PRODUCTIONALIZATION OF A PREDICTIVE MAINTENANCE SYSTEM FOR RAILWAYS
01. INTRODUCTION

02. DEFINITION OF CONDITION BASED MAINTENANCE (CBM)

03. CBM IMPLEMENTATION

04. CONCLUSION
01. INTRODUCTION

+ DISTINCT MAINTENANCE TYPES
+ MAINTENANCE REALITY PROCESS
+ MAINTENANCE OPTIMIZATION
3 DISTINCT MAINTENANCE TYPES

MAINTENANCE TYPE: REACTIVE, SCHEDULED AND PREDICTIVE

- **Reliability**: “up time” and safety increase
- **Ownership cost**: Minimize maintenance costs
- **Customers reputations**: Up of availability and quality
MAINTENANCE REALITY PROCESS

TODAY’S MAINTENANCE PROCESS IS 100% PREVENTIVE AND CAN BE IMPROVED.
HOW TO OPTIMIZE MAINTENANCE PROCESS WHEN MAINTENANCE IS BASED ON TASK

Is it possible to perform this check with real time monitoring?

Yes → Predictive maintenance

No → Scheduled maintenance

Optimization by CBM

Optimization by RCM

End

Check

OK ?

Repair

Task i
02. DEFINITION OF CBM

+ MAINTENANCE OPTIMIZATION PROCESS WITH CBM
+ CBM SYSTEM
+ CBM DATA WORKFLOW
+ CBM DETAILED ARCHITECTURE
In rolling stock railway maintenance, it is almost impossible to completely replace a preventive inspection by a predictive maintenance inspection.

To overcome this issue, predictive maintenance is integrated to preventive and corrective maintenance workflow process.

MAINTENANCE OPTIMIZATION WITH CBM

CBM SYSTEM GIVE ORDERS TO MAINTENANCE CENTER. THIS ORDER MUST BE INTEGRATED IN THE MAINTENANCE WORKFLOW PROCESS.
CBM SYSTEM

CBM system is a software tool created to organize predictive maintenance task. It is composed by several function:

- Gather data from on board train systems and sub-systems
- Order and link data from studied systems
- Analyze data
- Translate data from analyzed data to obtain maintenance orders
- Display results in industrial tools
**CBM DATA WORKFLOW**

AN ARCHITECTURE SPLITED IN 7 LAYERS

1. **Import**
   - Data definition
     - Sensor data
     - Data files
     - External database

2. **Data mining**
   - Preprocessing
     - Decoding
     - Noise removing
     - Filtering
     - Sampling
   - Indicator data fusion
     - Performance indicator
     - Diagnosis indicator
     - Failure indicator

3. **Storage**

4. **Indicator Analysis**
   - Time based analysis
   - Distribution analysis

5. **Prognostic**
   - Knowledge based prognosis
   - Physical rules engine
   - Rules engine

6. **Presentation**
   - Web interface
   - CMMS

7. **Decision support**
   - Maintenance orders
   - Health monitoring
   - Rolling stock monitoring

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**MATLAB and Compiler SDK TBX**

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- TUESDAY, JUNE 19, 2018
CBM – DATA IMPORT
DATA IMPORT VS ROLLING STOCK TYPE

Connected train (native sensors and network)

- RER-NG
  - Native data file:
    - Sub system data file
      - Passengers access
    - HVAC
    - Train data file
  - Data type:
    - Boolean data
    - Analog data
    - Context data
    - Maintenance and operation data

- R2N

- NAT

Unconnected train (integrate sensors and network)

- TGV
  - Additional sensors:
    - IoT
    - Data acquisition card

- Z2N

Transmission type:
- Volumetry
  - WiFi
  - ZONE
  - 4G
  - 3G
  - LoRa
  - SIGFOX

CBM off-board server

Wired data

CBM off-board server

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CBM – DATA PREPROCESSING
IMPORTATION, CLASSIFICATION, DECODING, FILTERING AND RE-SAMPLING

Off-board server
- Import:
  - FTP
  - Web Service
  - API
- Order:
  - Train type 1
  - System 1
  - System n
  - Train type n

CBM server
- Decode:
  - Context data
  - Boolean data
  - Analog data
- Preprocessing:
  - Cycles identification
  - Invalid cycle filtering system
- Data Cleaning:
  - Noise removing
  - Re-sampling

MATLAB and Parallel Computing TBX
MATLAB and Statistics & Machine Learning TBX
CBM – DATA PREPROCESSING

CBM BATTERY – CYCLE IDENTIFICATION

Battery current intensity (2 hours)

Cycle 1
Too short

Cycle 2
Exploitable cycle
- discharge
- charge in boost mode

Cycle 3
- charge in floating mode

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CBM – DATA PROCESSING
FROM TRAIN SIGNAL TO INDICATORS DATA

MATLAB, Statistics and Machine Learning TBX + Database TBX

Clean data → «Low level» indicator → Performance indicators → Indicator DBSM recording

CBM server

∑

«Low level» indicator

F(x)

Performance indicators
CBM – INDICATORS PROCESSING EXAMPLE

INDICATOR CREATION FOR BATTERY SYSTEM

Indicator definition:
An indicator is a “simple” calculated value extracted from a time data sensor.
Example:

Indicator 1: Current discharge quantity
Coding: current discharge area

Indicator 2: Current charge quantity in boost mode
Coding: current charge area

Performance indicator: discharge/charge ratio

CBM Server

SGBD Recording

MATLAB, Statistics and Machine Learning TBX + Database TBX
CBM – MAINTENANCE DATA PROCESSING

FROM INDICATORS DATA TO MAINTENANCE DATA

Indicators DBSM → Prognostic:
- Expert system
- Machine learning → Criticism estimator system

MATLAB, Statistics and Machine Learning TBX + Database TBX

Use of Predictive Maintenance TBX in study
CBM – PROGNOSTIC

INDICATOR ANALYSIS (TIME AND DISTRIBUTION)

Time analysis: how evolve an indicator during time

Distribution analysis: how indicator values are distributed among rolling stock fleet

CBM Server

Time analysis:
- Indicators value
- Optimum
- Average
- Abnormal behavior

Distribution analysis:
- Indicators value
- Optimum
- Average
- Abnormal behavior
CBM – VISUALIZATION

FROM MAINTENANCE DATA TO MAINTENANCE ORDERS GMAO SYSTEM

Maintenance DBSM → Train criticism estimator → Visualization of maintenance orders and maintenance data in maintenance factory

CBM server
CBM – VISUALIZATION TOOLS

VISUALIZATION TOOLS FOR CONDITION-BASED MAINTENANCE

Etat parc preventif NAT

Fonction Principale : Accès voyageurs

COM Valables : Traceabilité CBM.12/13/14/15 Porte

Joncherolles

PSL

Noisy

Vert 13

Jaune 25

Vert 43

Vue damier

Vue carte

6

7
# CBM – VISUALIZATION TOOLS

VISUALIZATION TOOLS FOR CONDITION BASED MAINTENANCE

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## Operation Tracabilité CBM MIT12/13/14/15 Porte sur rame 13H 50025

Tracabilité éditée le 2018-03-30 08:20:55

### Communication train

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<th>V4 503025</th>
<th>V5 504025</th>
<th>V6 505025</th>
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TÉLÉDIAG ST PIERRE DES CORPS

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# FAQs

**1. What is CBM?**

Condition-based maintenance (CBM) is an approach to maintenance that involves monitoring the condition of equipment and implementing maintenance actions based on that condition rather than fixed time-based intervals. CBM aims to reduce overall maintenance costs and improve equipment availability.

**2. What are visualization tools?**

Visualization tools are software applications used to display and analyze data in a graphical format, making it easier to understand complex information. In the context of CBM, these tools help in monitoring and analyzing the condition of assets, identifying trends, and predicting failures.

**3. How do visualization tools support CBM?**

Visualization tools for CBM provide a visual representation of data collected from assets, allowing maintenance teams to quickly identify patterns, trends, and potential issues. This can lead to more effective and efficient maintenance planning and execution.

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**Source:** ikos SNCF
## CBM – VISUALIZATION TOOLS

**VISUALIZATION TOOLS FOR CONDITION BASED MAINTENANCE**

### Accès voyageurs

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<th>Porte</th>
<th>Gauche</th>
<th>Droite</th>
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**–**  **TUESDAY, JUNE 19, 2018**
05. USE CASES

+ ALL OUR USE CASES
+ DOORS USE CASE
+ HVAC USE CASE
+ PANTOGRAPH USE CASE
ALL OUR USE CASES

FEW EXAMPLES OF OUR USE CASES

Compressor
Performance

Battery
Capacity ratio

Pantograph
Taring and up/down time

HVAC
Performance

Doors and Steps
Performance and adjustment

Traction
Engine performance

Brake
Brake performance

Toilette
Reservoir levels

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DOORS USE CASE

Problem with the door seal

Current (A)

Deviation

Time (CS)

CBM server

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PANTOGRAPH USE CASE

Pressure (Pa)

Deviation

Brief loss of contact with catenary

CBM server

Cloud
06. CONCLUSION

+ OUR LIFE CYCLE
+ OUR PRODUCT
CONCLUSION : OUR LIFE CYCLE

Without a single step, our maintenance is not optimized
CONCLUSION : OUR PRODUCT
A SOLUTION IN ADEQUACY WITH ROLLING STOCK FLEET CONSTRAINTS

A new maintenance process, centered on data

Our solution is a complete turnkey for SNCF. It optimizes the whole maintenance process without breaking the existent process. Our product use native train sensors when it’s possible and replace already existing maintenance task.

Data analysis
Understand and process data from train

Scheduling helper
Give information based on data to schedule maintenance center operation.

Native connected rolling stock fleet
All train with on board / off board communication systems and sensors

Maintenance helper
Give tool to optimize maintenance process
CONCLUSION : PROSPECTS
MAINTENANCE 4.0 FROM CBM TO THE WHOLE MAINTENANCE PROCESS CENTERED ON DATA

New train
Standardize and expand our CBM system to all rolling stock

Connect resources
Connect stock availability maintenance order and human resources to find the best possible maintenance order

Connect schedule
Use operational data to optimize the callback of rolling stock in maintenance center accordingly with connected resources

Technology
Always move forward with new tech BigData, AI, new algorithm...

Industrialize
Even if our system is in production we have to study how to grow our tech to absorb and compute always more data

Reactive Maintenance
Speed up (real-time data) data process to optimize reactive maintenance