



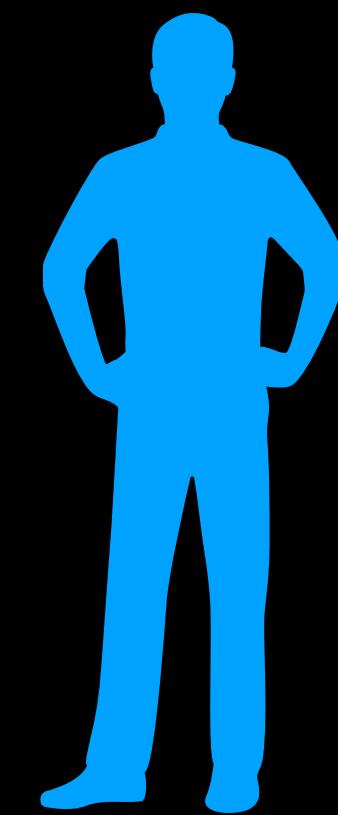
**DATA MASTERS**  
Predictive  
Maintenance

PREDICTIVE MAINTENANCE

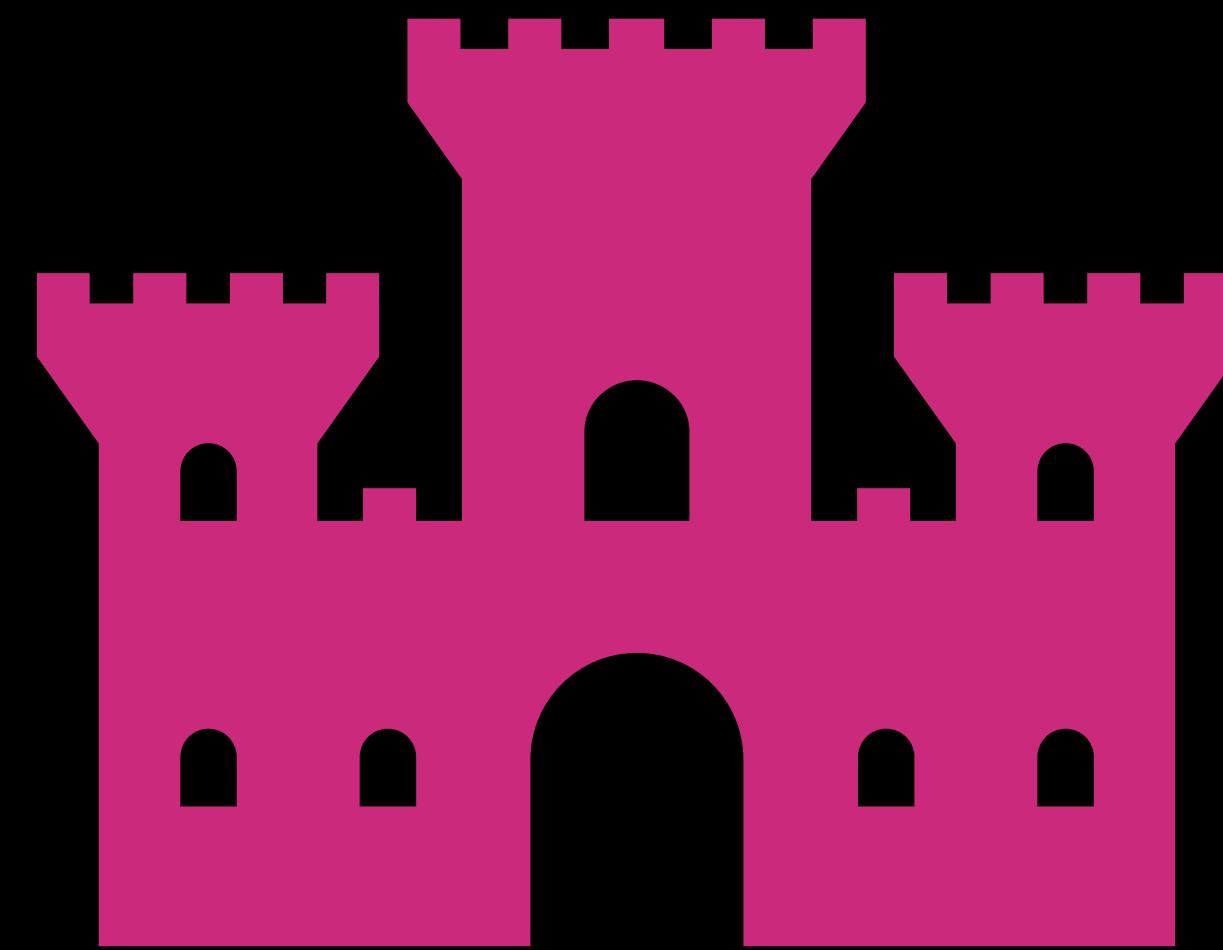
Why?

## PREDICTIVE MAINTENANCE

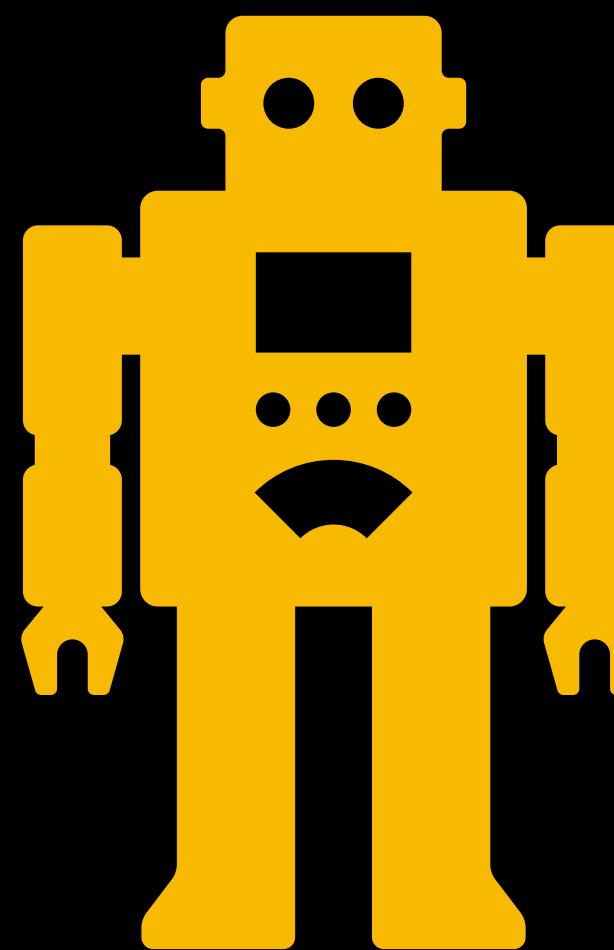
Why?



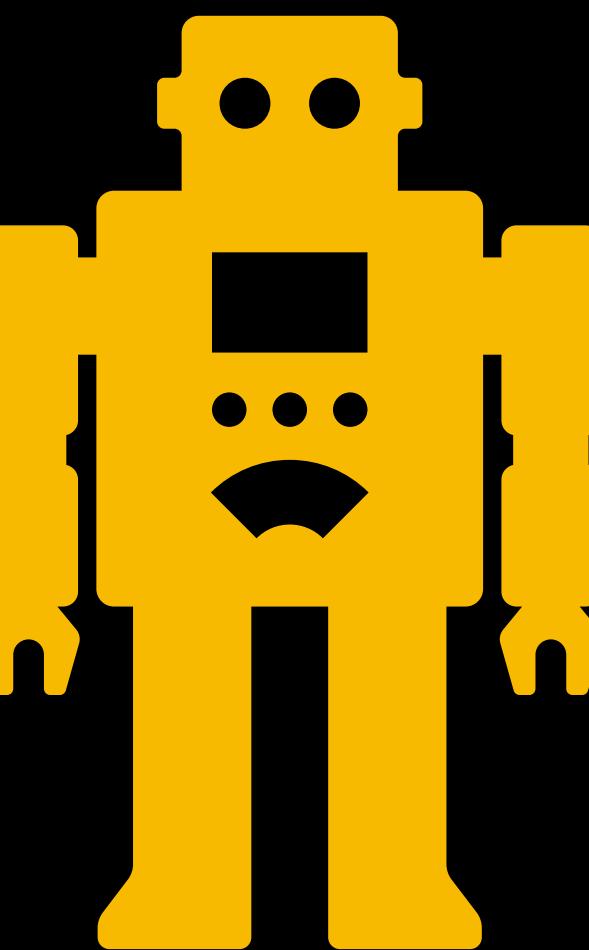
Mate



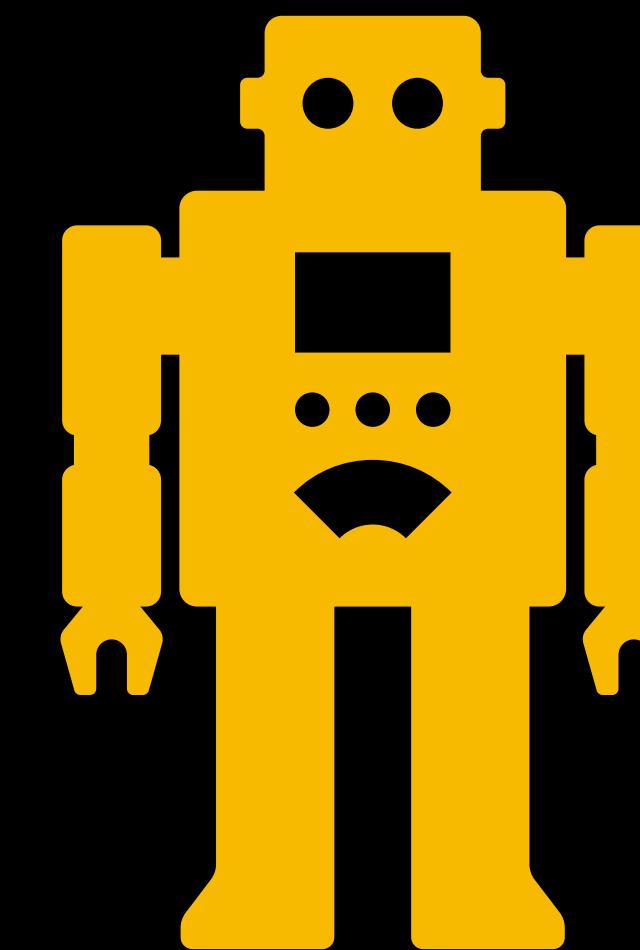
Warehouse



Forklift 1



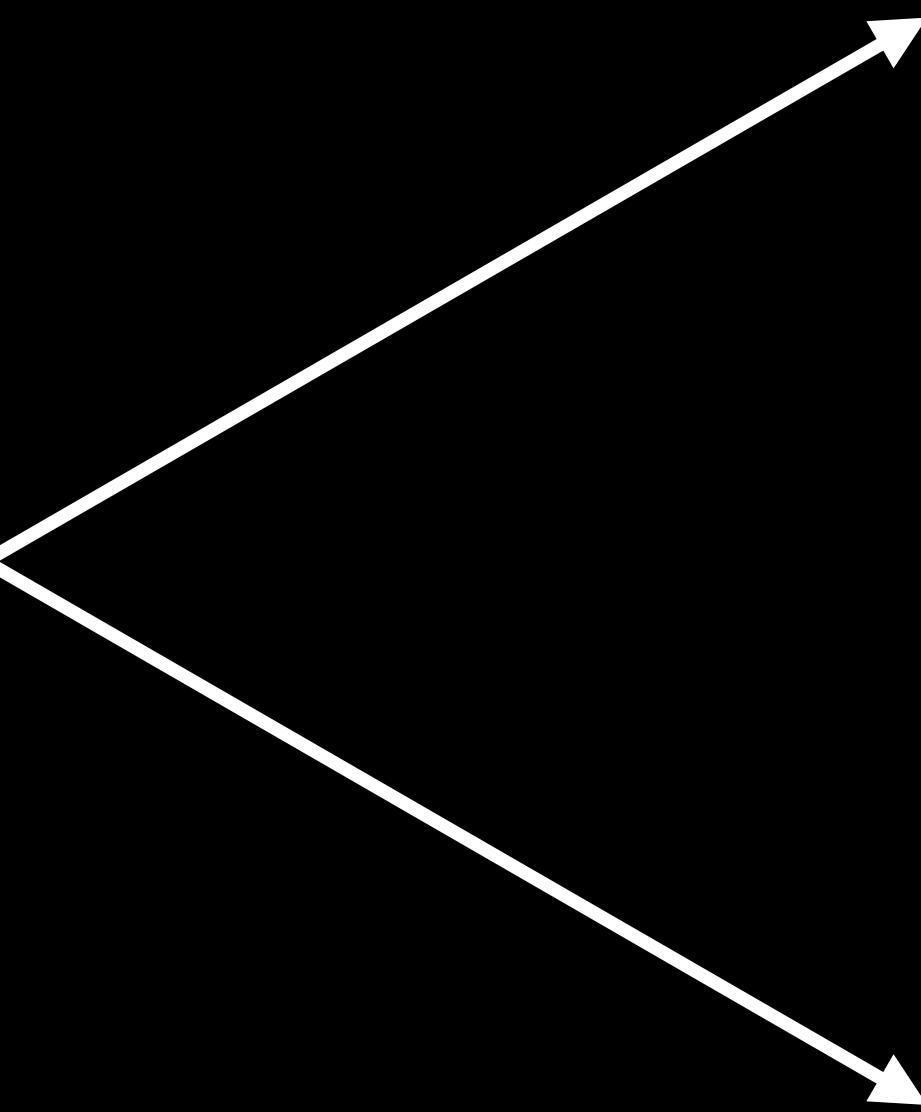
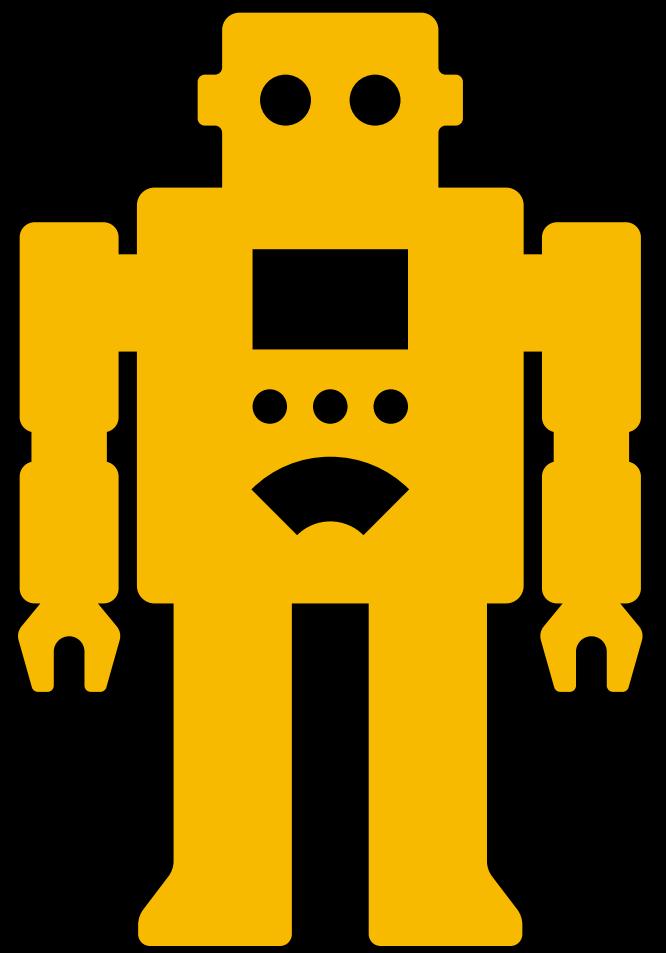
Forklift 2



Forklift 3

## PREDICTIVE MAINTENANCE

# Why?



### SERVICE

Too late  
- machine broke



### SERVICE

Too early  
- machine was fine

## PREDICTIVE MAINTENANCE

# Why?

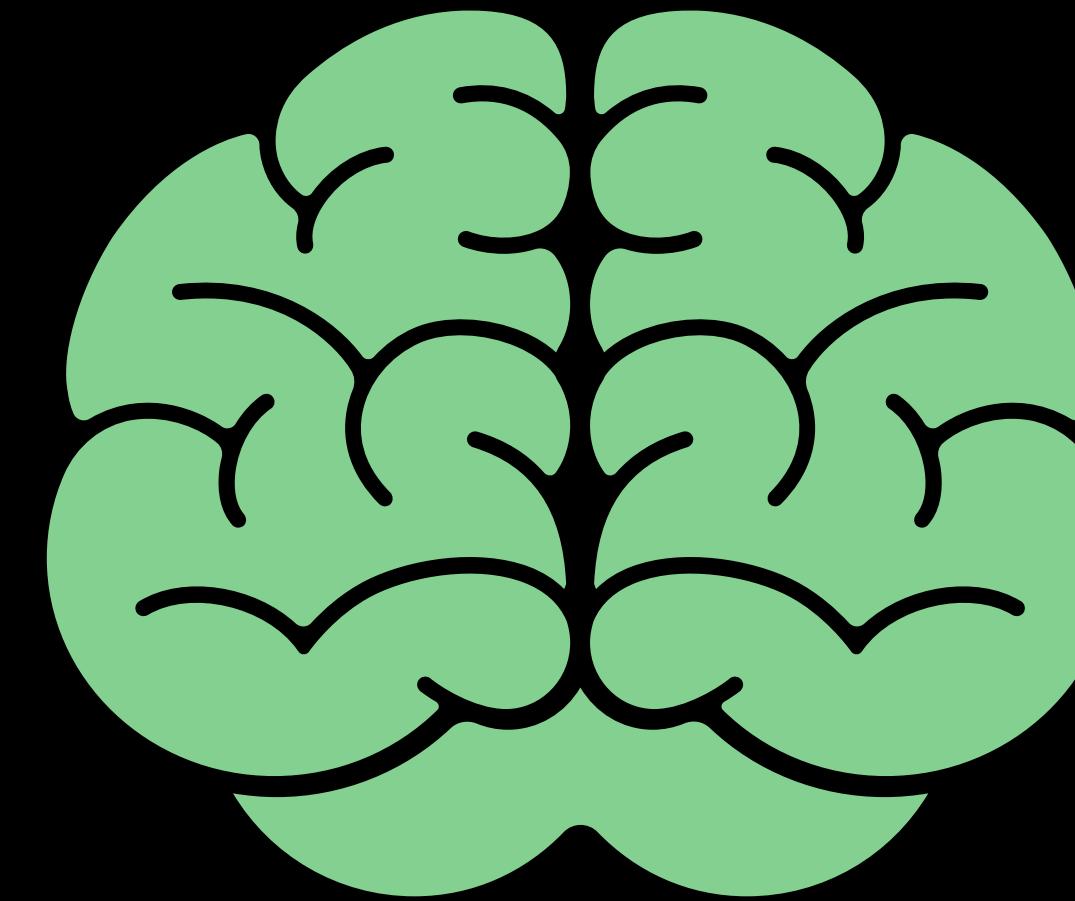
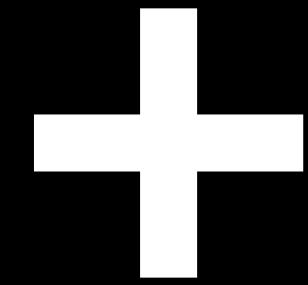
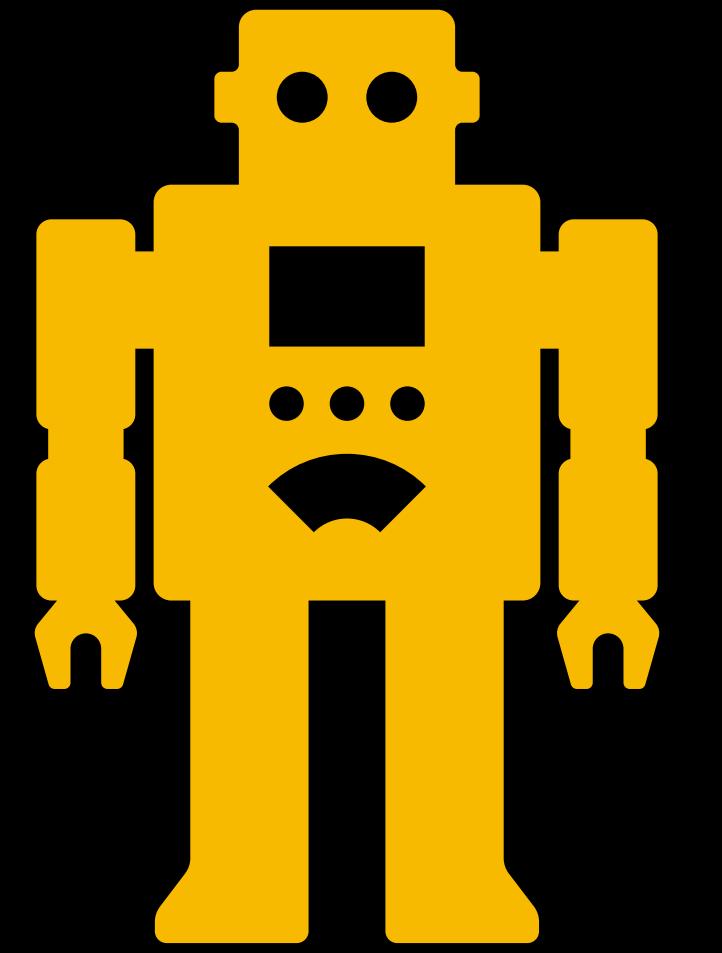


**EITHER WAY**  
**Costly**  
- unnecessary  
expenses



## PREDICTIVE MAINTENANCE

# Idea



## SENSORS

## Measurements

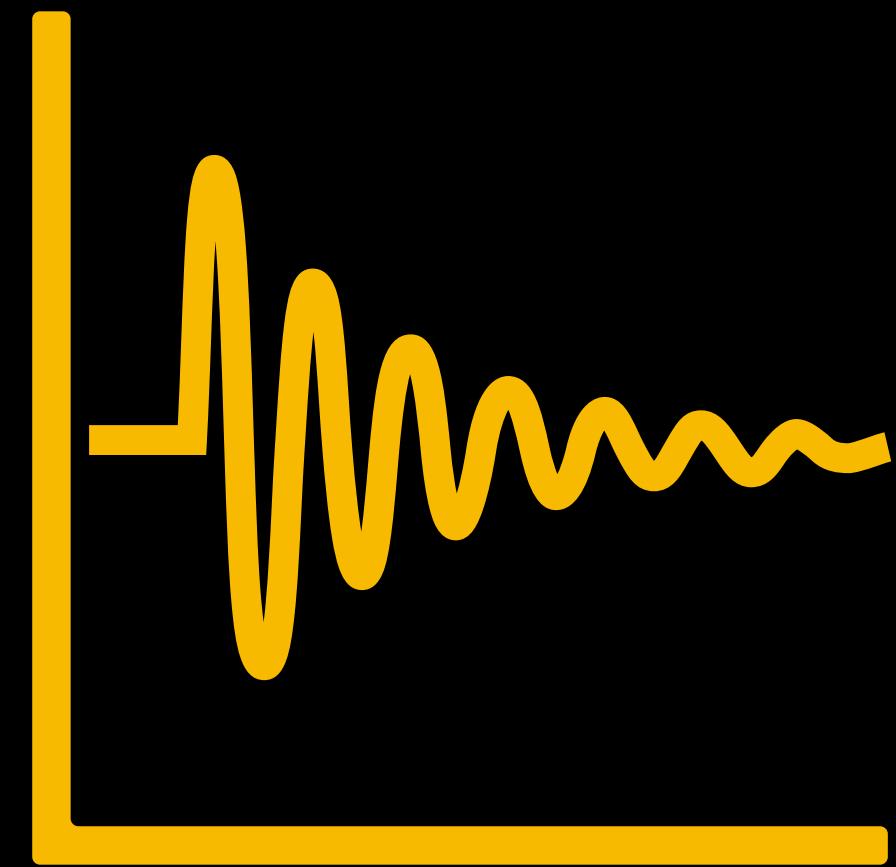
- have several sensors measure vibrations on the key components of the forklift
- model which analyzes the data and tells us when the forklift needs to go into service

**PREDICTIVE MAINTENANCE**

# Procedure

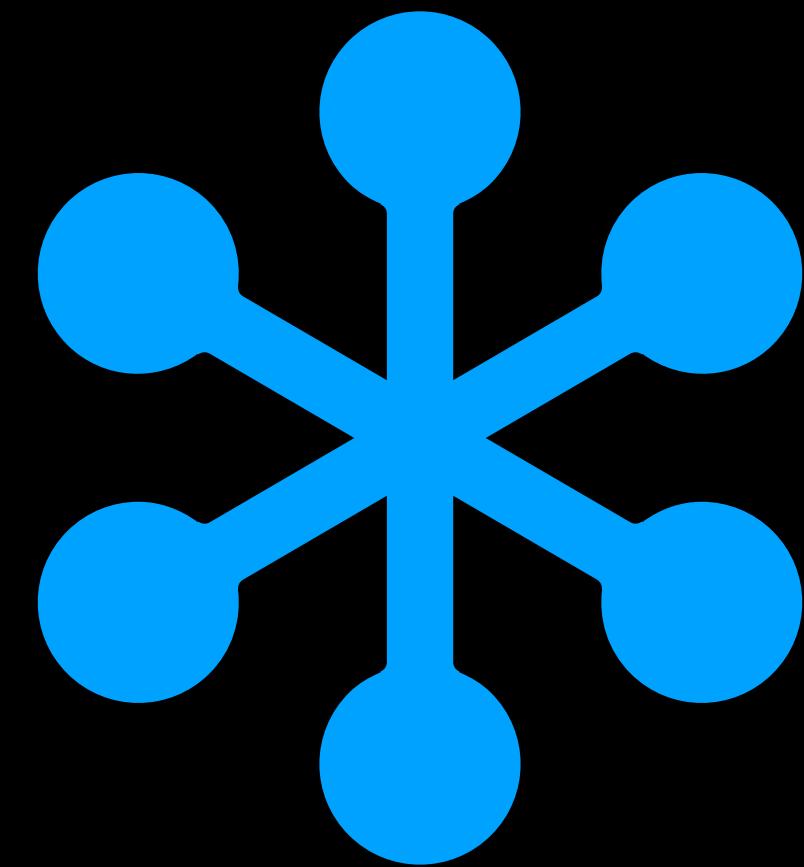
## PREDICTIVE MAINTENANCE

# Procedure



**STEP #1**

Data analysis



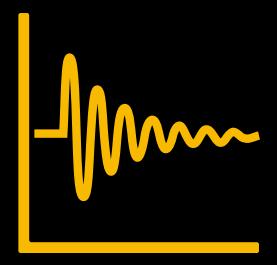
**STEP #2**

Modeling



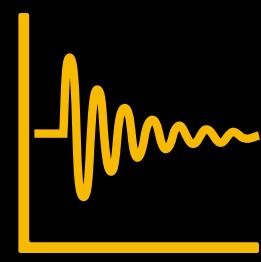
**STEP #3**

Evaluation



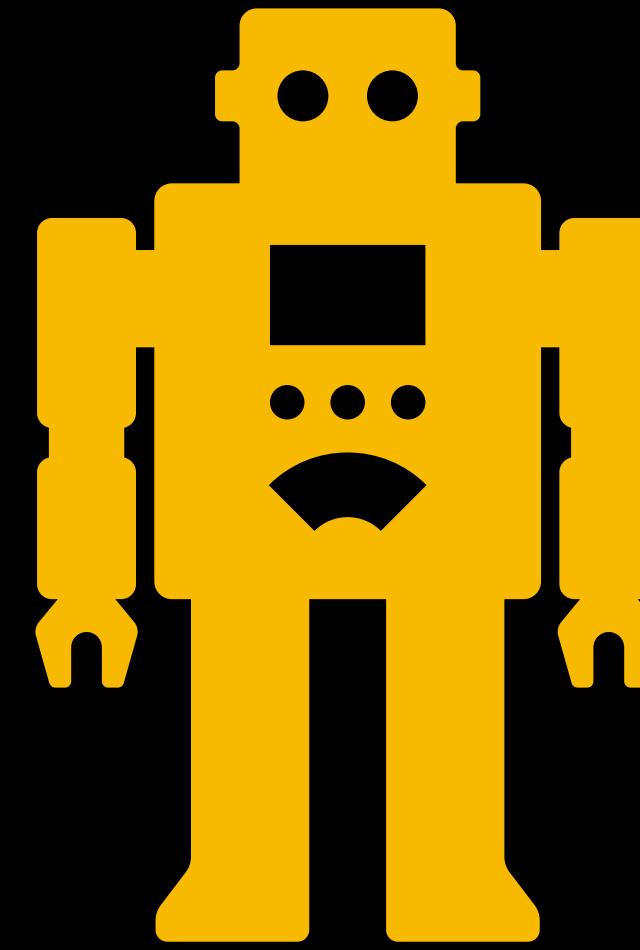
PREDICTIVE MAINTENANCE

# Overview



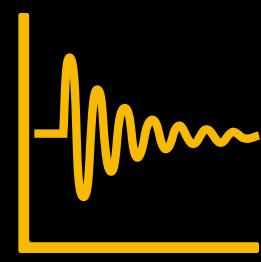
## PREDICTIVE MAINTENANCE

# Overview



### SENSORS

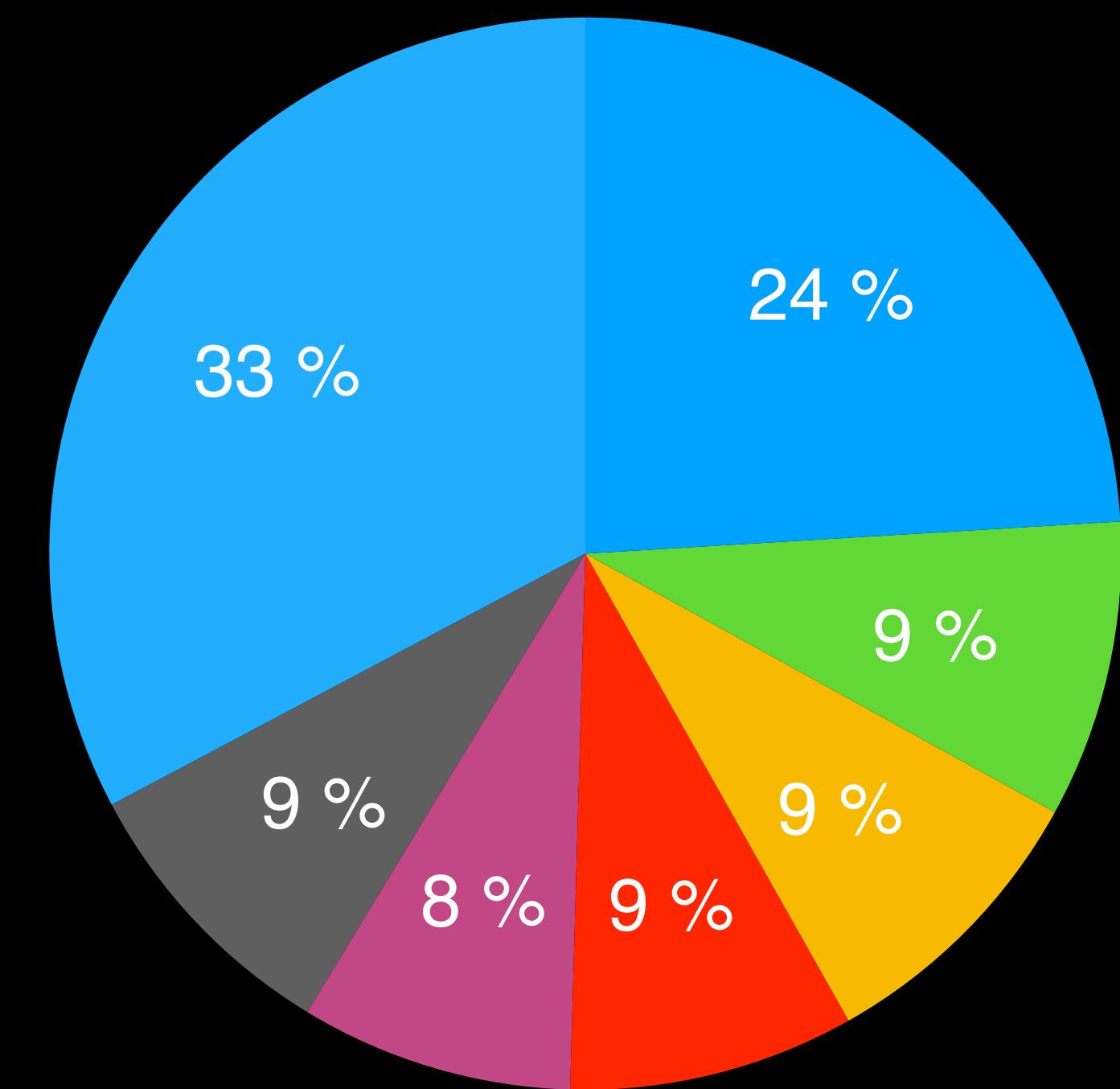
- Lifting motor
- Lifting gear
- Drive motor
- Drive gear
- Drive wheel
- Idle wheel

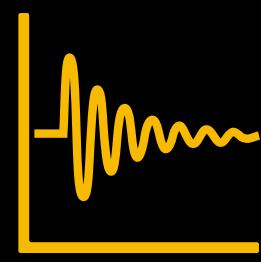


PREDICTIVE MAINTENANCE

# Distribution of data points

● FL01 ● FL02 ● FL03 ● FL04 ● FL05  
● FL06 ● FL07

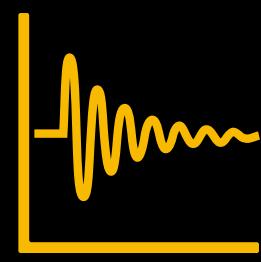




PREDICTIVE MAINTENANCE

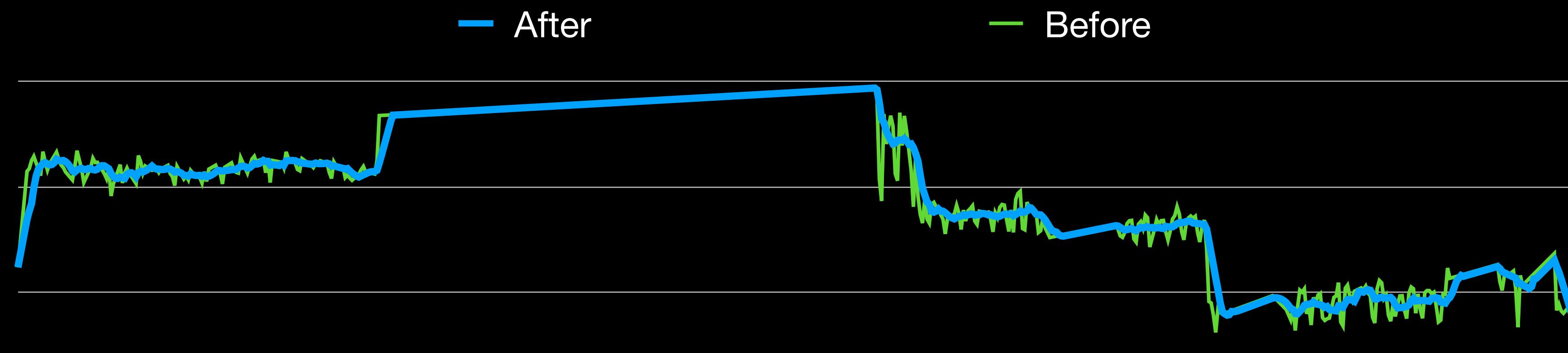
# FL01 sensor graph





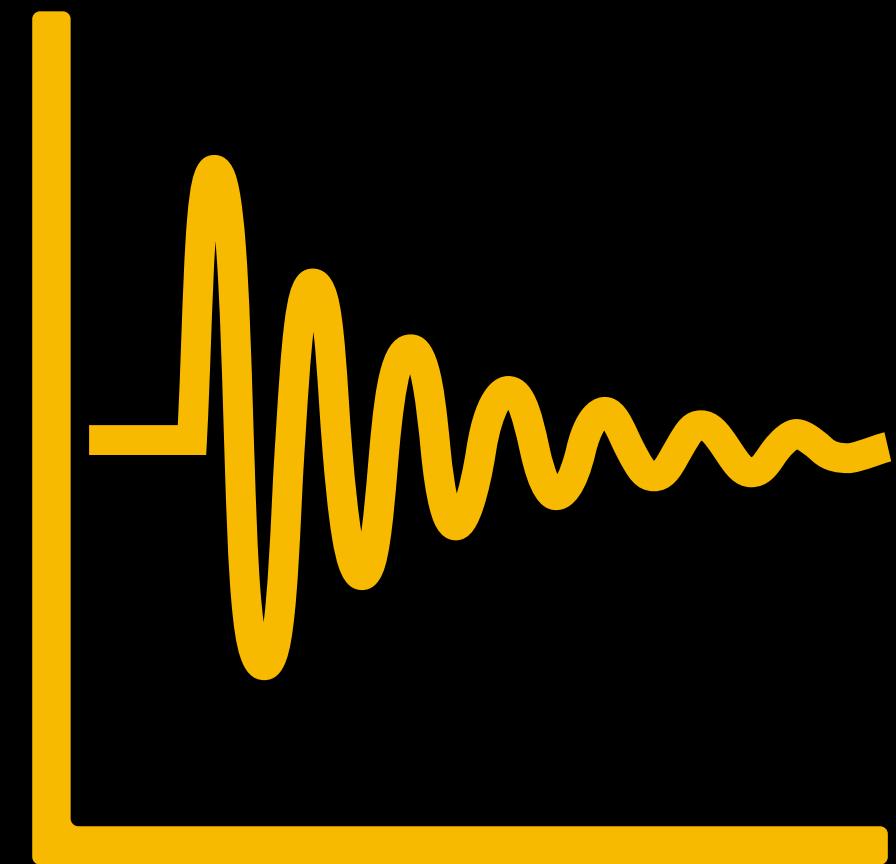
PREDICTIVE MAINTENANCE

# Rolling mean transformation



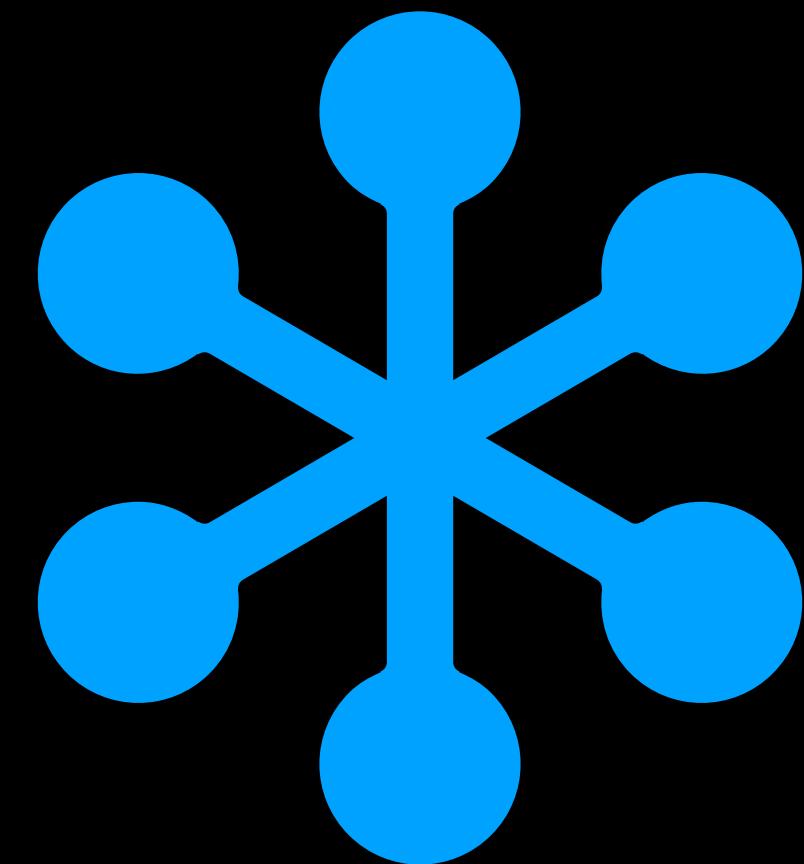
## PREDICTIVE MAINTENANCE

# Procedure



**STEP #1**

Data analysis



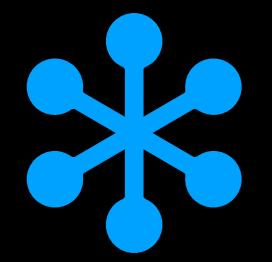
**STEP #2**

Modeling

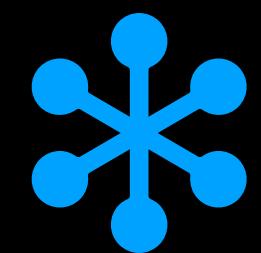


**STEP #3**

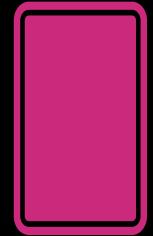
Evaluation



PREDICTIVE MAINTENANCE  
RNN



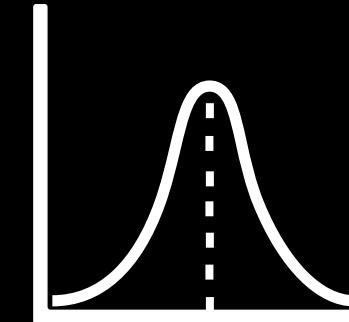
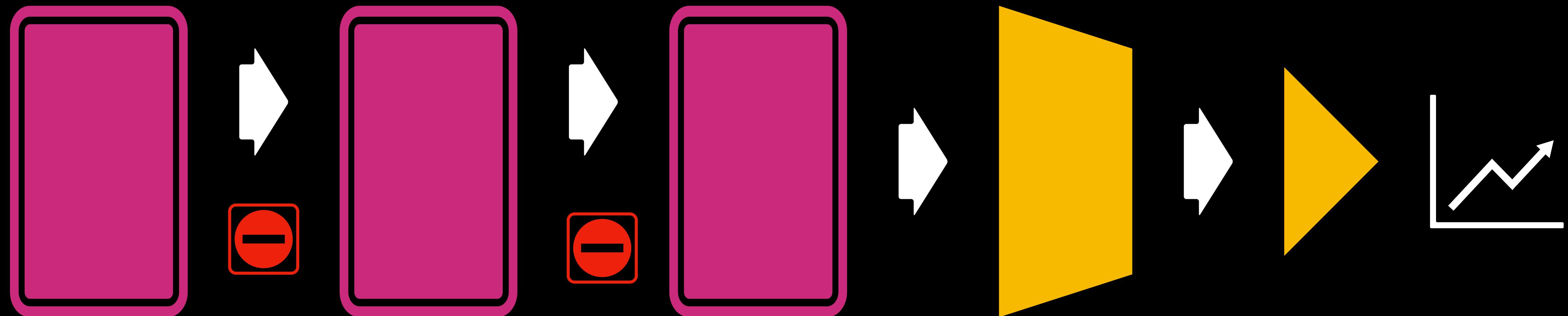
## PREDICTIVE MAINTENANCE RNN



DROPOUT

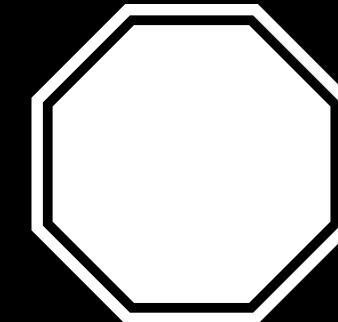
LSTM

DENSE



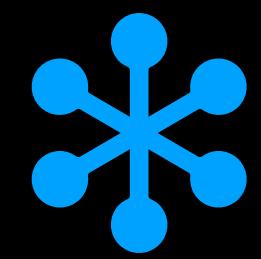
LOSS FUNCTION

Mean squared error



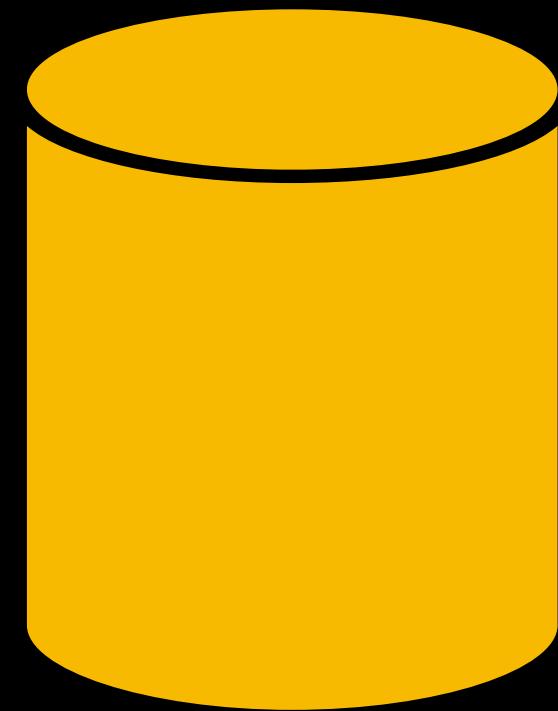
OPTIMIZER

Adam



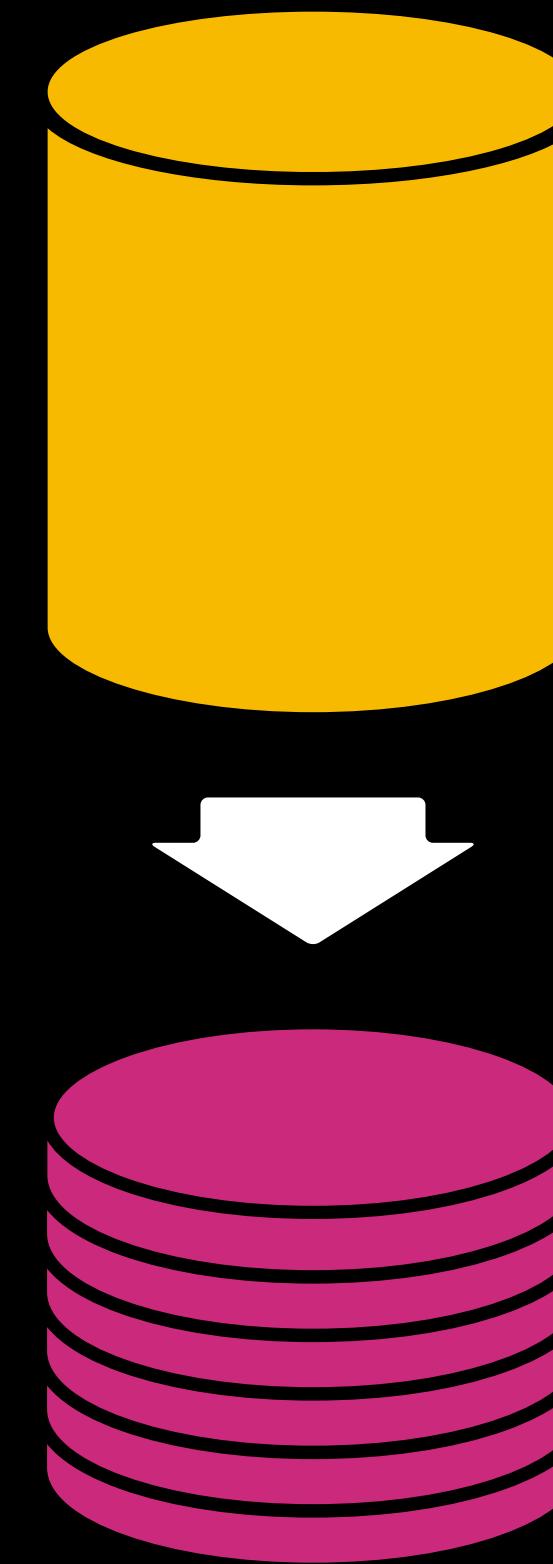
## PREDICTIVE MAINTENANCE

# Training paths



**PATH #1**

Per machine training

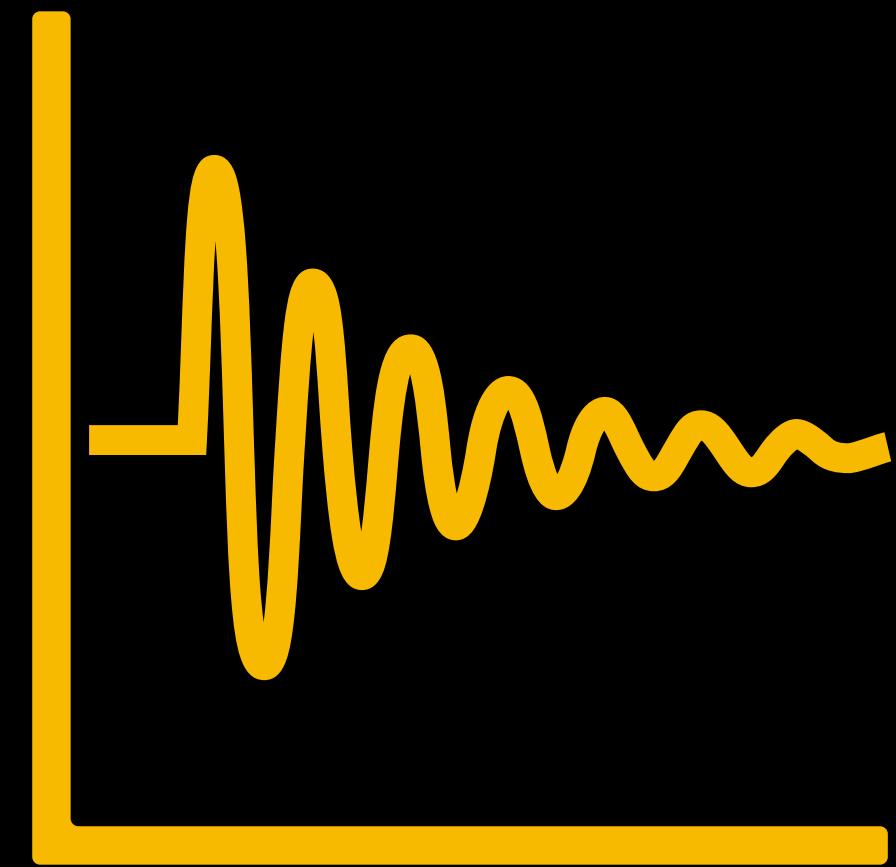


**PATH #2**

Transfer learning

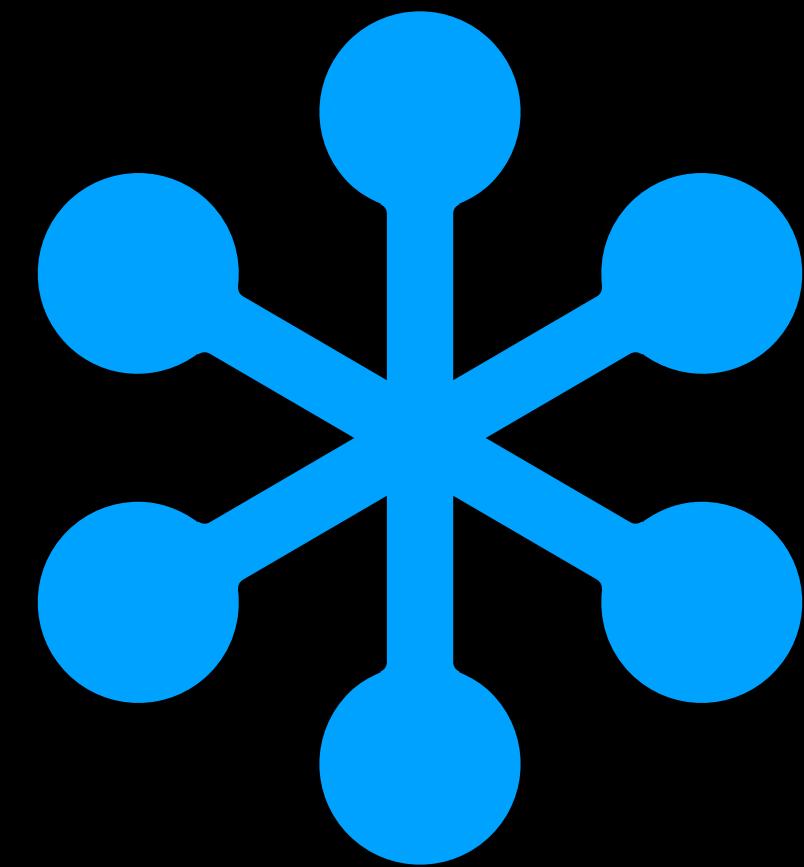
## PREDICTIVE MAINTENANCE

# Procedure



**STEP #1**

Data analysis



**STEP #2**

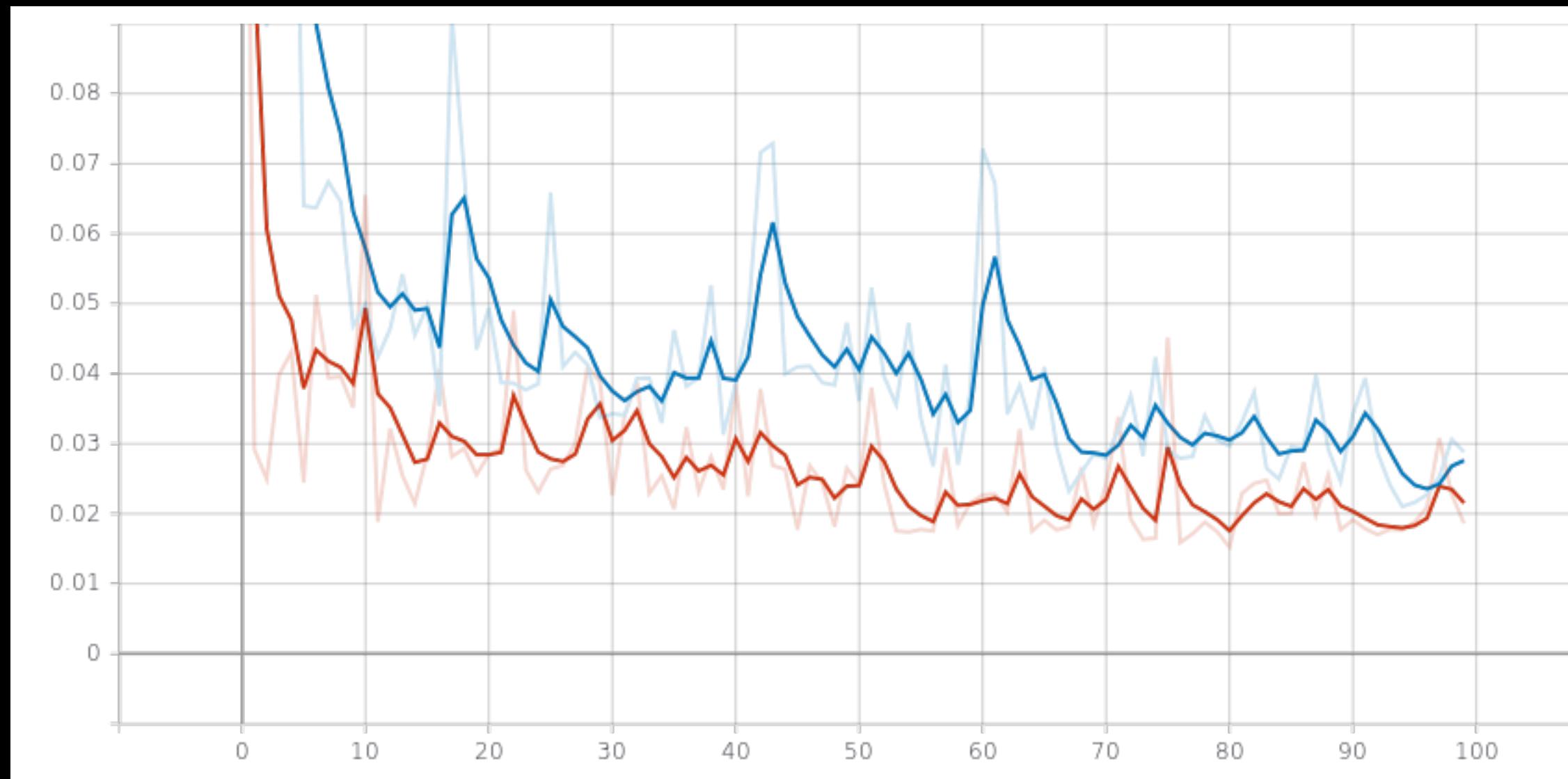
Modeling



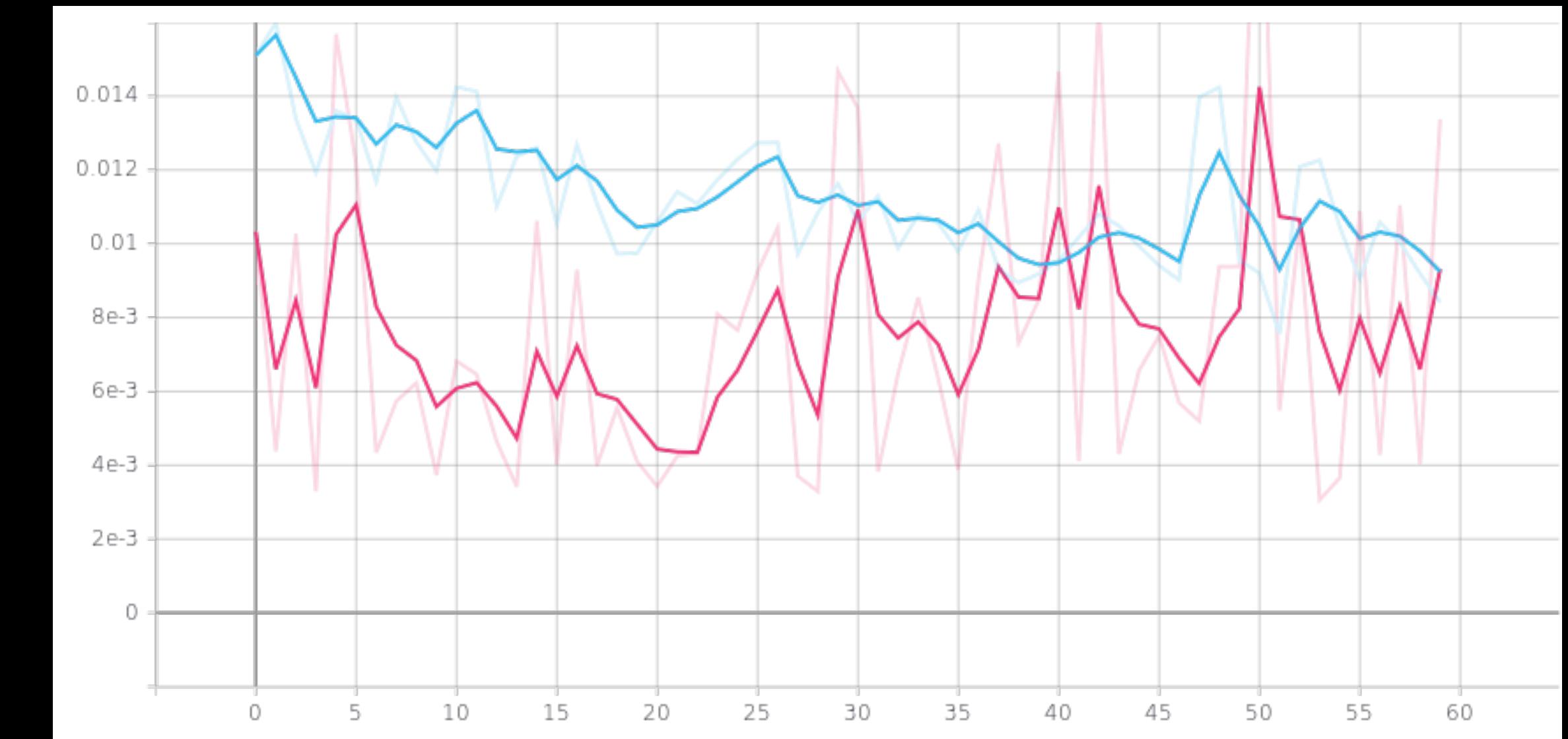
**STEP #3**

Evaluation

# PREDICTIVE MAINTENANCE Performance



**PATH #1**  
Per machine training

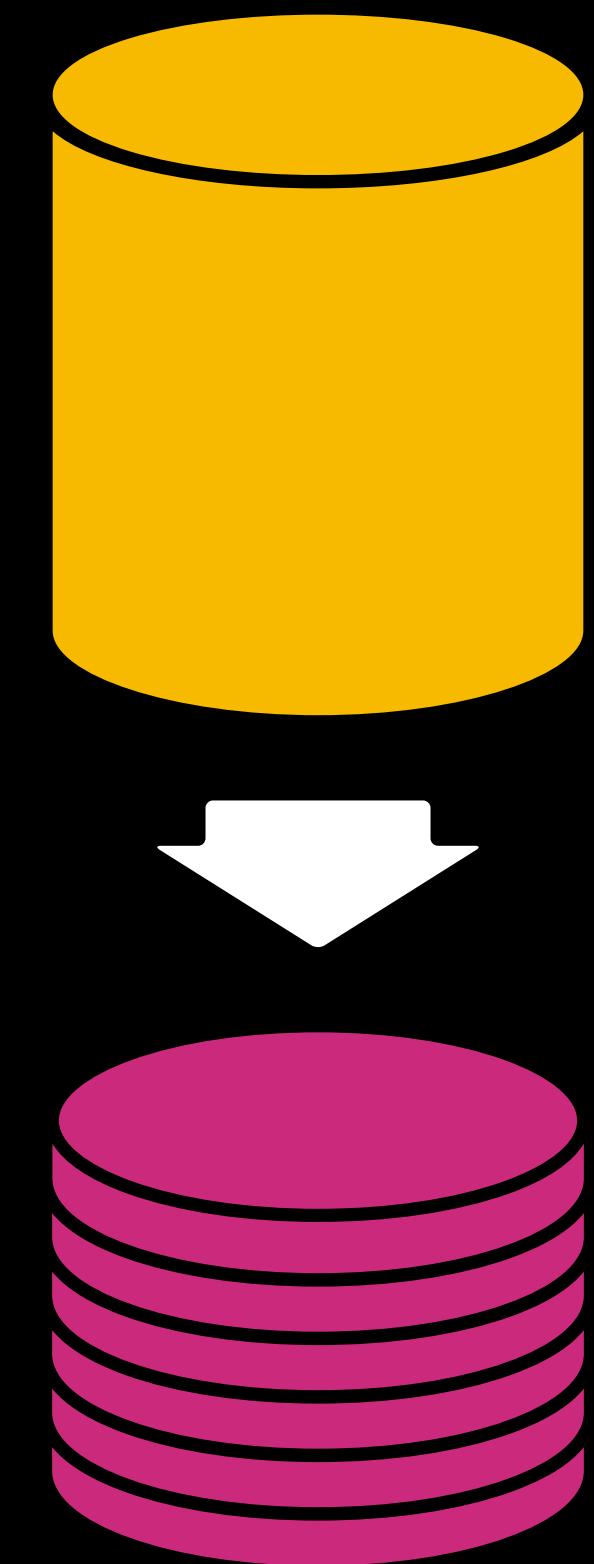


**PATH #2**  
Transfer learning



PREDICTIVE MAINTENANCE

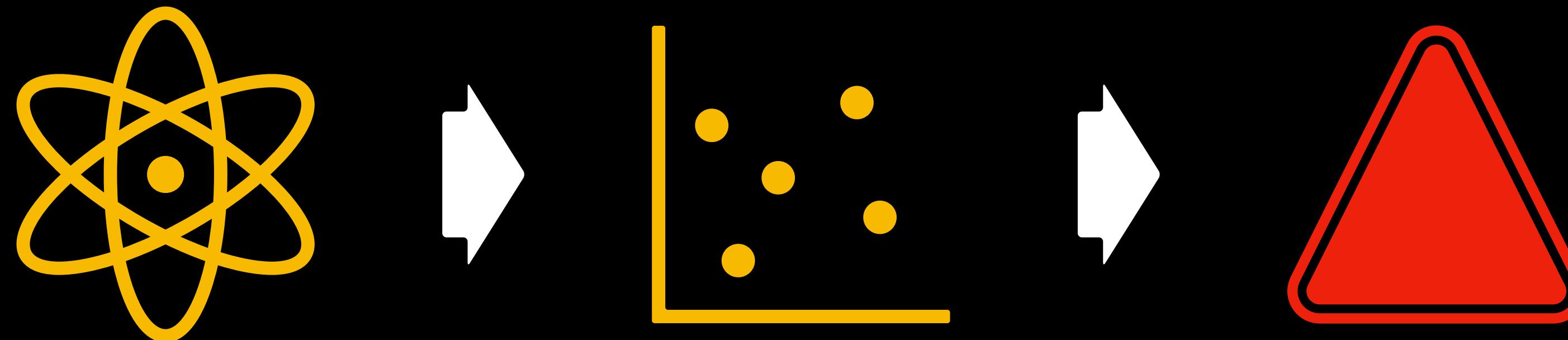
Approved model



PATH #2

Transfer learning

# ✓ PREDICTIVE MAINTENANCE Deployment



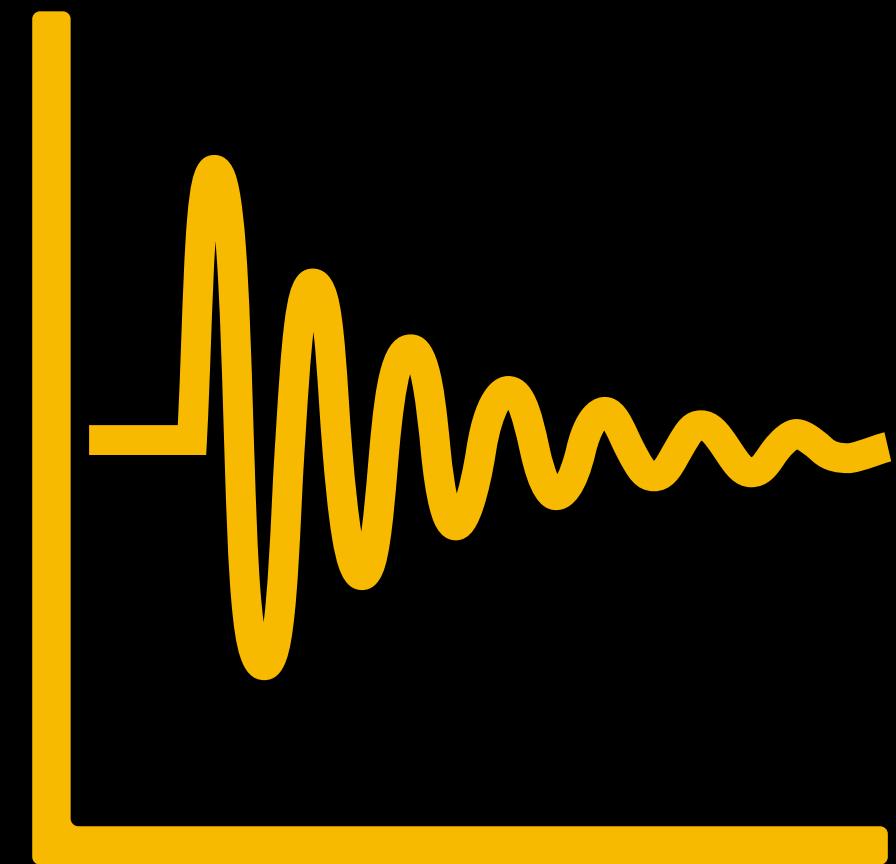
## DEPLOYMENT

The prediction error is above threshold:

- **something is not behaving correctly**

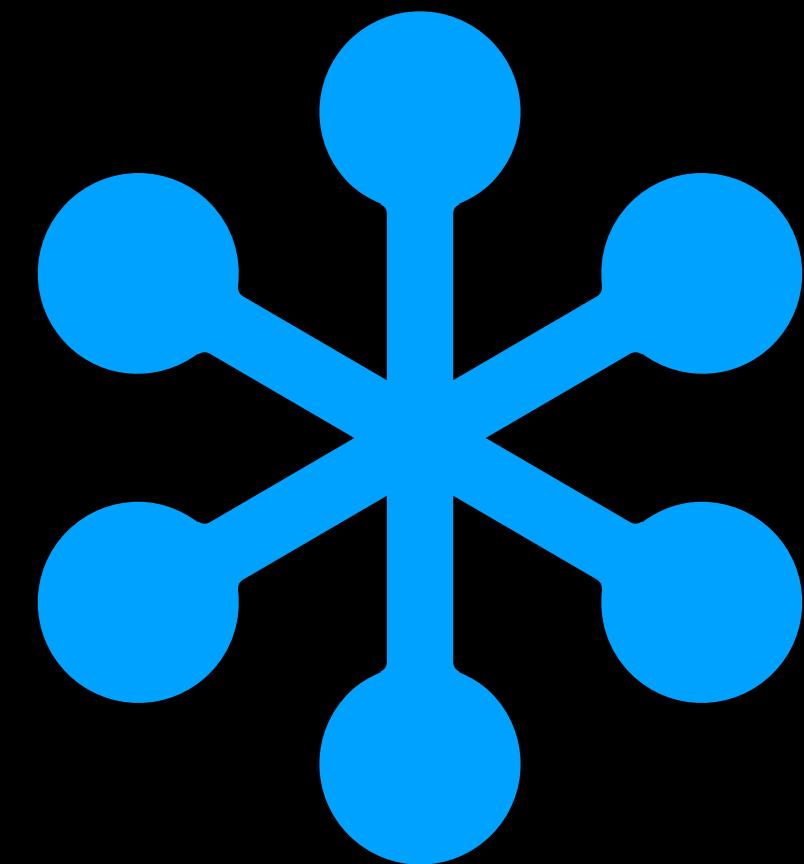
## PREDICTIVE MAINTENANCE

# Procedure



**STEP #1**

Data analysis



**STEP #2**

Modeling



**STEP #3**

Evaluation

“The alternative [to thinking ahead] would be to think backwards  
... and that's just remembering.”

—Sheldon, the theoretical physicist on **The Big Bang Theory**

