Data-driven approach to estimate maintenance life cycle cost of assets

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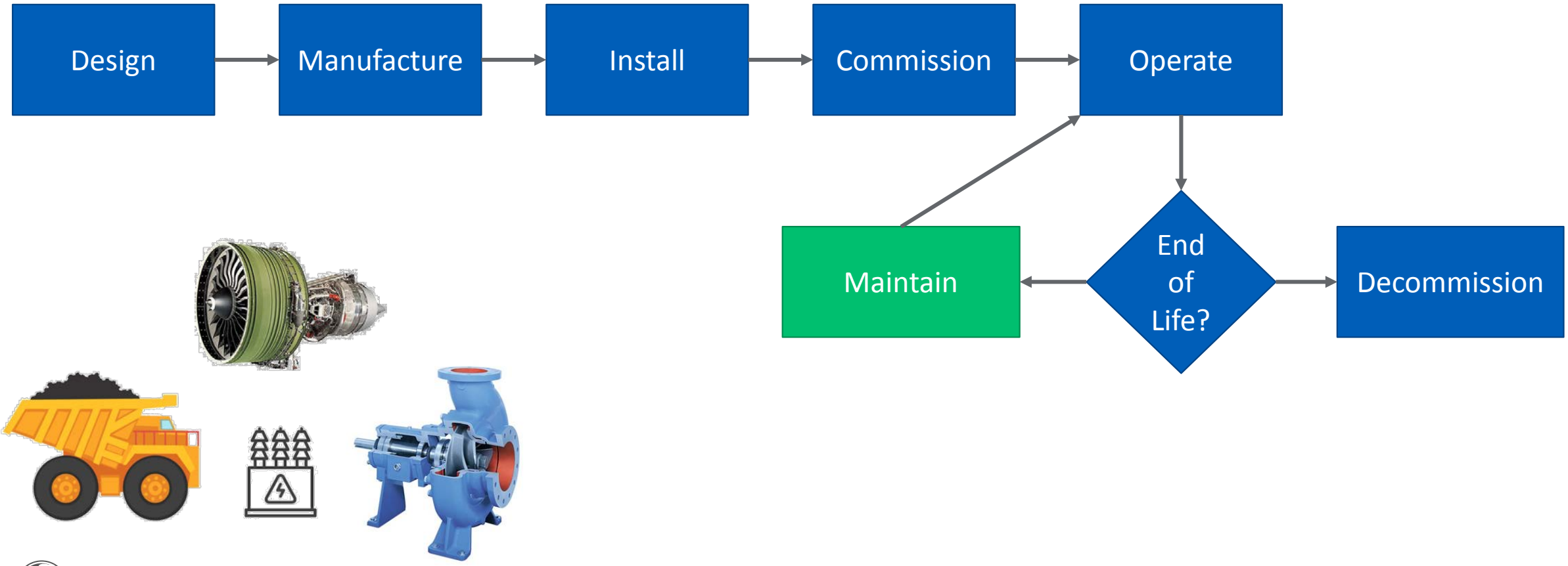
Maintenance in the lifecycle of a product



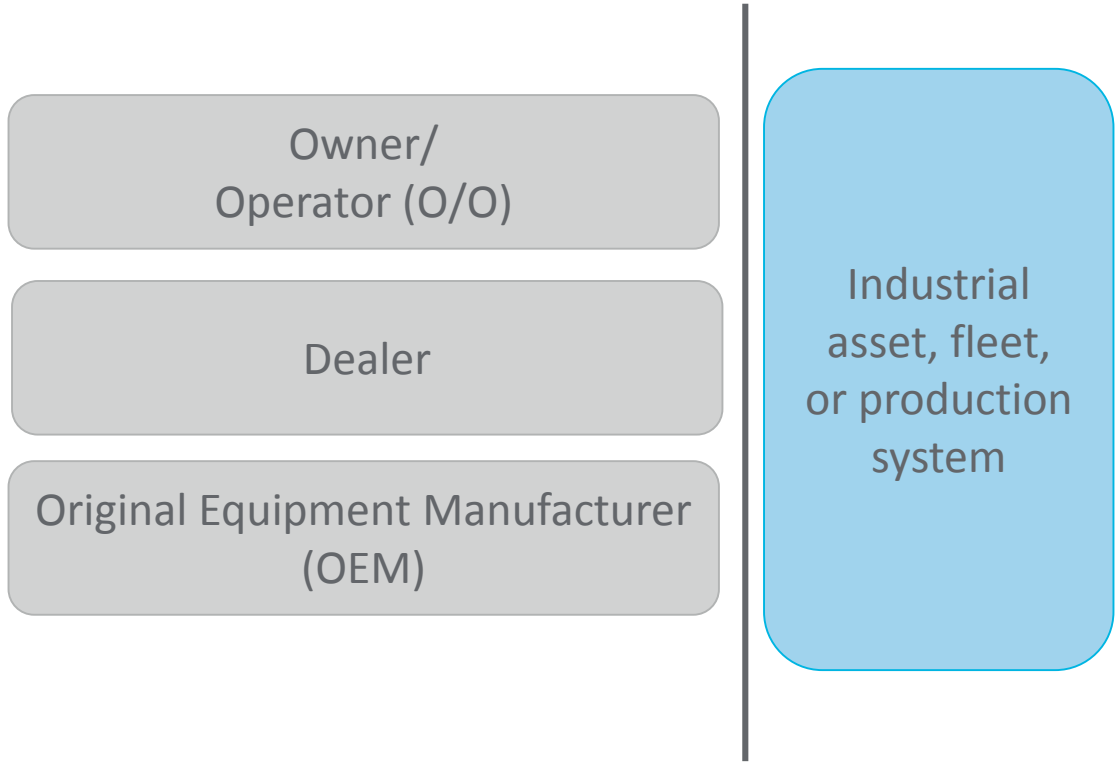
Opportunities and potential from maintenance data

OEM:

- Understand the gap between intended and actual use
- Information from operating context can help design improvements for future versions

O/O

- Insights to manage & improve asset performance

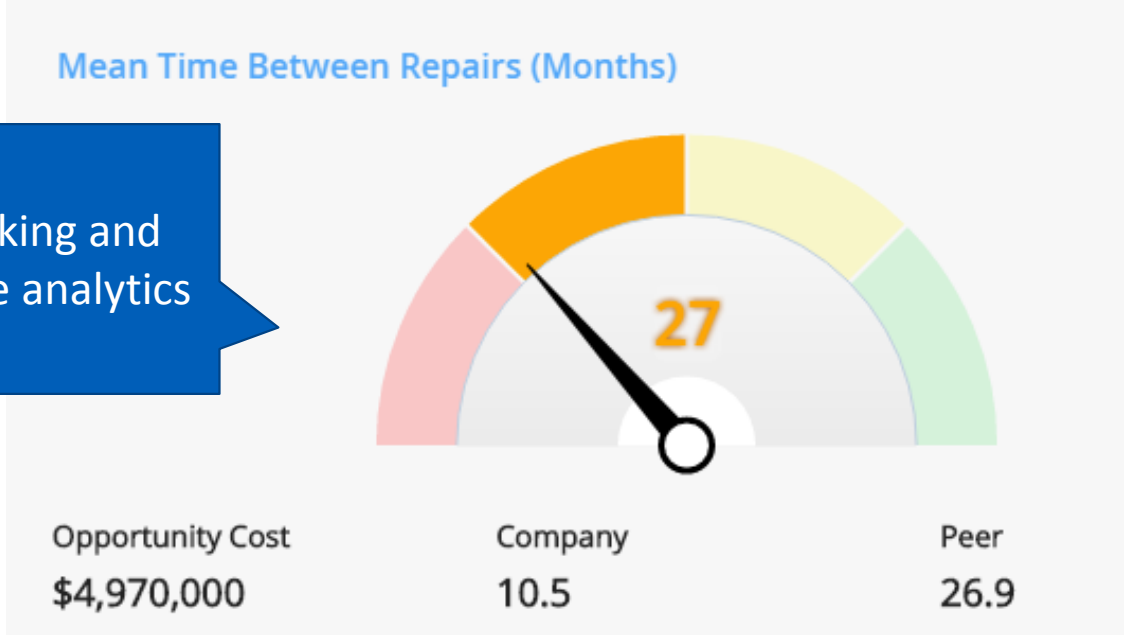


Who am I and what do I do?

Software for industrial applications such as APM

Asset Answers aggregates work history data from many industrial facilities around the world by asset type, manufacturers, and many other characteristics.

Benchmarking and comparative analytics



Maintenance data quality

Having **accurate** data is a common struggle.

Primarily driven by **humans**.

Significant limiting factor in reliability analytics.

Cultural Barriers – Viewed as an administrative burden.

Might take months to do a simple bad actor analysis.

Reliability Engineers spend 80% of their analysis time in processing and normalizing data.

Differences between sites – usage of Maintenance Management systems or work processes.

Three Main Challenges

Trust in Data

Utilization of Data

Effort to Standardize Data

Existing standards are theoretical

Standards for collecting, measuring, and analyzing industrial data

ISO 14224 – standards for data collection and coding

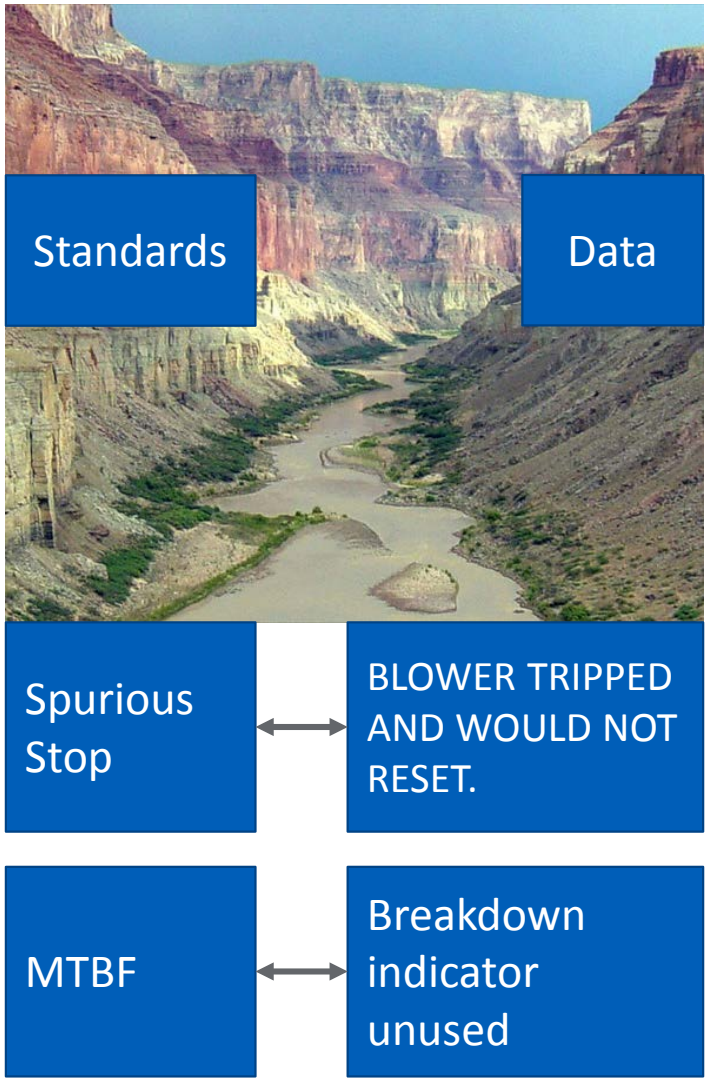
SMRP Best Practice Metrics – standards for calculating KPIs

Challenges

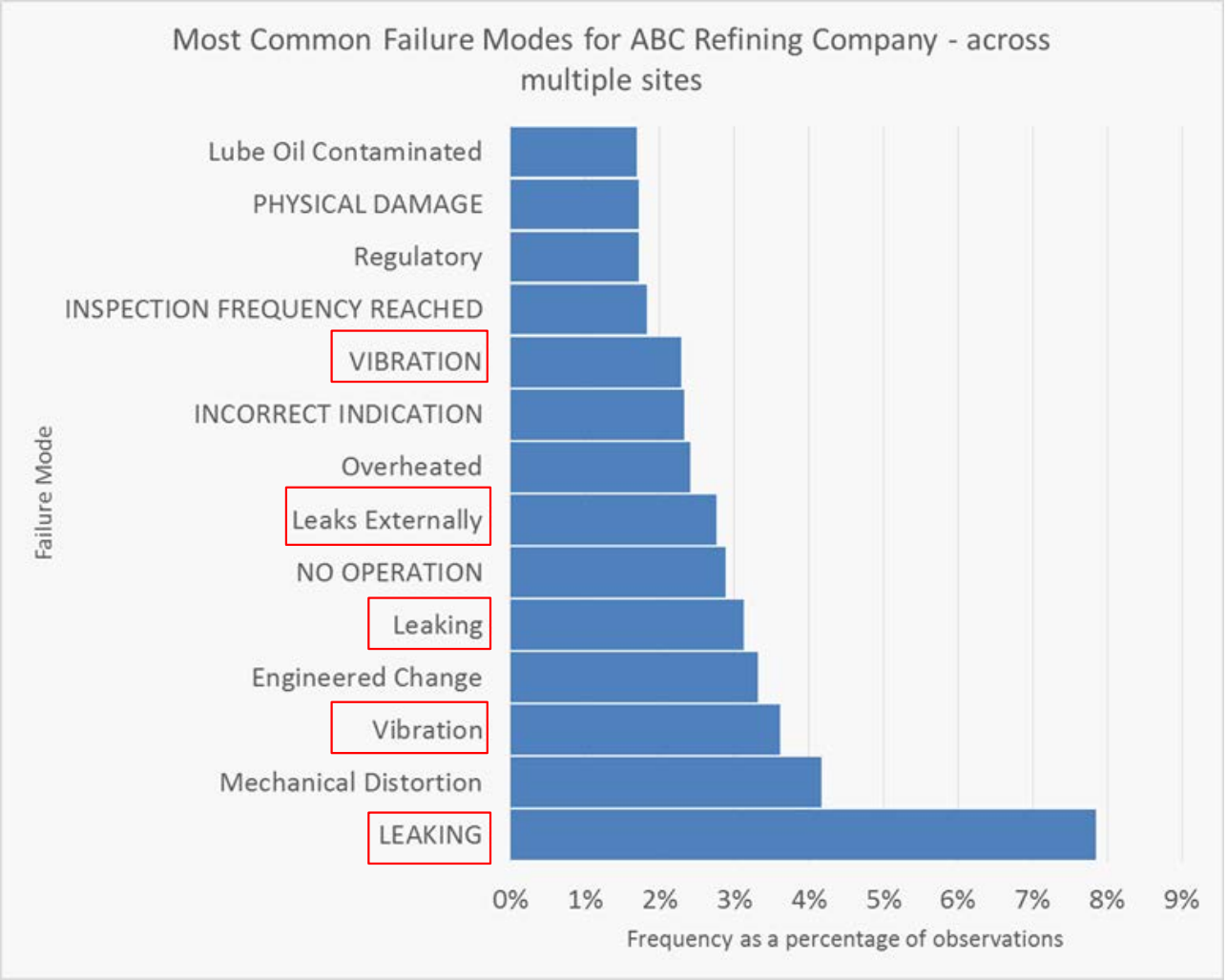
Codes may be used differently by different individuals (various levels of precision, different interpretations)

Codes may exclude certain conditions

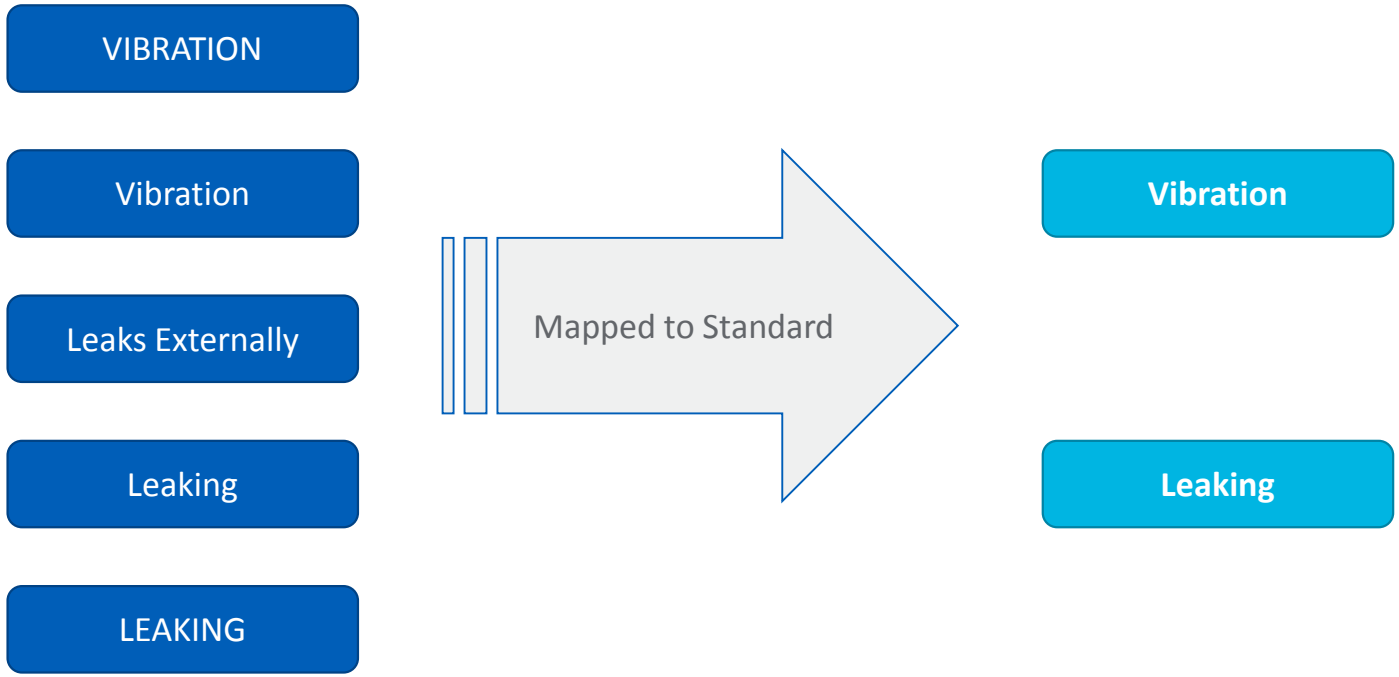
Local customizations based on context of use – standards may tend to only be guides in some cases



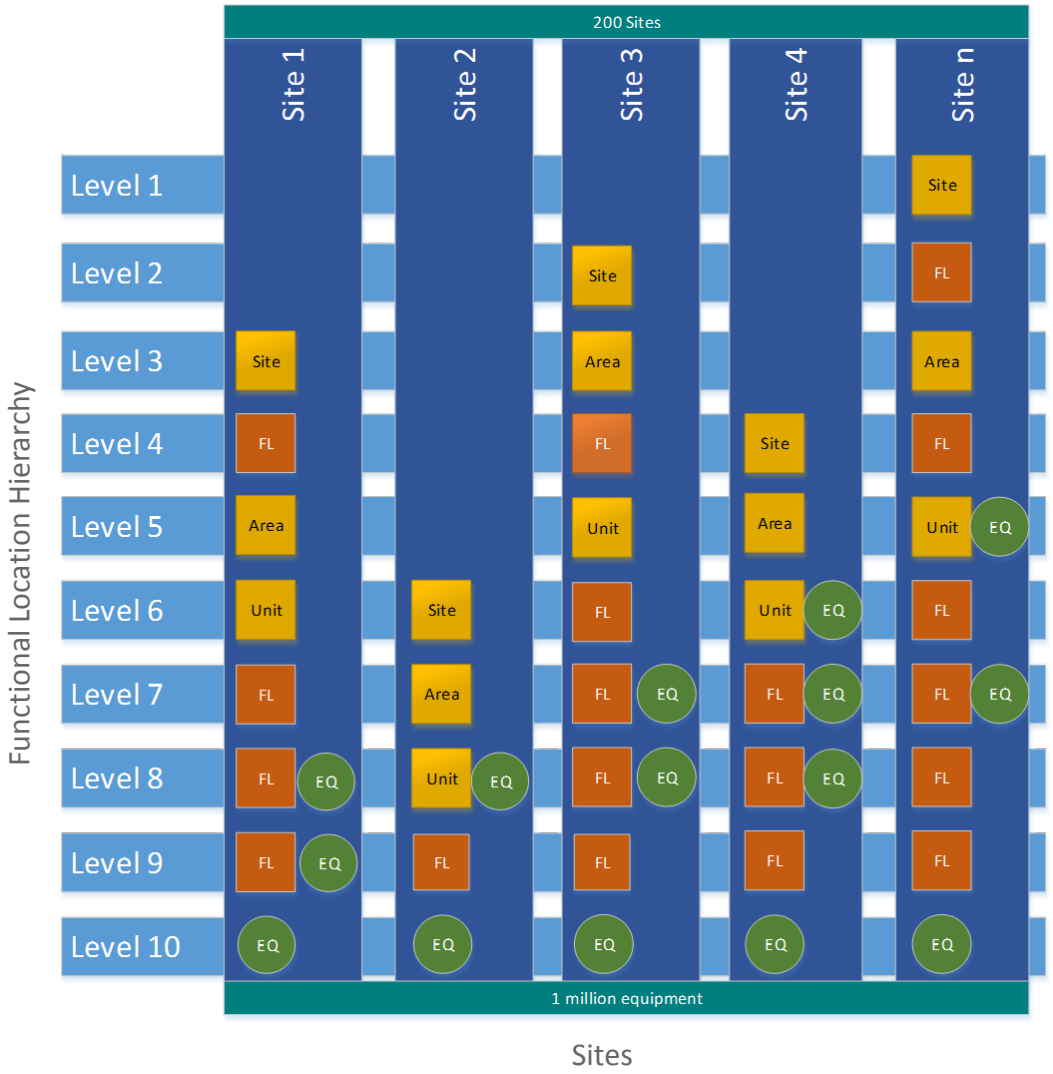
Standardization Woes – Example 1



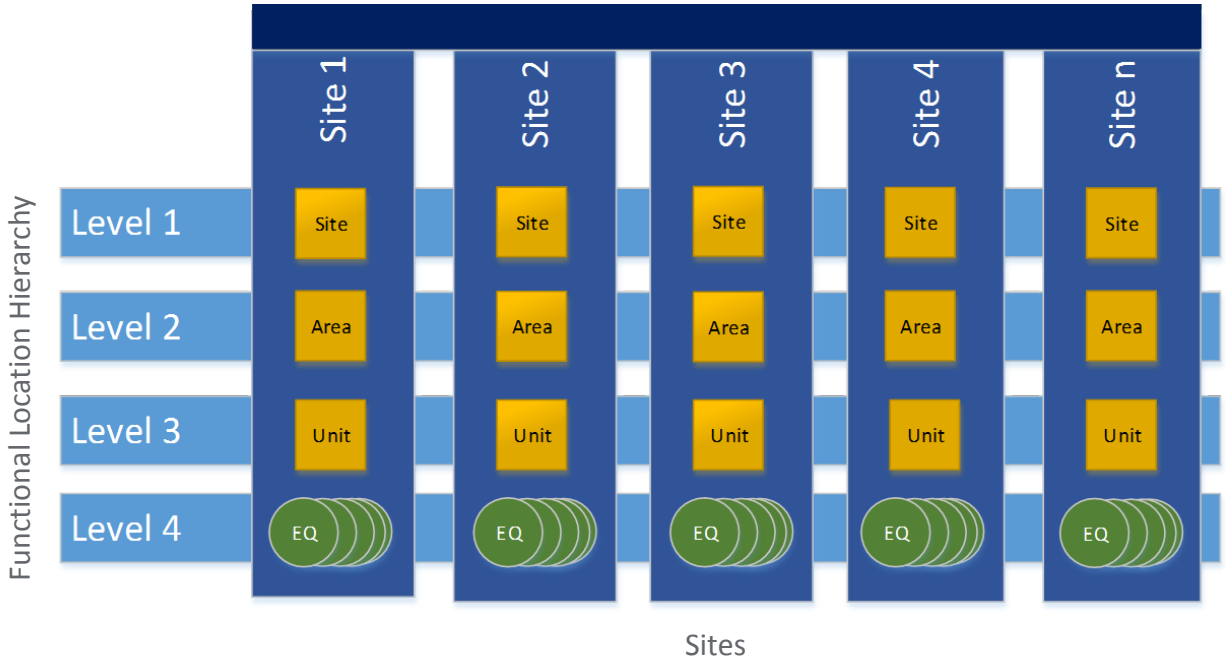
Standardization 1 Woes – Resolved



Standardization Woes – Example 2



Standardization 2 Woes – Resolved



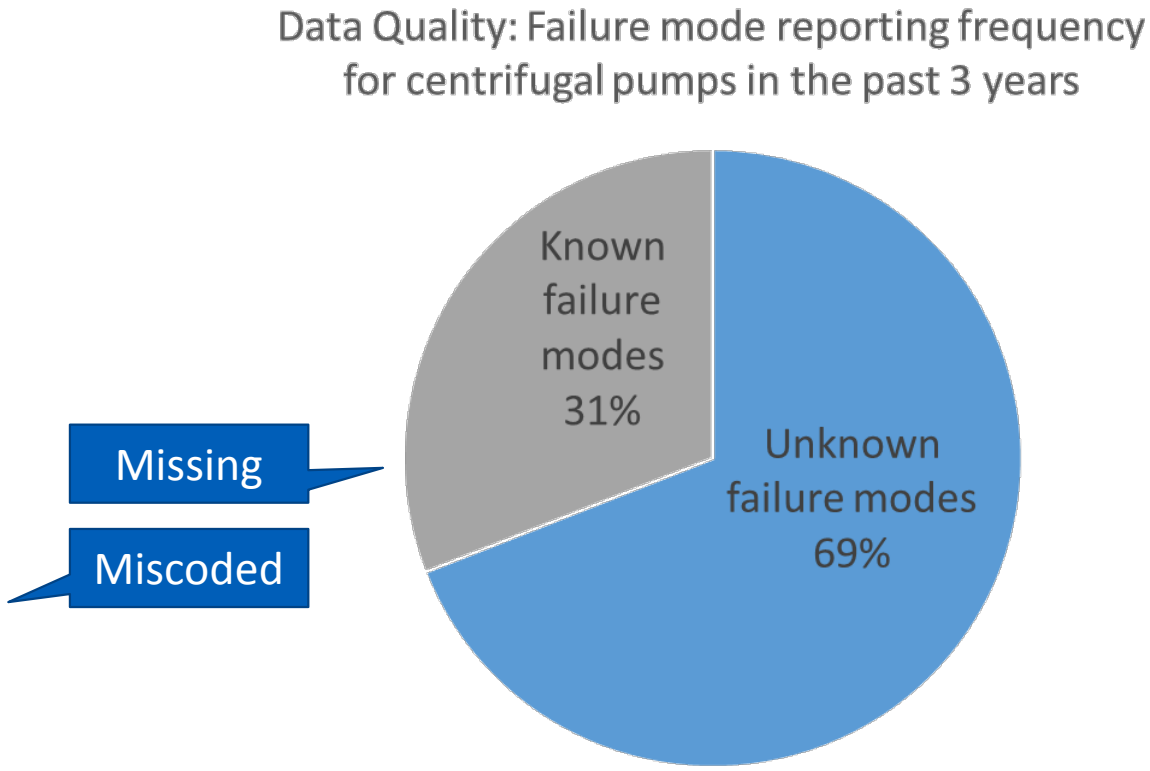
Completeness and Accuracy in maintenance data quality

Data largely missing and miscoded

Breakdown indicator not often used

Cost (or Claims) data generated for financial reporting may lack engineering information

Free Text Work Order Description	Miscoded Event Type
Repair leaking safety valve	PM
Daily Inspection of Analyzers	Repair



Importance of measuring data quality

Track data improvement efforts

Identify areas where the data is good –

- And use good data for benchmarking and developing analytics

By identifying where you have good data, you can get value from it now.

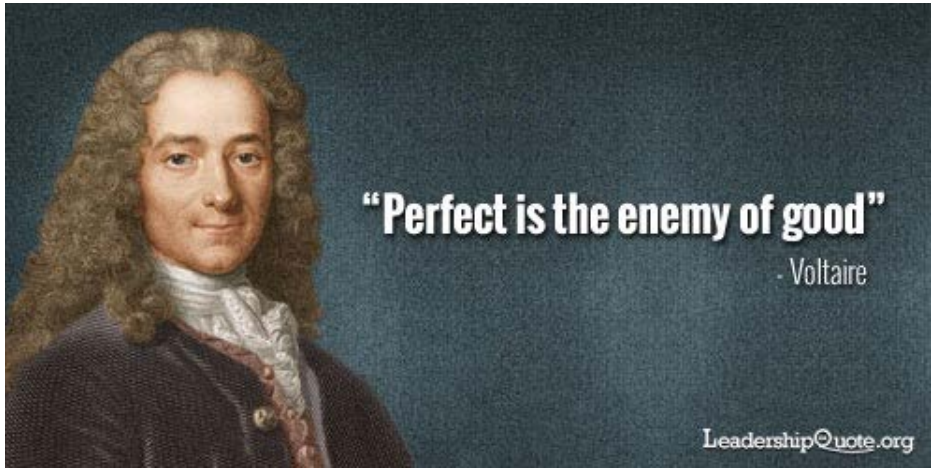
Identify areas where the data is good

Sufficiently - Good data

Perfect Data is a myth and a futile endeavor!

Data should be suitable for its application – serve the business purpose.

Should accurately reflect the real asset performance.



Key information often present in unstructured fields

Failure Mode information in unstructured field:

Free Text Work Order Description	Failure Mode	What I want to see:
Need to re-grout base to reduce long time vibration problem	Unknown	Vibration
Clear blocked piping/pump	Unknown	Plugged/Choked
The stuffing box was replaced not long ago because of a water leak in the drive head, the leak is back	Unknown	Leakage

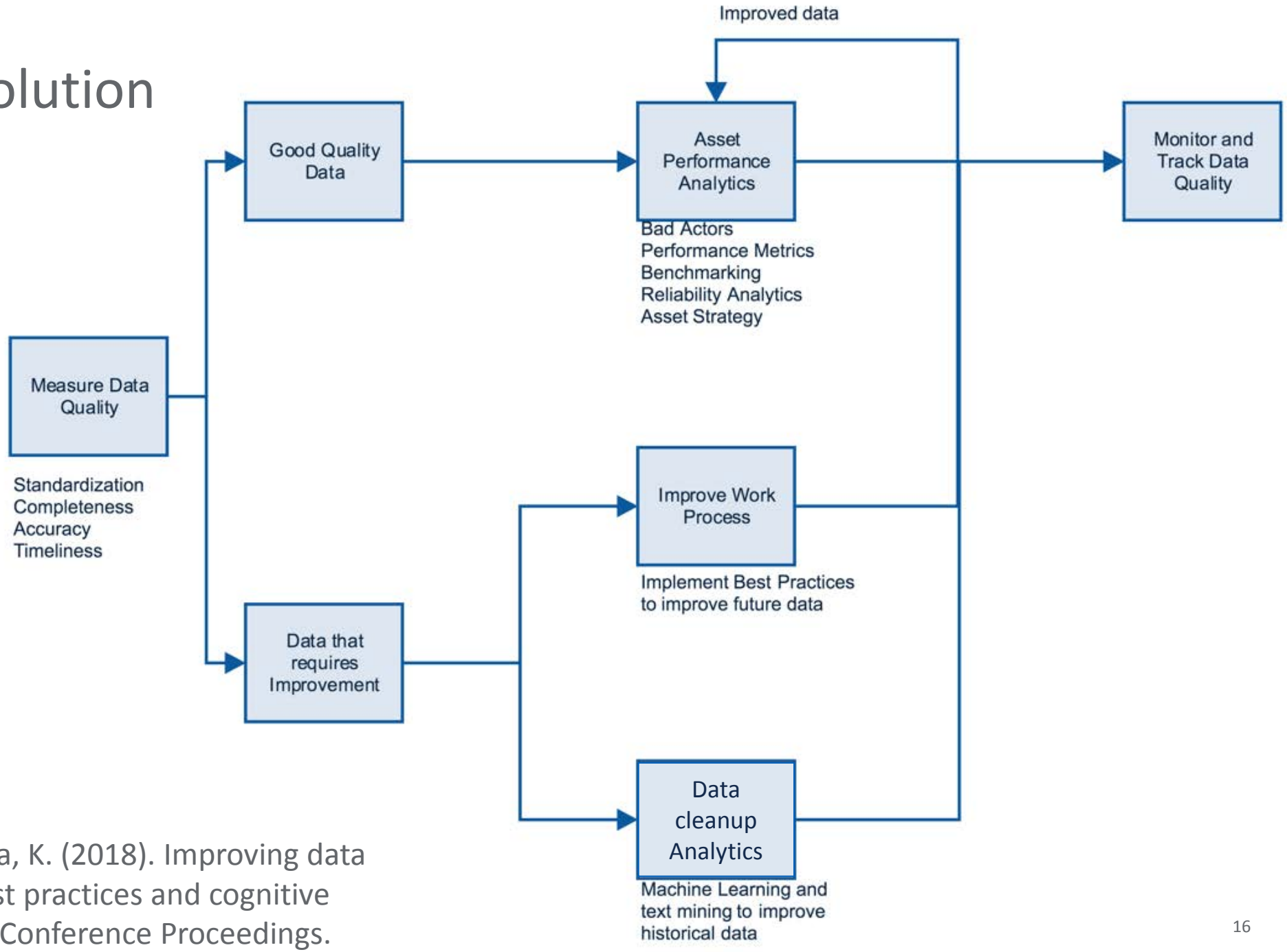
Data Quality Problem: Incorrectly coded work orders

Free Text Work Order Description	Event Type	What I want to see:
Repair leaking safety valve	PM	Repair
Daily Inspection of Analyzers	Repair	PM

Recording when a failure occurred:

Free Text Work Order Description	Breakdown?
WATER PUMP FAILURE. Water pump has failed and has leaked all the coolant out through the tattle hole	FALSE
Sump level sensor has failed. Cannot run plant without this sensor.	FALSE
Compressor lube box oil seal has failed. Requires seal replacement ASAP	FALSE

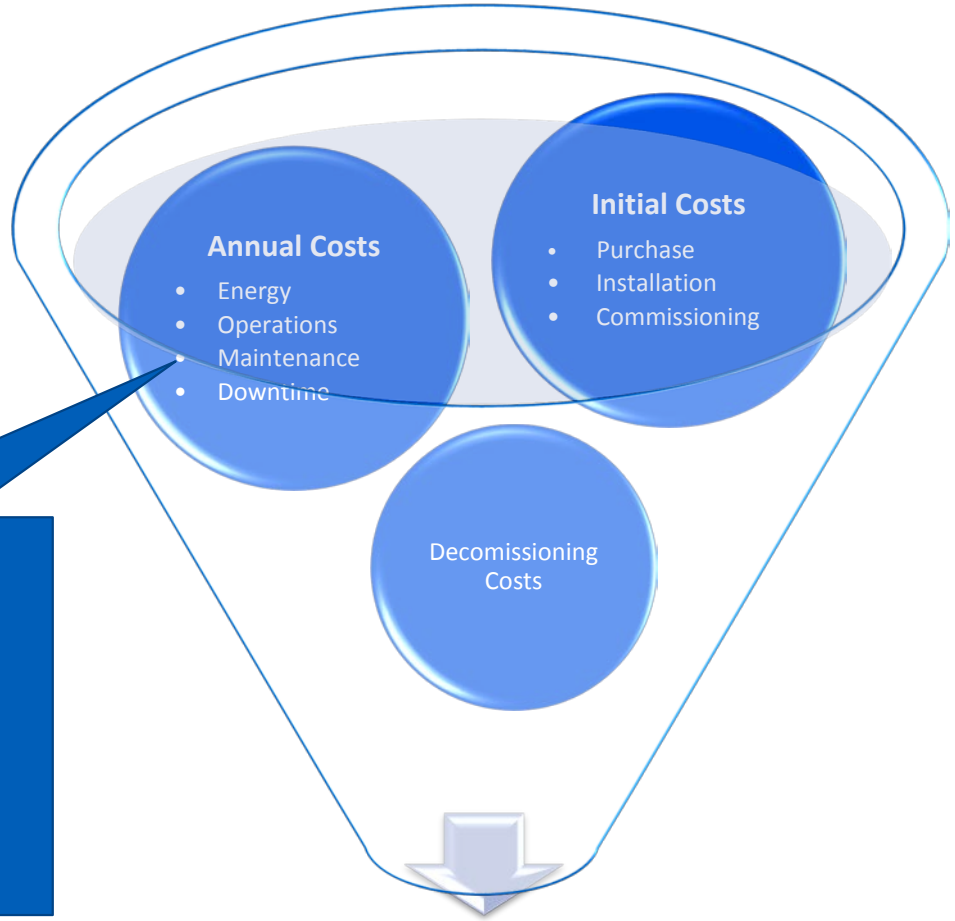
Two-pronged solution



Naik, M. & Saetia, K. (2018). Improving data quality using best practices and cognitive analytics. SMRP Conference Proceedings.

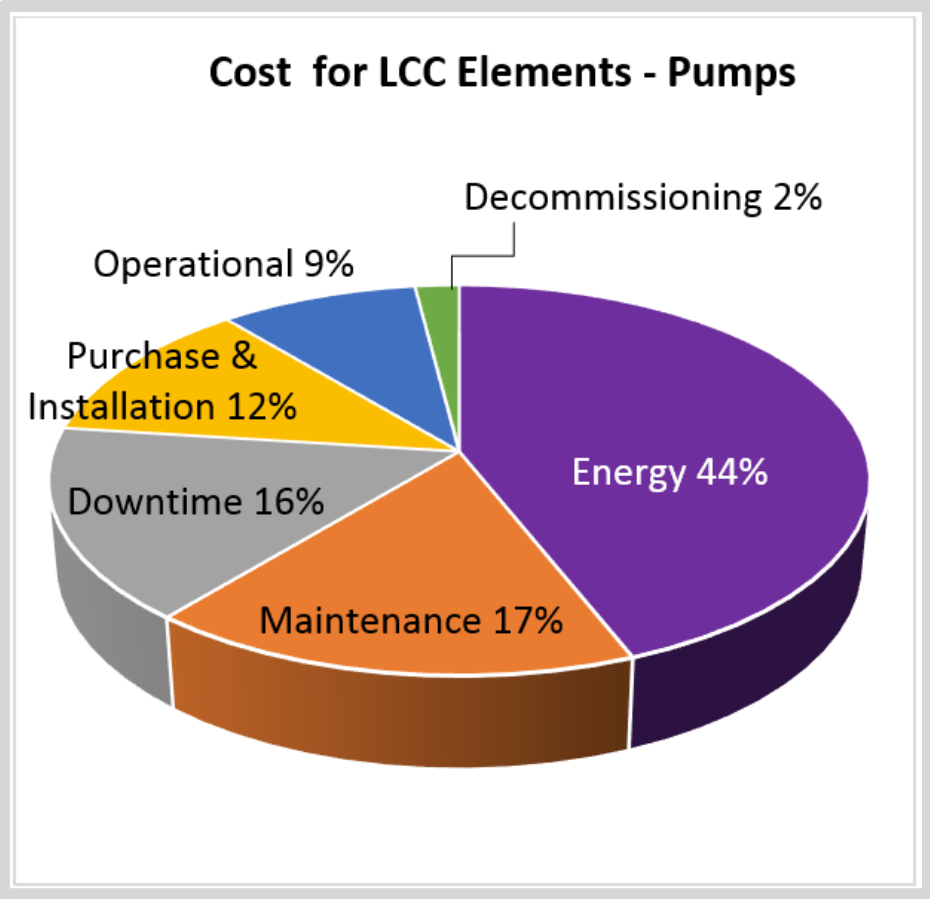
Case study: maintenance data for information sharing across product life cycle

Life Cycle Cost (LCC) Elements:

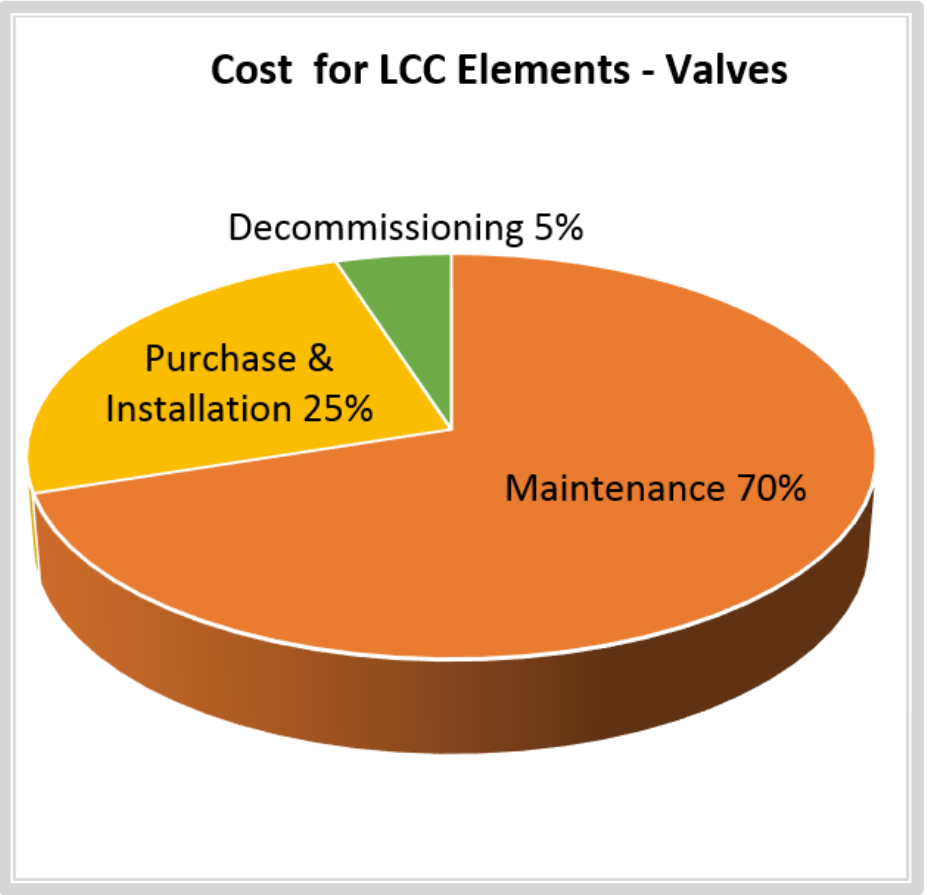


Maintenance Life Cycle Costs (MLCC) are 1 piece of the Total Cost of Ownership (TCO)

LCC Cost Distribution



Source: Flowserve, "HPX Hydrocarbon Processing Pump ISO 13709/API 610 (OH2)", Pg.7.



Source: William, M., 2004. "Lower you operating costs with regular valve maintenance." *Plant Services.*

Resolving data quality challenges through analytics to provide information & knowledge

Case study: Estimating elements of MLCC for different manufacturer and models of an asset

Selected 2 manufacturer and models

- Characterize of different failure events
- Evaluate benchmarking metrics, such as:
  - Maintenance cost,
  - Mean time to repair (MTTR),
  - Downtime, etc.
- Characterize risk mitigating actions

The missing breakdown indicator challenge

Strengths of models

- Consistency
  - Two similar inputs will always have the same classification by a computer model
- Scalability
  - Thousands of work orders in a very short period of time

Challenges with models

- Consistency
  - Variation in definition of ”functional failure”
- Models only as good as the data they are trained on
  - Inconsistent training data
  - Cases that are “obvious to a human, not to a machine”

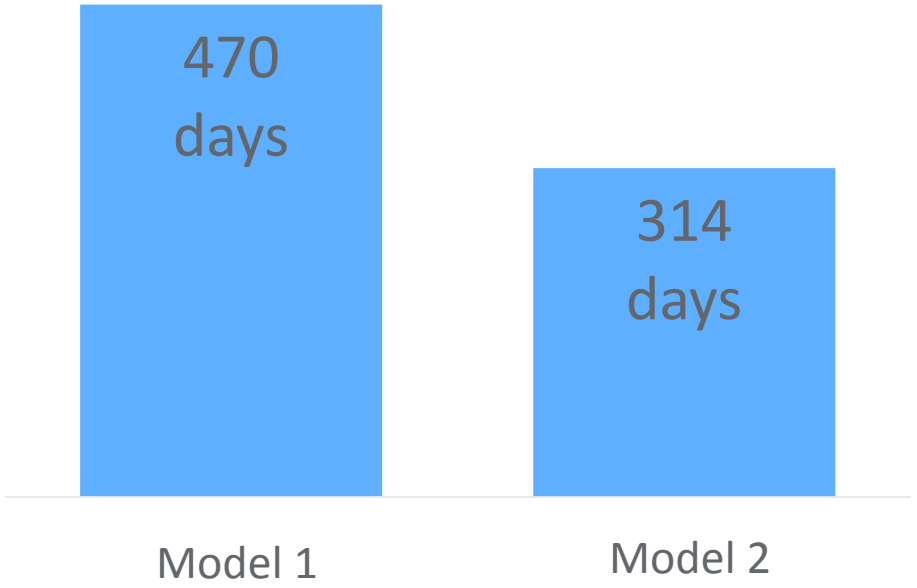
Results: comparison of reliability estimates

Of ~8,000 repair events, ~5,800 identified as failures

Work description	Is A Failure?
Seal is leaking badly	True
Block valve is broken open and inoperable	True
00120-Pump 1 Work Request	False
Check impeller size	False

Before: inability to calculate Mean Time Before Failure (MTBF)

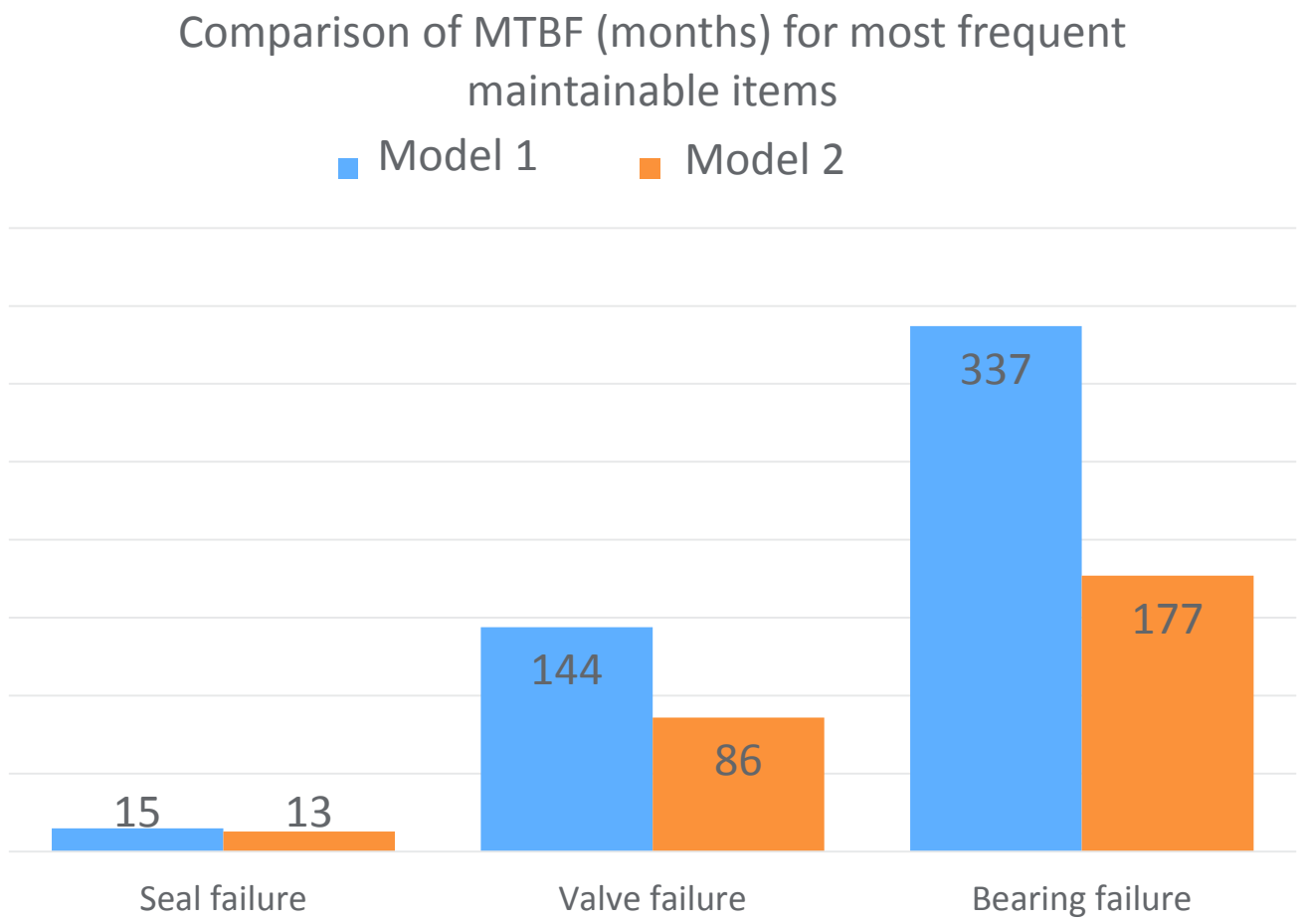
After: Comparison of MTBF (days)



Characterizing failure information through description

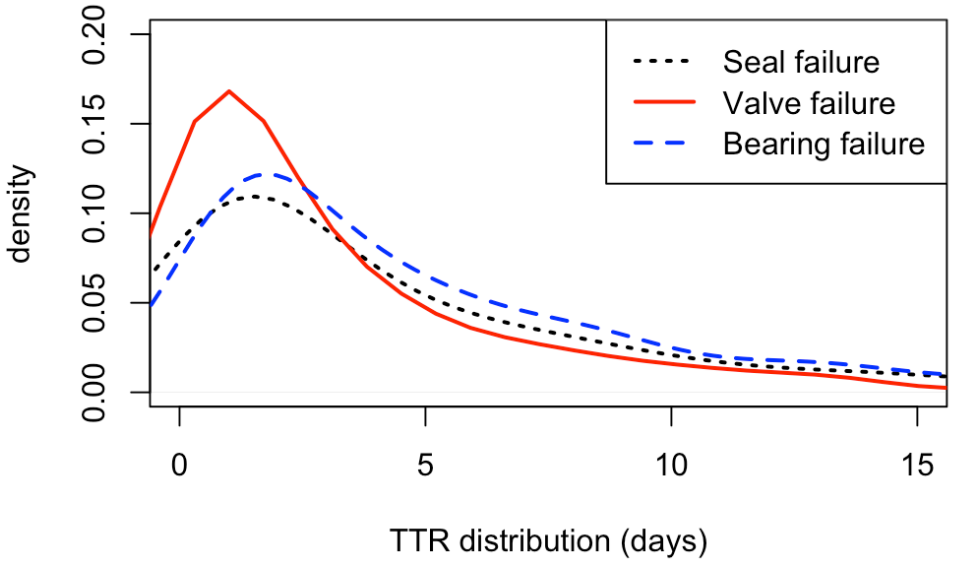
In **scalable, repeatable** way

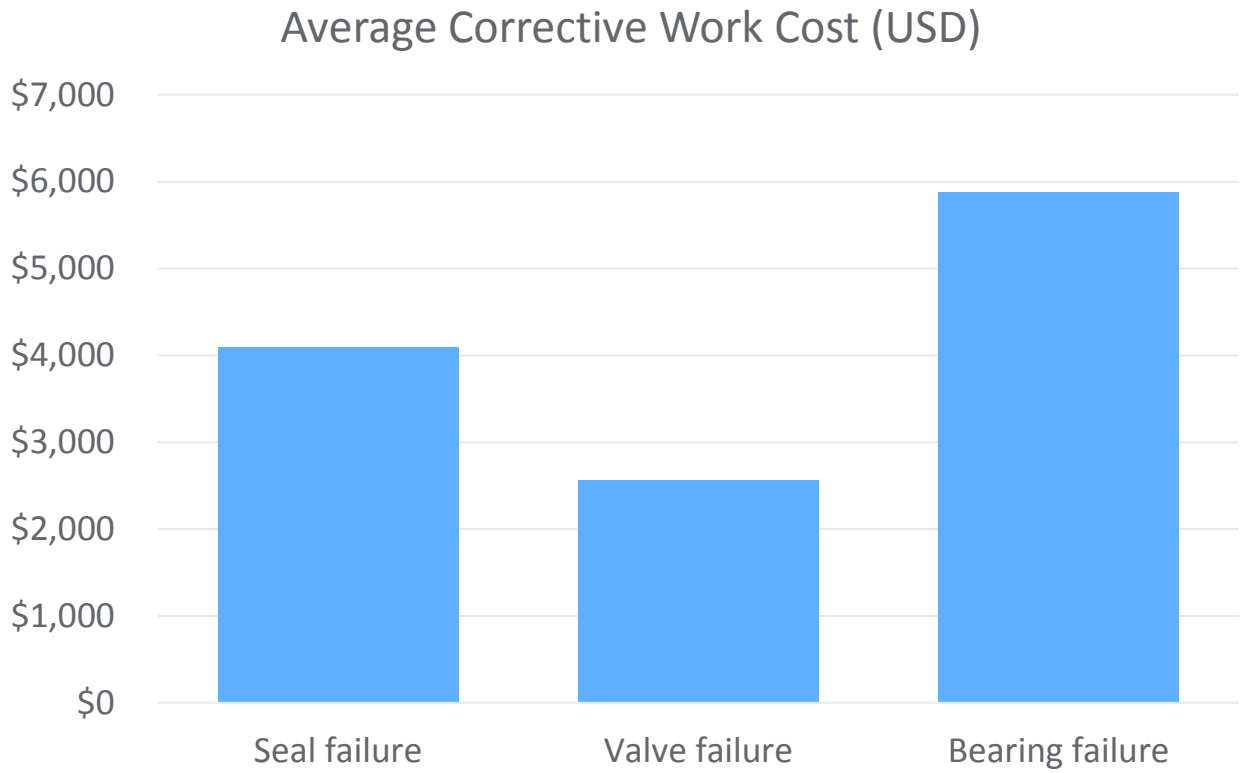
Work description	Maintainable Item
Seal is leaking badly	Seal failure
Block valve is broken open and inoperable	Valve failure
G5 Seal failure	Seal failure
P001-A NRV is passing	Valve failure



Other maintenance & reliability benchmarking measures

Valve failure events generally have shorter time to repair and cost less



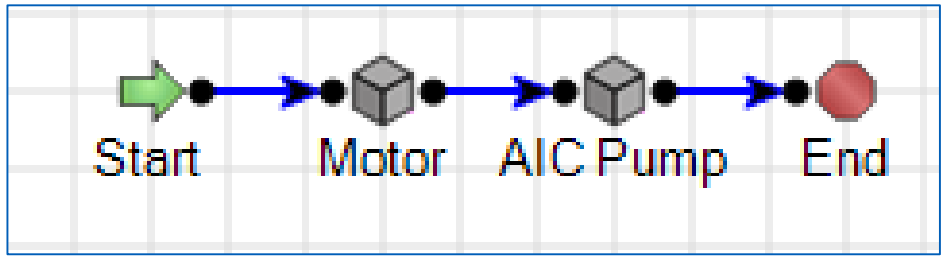


Simulating the cost of unreliability over 10 years

System reliability analysis: simple system with pump and motor

Assumed:

- Reliability is the only variation between the two models
- Production loss of $10,000 per day per pump (at the pump asset level)



Under these assumptions, production losses dominate the cost of unreliability

Simulated consequences by risk

Total unplanned corrective work cost

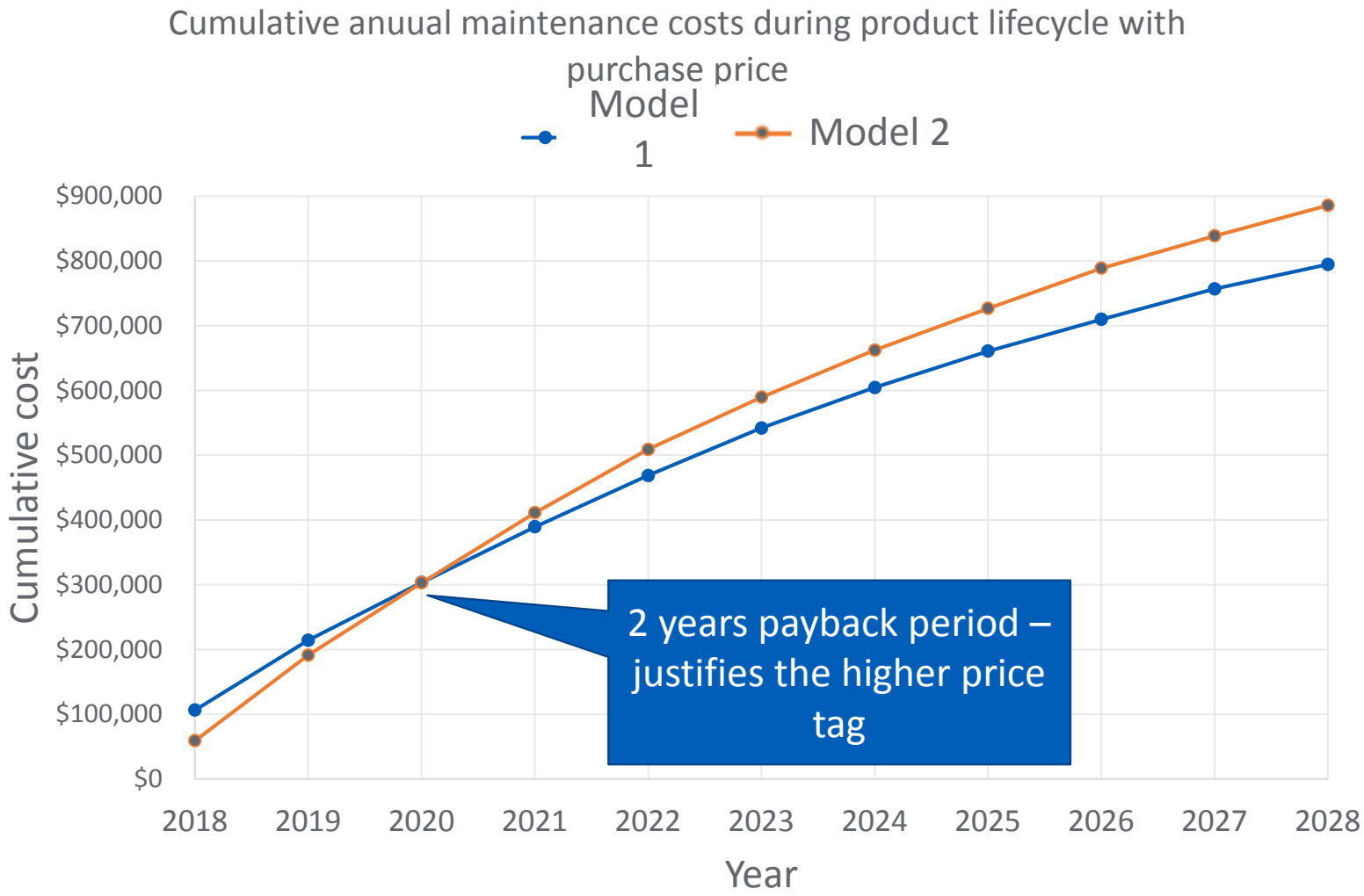
Total unplanned downtime
(factor for production losses)

Annual trends – with purchase price

Model 1 is the more reliable pump, and costs twice as much to purchase…

Model 1: $100,000

Model 2: $50,000



Discussion points

Maintenance data contains relevant information about the usage of industrial equipment, but not in its raw form

Need for development of adaptable work processes in which actionable information extracted from the maintenance data can be shared across different stakeholders in a product lifecycle.