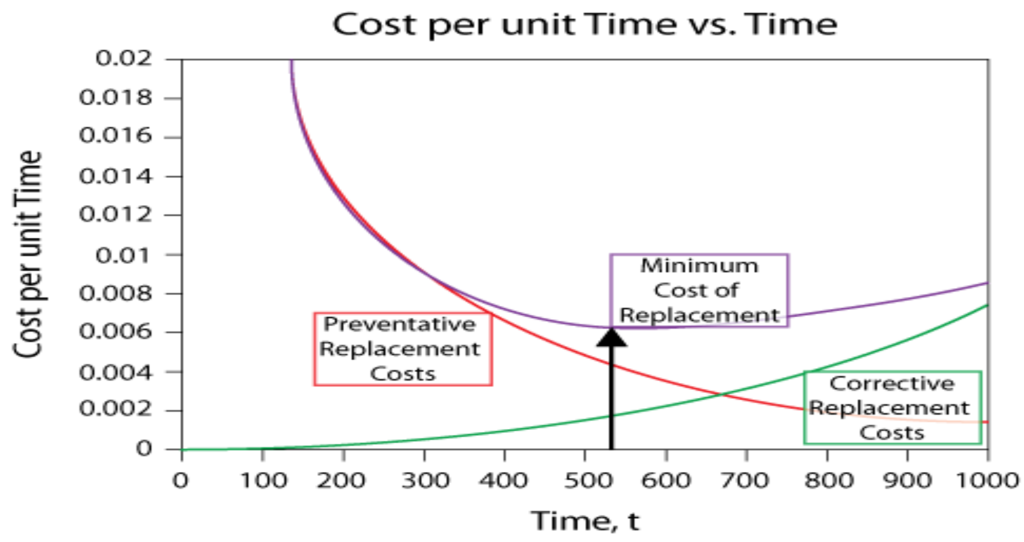
- Quantify the failure probability and its uncertainty
- Link reliability to cost
- Make assumptions and limitations explicit

The map is not the territory.

A model is a tool, not the real thing.

Example: optimal replacement (Barlow & Proschan, 1959)

$$CPUT(t) = \frac{\text{Total Expected Replacement Cost per Cycle}}{\text{Expected Cycle Length}} = \frac{C_P \cdot R(t) + C_U \cdot [1 - R(t)]}{\int_0^t R(s)\,ds}$$



But:

- Time value of money?
- System or component?
- Which cost components?

Source: reliawiki.com

For other methods see e.g. A. Jardine, 'Maintenance, Replacement and Reliability', and M. Powell (attwaterconsulting.com).

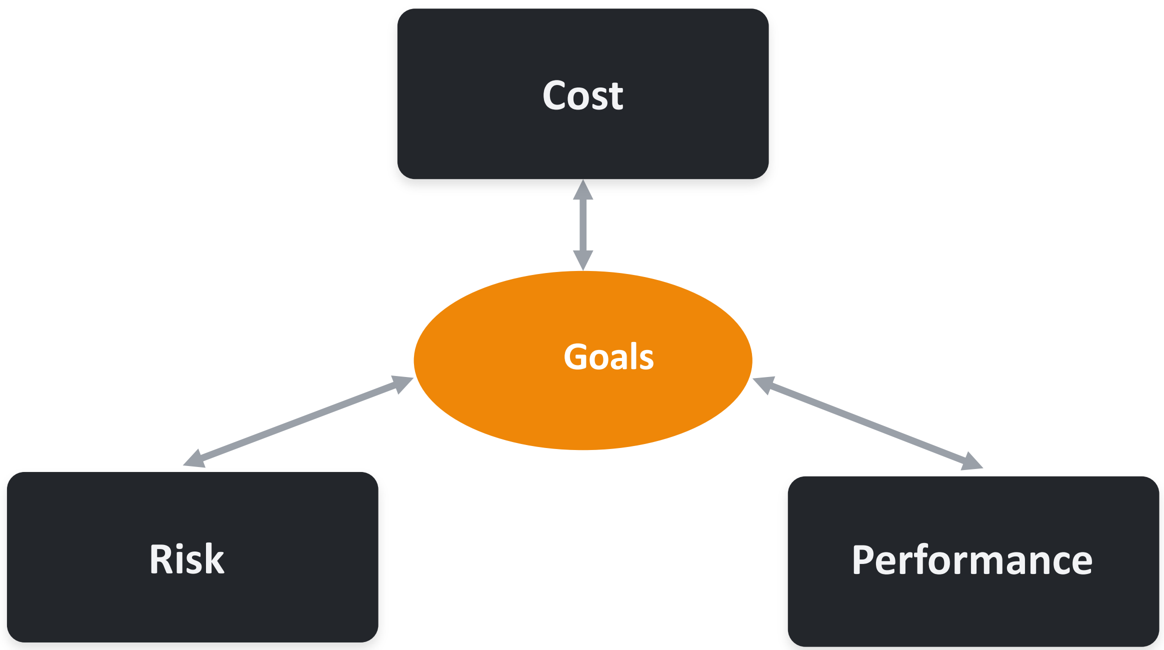
The model is input; you still decide

Critical thinking

Expert judgement

Assumptions:
'What if…?'

Within limited resources



Where it stalls in practice

Measurement data quality

...and how it is interpreted

No failure data

The Resnikoff conundrum

Domain knowledge & IT

Combining both worlds

Stochastic by nature

Failure is inherently uncertain, even when the main causes are known

Concept: the '5 primary sources of failure', source: reliabilityweb.com

Four building blocks for the approach

IT infrastructure

Sensors & servers · Data management · Remote access · APIs

Decision model

Business problem formulation · Decision model · Assumptions

Physics of failure

Reference condition · Operations & environment

Properties

Repeatable · Scalable · Robust

From concept to practice

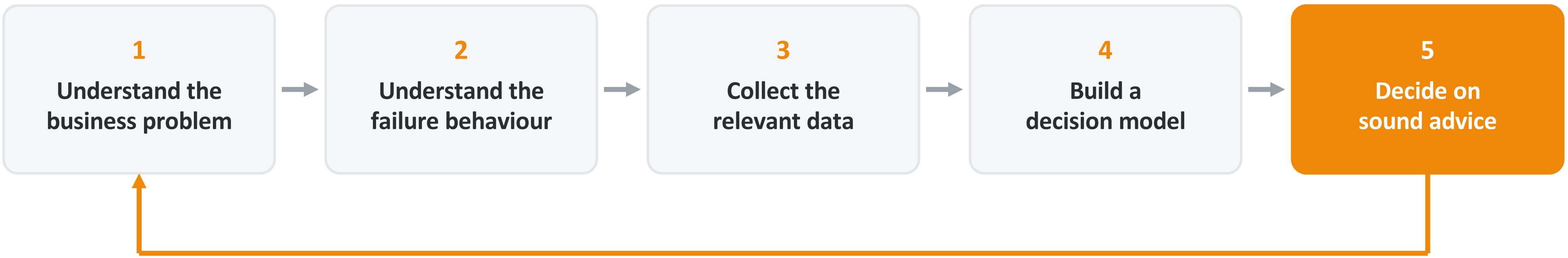
Organisation	Pilot vs. running business · Reliability maturity & knowledge
Method	Critical thinking · Define the decision model · Business case
Data & platforms	3rd party platforms · Data interpretation · Access
Statistics	Expert judgement · Bayes vs. frequentist · Stochastics

The result: better decisions

- Understand the relation between cost, performance and risk in business context
- Understand the limits of accuracy and knowledge
- Use knowledge and data in the decision process
- Hybrid approach: connect ‘traditional’ and ‘industry 4.0’

A good foundation?

The quality of your decision comes from the process, not the amount of data.



Questions?

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