# Development of a Predictive Maintenance System for Motors at Tate & Lyle
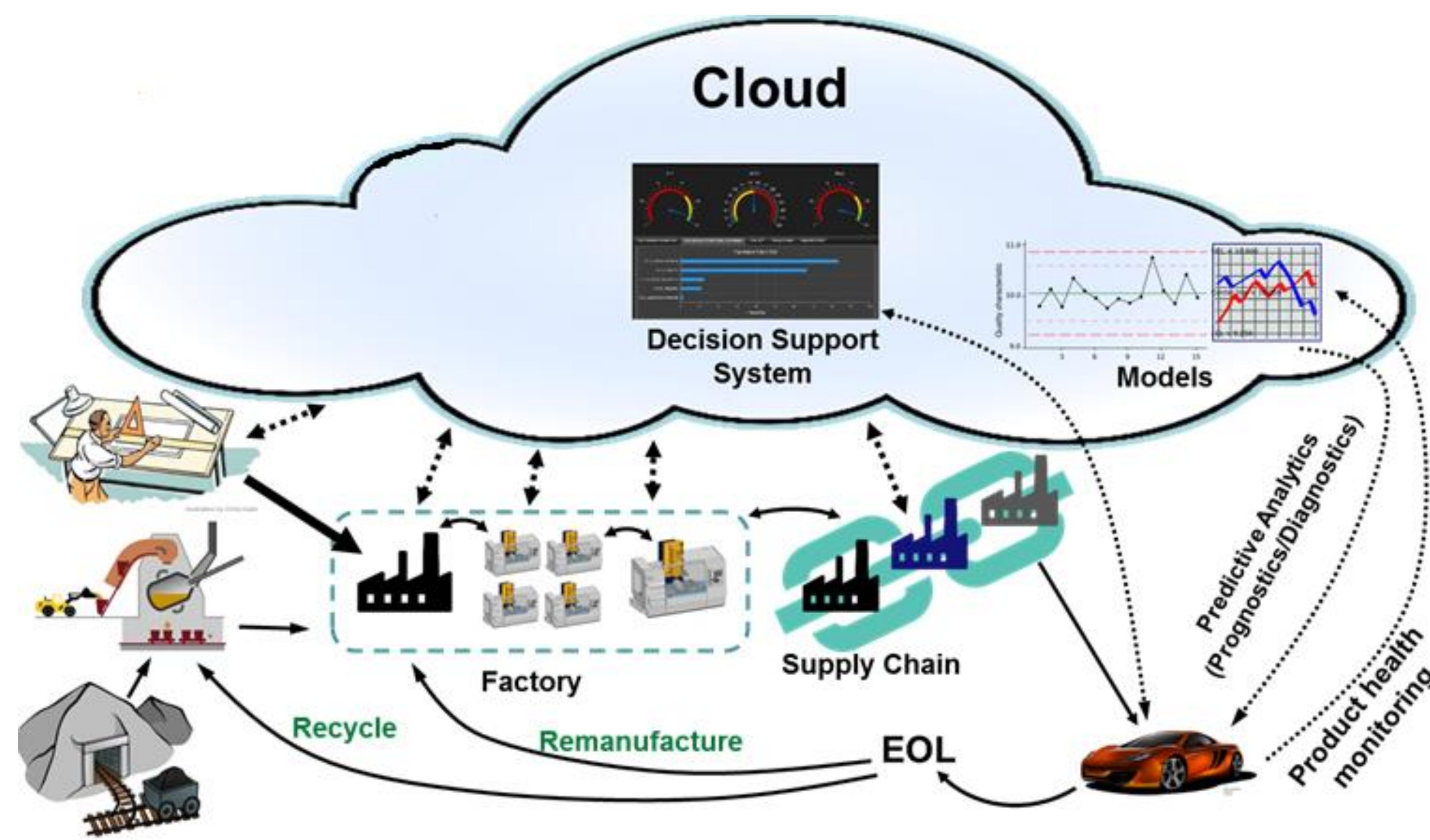
**Wo Jae Lee[1], Nithin Raghunathan[2], Khizar Rouf[3], John W. Sutherland[1]**

[1] Environmental and Ecological Engineering , [2]Birck Nanotechnology Center, [3]Engineering Technology,
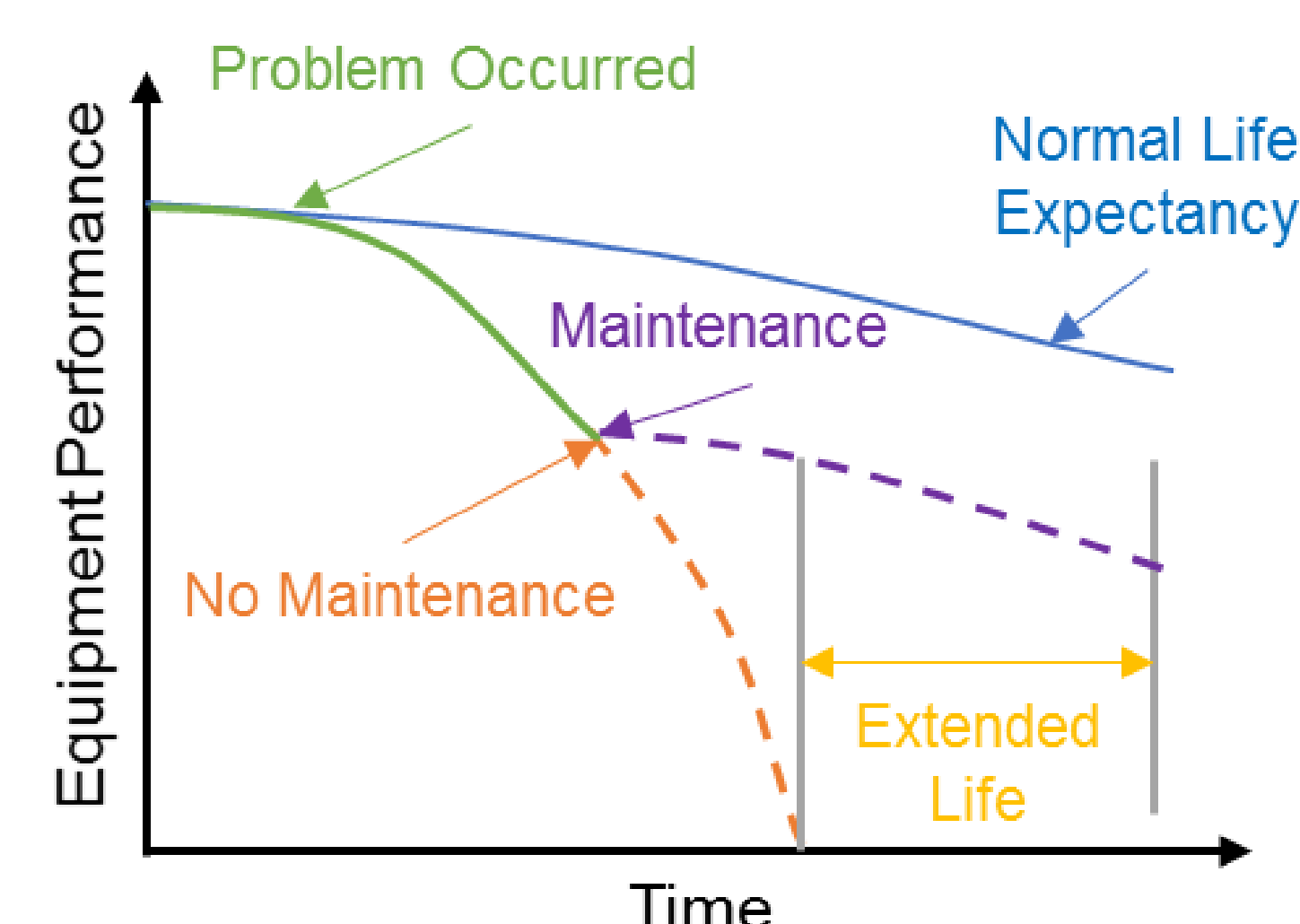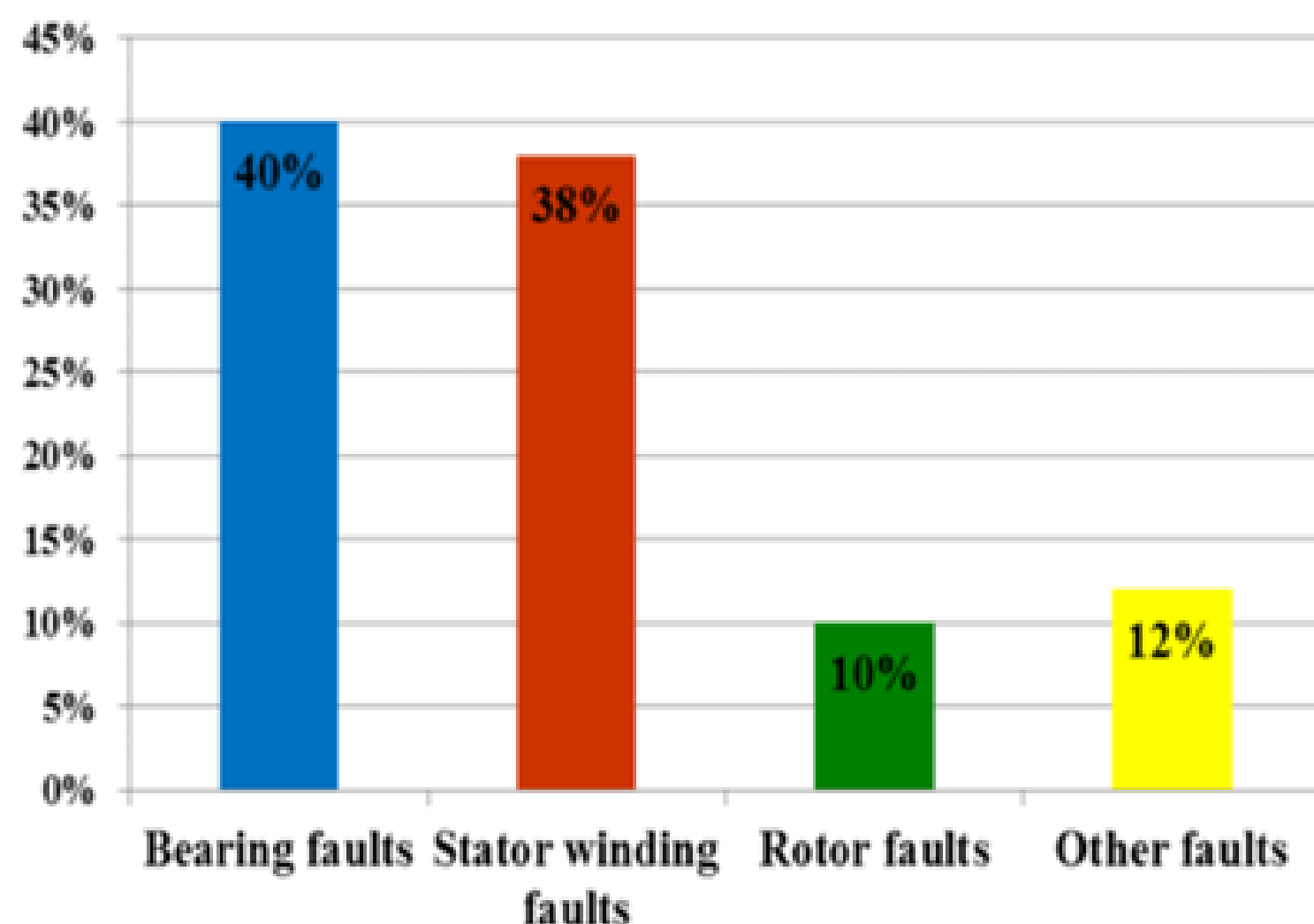Purdue University, West Lafayette, Indiana

## Vision: Smart/Sustainable Manufacturing



**"Fully integrated, collaborative systems" that respond in real time to meet changing conditions in the factory, supply network, and in customer demand (NIST)**

## Predictive Maintenance (PdM) of Motor

- **What is PdM?**
  - Develop intelligent monitoring system to avoid future equipment failure by identifying indicators of potential mal-operation / degradation

- **Benefit of PdM**
  - Increase up time and safety, minimize maintenance costs, and optimize supply chains

- **Two predictive maintenance modelling approaches**
  - Scenario 1: No failure data (Unsupervised Learning)
  - Scenario 2: Have failure data (Supervised Learning)



< Statistics of Failure Modes in Motors (Jin et al.) >
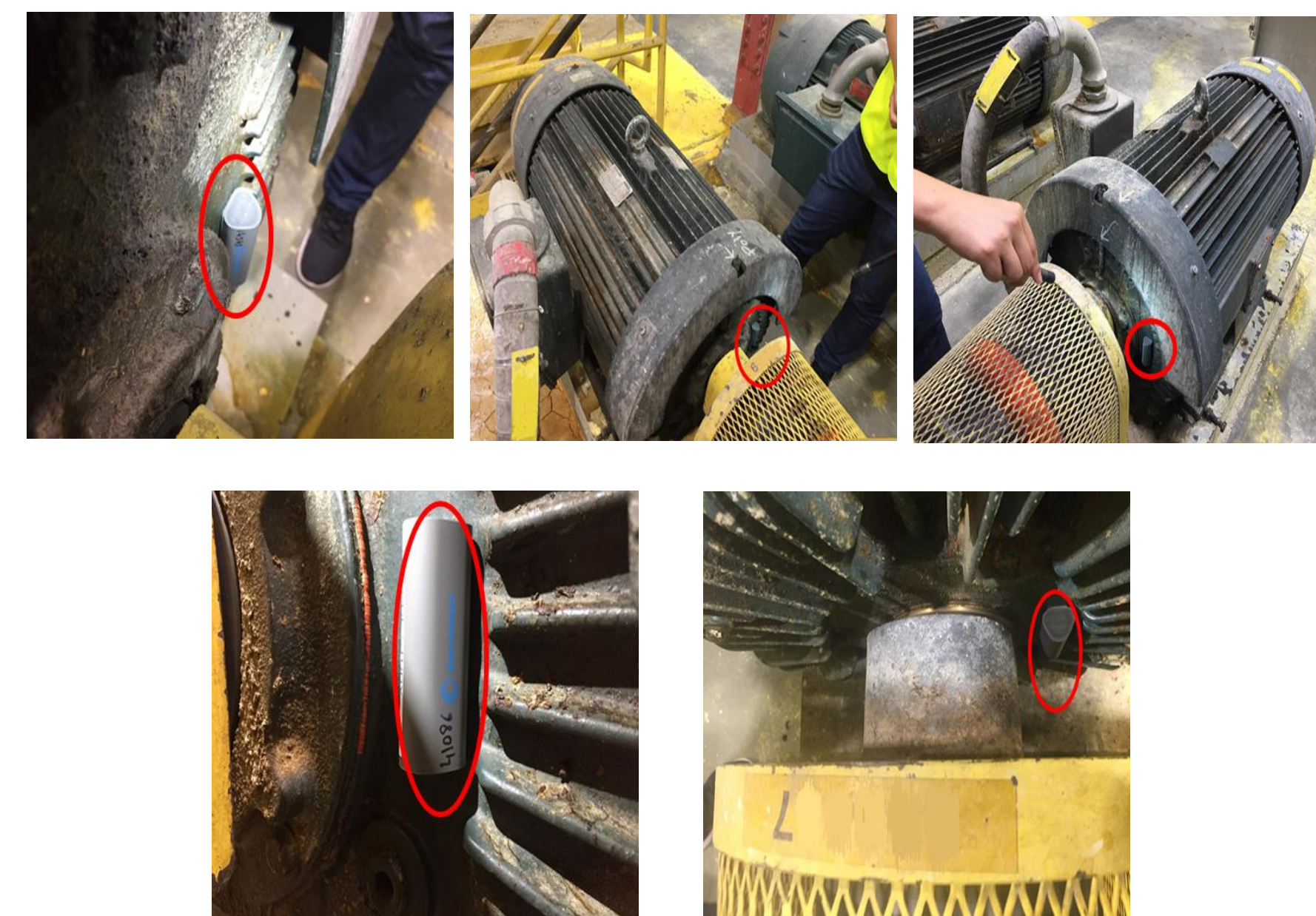
< Extending Life with PdM >
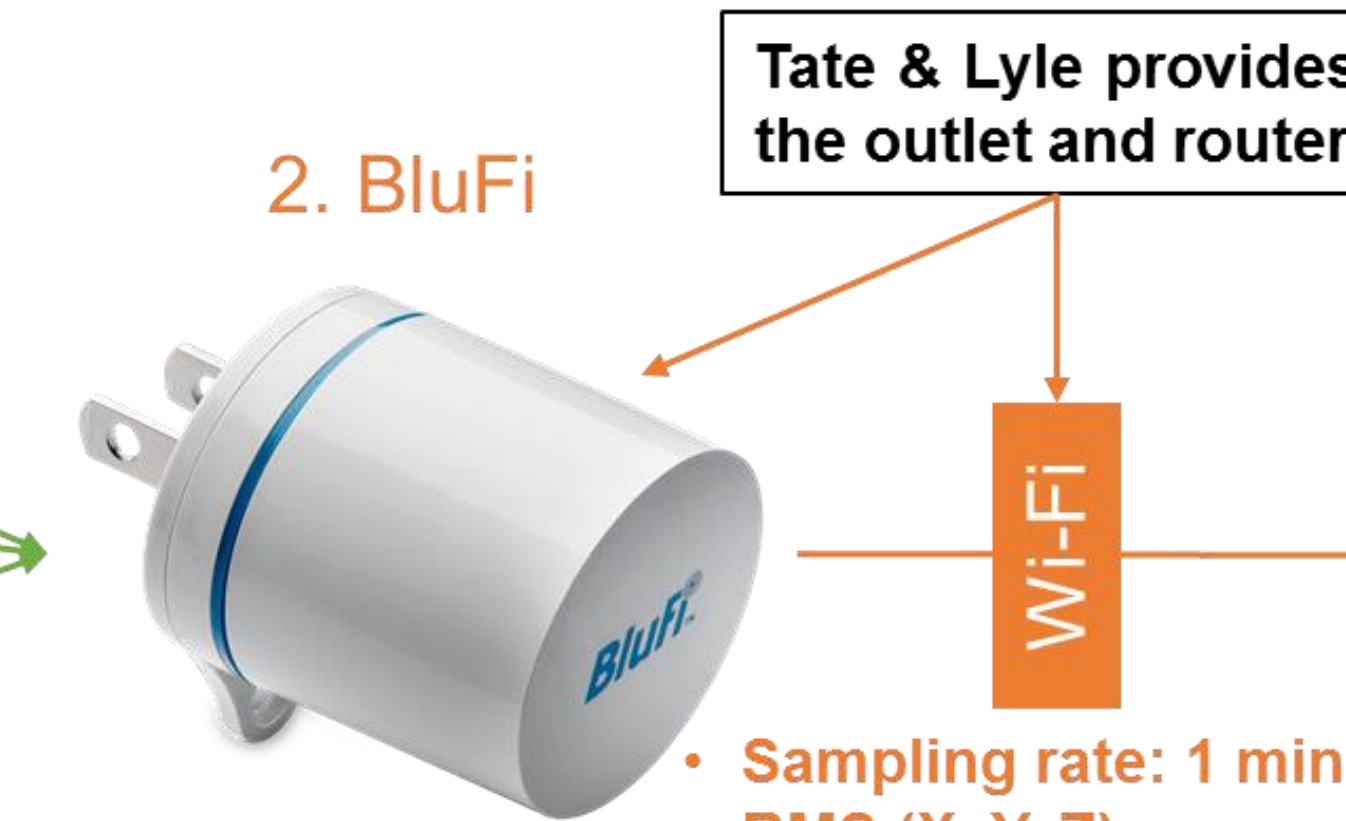
## Bluvision Sensor Deployment in the Plant

- Five sensors are mounted on the five motors near the bearings
- Acceleration (3-axis) and temperature data are collected to monitor the five motors



**DAQ System Architecture**

1. iBeacon (sensor)

2. BluFi

Tate & Lyle provides the outlet and router

3. Bluzone (Cloud)

- Sampling rate: 1 min.
- RMS (X, Y, Z)
- Peak to Peak (X, Y, Z)
- Temperature

Deployed on the motors to capture vibration (triaxial acceleration) and temperature and send the data to the Blufi through Bluetooth.

BluFi is a plug-in plug-out device that acts as an intermediary between the sensor and the Bluzone (Cloud). Data are sent to the Bluzone by Wi-Fi.
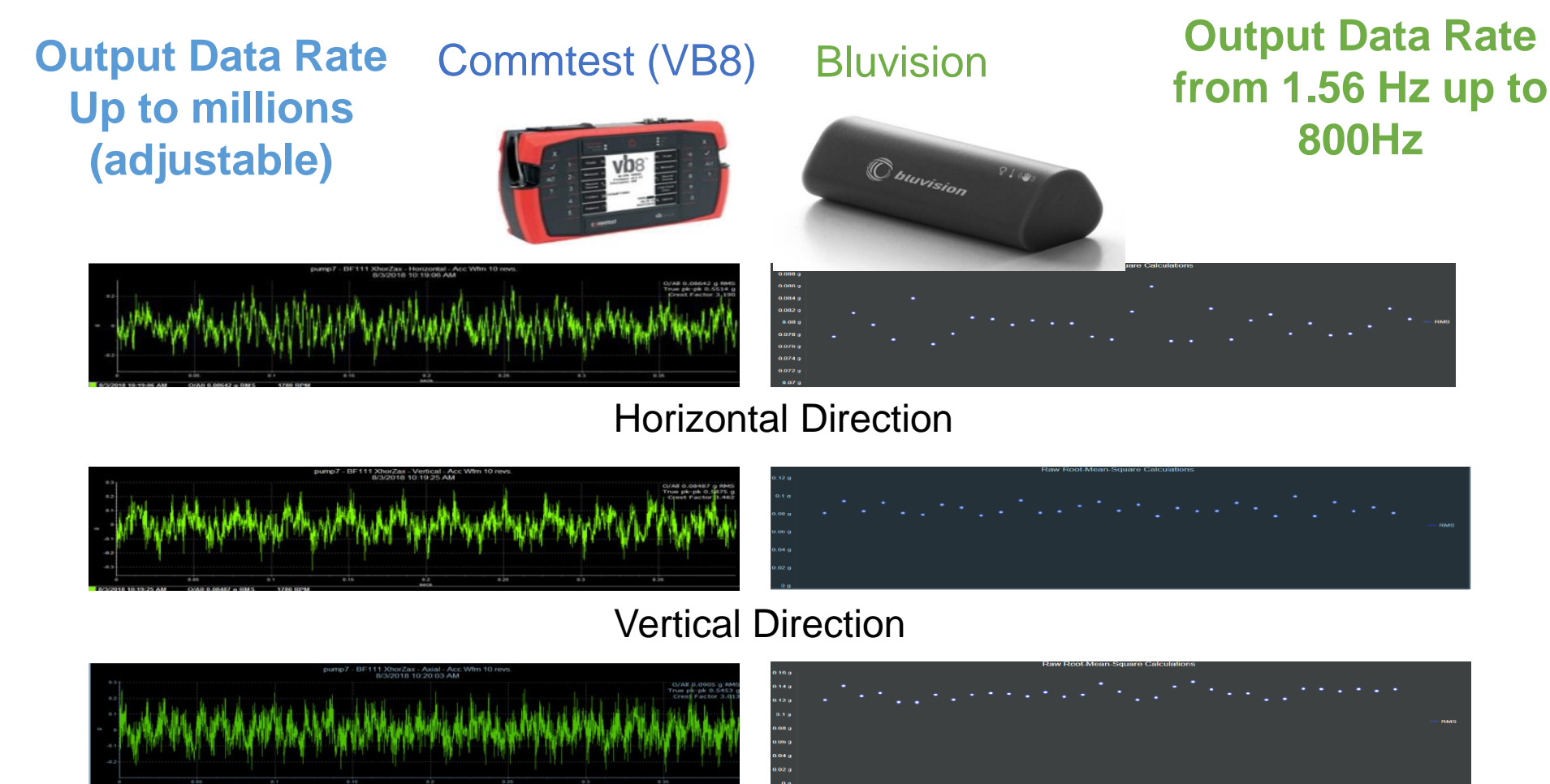
Acceleration and temperature data can be exported from Bluzone.

### Collaborative work with Tate & Lyle to Solve Problems When Deploying the DAQ in the Plant
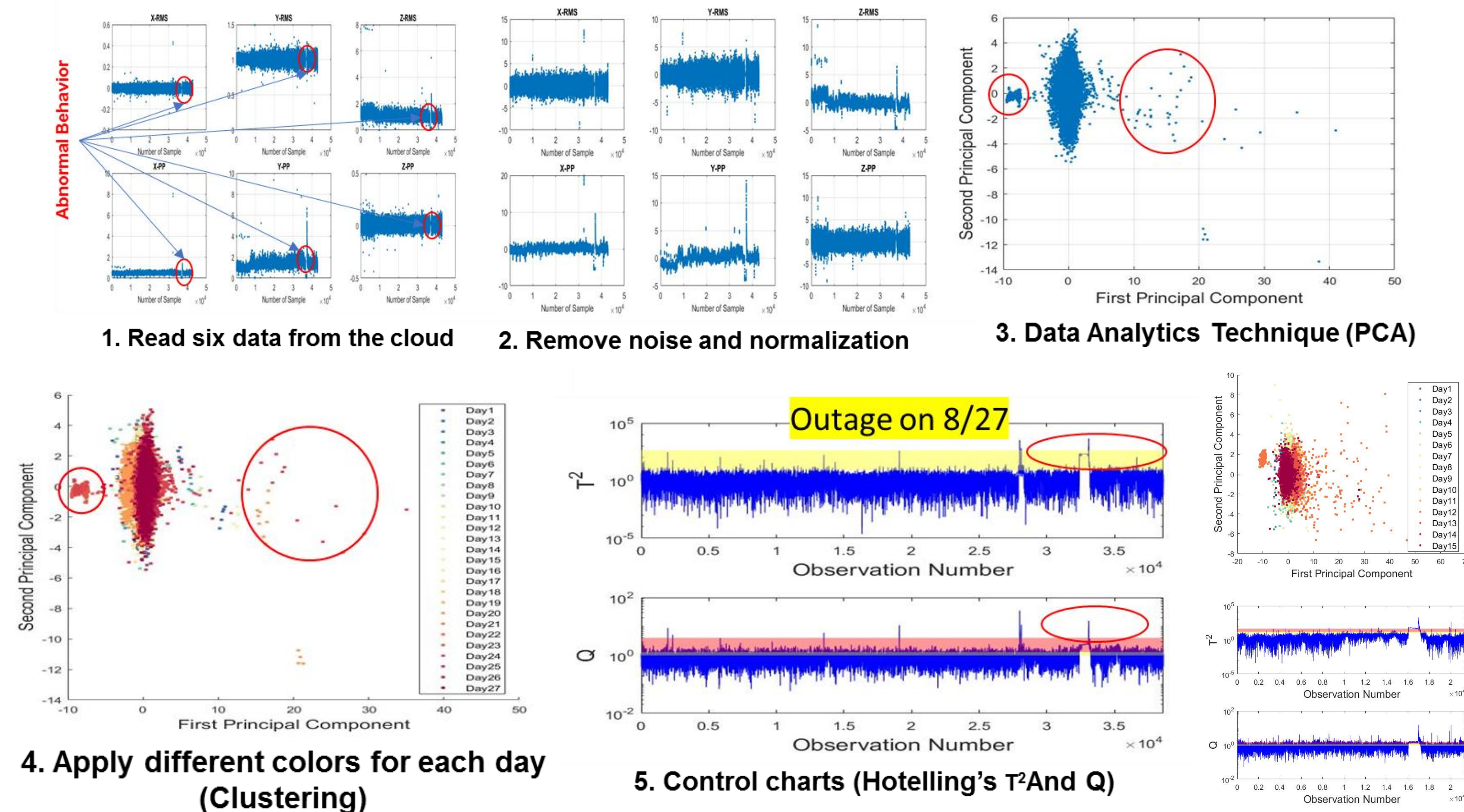
- Distance limit for the Bluetooth connection between iBeacon and BluFi
  - Tate & Lyle provides the outlet near the motors
- Possible damage on BluFi from factory activities (e.g., cleaning) and the BluFi's working condition (e.g., temperature range)
  - BluFi is stored in solid box (having outlet inside) provided by Tate & Lyle
- Wi-Fi setting for BluFi
  - Working with a network engineer to set the specific setting for BluFi (Tate & Lyle provides the line for our DAQ)

## Compare with Commtest Data



Output Data Rate Up to millions (adjustable)

Commtest (VB8)

Bluvision

Output Data Rate from 1.56 Hz up to 800Hz

Horizontal Direction

Vertical Direction

Axial Direction

| Acceleration Direction | Peak to Peak Error (%) | RMS Error (%) |
|---|---|---|
| X axis | 14.55 | 2.26 |
| Y axis | 5.08 | 5.14 |
| Z axis | 56.36 | 24.58 |

## Predictive Analytics Technique



1. Read six data from the cloud

2. Remove noise and normalization

3. Data Analytics Technique (PCA)

4. Apply different colors for each day (Clustering)

Outage on 8/27

5. Control charts (Hotelling's $T^2$ And Q)