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OPERATIONS & MAINTENANCE  
CONFERENCE IN THE ARAB COUNTRIES

# Dynamic fleet maintenance management

Integrating preventive maintenance and  
predictive CBM with operations  
scheduling

Adolfo Crespo del Castillo

 #OmaintecConf

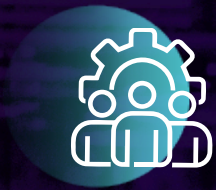
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## Dynamic fleet maintenance management



Problem Introduction



Dynamic Fleet Preventive  
Maintenance and Operations  
scheduling

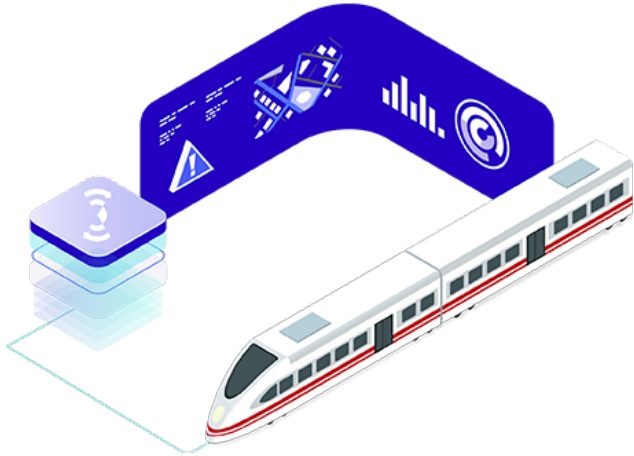


Dynamic Predictive CBM  
scheduling



# Problem Introduction

The field of asset management, as one of the critical areas for companies, is experimenting the new digital paradigm arrival, with the increase in the complexity of industrial assets systems as well as the more demanding service requirements and performance of the assets in a competitive market.



- The absence of digital solutions to dynamically calculate the operational and maintenance scheduling for a fleet of assets considering certain operations to program and task of maintenance to do
- The absence of well-established mathematical models or mechanisms for the seamless integration of indicators and data from predictive maintenance and existing maintenance decision-making processes
- Lack of solutions to integrate fleet operation scheduling and workload balance together with dynamic maintenance management



# Solution Proposal

This solution aims to optimise the management of operation and maintenance of asset fleets, enabling companies to reduce costs and maximise the utilisation of their assets, exploring the interaction between new predictive and existing preventive maintenance approaches and the balance of operation workload.



**Operation Scheduling**



**Preventive Maintenance scheduling**

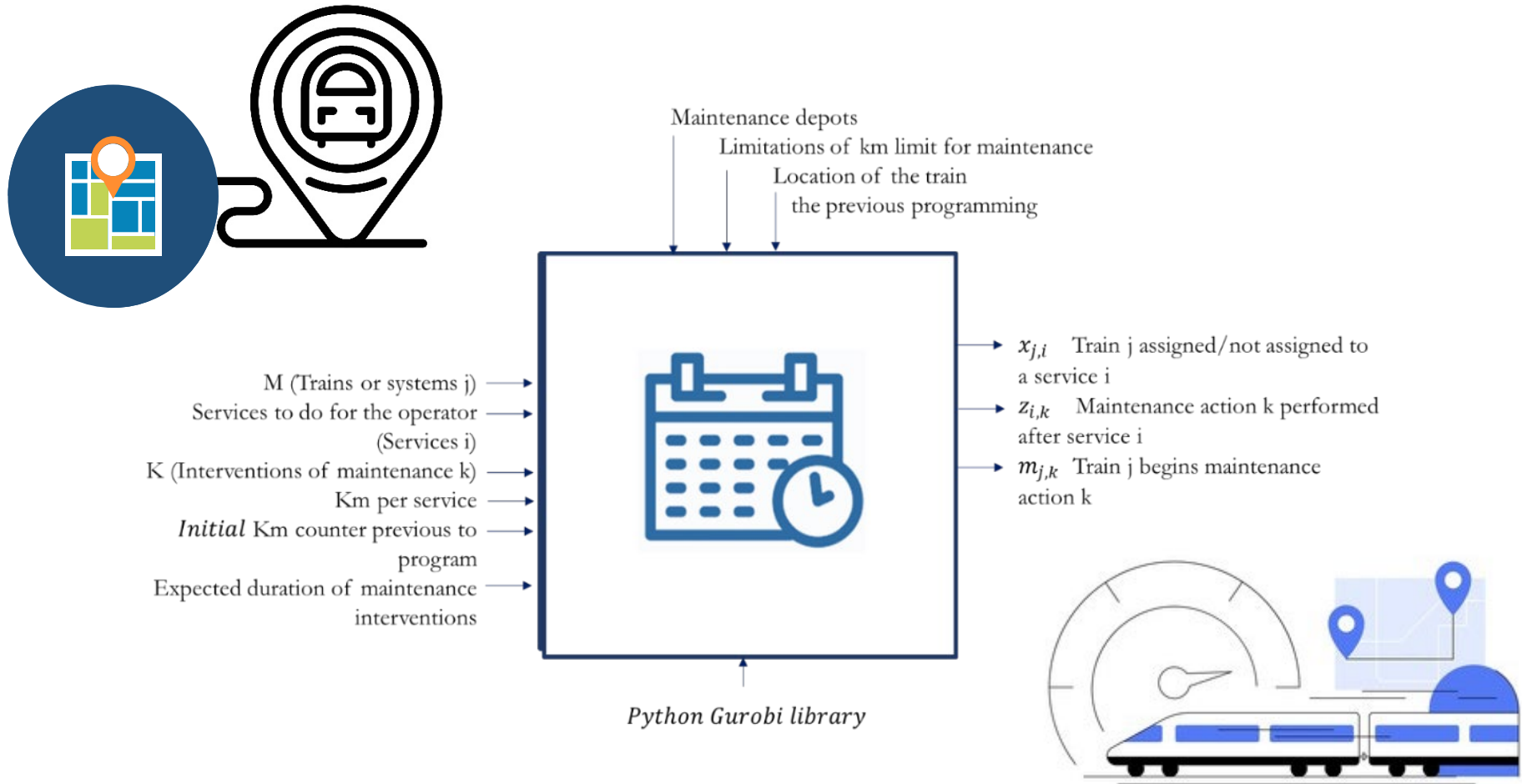


**Predictive Maintenance scheduling**

Adolfo Crespo del Castillo

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# Dynamic Fleet Preventive Maintenance and Operations scheduling



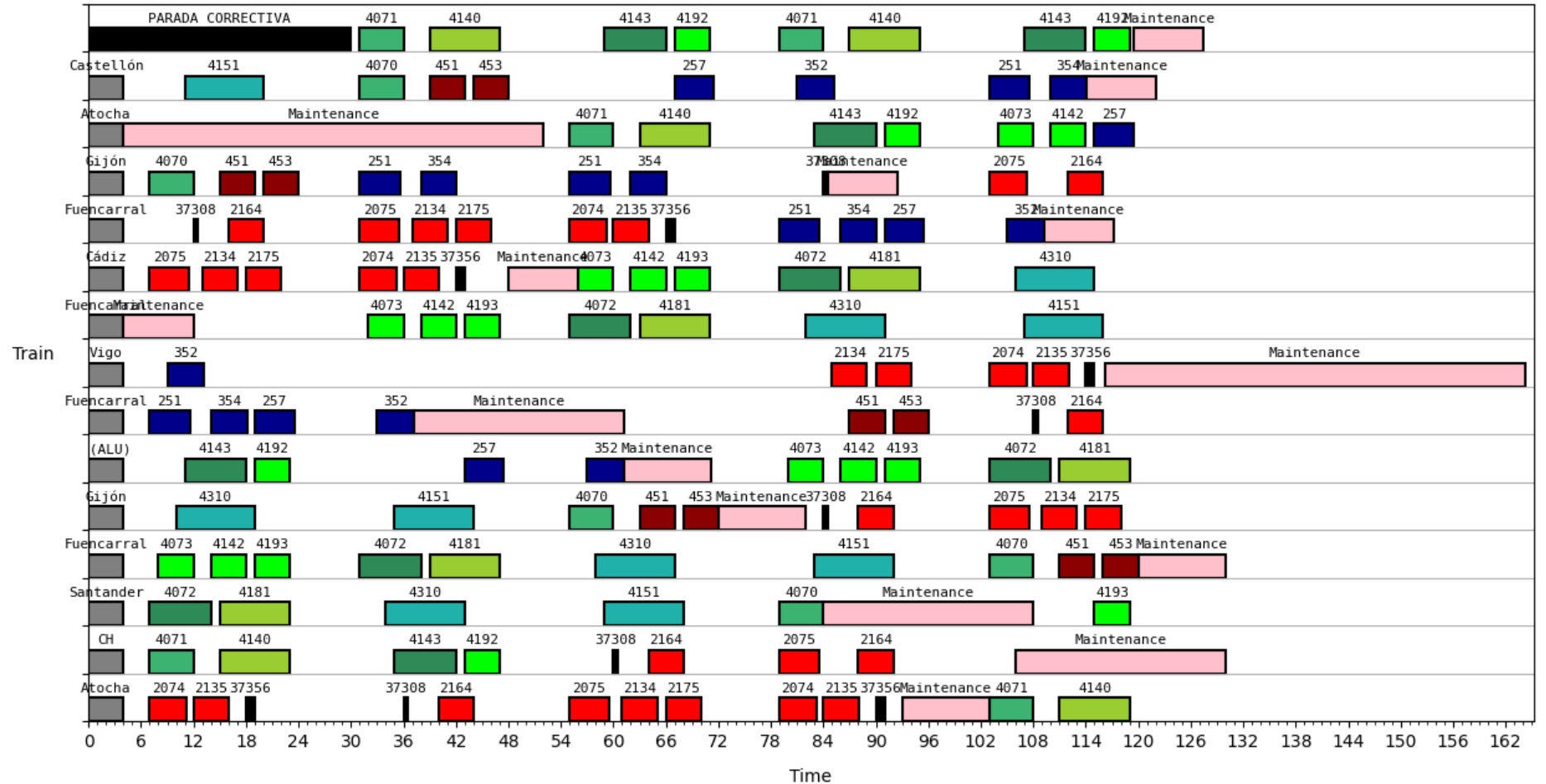


# Dynamic Fleet Preventive Maintenance and Operations scheduling

## KPIs:

- 400 Km usage maximisation of trains before maintenance

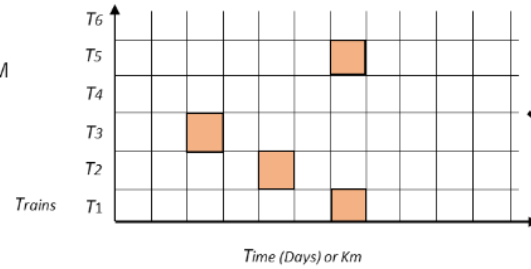
- Scheduling time saving



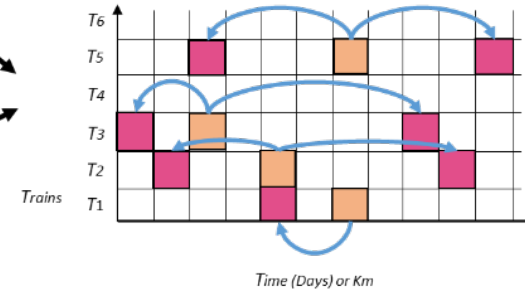
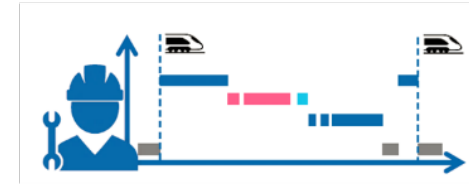
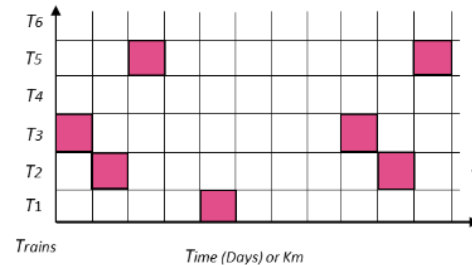
# Dynamic Predictive CBM scheduling



Predictive CBM Interventions allocation without considering preventive maintenance schedule

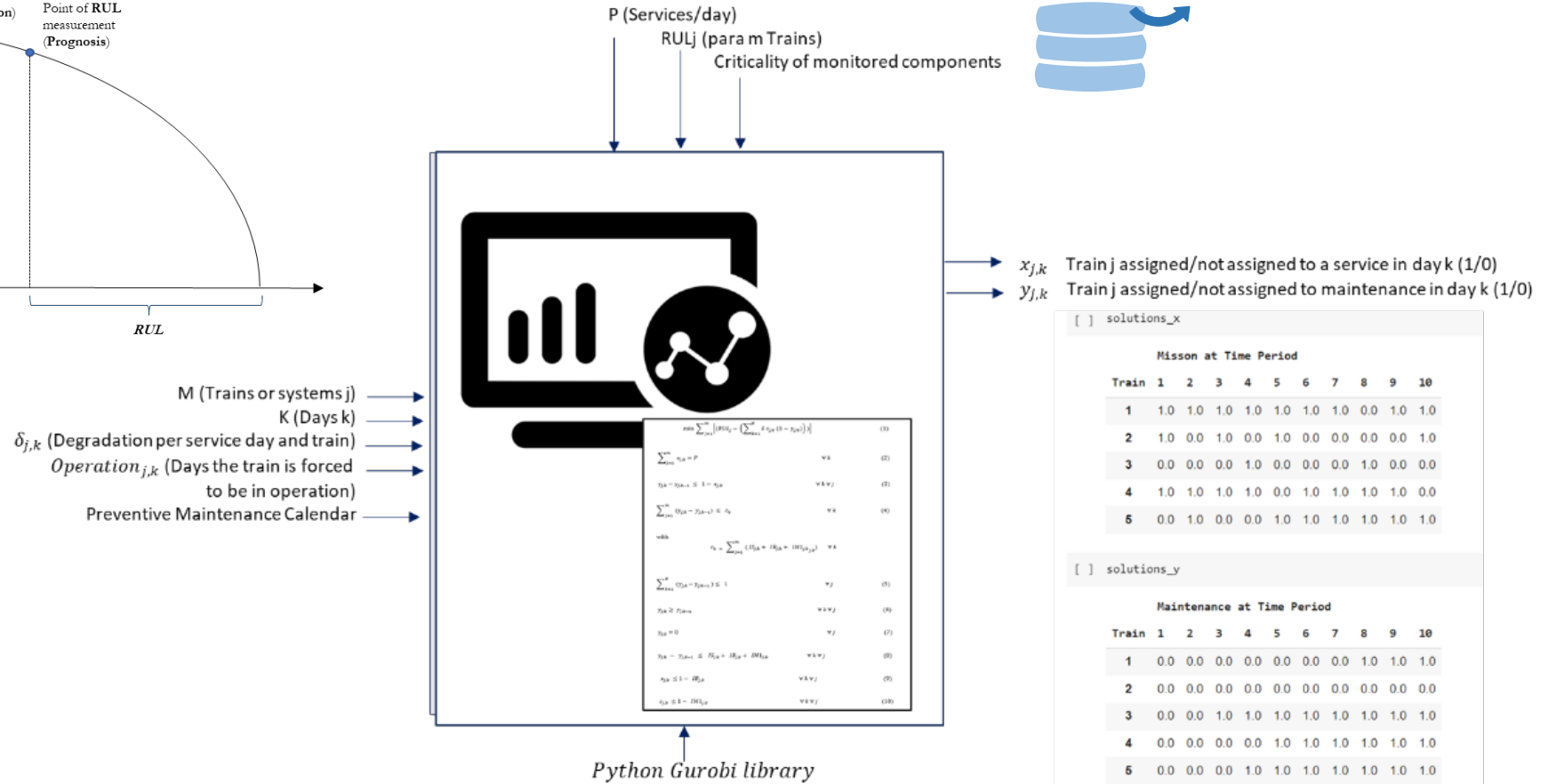
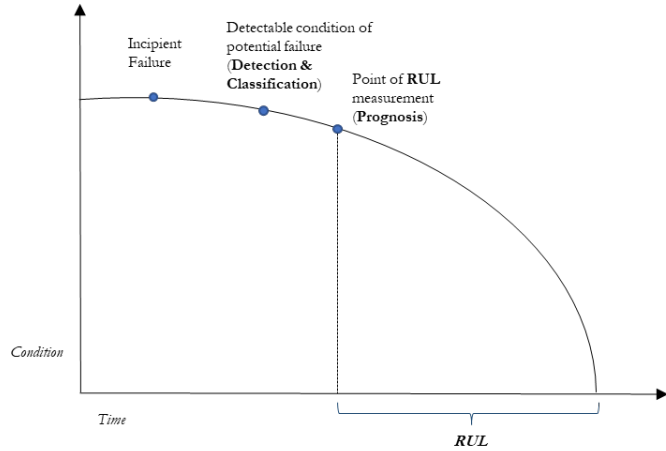


Opportunities for predictive maintenance in preventive inspections



Joint solution to minimise costs, satisfy demand, and respect constraints

# Dynamic Predictive CBM scheduling

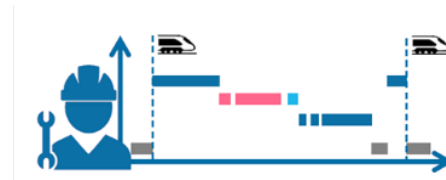






# Dynamic Predictive CBM scheduling

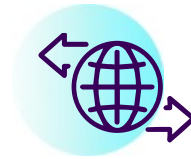
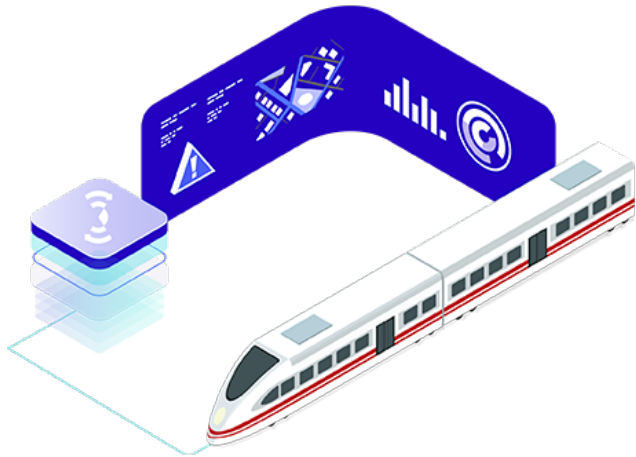
|  |   |
|--|---|
|  | Train sent to operation   |
|  | Preventive Maintenance Inspection - Train stopped                       |
|  | Train Idle  |
|  | CBM intervention performed opportunistically on a preventive inspection |



| RUL | Fleet    | Day1     | Day2     | Day3     | Day4     | Day5     | Day6     | Day7     | Day8     | Day9     | Day10    | Day11    | Day12    | Day13     | Day14   | Day15   |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|---------|---------|
| 24  | Train 1  |          |          | IW - OP  |          |          |          |          | IW - OP  |          |          |          |          |           | IW - OP |         |
| 10  | Train 2  |          | IW - OP  |          |          |          |          |          | IW - OP  | IDLE     |          | IDLE     | IDLE     | IDLE      | IDLE    | IW - OP |
| 12  | Train 3  |          | IM - STC | IM - STC | IM - STC |          |          |          |          |          |          | IW - OP  |          |           |         |         |
| 8   | Train 4  | IM - MLG | IM - MLG | IM - MLG | IM - MLG | IM - MLG | IM - MLG | IM - MLG | IDLE     |          |          | IW - OP  |          |           |         |         |
| 13  | Train 5  |          |          |          | IW - OP  |          |          |          |          | IDLE     | IW - OP  |          |          |           |         | IDLE    |
| 11  | Train 6  |          |          |          |          | IW - OP  |          |          |          |          |          | IW - STC |          |           |         | IS - OP |
| 6   | Train 7  |          |          |          |          |          | IW - STC |          |          |          |          |          | IW - OP  |           |         |         |
| 23  | Train 8  |          |          |          |          |          |          |          |          | IW - OP  |          |          |          |           |         |         |
| 10  | Train 9  |          | IW - OP  |          |          |          |          |          | IB - STC |          |          |          |          |           |         | IS - OP |
| 20  | Train 10 |          |          |          |          | IW - OP  |          |          |          |          |          | IW - OP  |          |           |         |         |
| 4   | Train 11 |          | IW - MLG |          |          |          |          | IW - OP  |          |          |          |          | IW - OP  |           |         |         |
| 11  | Train 12 | IM - STC | IM - STC |          |          |          | IW - OP  |          |          |          |          |          |          | IDLE - IS |         | IDLE    |
| 14  | Train 13 |          |          |          |          |          | IW - OP  |          |          |          |          |          |          |           | IW - OP | IDLE    |
| 7   | Train 14 | IDLE     |          |          |          | IDLE     |          |          |          | IDLE     |          | IDLE     | IB - STC |           |         |         |
| 6   | Train 15 |          |          | IDLE     | IDLE     |          |          |          |          |          | IW - MLG |          |          |           |         | IW - OP |
| 14  | Train 16 |          |          |          | IW - OP  |          |          |          |          |          |          |          | IW - OP  |           | IDLE    |         |
| 4   | Train 17 | IB - STC |          |          |          | IDLE     |          | IW - STC |          |          |          |          |          |           |         | IW - OP |
| 13  | Train 18 |          |          |          |          |          |          | IS - OP  |          |          |          |          |          | IDLE      |         | IDLE    |
| 14  | Train 19 |          |          |          | IW - OP  |          |          |          |          |          |          |          |          | IW - OP   | IDLE    |         |
| 13  | Train 20 |          |          |          | IW - OP  |          |          |          |          |          |          | IW - OP  |          | IDLE      | IDLE    |         |
| 12  | Train 21 |          |          |          |          | IW - OP  |          |          |          |          |          | IM - STC | IM - STC | IM - STC  |         |         |
| 5   | Train 22 |          |          |          |          |          |          | IM - MLG | IM - MLG | IM - MLG |          |          |          |           | IW - OP |         |
| 9   | Train 23 | IW - OP  |          |          |          | IDLE     | IM - STC | IM - STC | IM - STC |          | IDLE     |          | IDLE     |           |         |         |
| 6   | Train 24 |          |          | IDLE     | IDLE     |          |          |          |          | IDLE     | IB - STC |          |          |           |         | IW - OP |

**Total Cost = Cost of performing Predictive CBM + Cost Lost RUL + Cost of possible Corrective + Penalisation for Lost Operation**

# Conclusions



Industrial or transportation fleets need to operate almost continuously, needing to maximise operational time constrained by maintenance and regulation restrictions

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Preventive maintenance is scheduled dynamically for a certain planning horizon and type of stoppages. The usage (Km) of the fleet is maximized and the time used for scheduling reduced.

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Predictive maintenance is scheduled dynamically as anomaly detections arrive to the system. The RUL is probabilistic, hence the model reduces the total cost of scheduling predictive maintenance

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An integrated solution for scheduling fleet maintenance and operation has been developed and could be integrated in any digital platform

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