Case Study I

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Objective

- Develop a real-time data analysis tool that notifies the maintenance team of the existence of a failure in development
- Failures are undetectable according to traditional maintenance criteria (Threshold)

Equipment

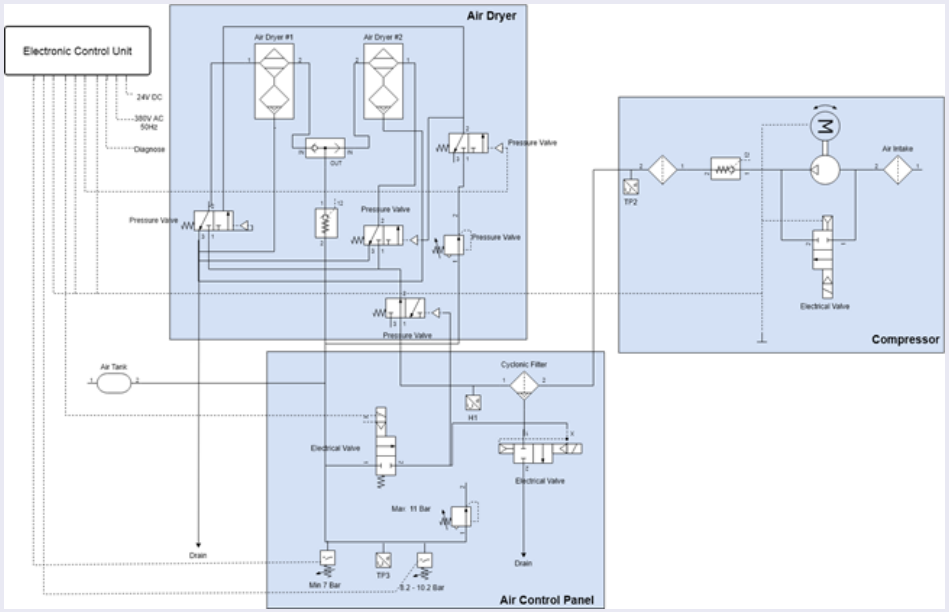
- Air Production Unit (APU) installed on the roof of Metro of Porto vehicles
- These units feeds the secondary suspension, responsible for maintaining the height of the vehicle level
- Absence of redundancy causes its failure to result in the immediate removal of the train for repair

Goal

- Early detection of APU malfunctions
- Detect anomalies based on sensor data in a learning environment with continuous data flows
- Objective is to focus on reducing operational problems, reducing the number of unforeseen stops and the stopping time

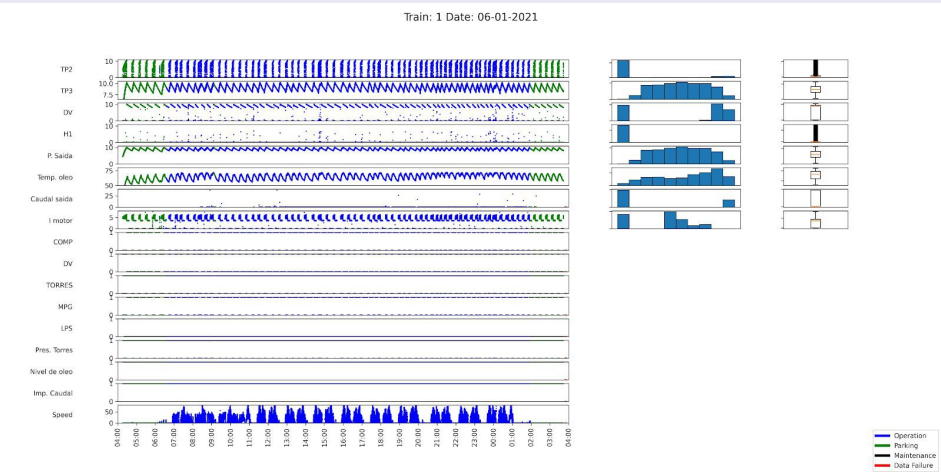
Signal Acquisition

- The signal acquisition system installed in the two APUs
- Collects data from eight sensors (pressure, temperature and electric current consumed, placed in different components of the APU)
- Eight digital signals collected directly from the APU control unit



Signal Acquisition

- The data acquisition rate is 1Hz, and the information is sent to the remote server every 5 minutes using the GSM network
- The data collection of the two units began on 12 March 2020 and is continuously operational to date
- Daily report is generated with the information of the sensor signals



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Analog Sensors

- TP2 - Measures the pressure on the compressor.
- TP3 - Measures the pressure on pneumatic panel.
- H1 - This valve is activated when the pressure is above the operating pressure of 10.2 bar.
- DV pressure - Measures the pressure generated when air dryers towers discharge the water. Zero means that the compressor is working under load.
- Motor Current - Measure the motor's current
  - close to 0A when the compressor turns off
  - close to 4A when the compressor is working offloaded
  - close to 7A when the compressor is operating under load
- Oil Temperature - Measure the temperature of the oil on the compressor.

Digital Sensors

- COMP - Signal of the air intake valve on the compressor. It is active when there is no admission of air on the compressor, meaning that the compressor turns off or working offloaded.
- DV electric - Signal that commands the compressor outlet valve. When it is active, it means that the compressor is working under load, and when it is not active, it means that the compressor is off or working offloaded.
- TOWERS - Defines which tower is drying the air and which tower is draining the humidity removed from the air. When it is not active, it means that tower one is working, and when it is active, it means that tower two is working.

Digital Sensors

- MPG - Is responsible for activating the intake valve to start the compressor under load when the pressure in the APU is below 8.2 bar. Consequently, it will activate the sensor COMP, which assumes the same behaviour as MPG sensor.
- LPS - Is activated when the pressure is lower than 7 bars.
- Oil Level - Detects the oil level on the compressor and is active (equal to one) when the oil is below the expected values.

Data Considerations

- APU01:
  - The Flow-meter and Caudal Impulses are not installed
  - The sensor that monitors the Oil Level is reversed

  .
- The data set available for this competition was collected on April 2020. It contains a single file with all variables and GPS coordinates.

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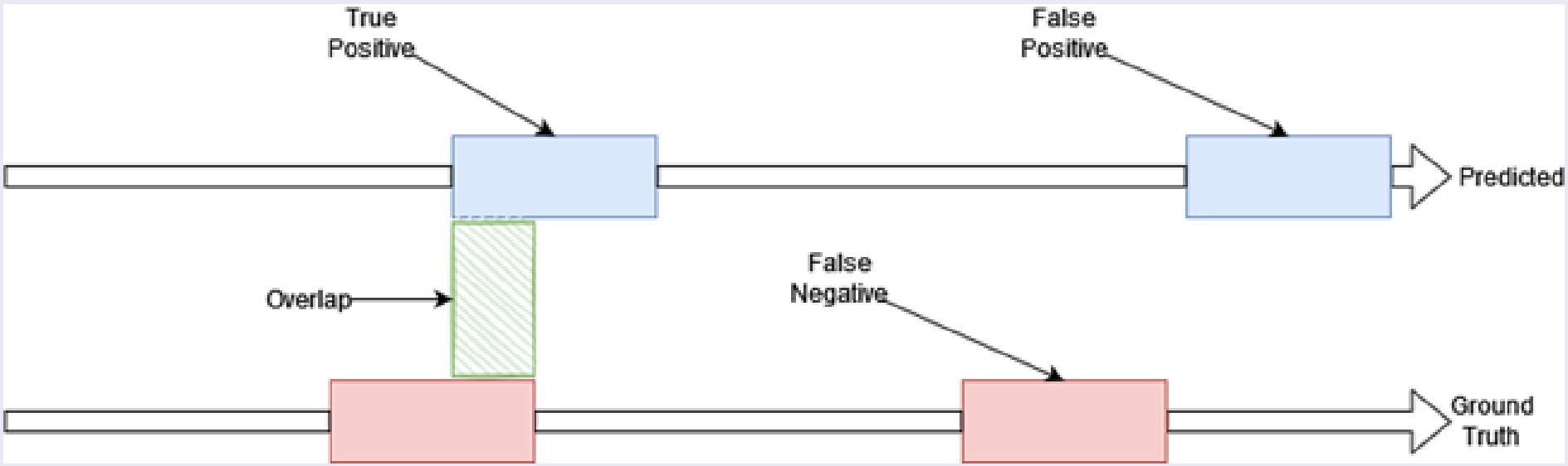
How to Submit a Solution?

- The prediction file is composed of a pair of timestamps, the start time of the failure/anomaly and the corresponding end time, for example:

```
Start, End
12:03:01.125 25-04-2020, 12:23:01.125 25-04-2020
13:03:01.125 25-04-2020, 13:23:01.125 25-04-2020
14:03:01.125 25-04-2020, 14:23:01.125 25-04-2020
```

How to Evaluate a Solution?



Evaluation

- Each team will have to do a presentation for a team of experts that will assess the proposal based on the following key points:
  - How many failures and anomalies the algorithm detected? Our goal is to minimise the number of false positives and false negatives – $min(\#FP + \#FN)$
  - Interval predictions that are larger than 120 % of the failure duration will be penalised
  - How much time is required by the algorithm to detect the failure? Our goal is to discover the problems as early as possible after it manifests. The requirement from Metro of Porto is to detect the failure at least 2 hours before the train becomes non-operational.

Evaluation

- Each team will have to do a presentation for a team of experts that will assess the proposal based on the following key points:
  - Quality of the presentation
  - Degree of innovation on the proposed solution
  - How well can the team explain the root cause of the failure

Starter Kit

- Google Colab
- Discord
- Submission must be sent to “bruno.miguel.veloso@gmail.com”
- The winner will receive one award

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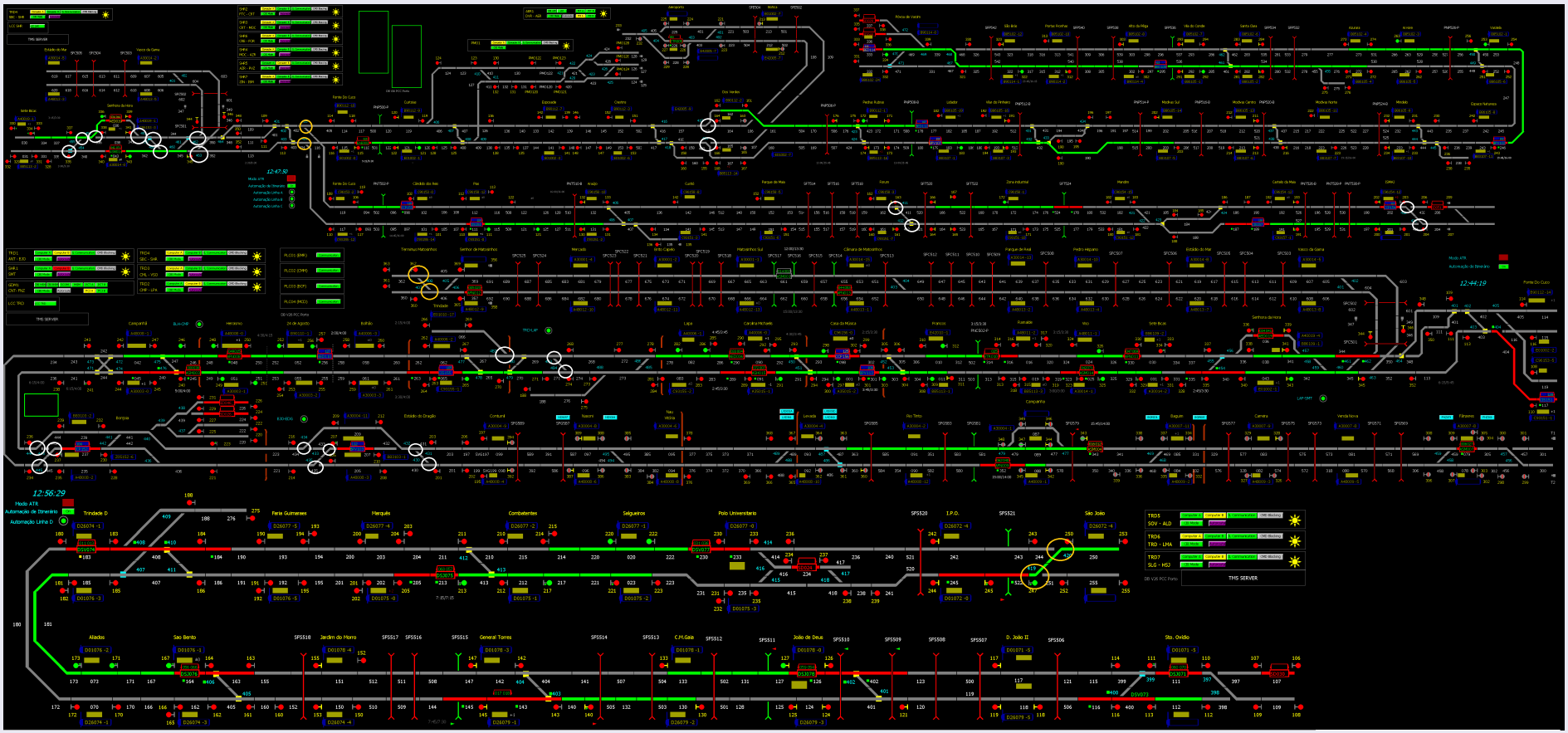
XPM Project

- Rail circulation in the Porto metro network is supervised and controlled by a Signaling system.
- This system, whose main objective is:
  - guarantee the safety of people and goods
  - prevents the approach of two vehicles
  - guarantees the in existence of incompatible routes
  - eliminates over-speed situations

XPM Project



XPM Project

- The functioning of the signaling is ensured by:
  - vehicle detection subsystem (allows you to know the location of each vehicle)
  - Signal subsystem (allows to give Drivers directions to advance or stop)
  - Lane Changers subsystem

XPM Project

- As is evident, the breakdown, unavailability or abnormal functioning of any of these equipment has high consequences on the operation of the metro, which can lead to delays, service interruptions, or even, in more extreme cases, accidents.
- All these equipment's generate operating logs, recording events and alarms related to the movement of underground vehicles.
- On a normal day of operation, around 1 million records are produced relating to the events described above.
- The analysis of these logs should make it possible to find early evidence of the development of malfunctions.