

# Digital Twins for Electric Power Utilities

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# Five Levels of Digital Twins

- **Level 1: Virtual Twin**

A physically accurate realistic digital representation of an asset, facility, or product that emulates its real-world counterpart



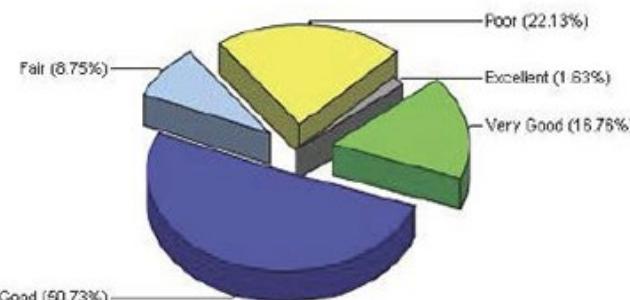
# Five Levels of Digital Twins

- **Level 2: Connected Twin**

Integrates real-time and right-time data to provide insights into the performance of an asset at specific points in time

Roof Condition Index (RCI)		Estimated Area (sf)	Percentage of Total
100	Excellent	5,135	1.63%
85	Very Good	52,920	16.76%
70	Good	160,195	50.73%
50	Fair	27,640	8.75%
30	Poor	69,880	22.13%
Total Estimated Area (sf)		315,770	100%

Executive Roof Condition Index

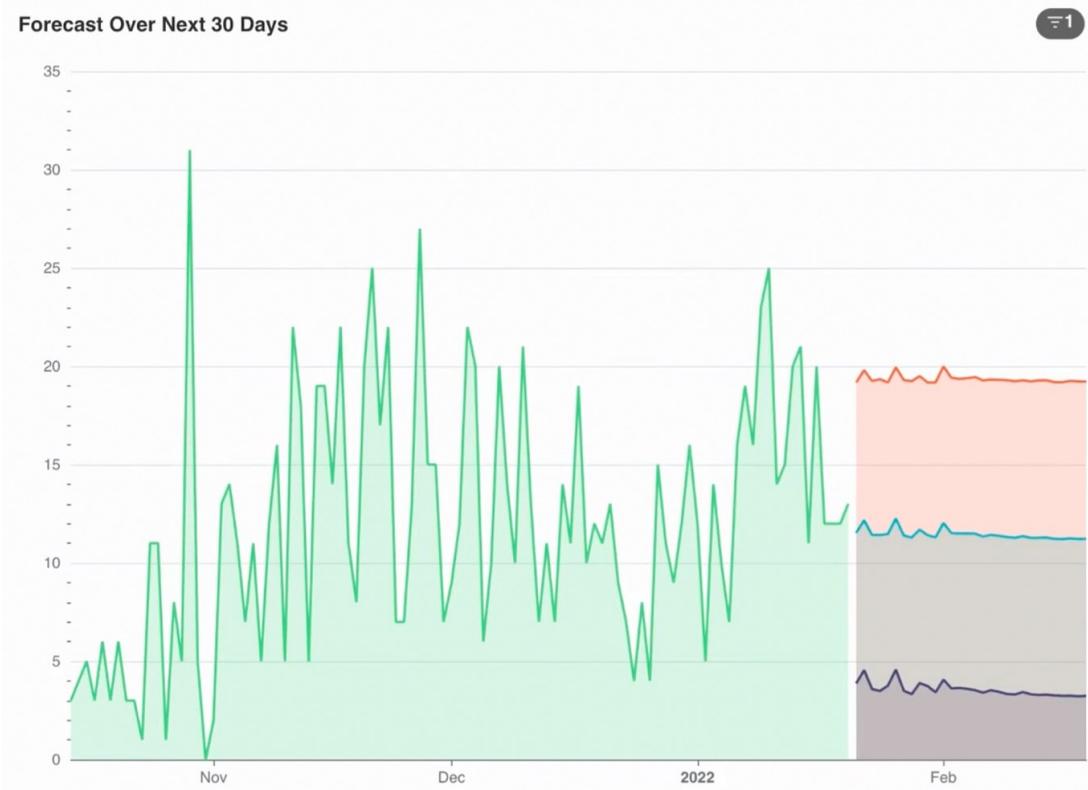


- Elizabeth Baron

# Five Levels of Digital Twins

- **Level 3: Predictive Twin**

Leverages data to predict unmeasured quantities and future states based on historical data and calibrated physics-based models

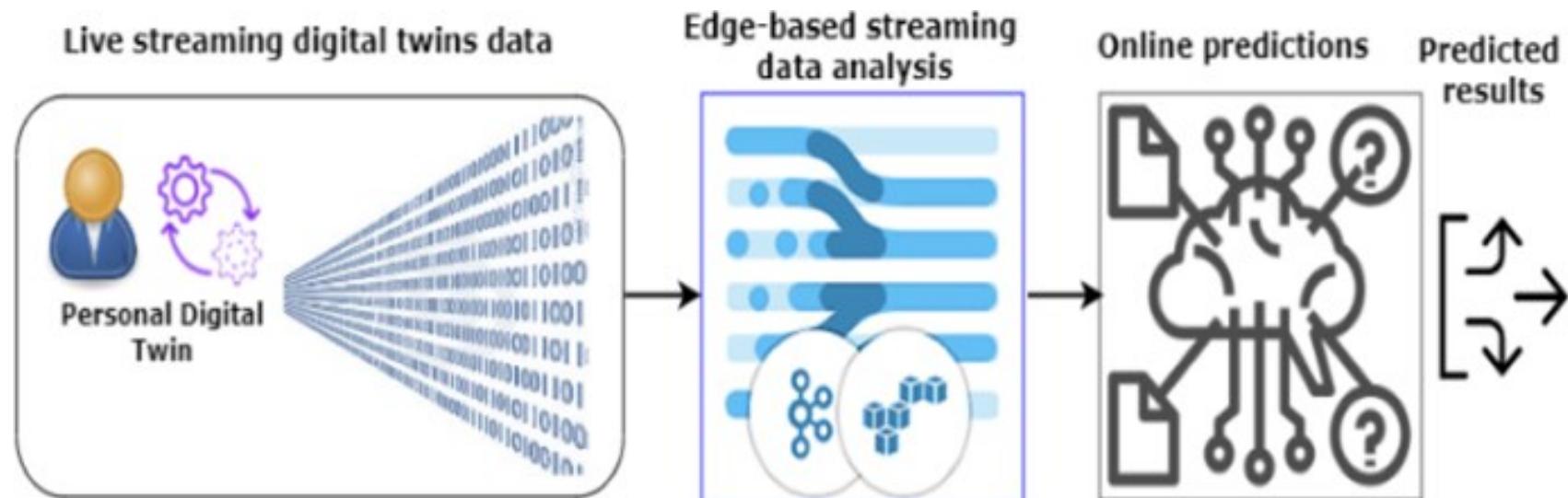


- Elizabeth Baron

# Five Levels of Digital Twins

- **Level 4: Prescriptive Twin**

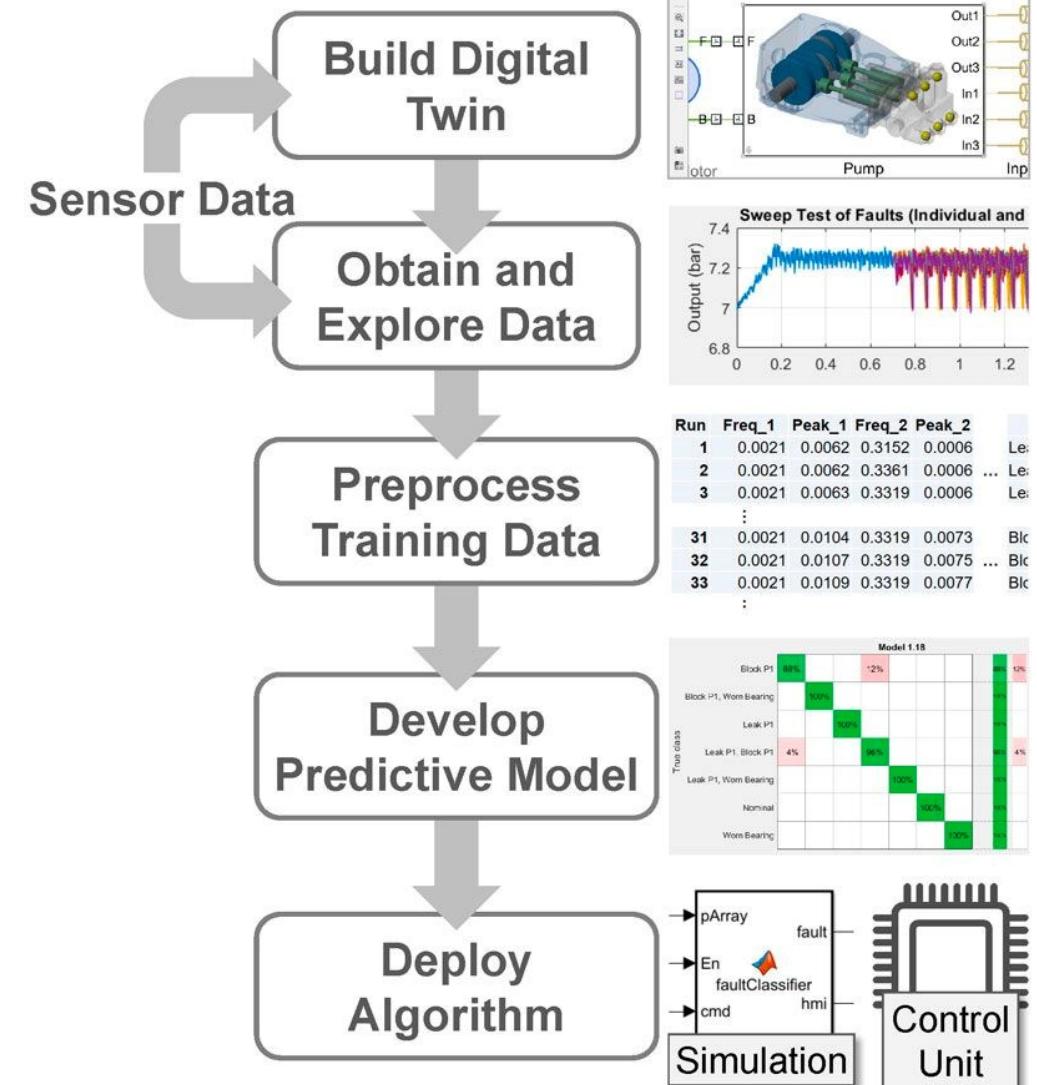
Leverages advanced modeling and real-time simulation for potential future scenarios as well as prescriptive analytics and recommendations



# Five Levels of Digital Twins

- **Level 5: Autonomous Twin**

Uses multiple real-time data feeds to learn and make decisions to correct issues automatically and enable predictive and prescriptive analytics



# Project 1 Introduction

- Topic: **LiDAR Scanning and Imaging for Hydropower Turbine Condition Assessment**
- Dataset: LiDAR point cloud & 360 images
- Remote inspection/monitor degradation
- LiDAR:
  - Real Dimension
  - Depth information
- 360 Image:
  - High resolution
  - Good for Documentation (inspection log)

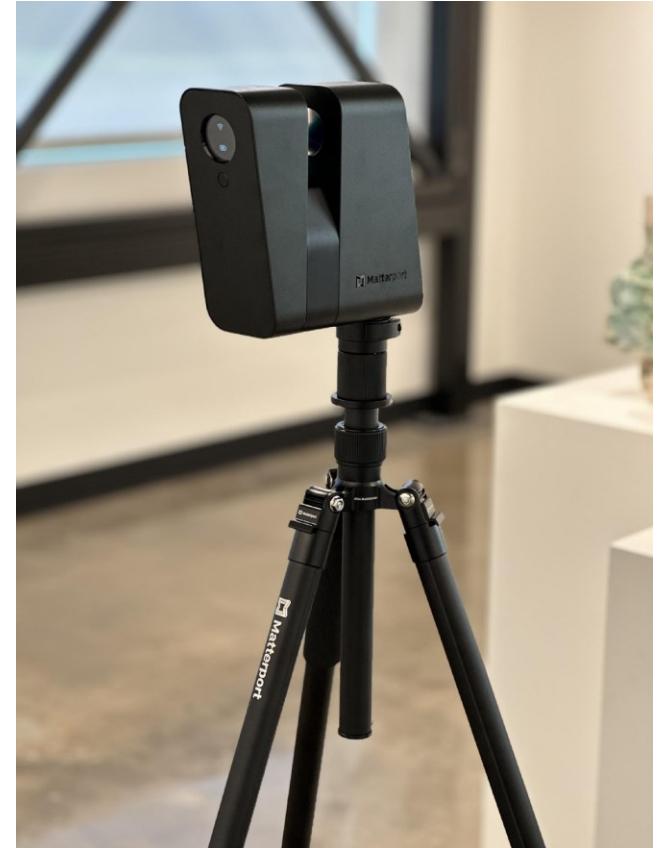
# Data Collection Equipment



FARO Scanner



Titan 360 Camera



Matterport Pro 3

# Data Collection & Registration

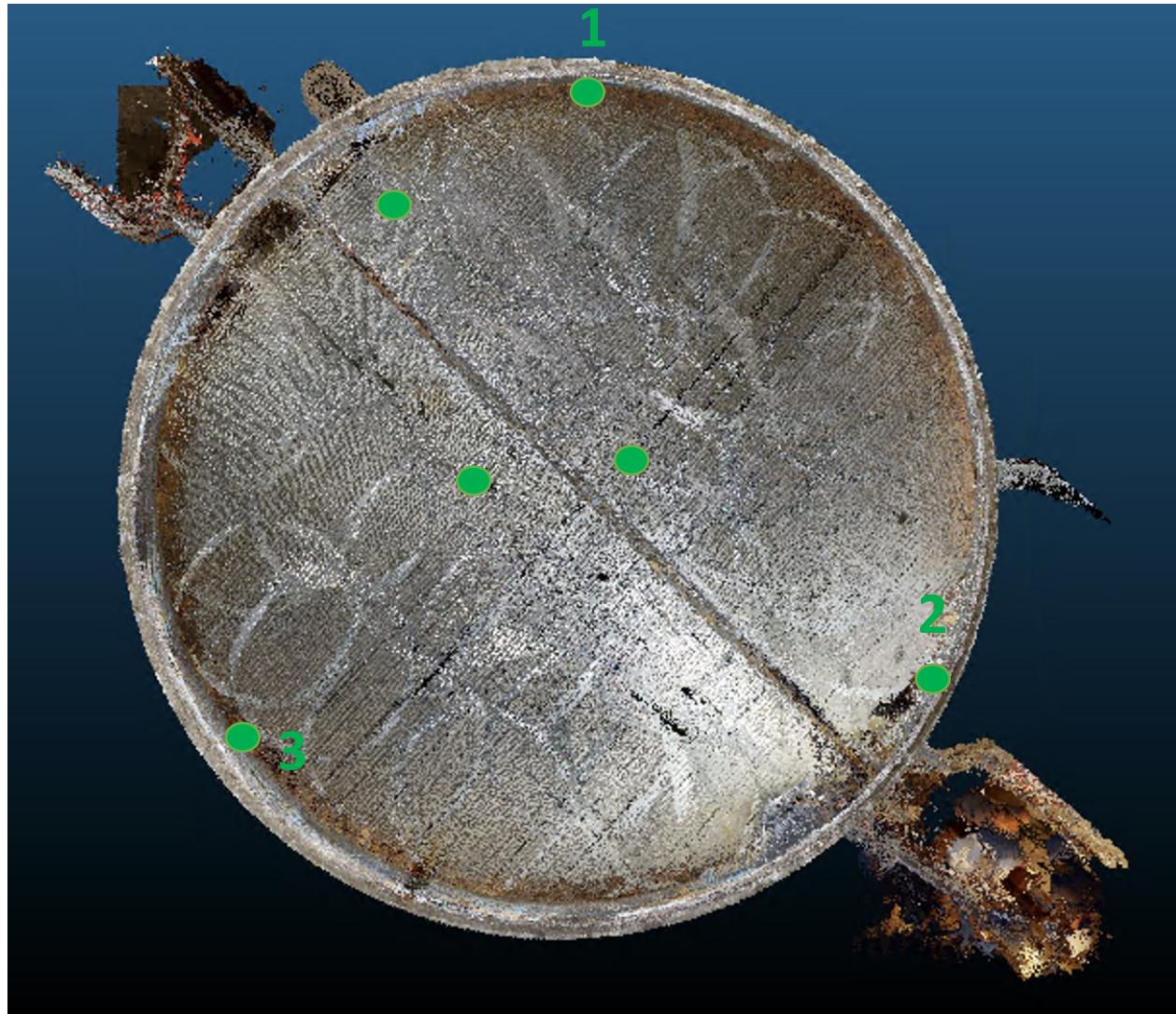


Top-down view

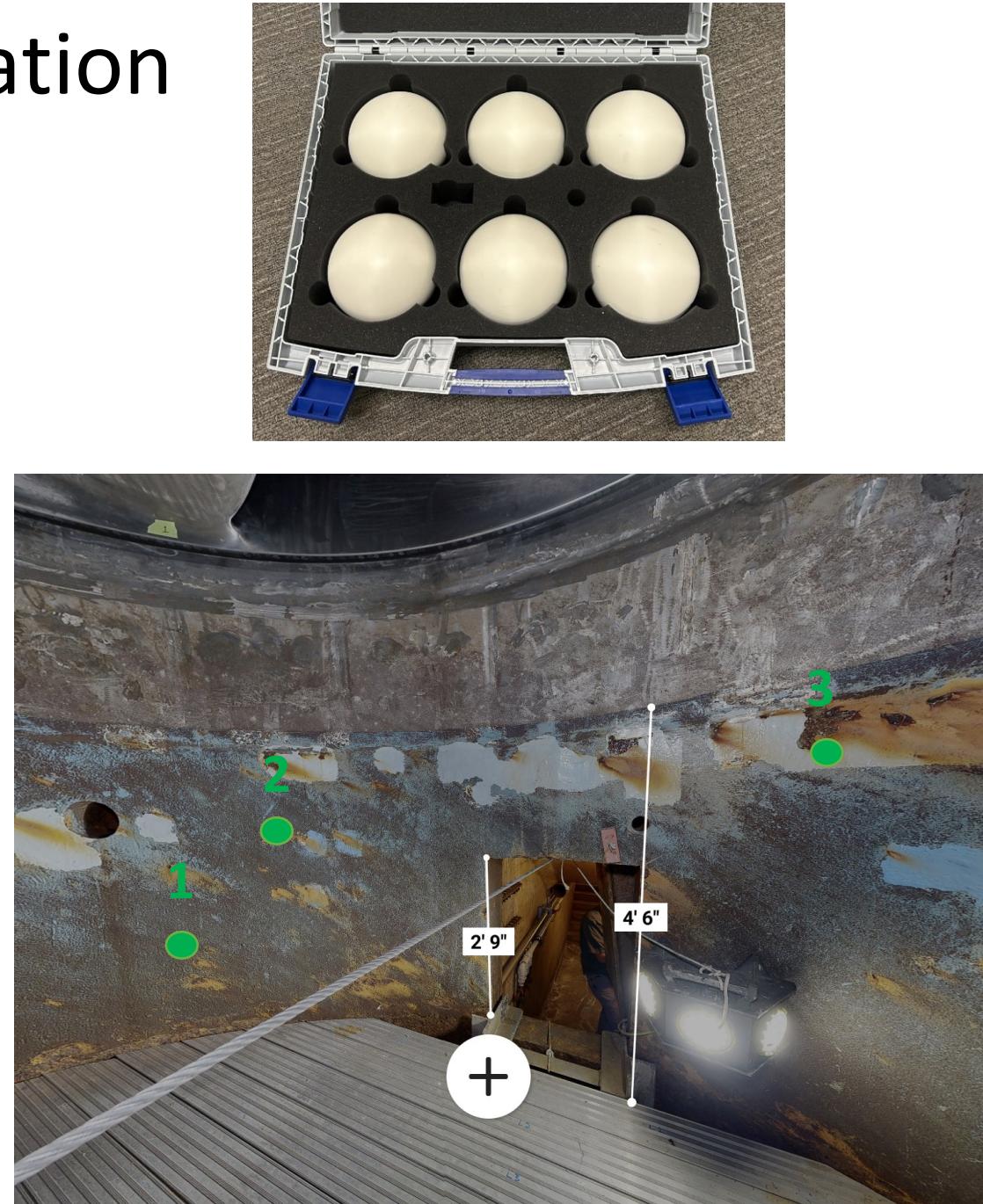


Bottom-up view

# Place Targets for Later Registration

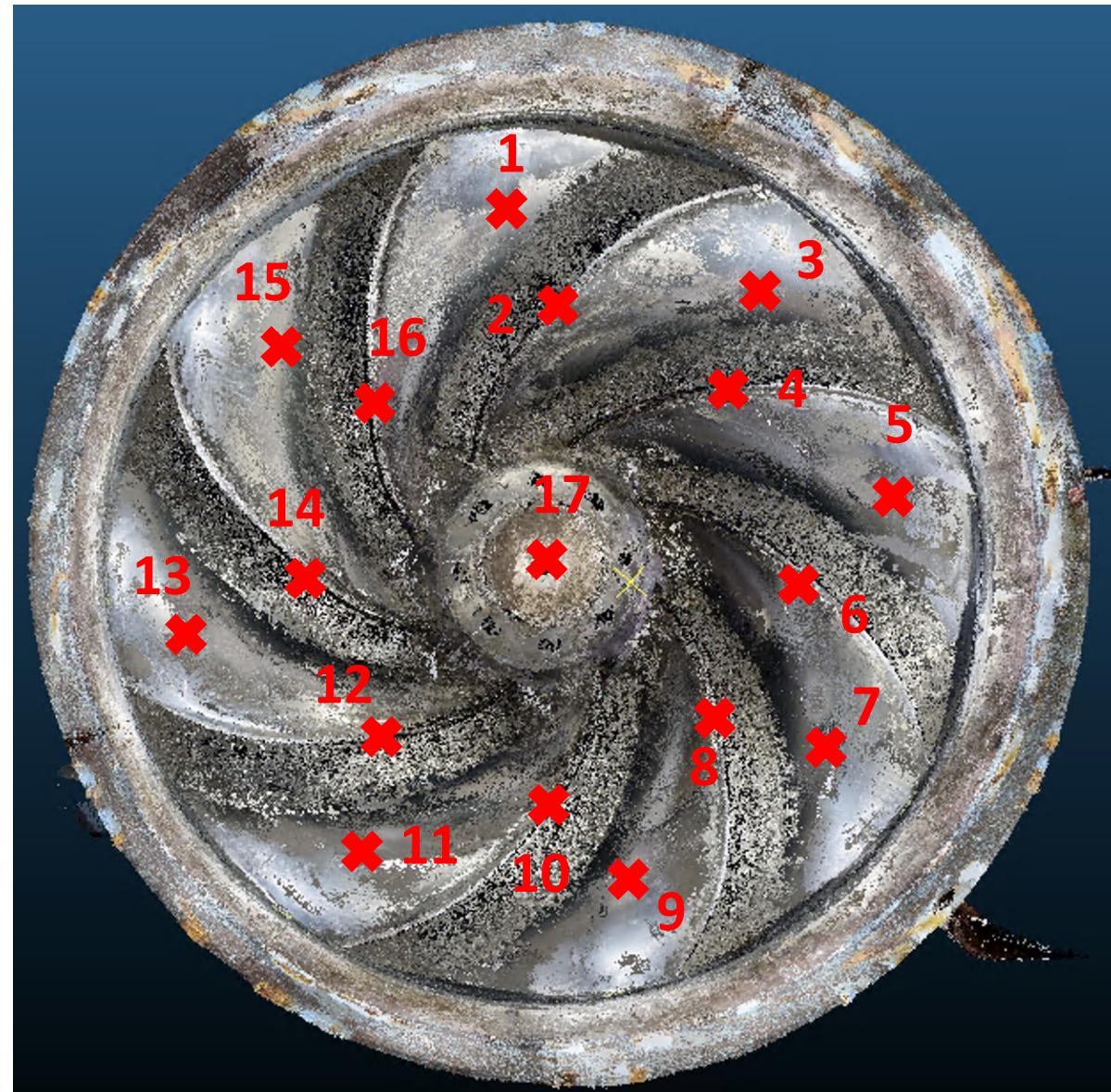
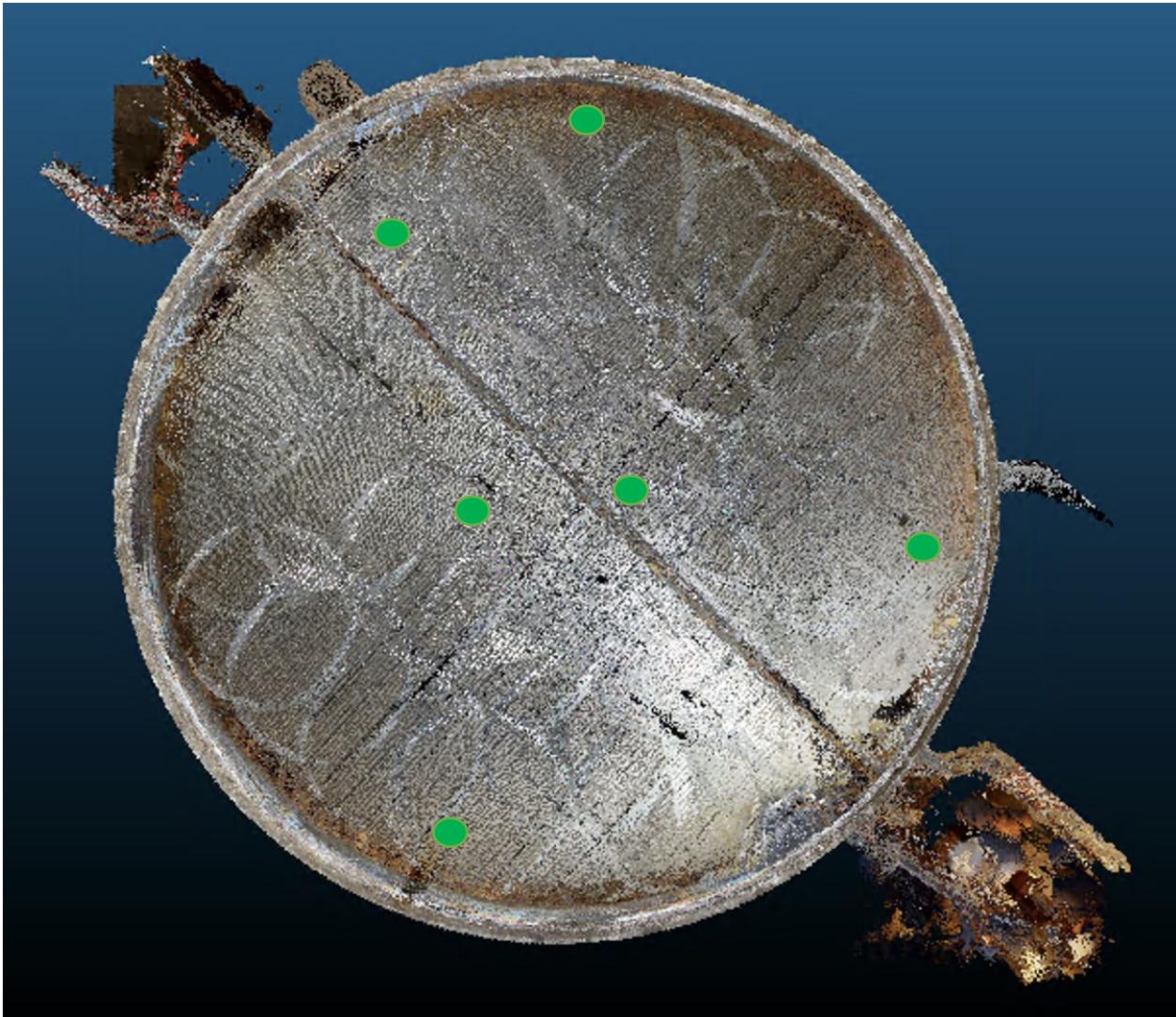


● Targets



Place scanner/360 camera at 5' to 6 ' height

● Targets  
✖ Scanner/camera



# Faro Scanner Setup



Set up tripod



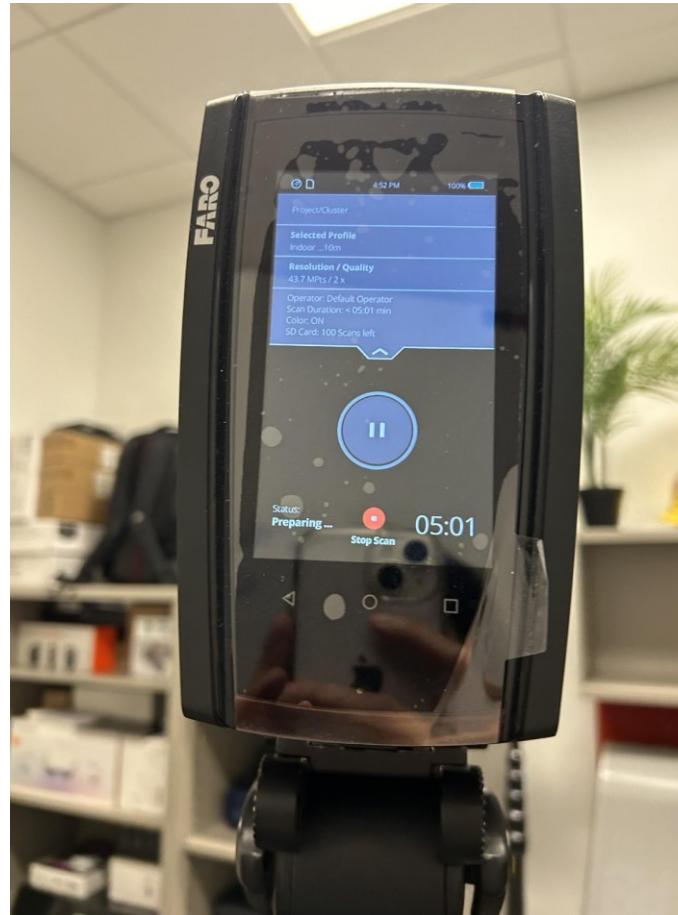
Check the bubble level



Place Scanner

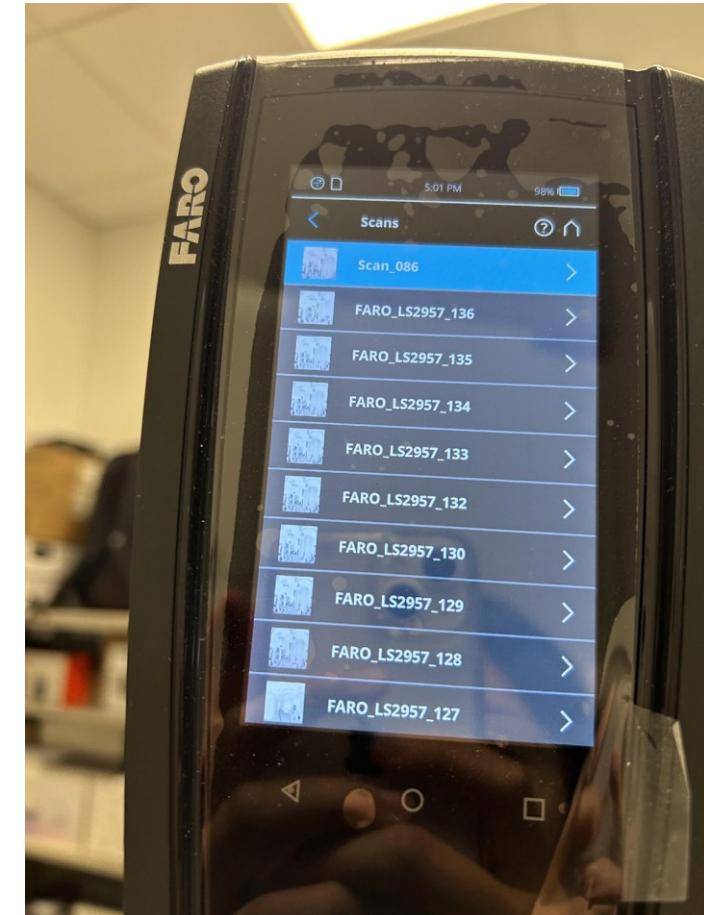


Start scanning



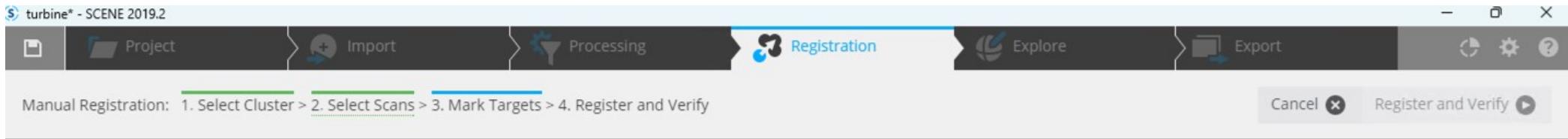
During Scanning:

1. Stay outside the turbine
2. Find a corner not to avoid targets



Check the collected scans

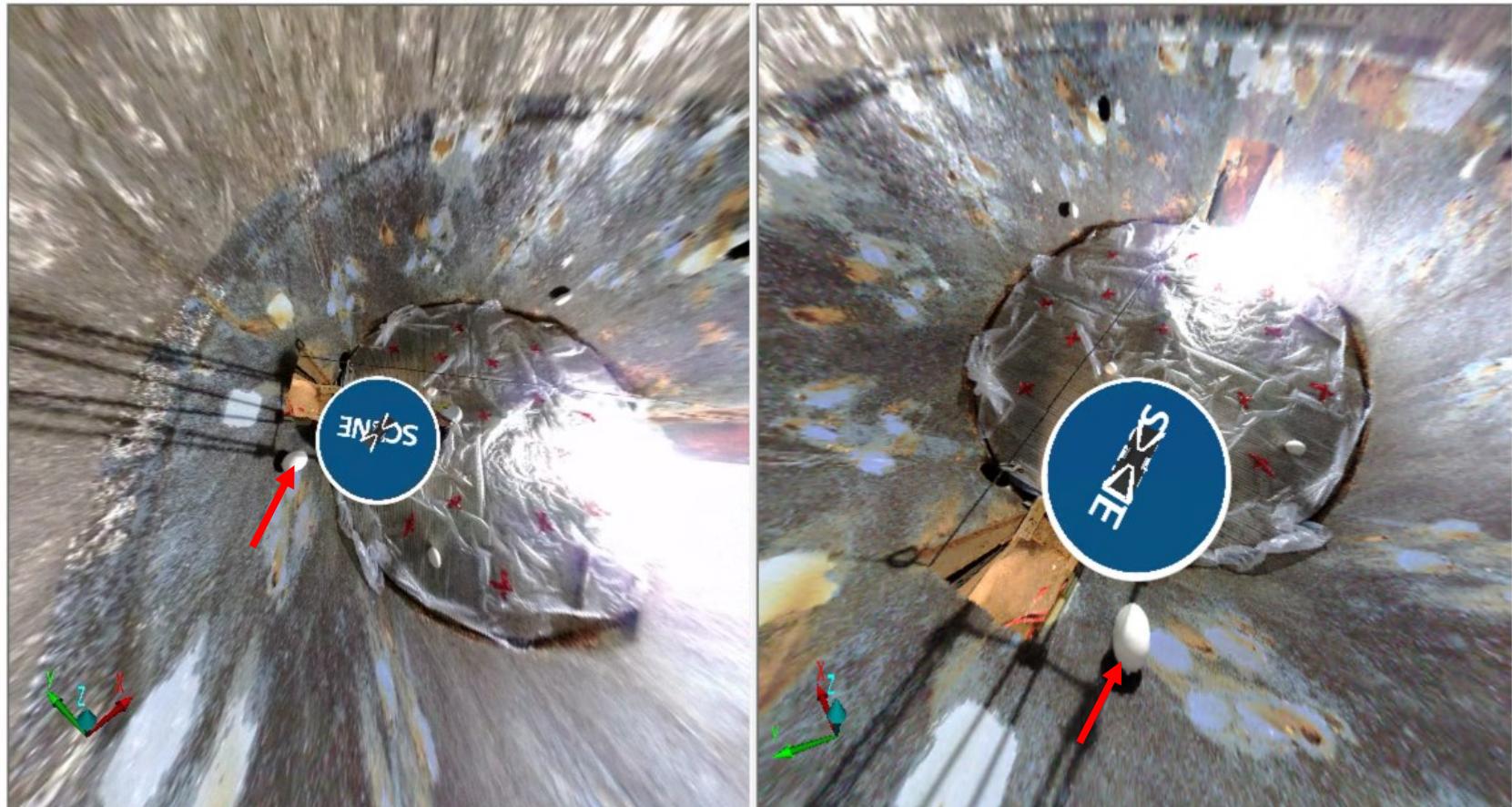
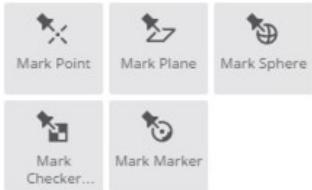
# Faro Scanner Data Registration



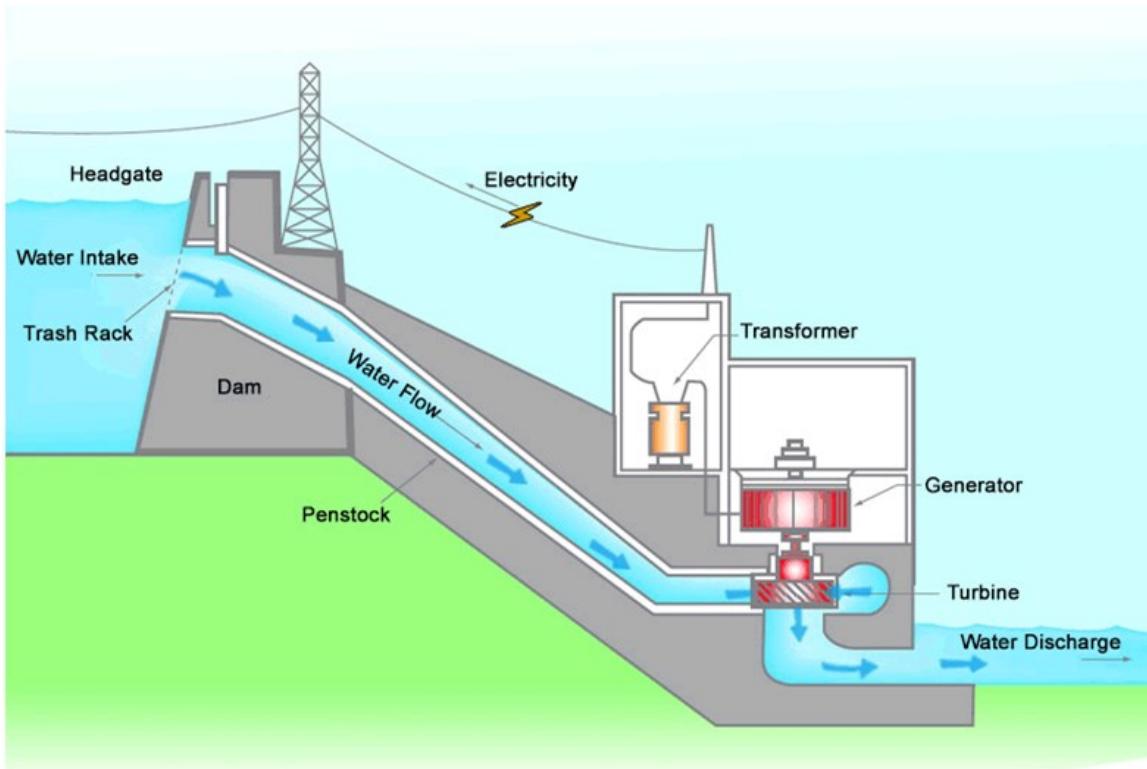
## Mark Targets

Use the tools below to mark identical targets in both scans until correspondences are found.

First: Scan\_071  
Second: Scan\_072



# How a typical HPP works?

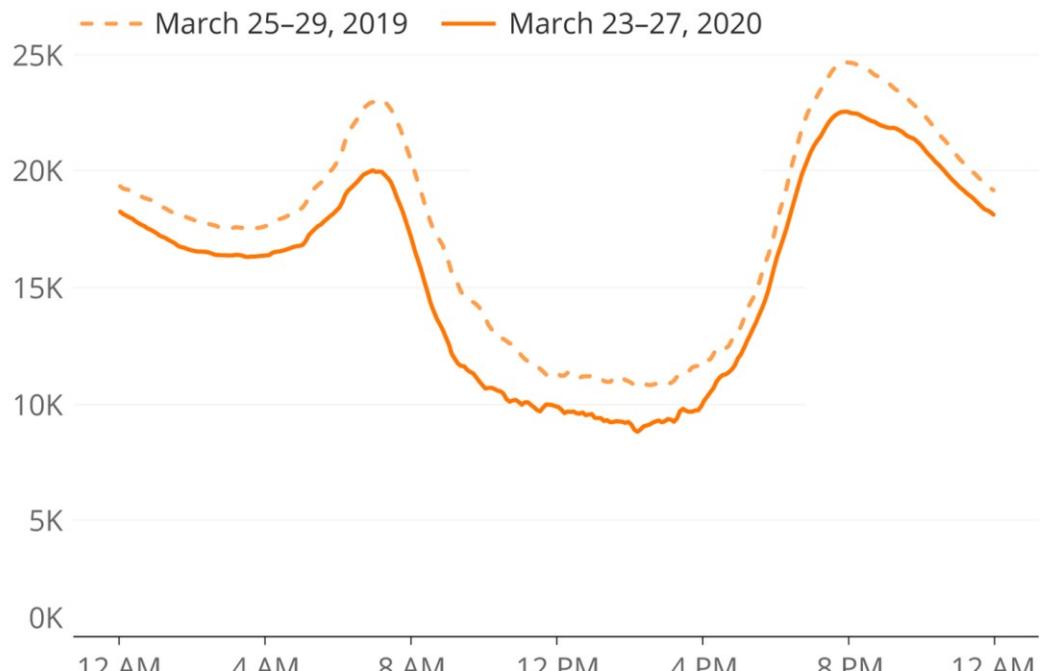


Potential Energy  
Kinetic Energy  
Electrical Energy

# Daily electricity usage

## Going daffy

California average daily net electricity demand, megawatts



Source: California Independent System Operator  
Net demand refers to demand minus solar and wind.



- Noise
  - Odometer
    - ex: 5-10k miles
  - Time
    - ex: 2 months
- Reactive Maintenance
- Preventive Maintenance

