

# Prognostics & Health Management System for Mass Transportation

# PHM Project Overview

Combine the IIoT, 5G, deep learning algorithm and edge computing to develop a Prognosis and Health Management (PHM) system for various equipment. Besides functions of real-time monitoring, the PHM system can detect potential trends of anomalies and deviations from normal operating conditions and predict when a fault will occur.



# Our solution – Intelligent Fault Catcher (IFC)

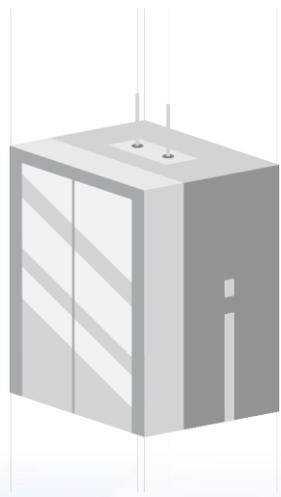
**AI Powered PHM solution** with IoT edge computing for APG & elevator

- a) Health Monitoring
- b) Anomaly/Fault detection
- c) RUL prediction

**Interactive Dashboard** for Monitoring & PHM for APG and elevator

## Elevator

- PHM System
  - Data acquisition
  - Data management
  - Data analysis
  - Dashboard



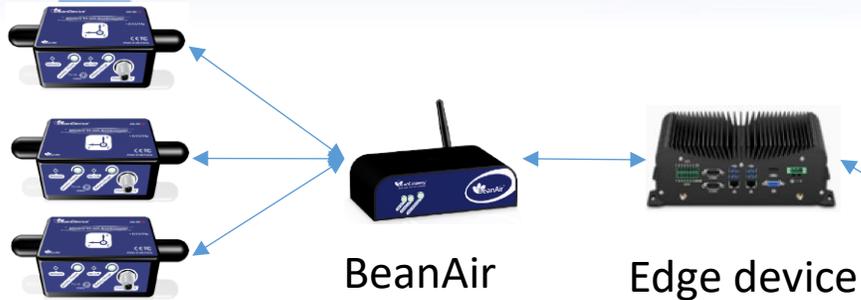
## Automatic Platform Gate (APG)

- PHM System
  - Data acquisition\*
  - Data management
  - Data analysis
  - Dashboard



# Software Architecture

## Elevator site

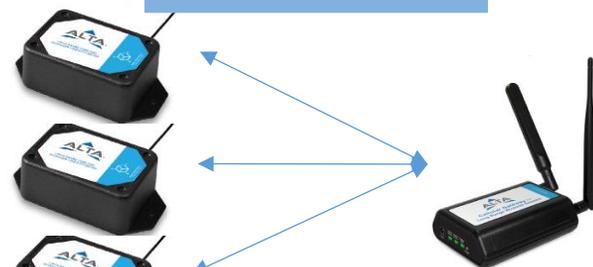


BeanAir gateway

Edge device

BeanAir sensors  
(raw data)

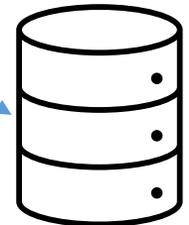
## APG site



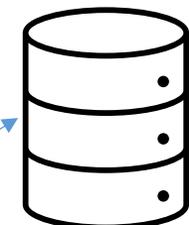
Monnit gateway

Monnit sensors  
(preprocessed data)

## Server



MongoDB Database



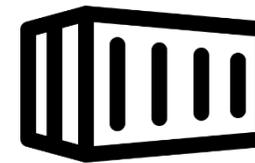
MySQL Database



APG Log File

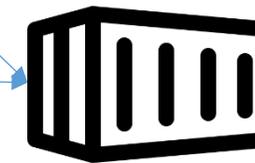


iMonnit

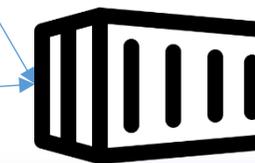


Health Index Models

RESTful API



Database API



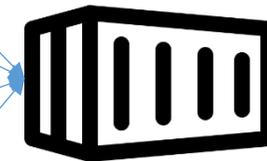
Fault Prediction Models

Webhook

RESTful API

RESTful API

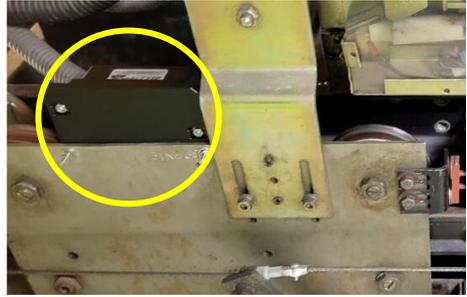
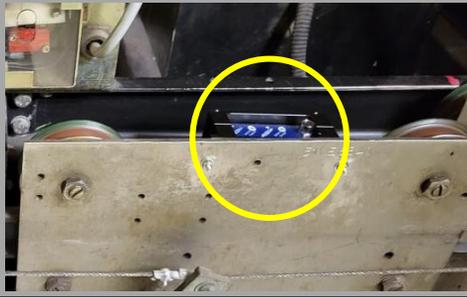
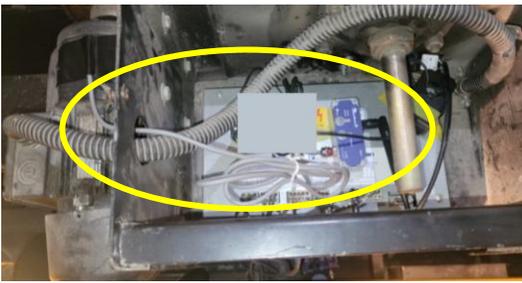
RESTful API



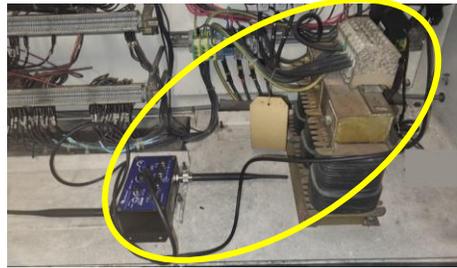
Dashboard

# PHM: Elevator

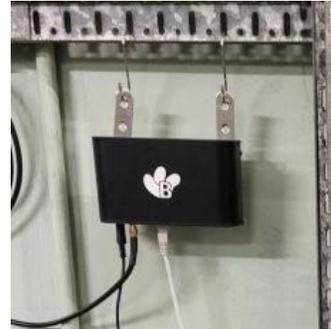
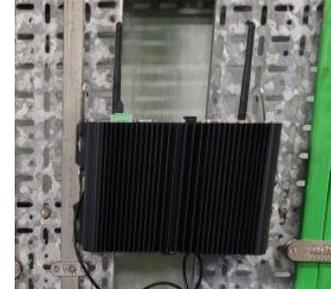
# Recap of Sensor Installation

Monitored Component	Installation Location	Sensor/Hardware	Photo
Cabin door	Left cabin door	Inclinometer + Integrated temperature sensor	
	Right cabin door	Accelerometer	
	Cabin roof and door motor box	Current sensor + DAQ	
	Door motor box	Temperature sensor	

# Recap of Sensor Installation

Monitored Component	Installation Location	Sensor/Hardware	Photo
Cabin	Cabin roof	Accelerometer	
Traction motor	Traction motor	Accelerometer	
	Control cabinet	Current sensor + DAQ	

# Recap of Supplementary Hardware Installation

Purpose	Installation Location	Sensor/Hardware	Photo
Gateway (Sensor data aggregation and transmission)	Control room	Collects the sensor data, and transmits the data to the edge device via the router. The gateway also manages the wireless sensor network and controls external access to it to enhance security.	
Router	Control room	Used to establish connection between the gateway and the edge device. Connects the local network to the internet via a SIM card providing cellular data.	
Edge device (Database, data analysis, web server)	Control room	Runs BeanScape (sensor supervision software) to monitor and operate the sensors in real time, and stores the sensor data locally.	

# FLAIR Elevator Dataset

## Sensor Data

Door current

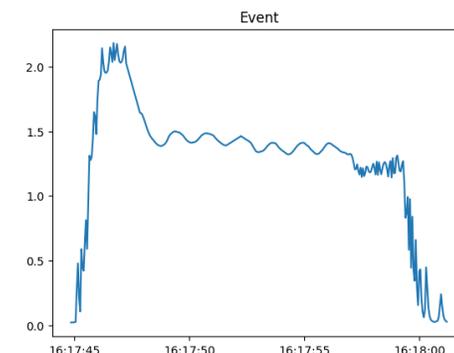
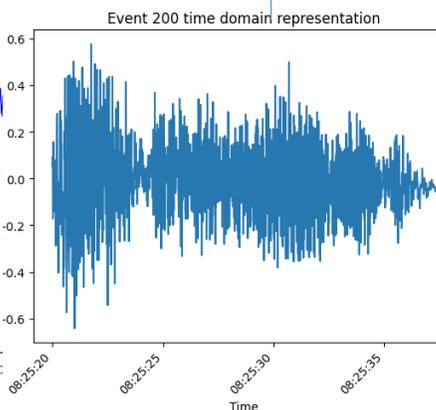
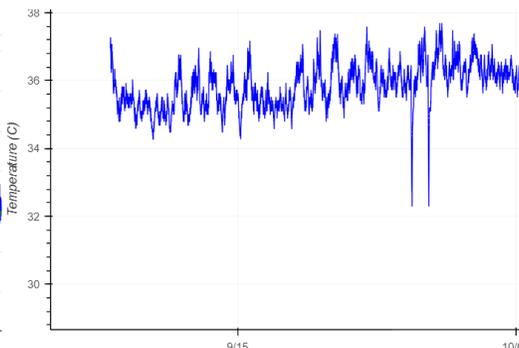
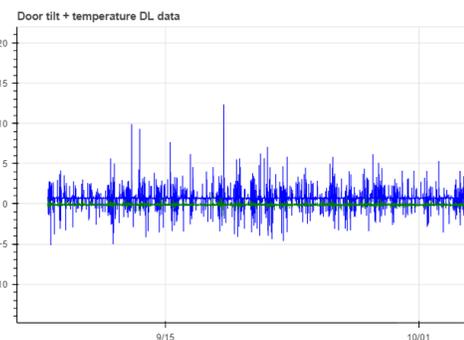
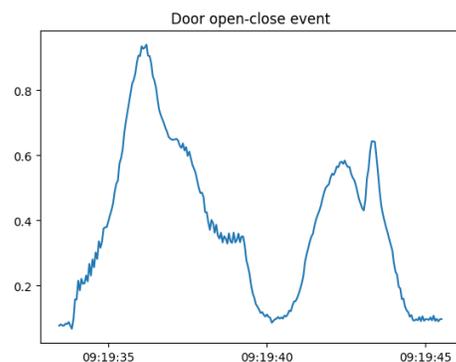
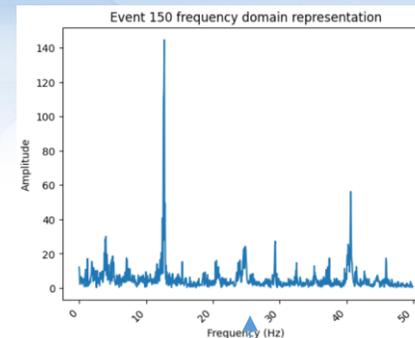
Door tilt

Door motor temperature

Traction motor vibration

Traction motor current

FFT

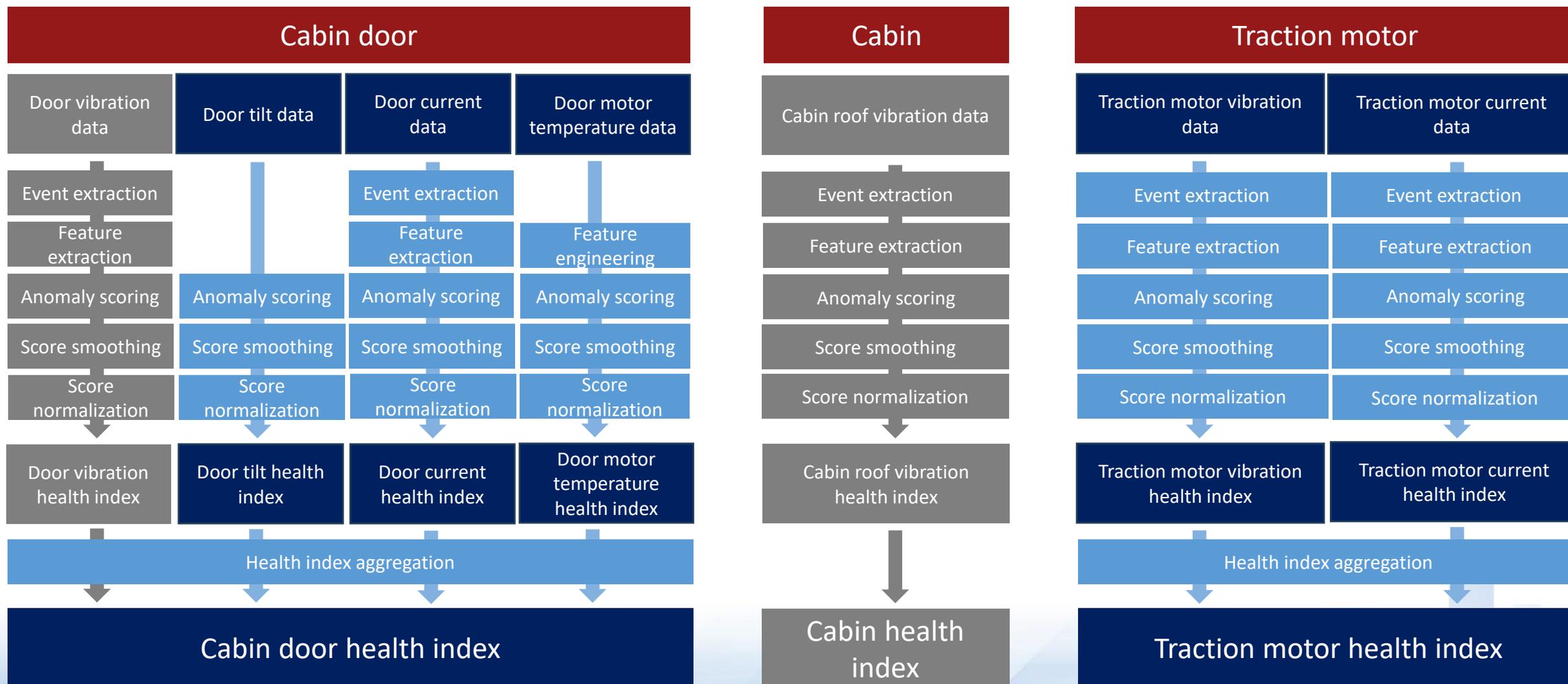


## Fault/Maintenance Data

No fault/maintenance data available.

# Data Analysis on FLAIR Elevator Dataset

## Health Index Generation



# Elevator PHM System Dashboard

Intelligent Fault Catcher

- 🏠 APG
- 📊 Log Prediction
- 🚗 Lift
- 📅 Alert Record
- 👤 Account
- 🚪 Log out

### TSY-SL7 Health Index

Cabin Door			Traction Motor	
Door Current	Door Tilt	Door Motor Temperature	Traction Current	Traction Vibration
NaN	0.71	0.58	0.73	0.83

**Traction Vibration**  
 Last Updated: 2024-07-22 12:23:40  
 Sensor Battery Level: N/A

Start:

End:

Resolution: Daily

GET DATA

#### Traction Vibration Health Index

Health Index Monitoring Functionalities:

- Door current
- Door Tilt
- Door motor temperature
- Traction current
- Traction vibration

# APG Dataset

## Event Log Data

```

:Name:Plaform:Door:DCU:Value
EVENT:MMS VERSION:::V 0.36-Dec 22 2021 - 11_19_54 VER#370-1640171994
TFORM EVENT:ALL DOORS CLOSED AND LOCKED:2:::FALSE
ALARM:EED/TAD NOT CLOSED:2:41:81:ACTIVE
EVENT:EED / TAD NOT LOCKED:2:41:81:TRUE
TFORM ALARM:TAD 1 OPENED:2:::ACTIVE
TFORM ALARM:LCP LOCAL COMMAND:2:::ACTIVE
TFORM ALARM:LOCAL CONTROL ACTIVATED:2:::ACTIVE
TFORM EVENT:LCP DOOR OPEN COMMAND:2:::TRUE
TFORM ALARM:UNEXPECTED UNLOCKING:2:::ACTIVE
TFORM EVENT:APG CLOSED AND LOCKED LOOP:2:::FALSE
EVENT:OPEN ENABLE:2:40:1:TRUE
EVENT:OPEN COMMAND:2:40:1:TRUE
EVENT:LEAF LOCKED SWITCH:2:40:1:TRUE
EVENT:REMOTE OPEN COMMAND:2:40:1:TRUE
EVENT:DOOR OPENING CHIME:2:40:1:TRUE
EVENT:LEAF LOCKED:2:40:1:FALSE
EVENT:LEAF FREE:2:40:1:FALSE
EVENT:OPEN ENABLE:2:40:2:TRUE
EVENT:OPEN COMMAND:2:40:2:TRUE
EVENT:LEAF LOCKED SWITCH:2:40:2:TRUE
EVENT:REMOTE OPEN COMMAND:2:40:2:TRUE
EVENT:LEAF LOCKED:2:40:2:FALSE
EVENT:LEAF FREE:2:40:2:FALSE
EVENT:OPEN ENABLE:2:39:3:TRUE
EVENT:OPEN COMMAND:2:39:3:TRUE
EVENT:LEAF LOCKED SWITCH:2:39:3:TRUE
EVENT:REMOTE OPEN COMMAND:2:39:3:TRUE
EVENT:DOOR OPENING CHIME:2:39:3:TRUE
    
```

## Fault Log Data

ID	DeviceID	Status	Message	DateTime
1	1	OK	Some text	2018-1-1 20:23:10
2	1	Fault	Something gone wrong	2018-1-1 18:22:10
3	1	Fault	Something gone wrong	2018-1-1 18:20:10
4	1	OK	Some Text	2018-1-1 17:00:00
5	1	OK	Some text	2018-1-1 10:23:00
6	1	Fault	Something wrong	2018-1-1 10:21:00
7	1	OK	Some text	2018-1-1 10:20:00

```

| ANALOG VALUE:Closing Time:1:4:75:3.40
| ANALOG VALUE:Opening Current Average:1:4:73:0.61
| ANALOG VALUE:Closing Current Average:1:4:73:0.54
| ANALOG VALUE:DCU Voltage:1:4:73:92.00
| ANALOG VALUE:Opening Time:2:16:50:3.00
| ANALOG VALUE:Closing Time:2:16:50:3.40
| ANALOG VALUE:Opening Current Average:2:16:50:0.53
| ANALOG VALUE:Closing Current Average:2:16:50:0.50
| ANALOG VALUE:DCU Voltage:2:16:50:92.00
| ANALOG VALUE:Opening Time:1:4:74:3.10
| ANALOG VALUE:Closing Time:1:4:74:3.50
| ANALOG VALUE:Opening Current Average:1:4:74:0.74
| ANALOG VALUE:Closing Current Average:1:4:74:0.78
| ANALOG VALUE:DCU Voltage:1:4:74:91.00
| ANALOG VALUE:Opening Time:2:15:51:3.00
| ANALOG VALUE:Closing Time:2:15:51:3.50
| ANALOG VALUE:Opening Current Average:2:15:51:0.62
| ANALOG VALUE:Closing Current Average:2:15:51:0.58
| ANALOG VALUE:DCU Voltage:2:15:51:92.00
| ANALOG VALUE:Opening Time:1:3:75:3.00
| ANALOG VALUE:Closing Time:1:3:75:3.70
| ANALOG VALUE:Opening Current Average:1:3:75:0.59
| ANALOG VALUE:Closing Current Average:1:3:75:0.50
| ANALOG VALUE:DCU Voltage:1:3:75:91.00
| ANALOG VALUE:Opening Time:2:15:52:3.10
| ANALOG VALUE:Closing Time:2:15:52:3.50
| ANALOG VALUE:Opening Current Average:2:15:52:0.55
| ANALOG VALUE:Closing Current Average:2:15:52:0.55
    
```

# PHM: Automatic Platform Gate (APG)

# APG PHM System Dashboard - Home Page



**FLAIR**  
Intelligent Fault Catcher

✓ 1 Monitored DCU    0 199 Unmonitored DCU

Station1    PSD

This Station Platform - PSD

Platform 1 Door 40 to 21    To Head Station >

< To Tail Station    Platform 2 Door 1 to 20

Platform 1 Door 20 to 1    To Head Station >

< To Tail Station    Platform 2 Door 21 to 40

### Top Faulty Equipments

Number of Problems

1-31-20  
DCU ID

### Total Problem Count

Problem Count

2 Months Moving Average    Problem Count

Month

Home

APG

Elevator

Log Prediction

Alert Record

Account

Log out

## DCU-131 Health Index

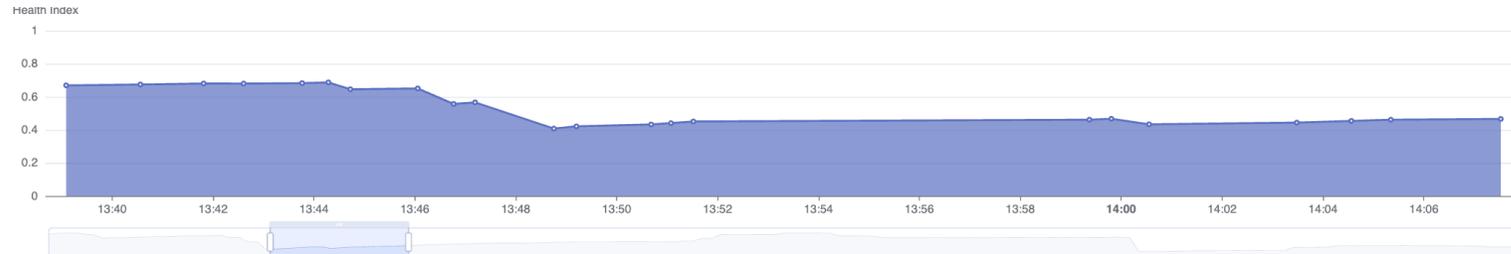
DCU-131

0.63

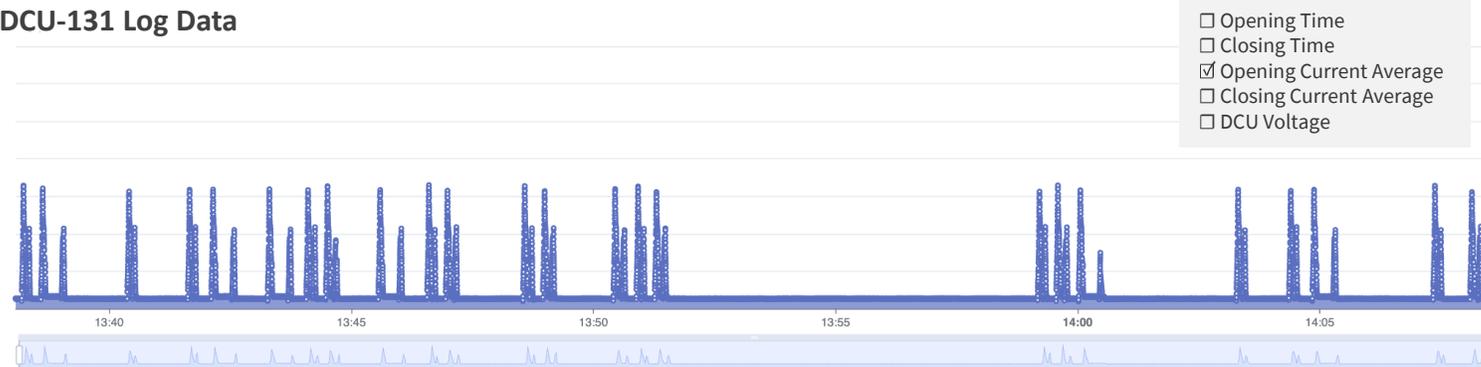
### DCU-131

Last updated: 30/10/2023 4:55PM

#### DCU-131 Health Index



#### DCU-131 Log Data



Home

APG

Elevator

Log Prediction

Alert Record

Account

Log out

## APG Fault Prediction

### Choose model

LSTM-Random Forest  
Uses 7 days of data to predict faults within 1 day

Transformer  
Uses 30 days of data to predict faults within 7 days

### Upload data

Event logs

Choose file

Fault log

Choose file

### Run prediction task

Predict

Running Tasks	Data Start Date	Data End Date	Model	Status
20240103195047	25/11/2023	31/11/2023	LSTM-Random Forest	Running

Rows per page: 10 ▾ 1-10 of 210 < >

Completed Tasks	Data Start Date	Data End Date	Model	Predicted Faults
20240103194037	25/10/2023	31/10/2023	LSTM-Random Forest	3
20240103180937	24/10/2023	30/10/2023	LSTM-Random Forest	7
20240103163858	23/10/2023	29/10/2023	LSTM-Random Forest	2
20240103150859	22/10/2023	28/10/2023	LSTM-Random Forest	6
20240103133954	01/10/2023	30/10/2023	Transformer	9
20240103121205	01/09/2023	30/09/2023	Transformer	6
20240103104455	01/08/2023	30/08/2023	Transformer	2
20240103092000	01/07/2023	30/07/2023	Transformer	10
20240103075844	01/06/2023	30/06/2023	Transformer	8
20240103063824	01/05/2023	30/05/2023	Transformer	5

Rows per page: 10 ▾ 1-10 of 210 < >

**FLAIR**  
Intelligent Fault Catcher

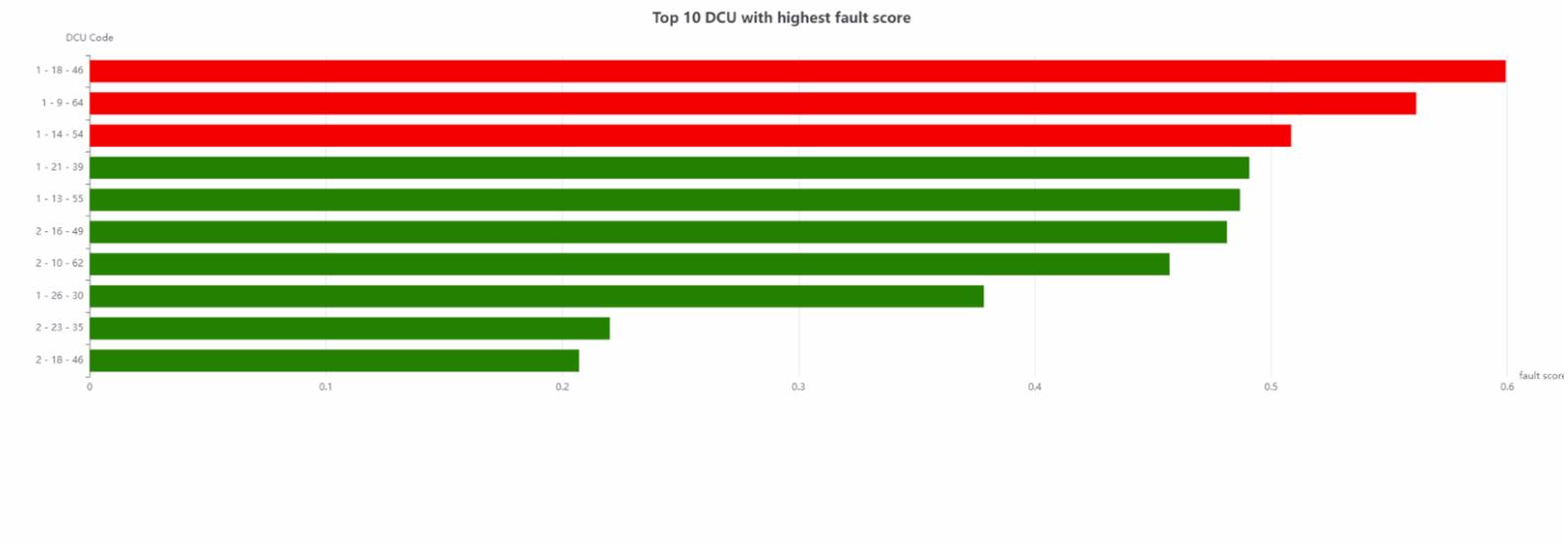
- Home
- APG
- Elevator
- Log Prediction
- Alert Record
- Account
- Log out

✓ 1 Monitored DCU    199 Unmonitored DCU

**Prediction Task 20240103194037**

Data start date: 25/10/2023  
Data end date: 31/10/2023  
Model: LSTM-Random Forest  
Predicted faults: 3

Uploaded files:  
0324-030000.log  
0325-030000.log  
0326-030000.log  
0327-030000.log





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<https://www.hkflair.org>