

# PRODUCTIONALIZATION OF A PREDICTIVE MAINTENANCE SYSTEM FOR RAILWAYS



01. INTRODUCTION

02. DEFINITION OF CONDITION BASED MAINTENANCE (CBM)

03. CBM IMPLEMENTATION

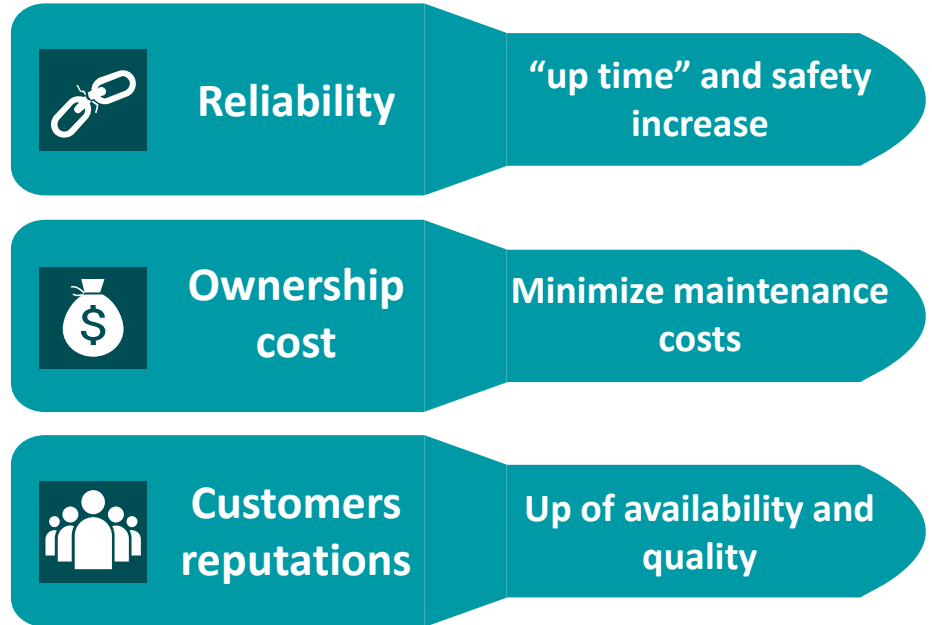
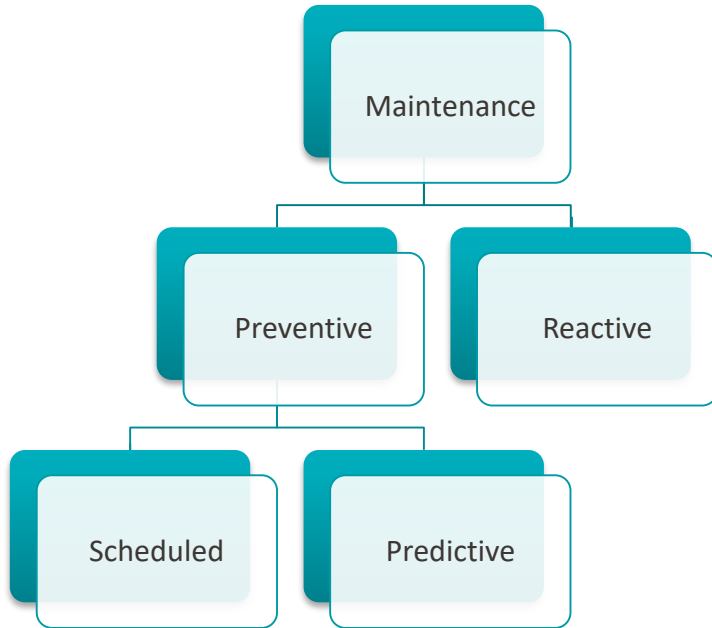
04. CONCLUSION

# 01. INTRODUCTION

- + DISTINCT MAINTENANCE TYPES
- + MAINTENANCE REALITY PROCESS
- + MAINTENANCE OPTIMIZATION

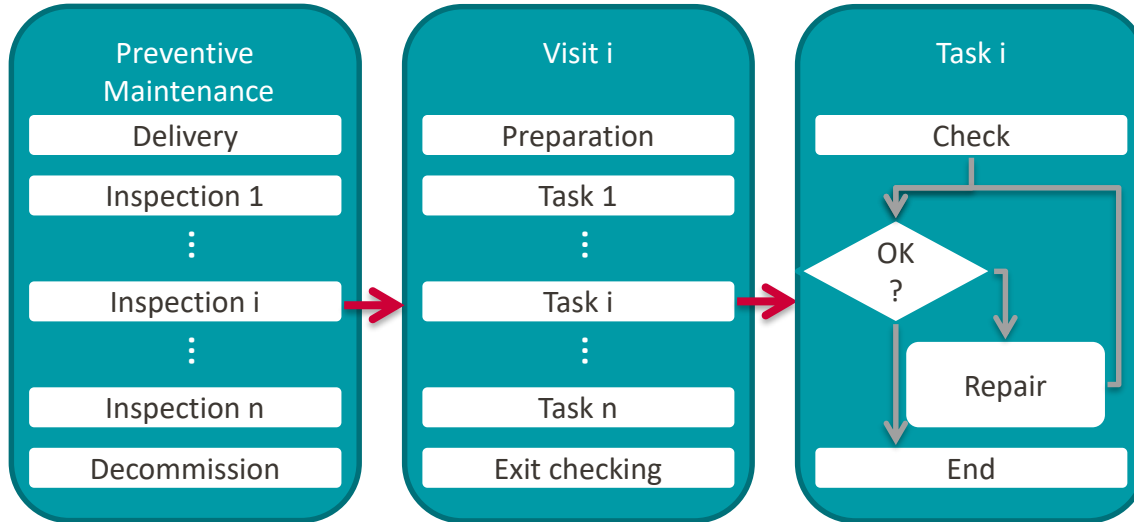
# 3 DISTINCT MAINTENANCE TYPES

MAINTENANCE TYPE : REACTIVE, SCHEDULED AND PREDICTIVE

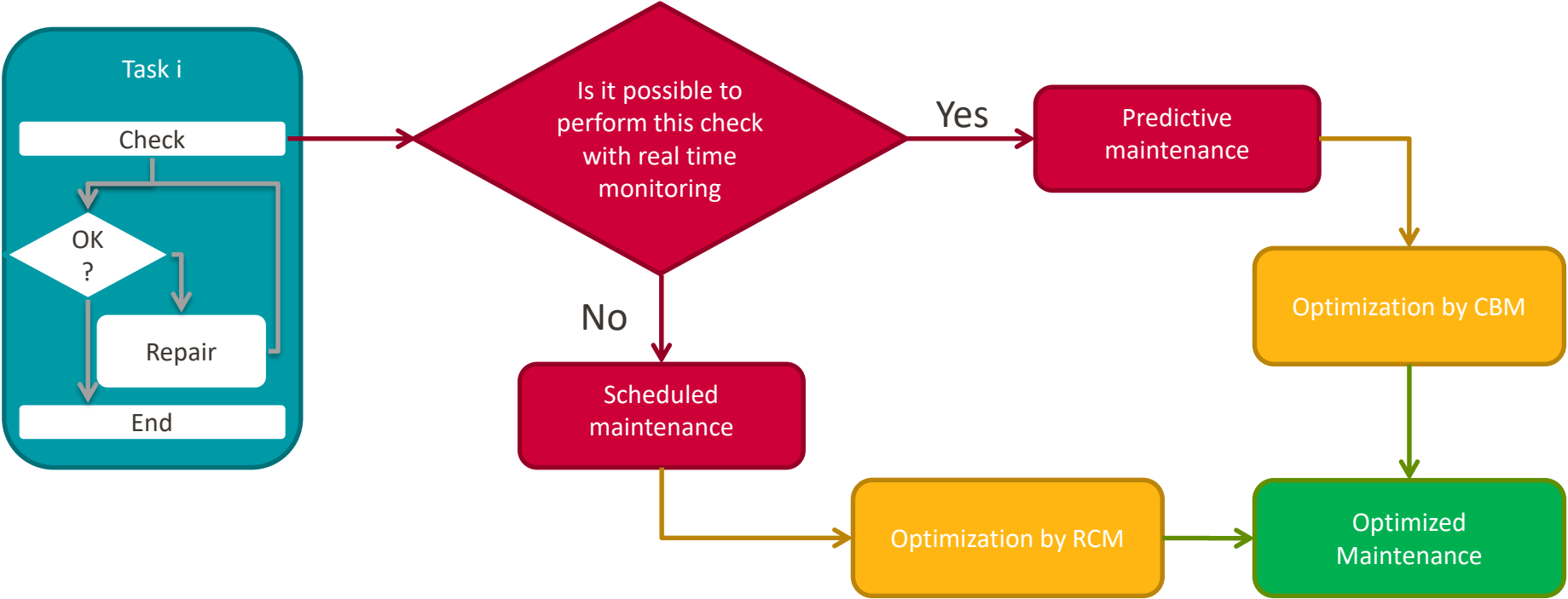


# MAINTENANCE REALITY PROCESS

TODAY'S MAINTENANCE PROCESS IS 100% PREVENTIVE AND CAN BE IMPROVED.



# HOW TO OPTIMIZE MAINTENANCE PROCESS WHEN MAINTENANCE IS BASED ON TASK



# 02. DEFINITION OF CBM

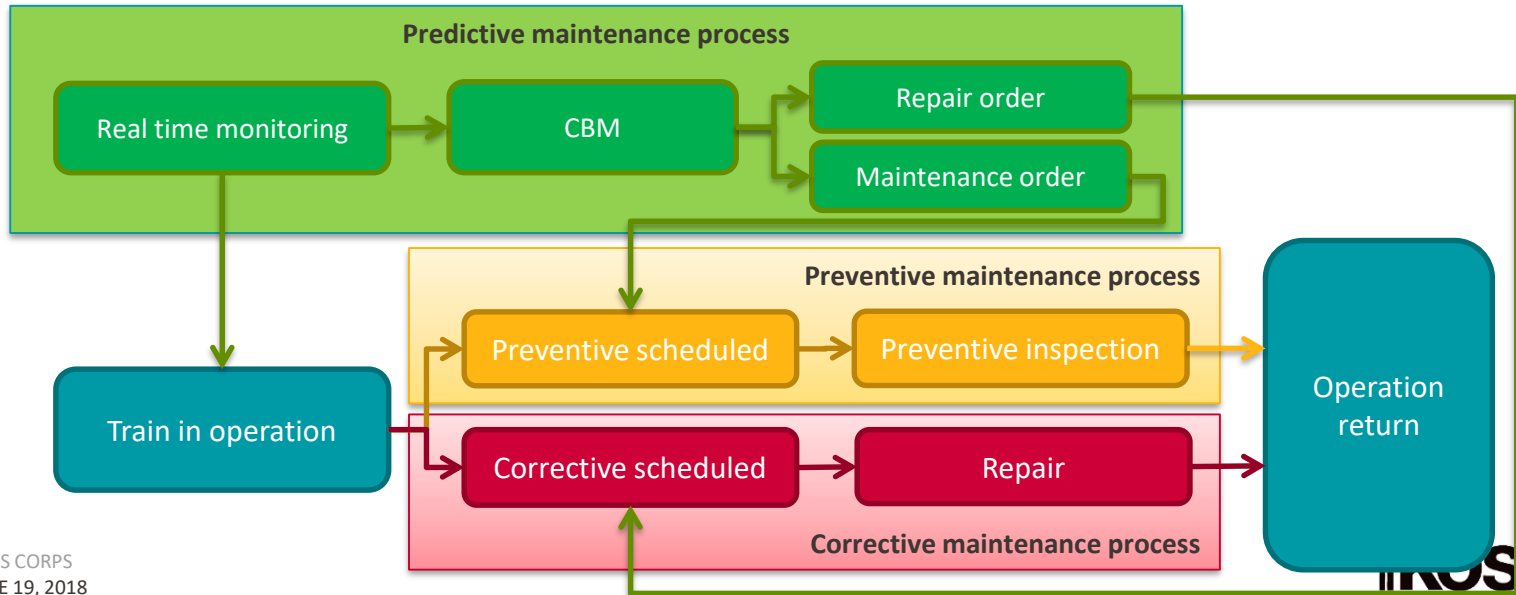
- + MAINTENANCE OPTIMIZATION PROCESS WITH CBM
- + CBM SYSTEM
- + CBM DATA WORKFLOW
- + CBM DETAILED ARCHITECTURE

# MAINTENANCE OPTIMIZATION WITH CBM

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

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.

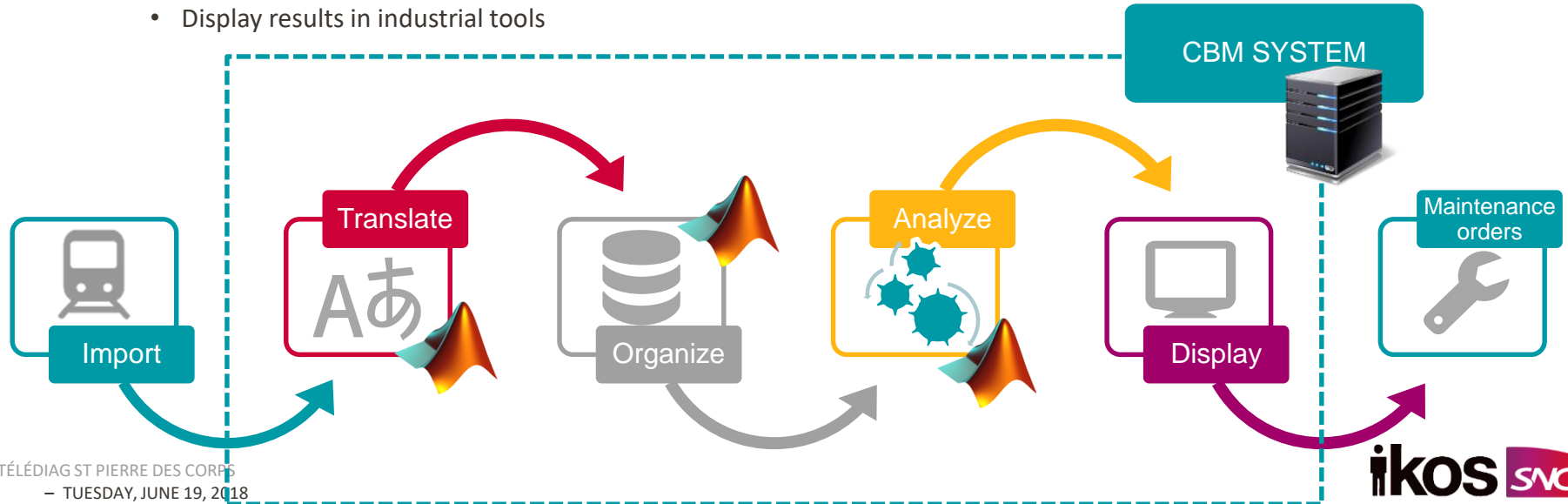




# CBM SYSTEM

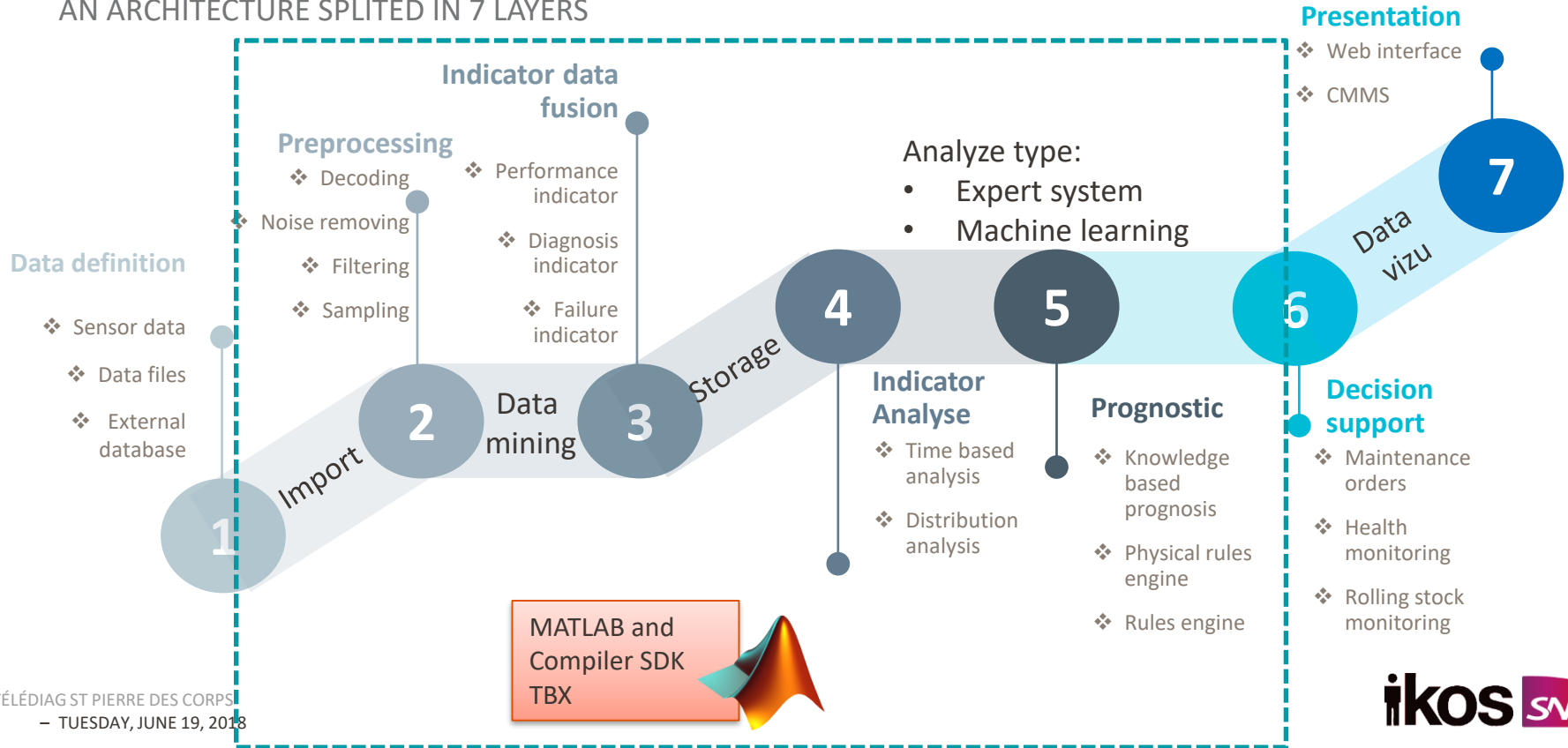
CBM system is a software tool created to organize predictive maintenance task. It is composed by several function :

- 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



# CBM – DATA IMPORT

DATA IMPORT VS ROLLING STOCK TYPE

1

## Connected train (native sensors and network)



RER-NG



R2N



NAT

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

Transmission type:



4G

3G

## Unconnected train (integrate sensors and network)



TGV



Z2N

Additional sensors:

- IoT
- Data acquisition card



Volumetry ↑

7



Wired data

CBM off-board server



# CBM – DATA PREPROCESSING

IMPORTATION, CLASSIFICATION, DECODING, FILTERING AND RE-SAMPLING

2

Off-board server

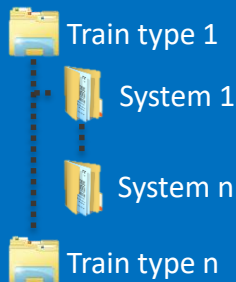


Import :

- FTP
- Web Service
- API



Order :



Decode :

- Context data
- Boolean data
- Analog data

MATLAB and  
Parallel  
Computing TBX

CBM server



Preprocessing :

- Cycles identification
- Invalid cycle filtering system

Data Cleaning :

- Noise removing
- Re-sampling

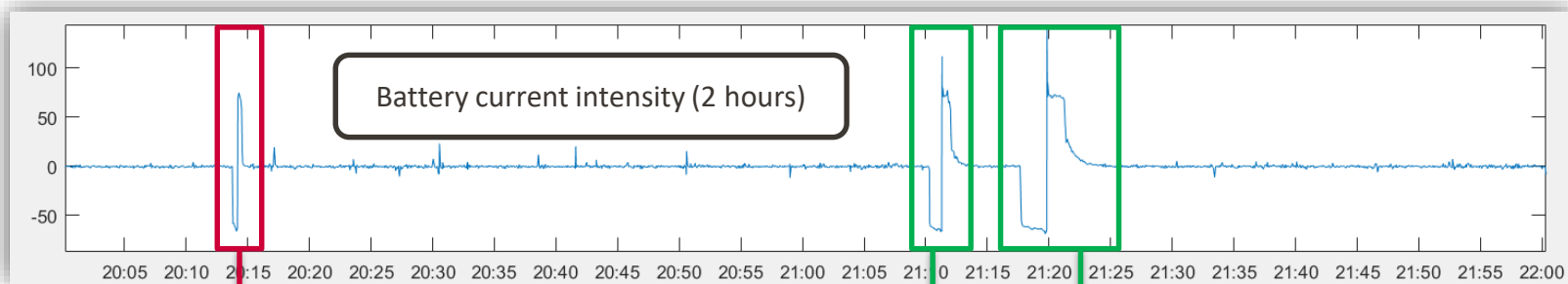
MATLAB and Statistics & Machine Learning  
TBX

7

# CBM – DATA PREPROCESSING

## CBM BATTERY – CYCLE IDENTIFICATION

2



Cycle 1

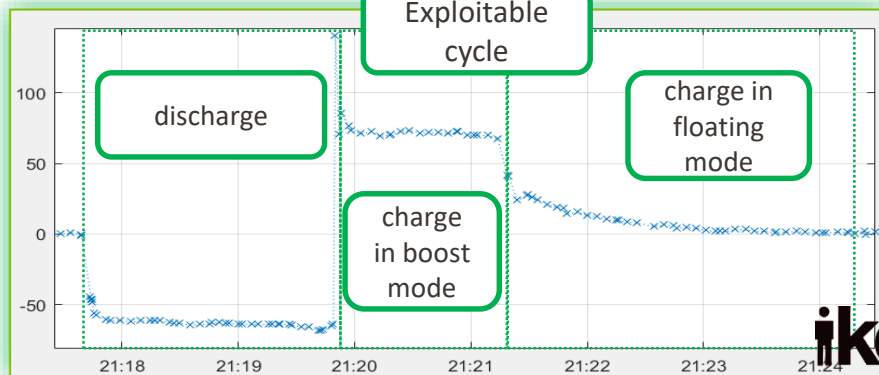
Too short



Cycle 2

Cycle 3

Exploitable cycle

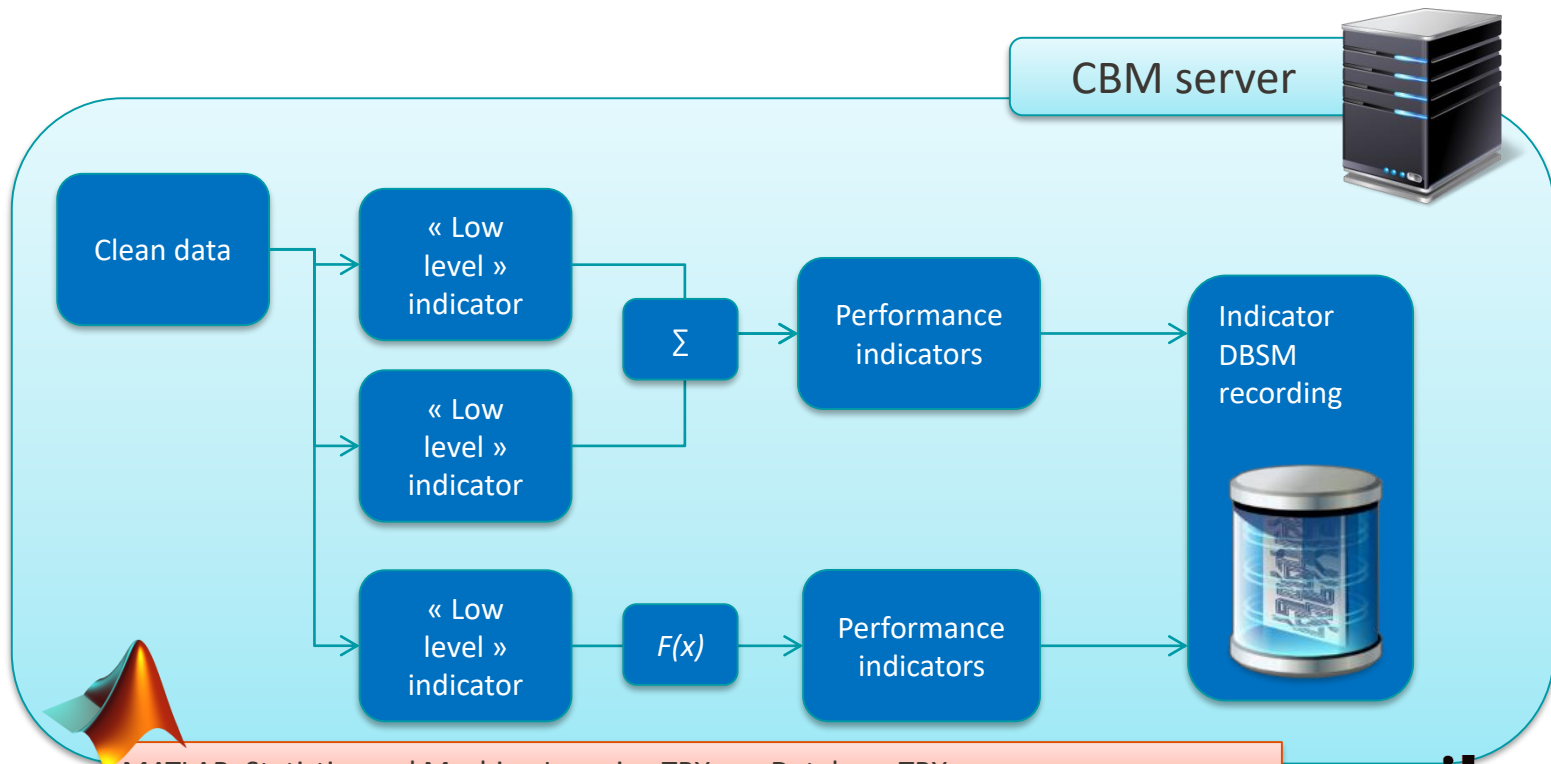


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# CBM – DATA PROCESSING

FROM TRAIN SIGNAL TO INDICATORS DATA

- 2
- 3
- 4
- 7



# CBM – INDICATORS PROCESSING EXAMPLE

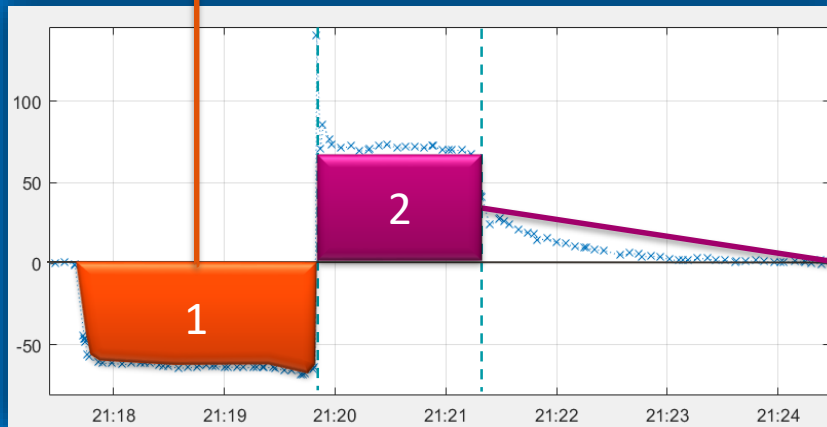
## INDICATOR CREATION FOR BATTERY SYSTEM

3

Indicator definition :

An indicator is a “simple” calculated value extracted from a time data sensor.

Example :



7

CBM Server



Indicator 1 : Current discharge quantity

Coding : current discharge area

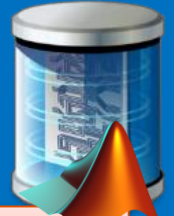
Indicator 2 : Current charge quantity in boost mode

Coding : current charge area

Performance indicator : discharge / charge ratio

%

SGBD Recording

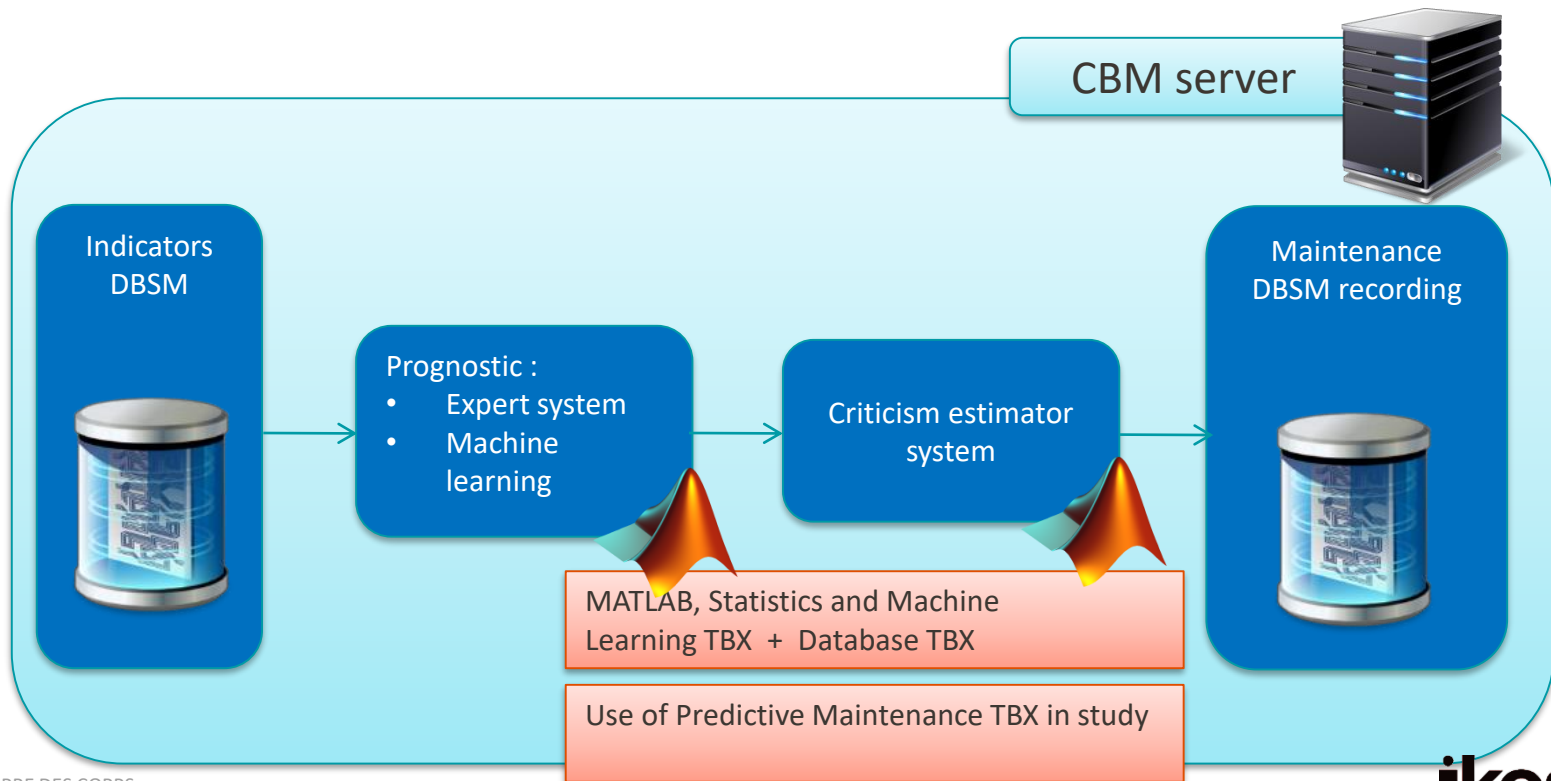


MATLAB, Statistics and Machine Learning TBX + Database TBX

# CBM – MAINTENANCE DATA PROCESSING

FROM INDICATORS DATA TO MAINTENANCE DATA

- 4
- 5
- 6
- 7





# CBM – PROGNOSTIC

## INDICATOR ANALYSIS (TIME AND DISTRIBUTION)

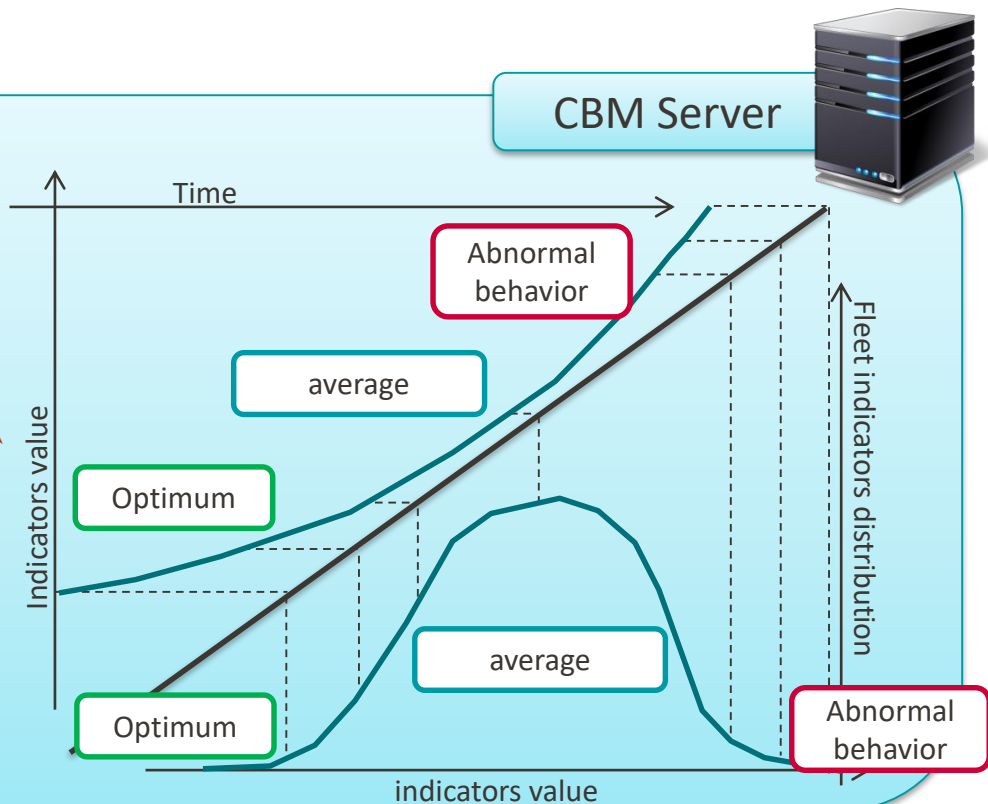
4

Time analysis :  
how evolve an indicator  
during time



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

7



# CBM – VISUALIZATION

FROM MAINTENANCE DATA TO MAINTENANCE ORDERS GMAO SYSTEM



CBM server

6

7

Maintenance DBSM



Train criticism estimator

Visualization of maintenance orders and maintenance data in maintenance factory



TM

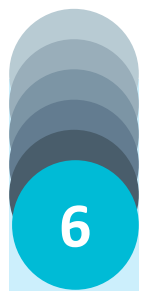
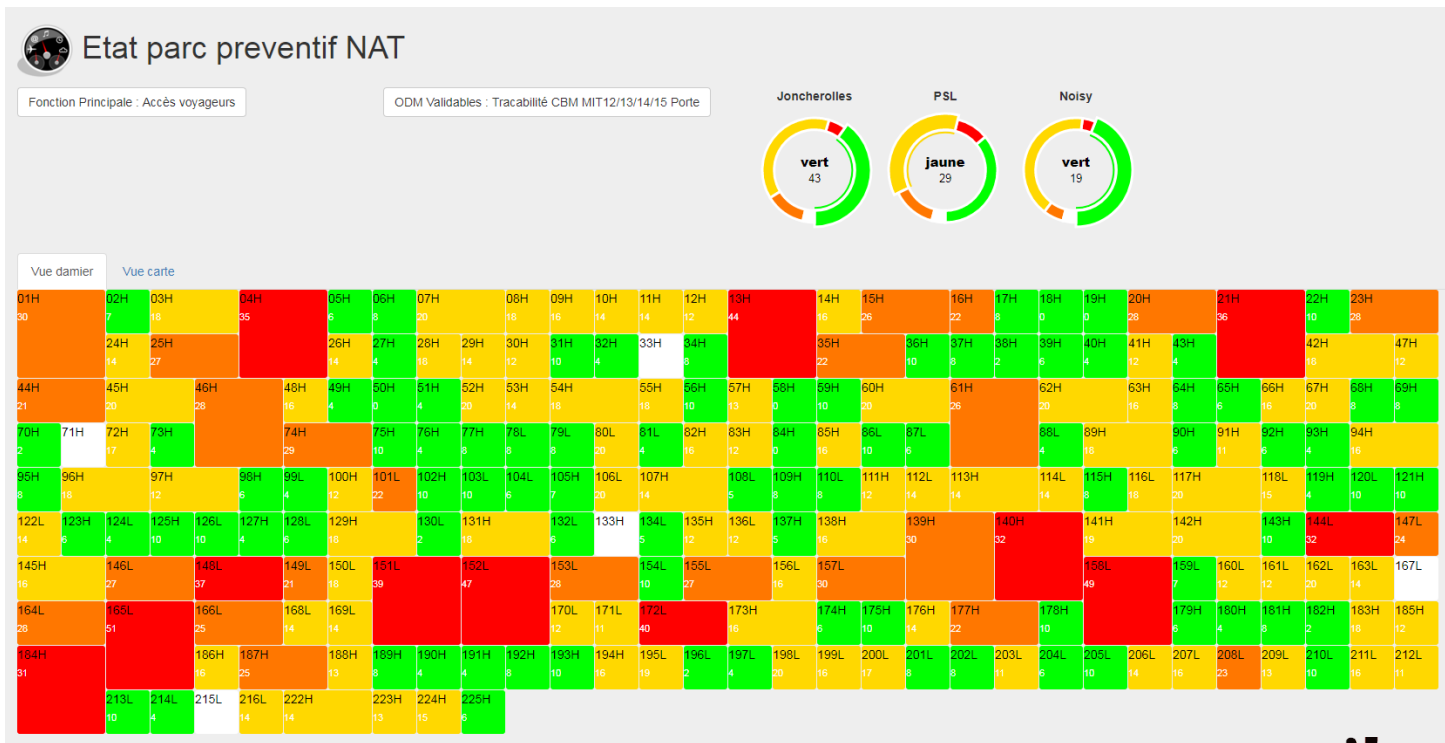


STF



# CBM – VISUALIZATION TOOLS

VISUALIZATION TOOLS FOR CONDITION-BASED MAINTENANCE



# CBM – VISUALIZATION TOOLS

## VISUALIZATION TOOLS FOR CONDITION BASED MAINTENANCE

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

Tracabilité éditée le 2018-03-30 08:29:55

Communication train



#### Tâches validées par CBM

Tâches	V1 50025		V2 501025		V3 502025		V4 503025		V5 504025		V6 505025		V7 506025		V8 50026	
	G	D	G	D	G	D	G	D	G	D	G	D	G	D	G	D
Com de la DCU	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Date (jours)	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	G	D	G	D	G	D	G	D	G	D	G	D	G	D	G	D
Z50-AAAA-NB-01-02-03AAA-310A-A Côte de passage	✗	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓
Z50-AAAA-NA-00-00-01AAA-300A-A Hauteur brosses seuils de portes	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Z50-AAAA-NB-01-03-02AAA-361A-A Courroie du mécanisme de porte	✗	✓	✗	✓	✗	✓	✗	✗	✓	✓	✓	✓	✓	✗	✓	✗
Z50-AAAA-NB-01-04-00AAA-300A-A Fin de course fermeture porte (S1)	✗	✓	✗	✓	✗	✓	✗	✗	✓	✓	✓	✓	✓	✗	✓	✗

6

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# CBM – VISUALIZATION TOOLS

## VISUALIZATION TOOLS FOR CONDITION BASED MAINTENANCE

### Accès voyageurs

Gauche



#### Porte

- Version du Soft de la DCU *Date dernier cycle: 2018-03-01 16:39:00*
- Rebond à la fermeture Porte (cause DCU) *Date dernier cycle: 2018-03-01 16:39:00*
- Réglage du FCF ou de la courroie porte *Date dernier cycle: 2018-03-16 20:48:00*
- Effort O/F Porte *Date dernier cycle: 2018-03-16 20:48:00*
- Réglage butée Porte *Date dernier cycle: 2018-03-16 20:48:00*
- Frottement périphérique joint porte *Date dernier cycle: 2018-03-16 20:48:00*
- Fonctionnement O/F Porte *Date dernier cycle: 2018-03-16 20:48:00*
- Réglage brosse porte *Date dernier cycle: 2018-03-16 20:48:00*

#### UFR

- Fonctionnement O/F UFR *Date dernier cycle: 2018-03-16 20:48:00*
- Effort O/F UFR *Date dernier cycle: 2018-03-16 20:48:00*
- Réglage du FCF UFR *Date dernier cycle: 2018-03-16 20:48:00*
- Réglage de la courroie UFR *Date dernier cycle: 2018-03-16 20:48:00*

#### PMR

- Fonctionnement O/F PMR *Date dernier cycle: 2018-03-16 20:37:00*
- Effort O/F PMR *Date dernier cycle: 2018-03-16 20:37:00*
- Réglage du FCF PMR *Date dernier cycle: 2018-03-16 20:37:00*
- Réglage butée PMR *Date dernier cycle: 2018-03-16 20:37:00*
- Réglage de la courroie de la PMR *Date dernier cycle: 2018-03-16 20:37:00*

#### DCU

- Com de la DCU *Date dernier cycle: 2018-03-16 21:01:00*

Droite



#### Porte

- Version du Soft de la DCU *Date dernier cycle: 2018-03-09 12:09:00*
- Rebond à la fermeture Porte (cause DCU) *Date dernier cycle: 2018-03-09 12:09:00*
- Réglage du FCF ou de la courroie porte *Date dernier cycle: 2018-03-16 20:55:00*
- Effort O/F Porte *Date dernier cycle: 2018-03-16 20:55:00*
- Réglage butée Porte *Date dernier cycle: 2018-03-16 20:55:00*
- Frottement périphérique joint porte *Date dernier cycle: 2018-03-16 20:55:00*
- Fonctionnement O/F Porte *Date dernier cycle: 2018-03-16 20:55:00*
- Réglage brosse porte *Date dernier cycle: 2018-03-16 20:55:00*

#### UFR

- Fonctionnement O/F UFR *Date dernier cycle: 2018-03-16 19:07:00*
- Effort O/F UFR *Date dernier cycle: 2018-03-16 19:07:00*
- Réglage du FCF UFR *Date dernier cycle: 2018-03-16 19:07:00*
- Réglage de la courroie UFR *Date dernier cycle: 2018-03-16 19:07:00*

#### PMR

- Fonctionnement O/F PMR *Date dernier cycle: 2018-03-16 20:55:00*
- Effort O/F PMR *Date dernier cycle: 2018-03-16 20:55:00*
- Réglage du FCF PMR *Date dernier cycle: 2018-03-16 20:55:00*
- Réglage butée PMR *Date dernier cycle: 2018-03-16 20:55:00*
- Réglage de la courroie de la PMR *Date dernier cycle: 2018-03-16 20:55:00*

#### DCU

- Com de la DCU *Date dernier cycle: 2018-03-16 20:55:00*

6

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# 05. USE CASES

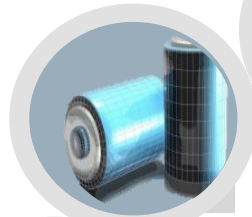
- + ALL OUR USE CASES
- + DOORS USE CASE
- + HVAC USE CASE
- + PANTOGRAPH USE CASE

# ALL OUR USE CASES

FEW EXAMPLES OF OUR USE CASES

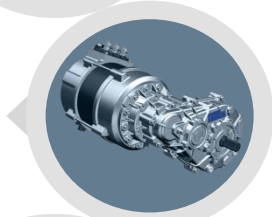
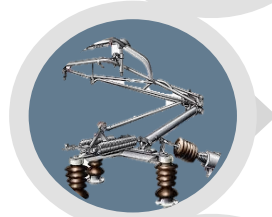
## Compressor

Performance



## Battery

Capacity ratio

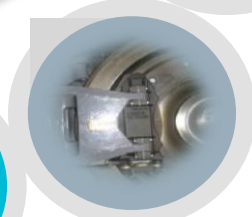


## Pantograph

Taring and up/down time

## HVAC

Performance



## Doors and Steps

Performance and adjustment

## Traction

Engine performance

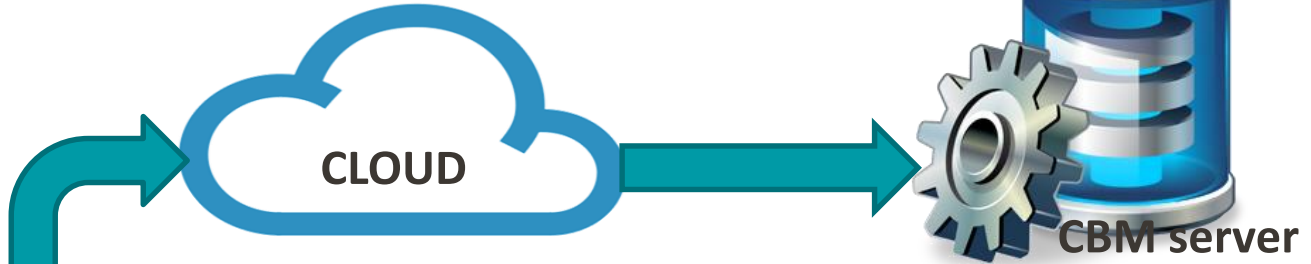
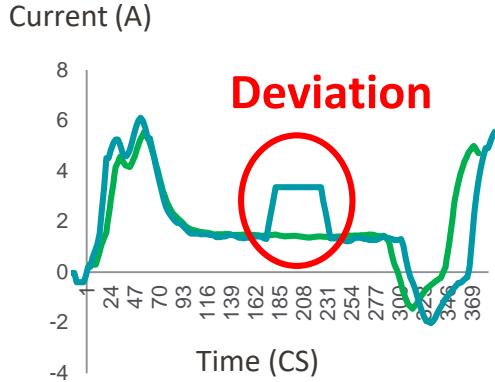
## Brake

Brake performance

## Toilette

Reservoir levels

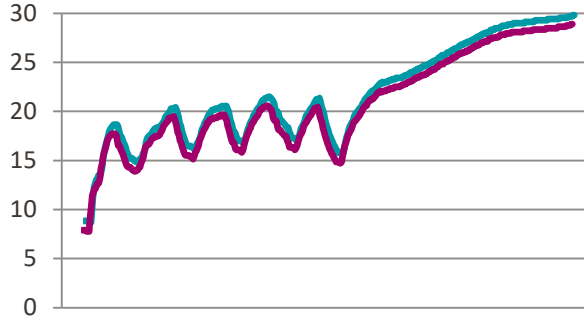
# DOORS USE CASE





# HVAC USE CASE

Temperature (°C)

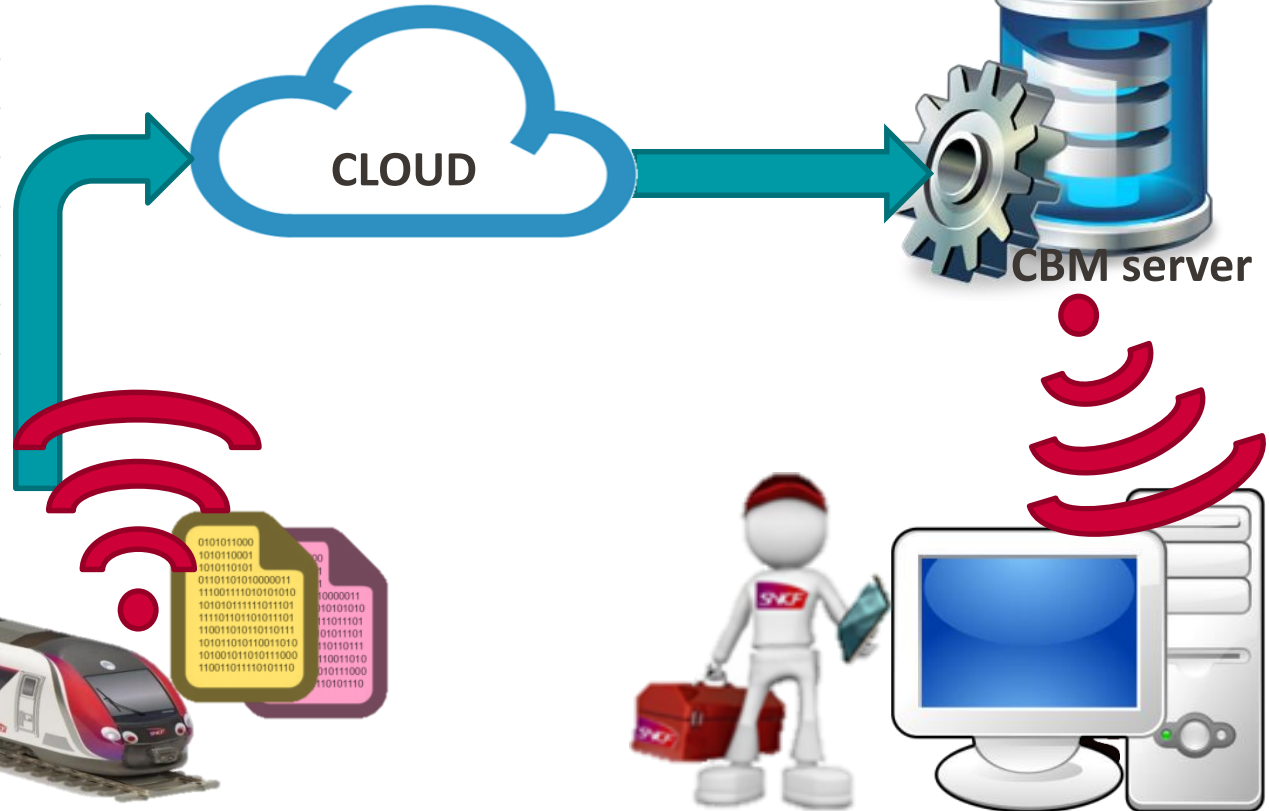


Time (CS)

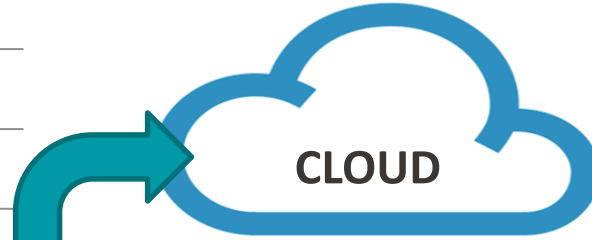
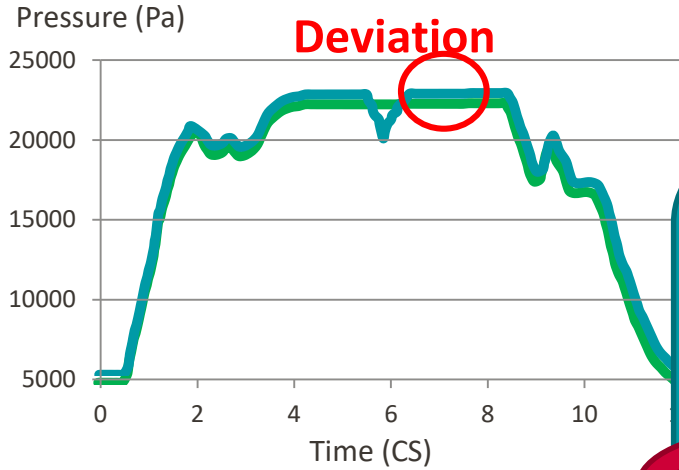


**HVAC**

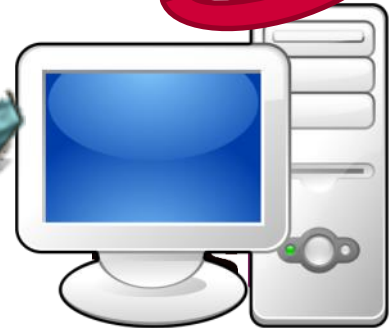
TÉLÉDIAG ST PIERRE DE JOUR  
- TUESDAY, JUNE 19, 2018



# PANTOGRAPH USE CASE



**Brief loss of contact  
with catenary**



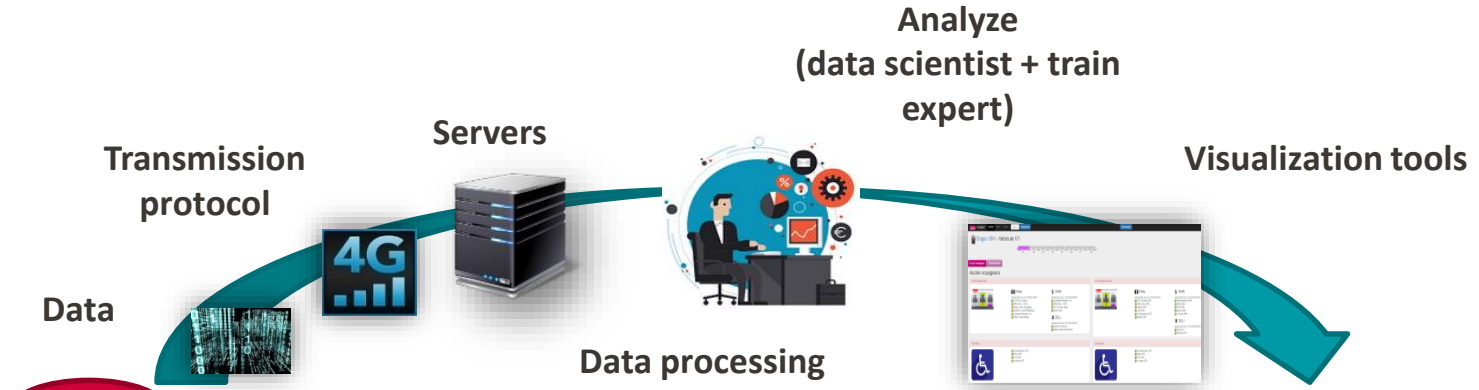
TÉLÉDIAG ST PIERRE DES CORPS

- Pantograph

# 06. CONCLUSION

- + OUR LIFE CYCLE
- + OUR PRODUCT

# CONCLUSION : OUR LIFE CYCLE

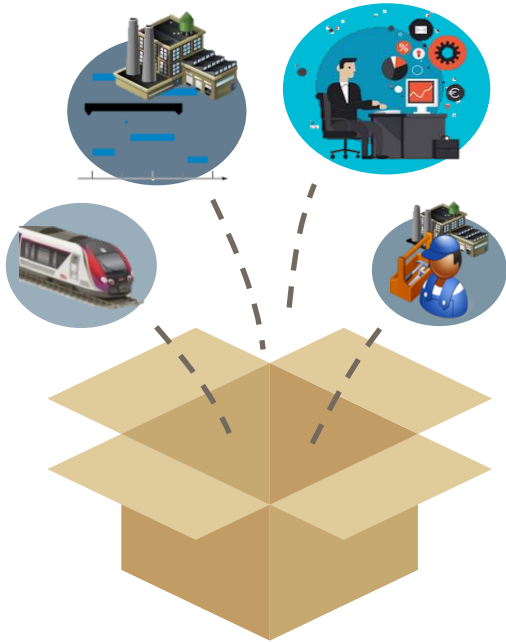


*Without a single step, our maintenance is not optimized*



# 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