# Domain Adaptation for One-Class Classification:
## Monitoring the Health of Critical Systems Under Limited Information

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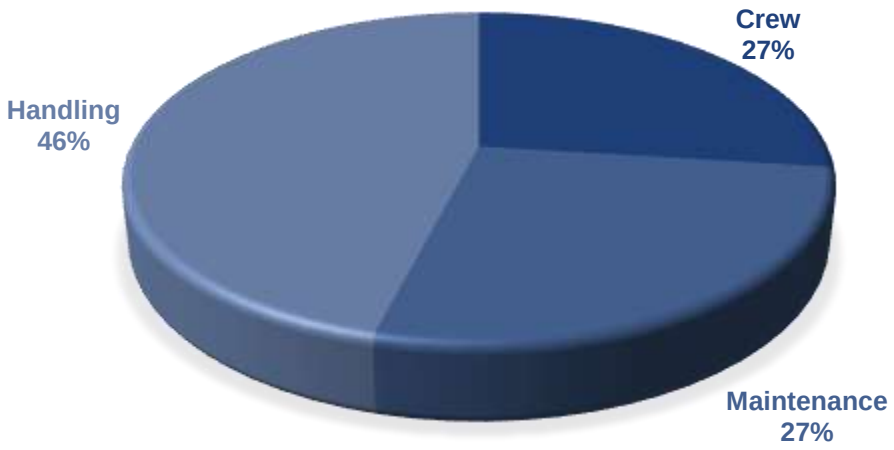
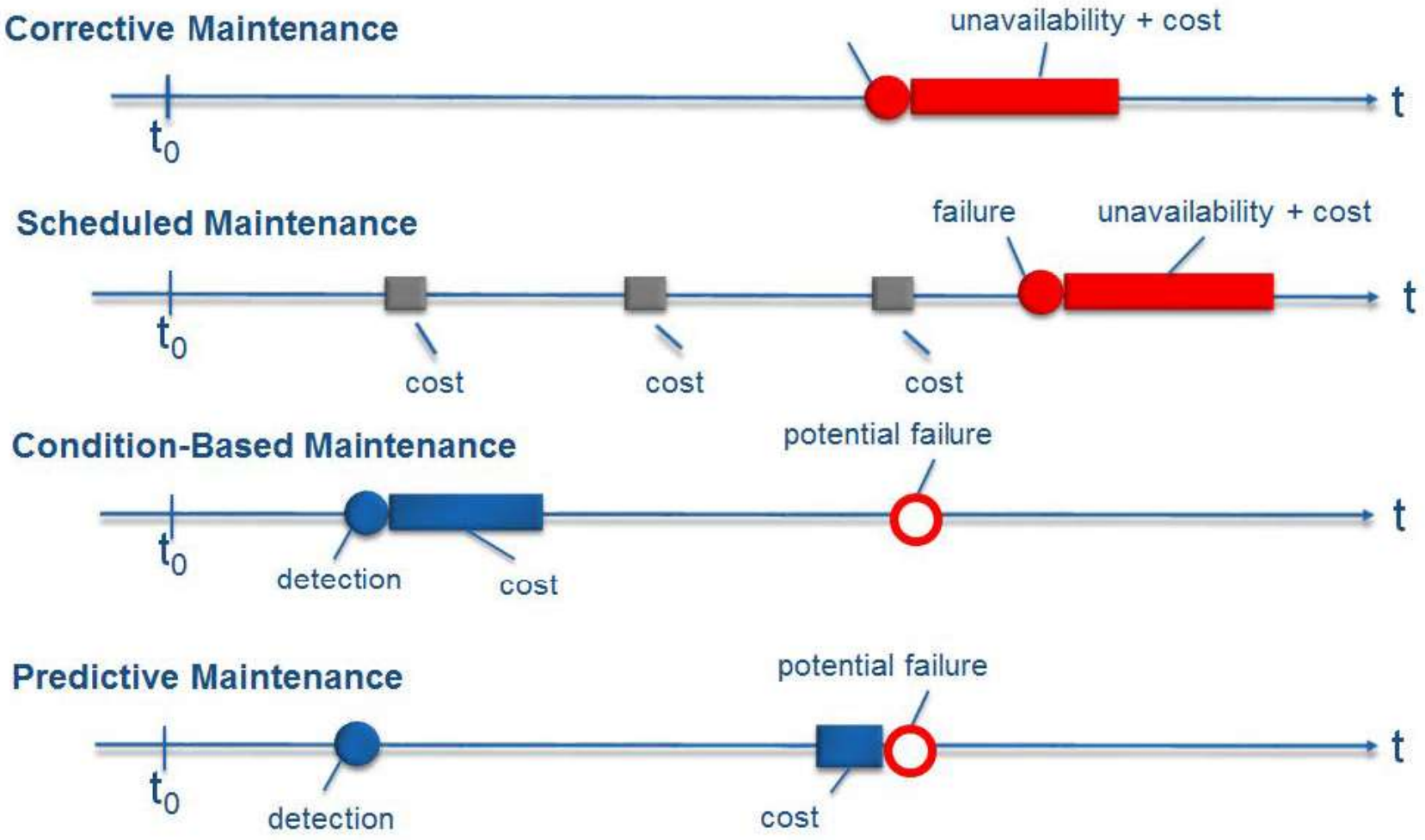
# Maintenance of Critical Systems

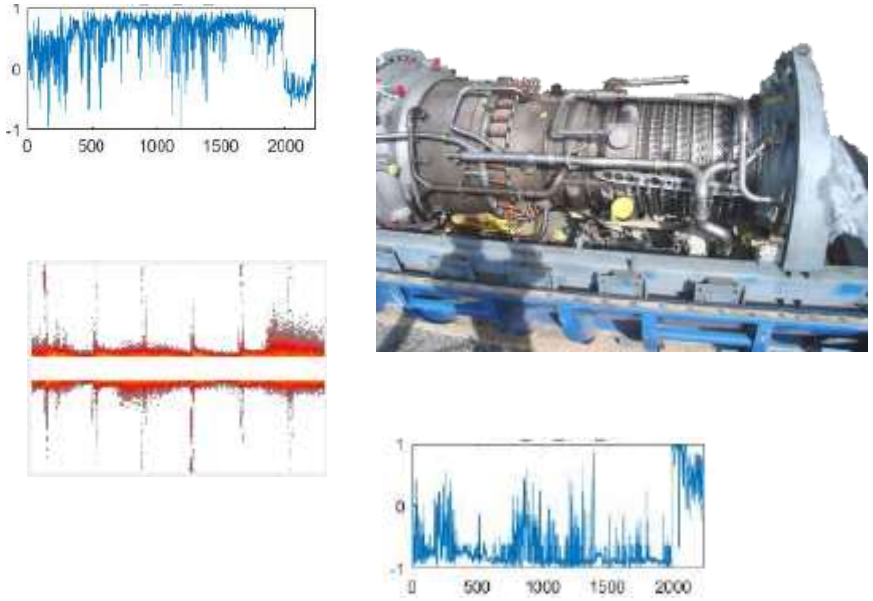
E.g. costs in Aircraft Operation




# When to perform Maintenance Operations?



# Challenges in the Monitoring of Complex Industrial system



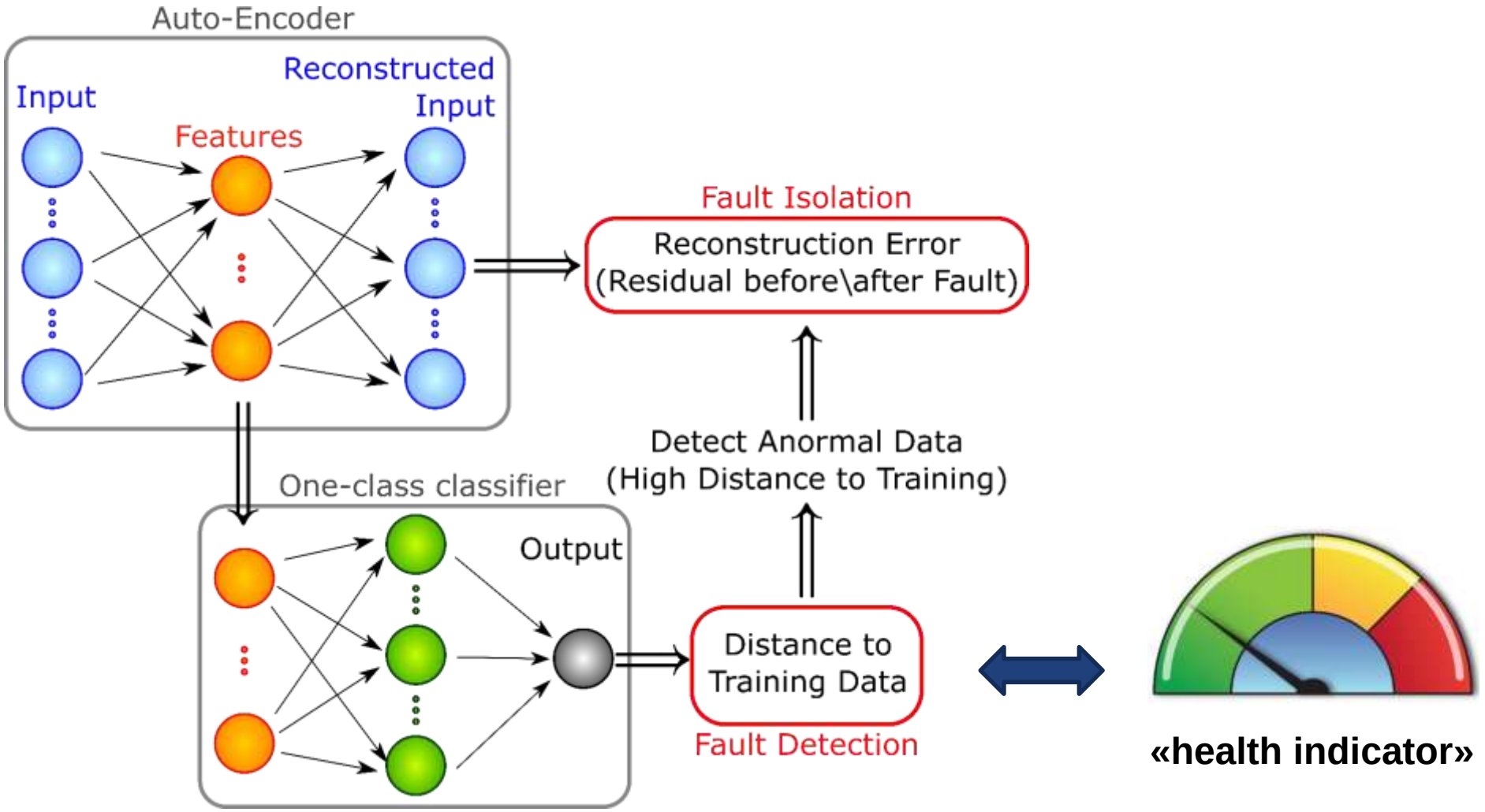

Large number and large variety of sensors
→ Heterogeneous condition monitoring data

Rare Faults:
Many possible faults
Preventive maintenance
reliable systems
→ Not sufficient examples to learn from

Diagnostics from classification results impossible
→ No clear fault signatures

Recorded data not representative
(varying operating conditions)
→ Not enough data from one system

# Proposition: Hierarchical Neural Networks – ELM[1]



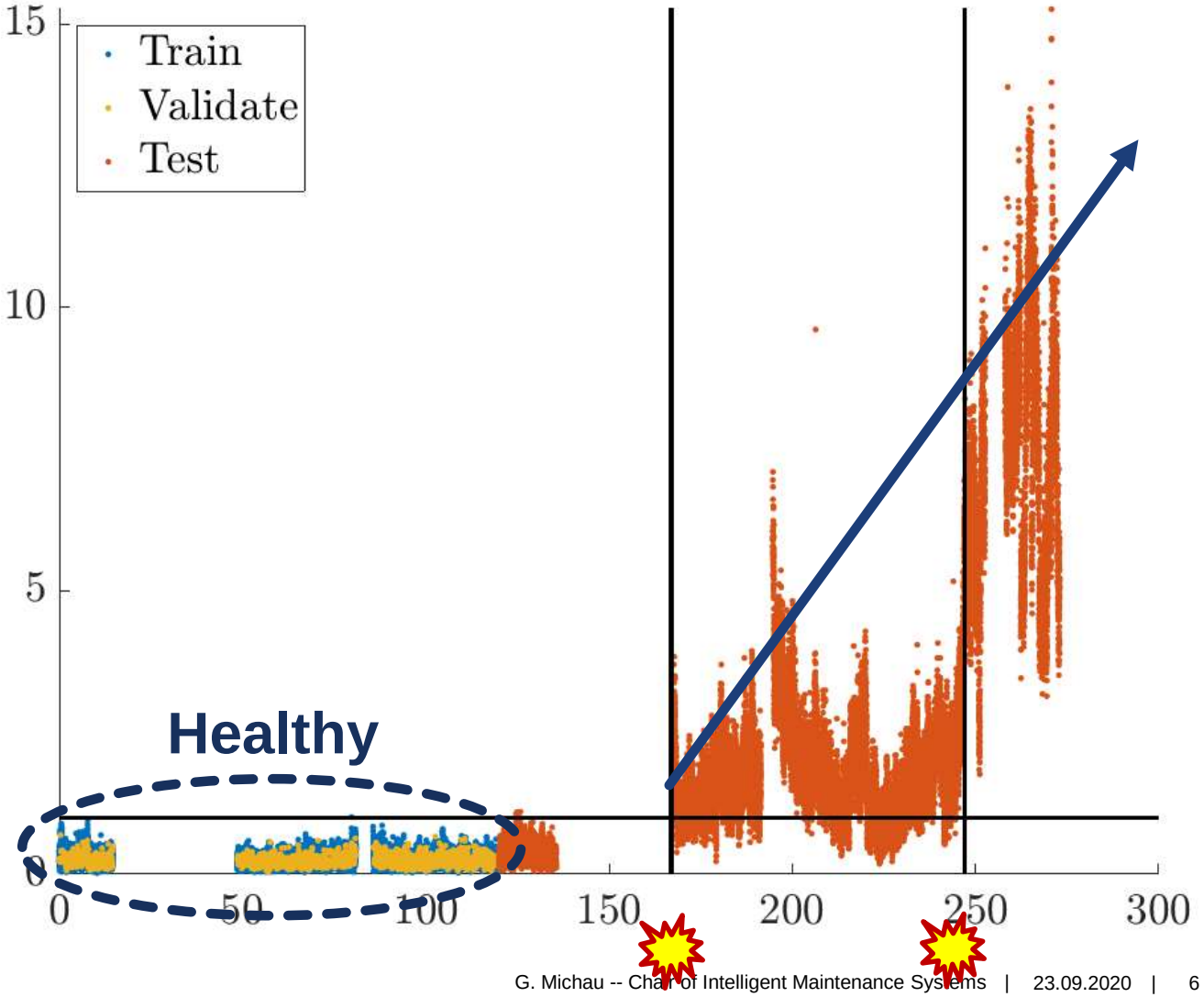

1. Michau, G., Thomas, P., & Fink, O. (2017). Deep feature learning network for fault detection and isolation. In *PHM 2017, St. Petersburg, USA, 2-5 October 2017* (pp. 108-118). PHM Society

# Example on a Generator (PHM Society 2017)

275 days
60 000 points
1 fault

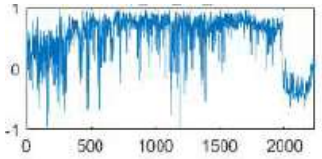
320 monitoring sensors:

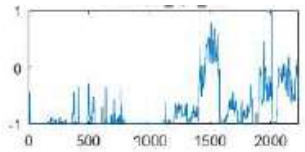
- Partial discharge
- Rotor shaft voltage
- Rotor flux
- Stator end winding vibration
- Stator Water Temperature

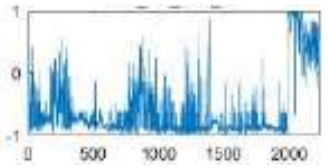



**Abnormal behavior 100 days before!**

# Challenges in the Monitoring of Complex Industrial system

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Unsupervised Anomaly Detection

gnostics from classification results impossible
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# New Challenges

What if, I don’t have so much training data?

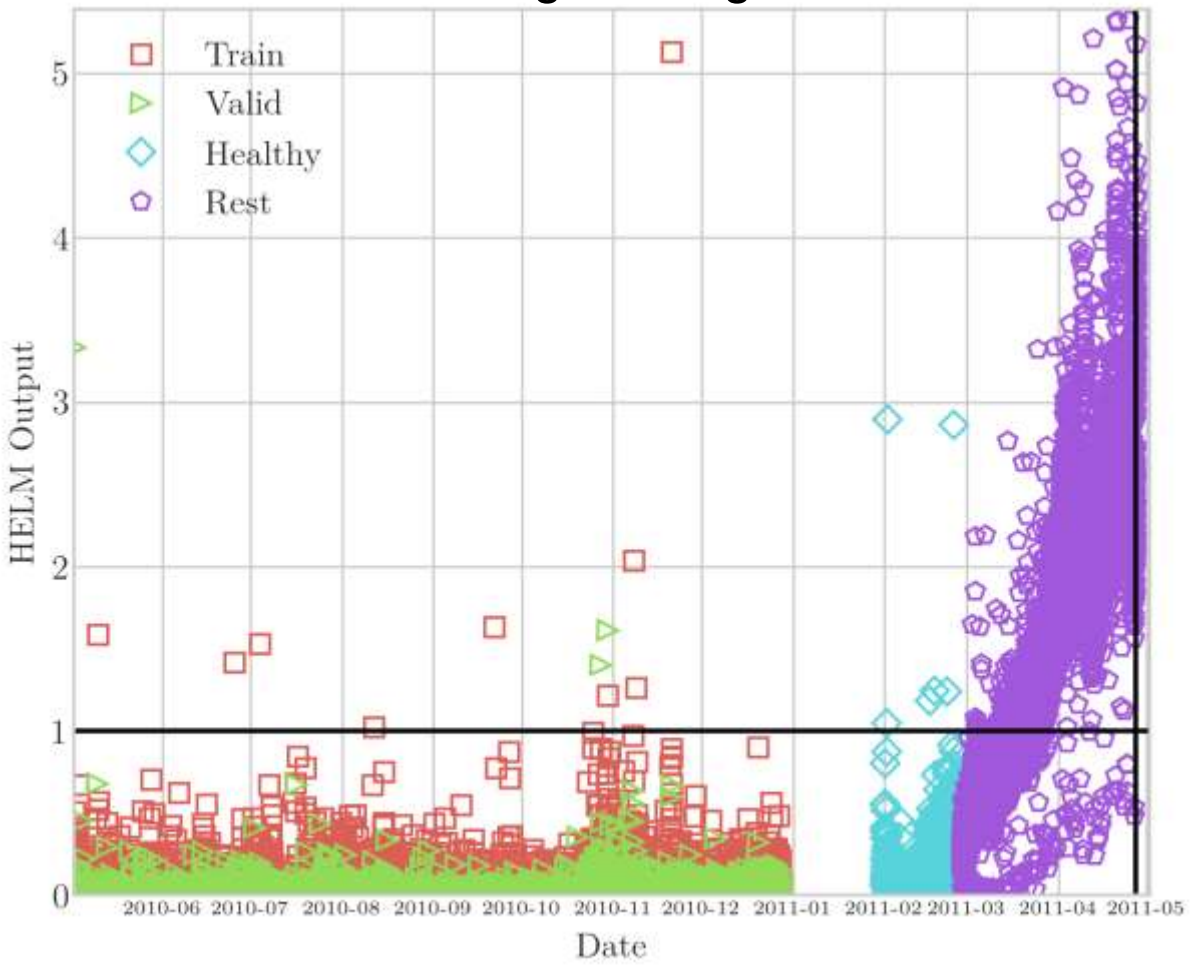
- What if my system is new (or has been refurbished)?
- What if I am expecting operating conditions to change?

$\Rightarrow$Use data from other similar systems

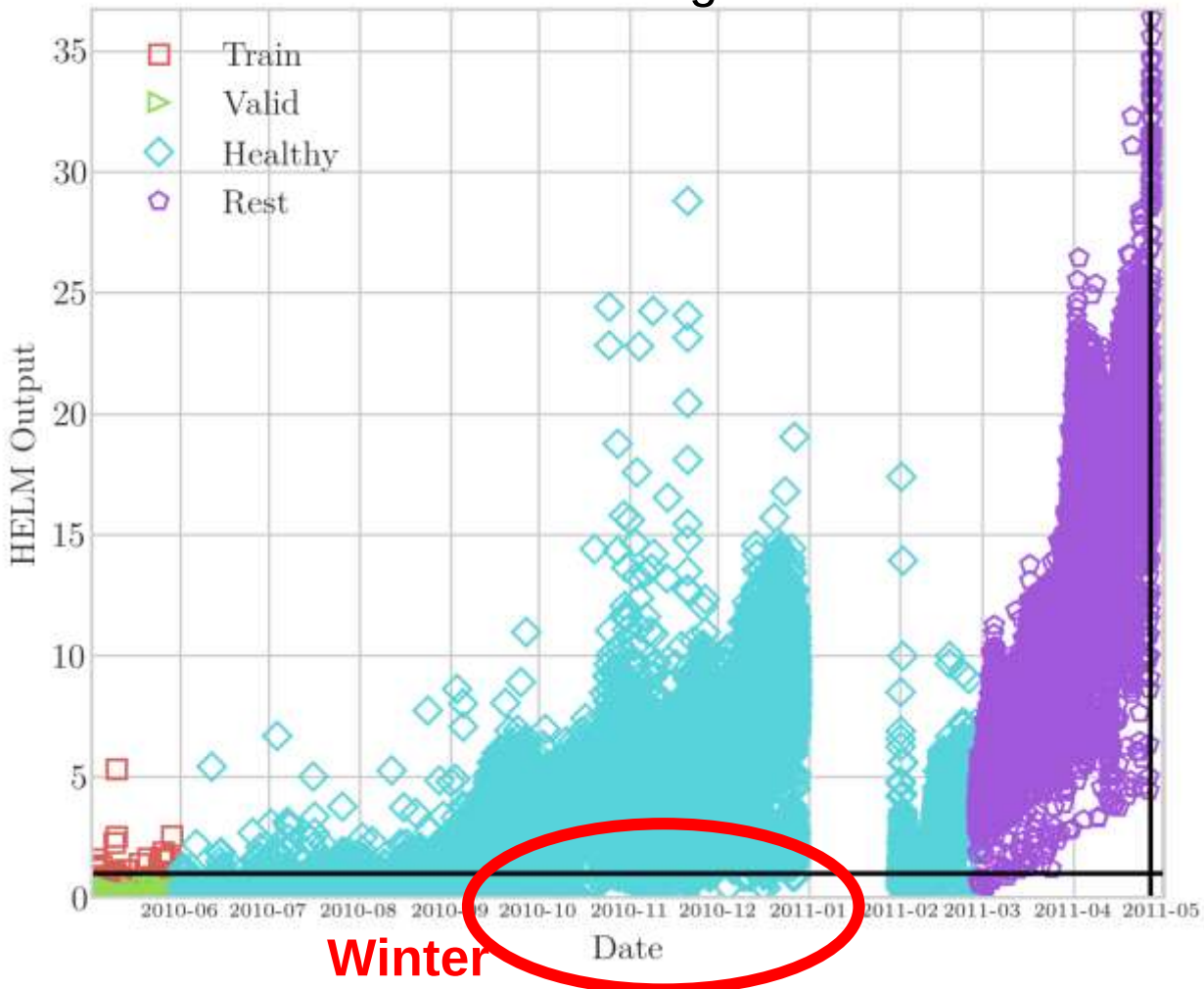
**Fleet approach** to PHM (from manufacturer perspective)

# Example: Stator Data

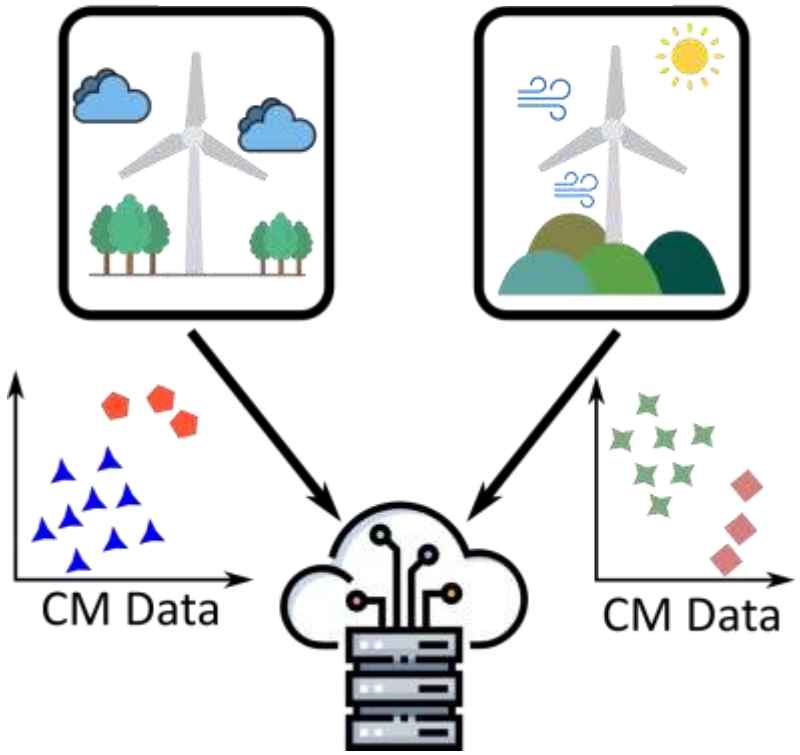
Long training

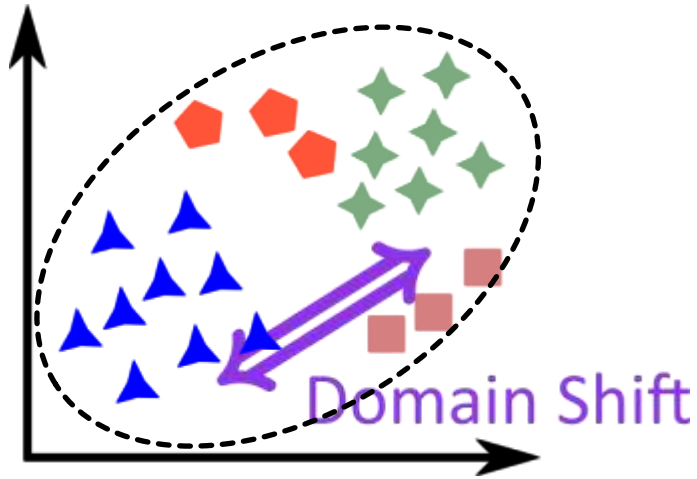



Short training



# Solution: Learn from other units




Identify similar units and operating conditions

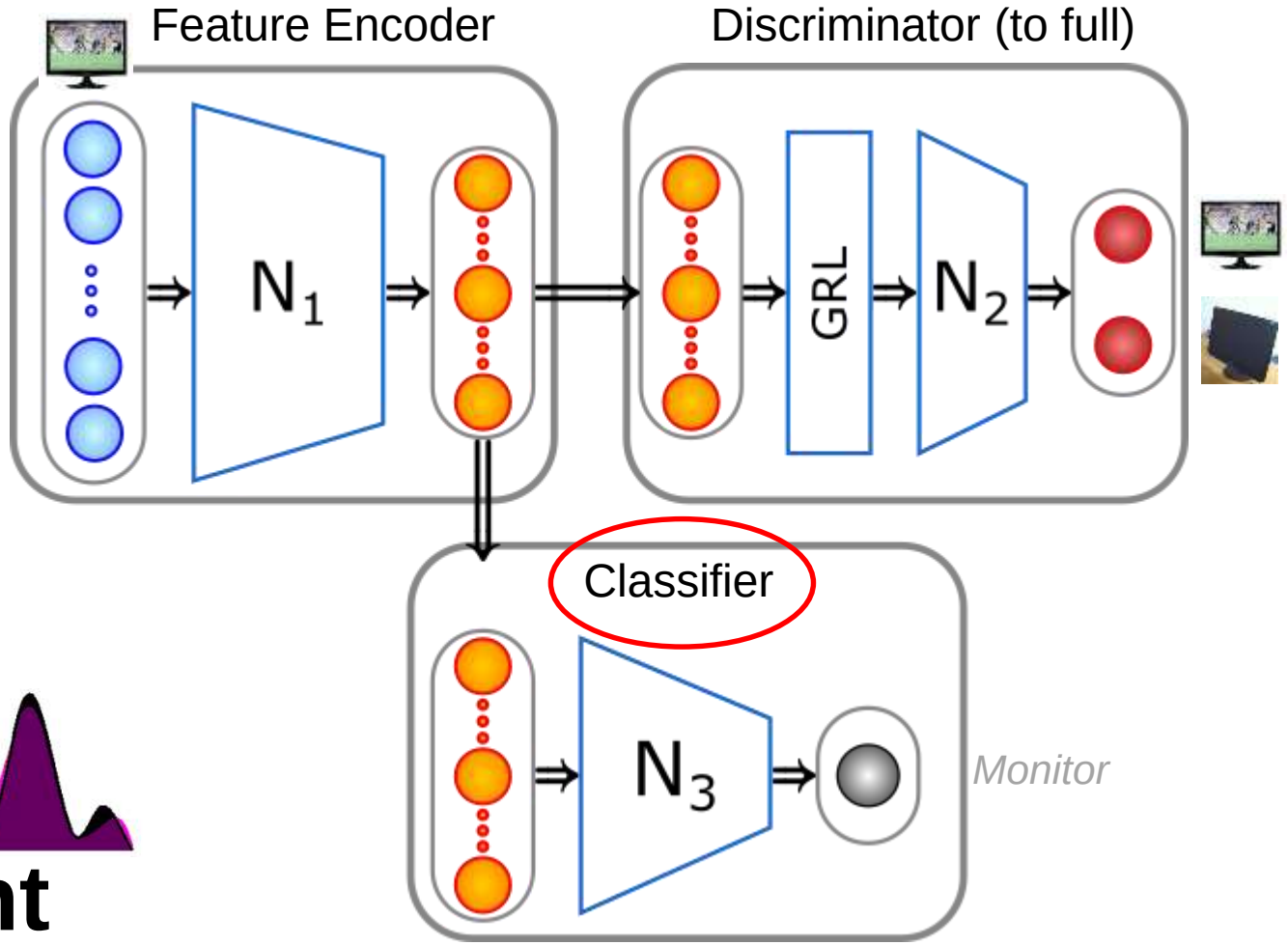
- ✗ Not always possible
- ✗ Multi-dimensional time series comparison

# Domain Adaptation Neural Network

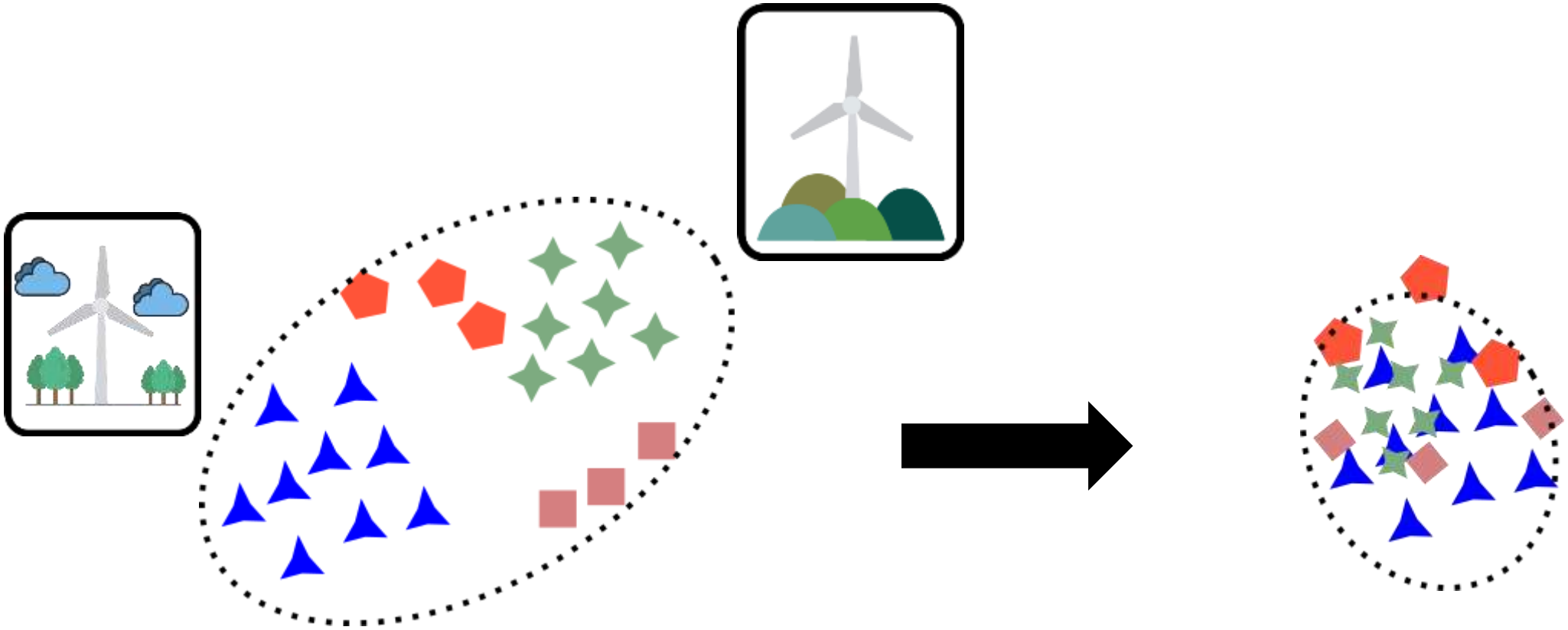
Source

Target

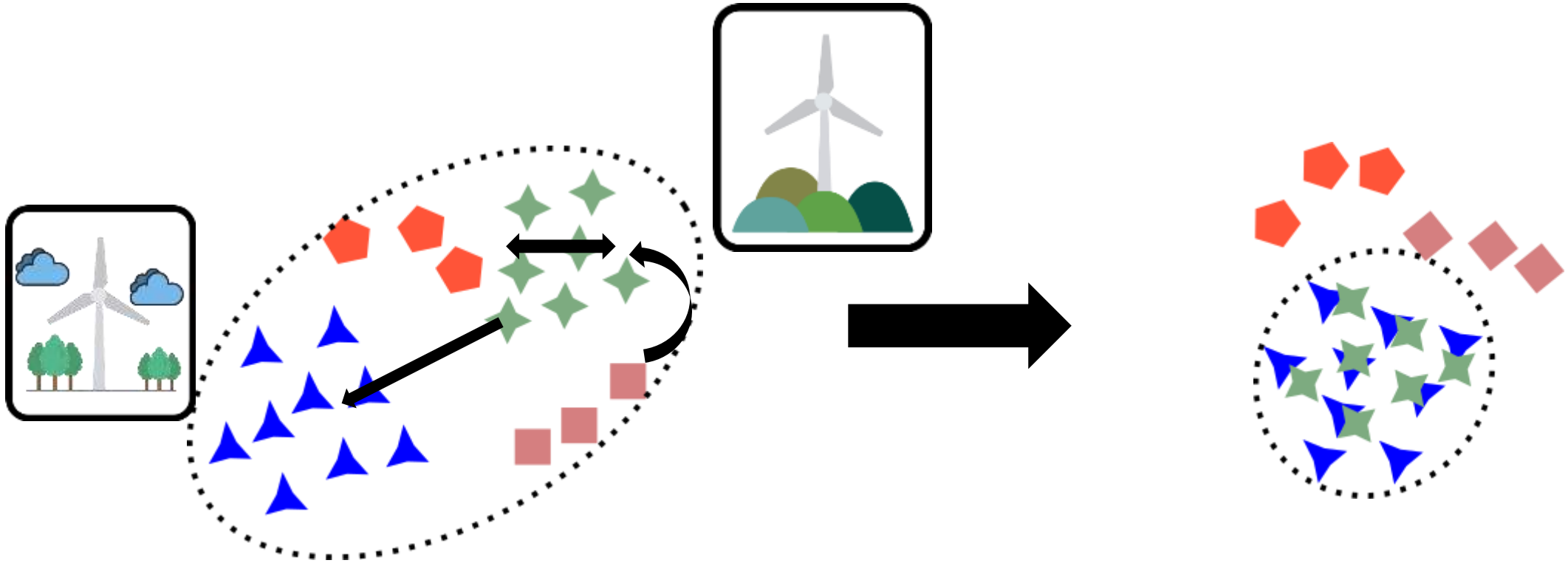
**Domain Alignment**



# Risk in Unsupervised Alignment



# Keep inter-sample relationships while doing the overlap

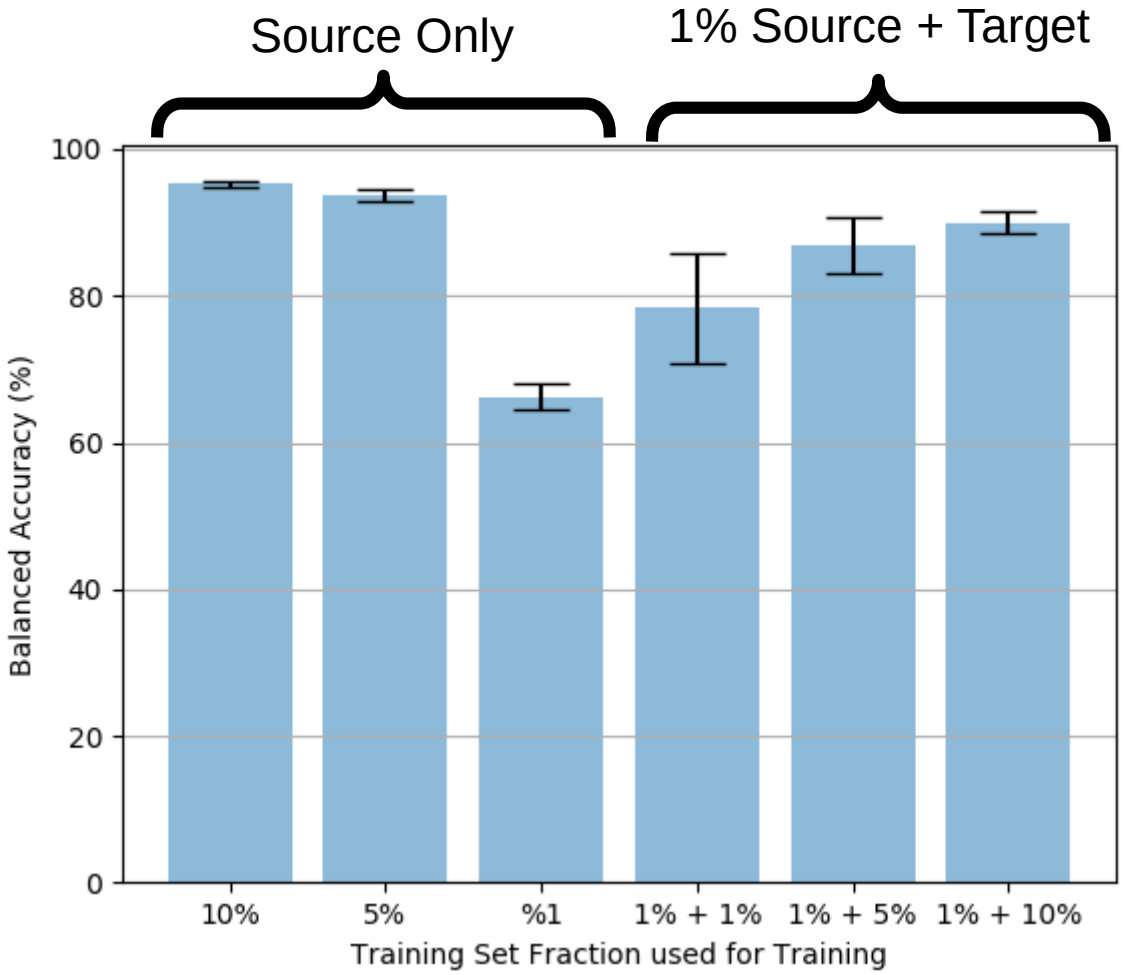


## Dimensionality Reduction Tool (Multi-dimensional Scaling)

Add this as an additional loss to minimize (instead of classification loss)

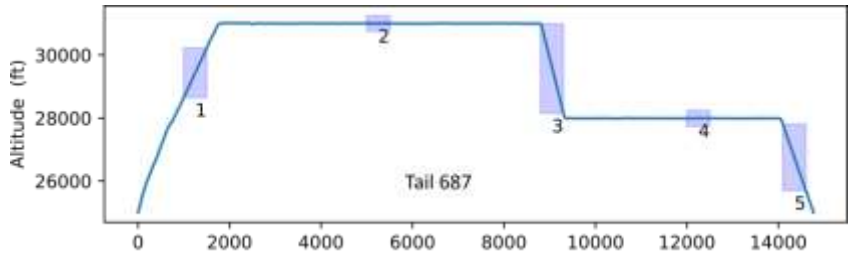
# Case Study – Anomalous Digit Detection on MNIST – MNIST-M


Main Class: 0
Anomalies: 1-9

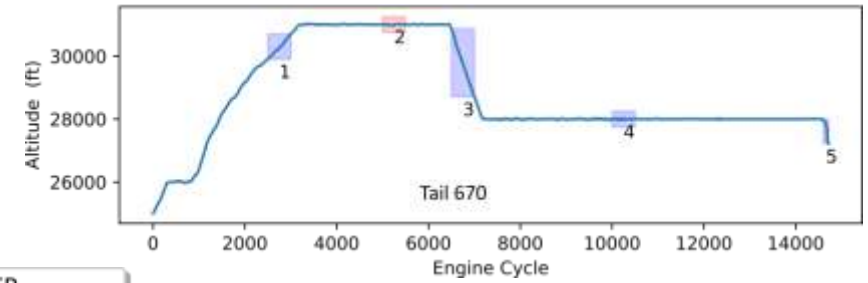


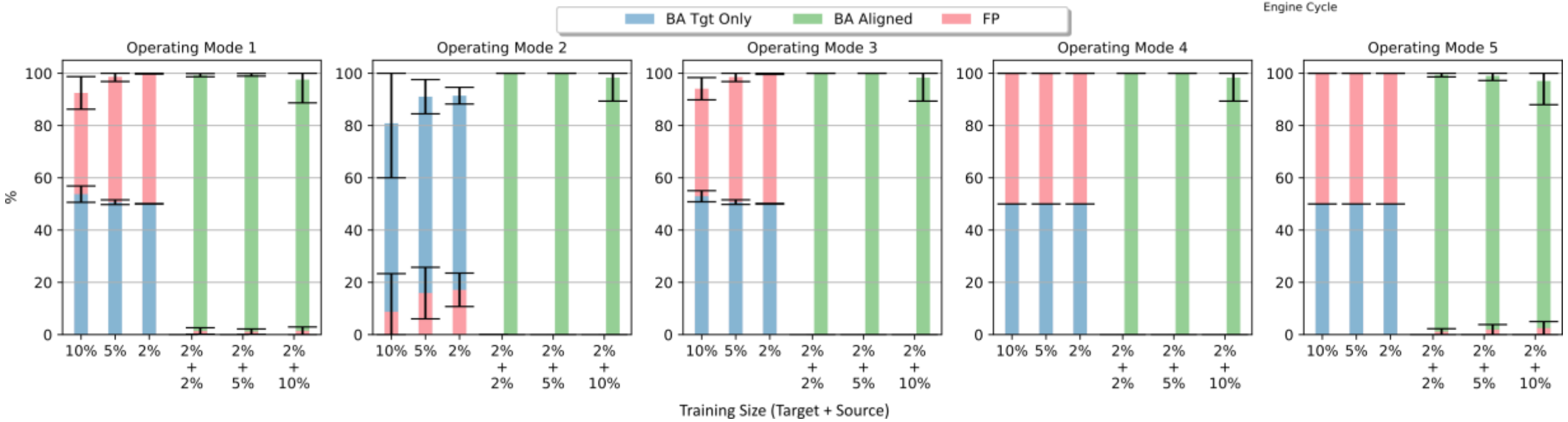
# Flight Engine Data Monitoring

Source




Target



# Thanks for your attention!