UIC HIGHSPEED Morocco 2023

HIGH-SPEED RAIL : THE RIGHT SPEED FOR OUR PLANET

Under the High Patronage of his Majesty King Mohammed VI

Session2.2 Room Karam2
Rolling stock / Maintenance and RAMS

Moderator : Mr. Luciano BORGES ,
Rolling Stock Managing Director - ONCF
Chief Executive Officer - SIANA, Morocco

ONCF UIC

Session2.2 Rolling stock / Maintenance and RAMS Speaker Lists;

1	2	3	4	5
				
Mr. Hicham EL KIMI	Mr.Giacomo BERSANO	Ms.Simona Gurrì	Mr.LU Hang	Ms. Cai Yi
Morocco	France	Italy	China	China

11TH WORLD CONGRESS OF HIGH-SPEED RAIL

Marrakech, 7-10 MARCH 2023

Moroccan High Speed Train 'Alboraq' Maintenance : Which policy for which results ?

Hicham EL KIMI
Production Director
ONCF ,Morocco
Session2-2.2 Rolling stock / Maintenance and RAMS

HOW ALBORAQ FLEET REACHED SUCH A STEADY PERFORMANCE?

CHANCE ? SMALL FLEET EFFECT ?

It sounds obvious that Rail is at the heart of mobility needs … and their evolution

Fundamental needs …

COST

Availability

Mobility

Safety

Quality

… structuring and addressing …

Door to door

Intermodality

Complimentarity

Mass Mobility

Infrastructure

Connecting territories

Inter Region development

Regional Competitivity Clusters

Socio economic Balance

… evolution

High Speed Trains

Green Mobility

Light Trains

Hydrogen Train

Digital

Peer to Peer

Connected Trains

Hyperloop

Autonomous trains

UrbanLoop

HIGH-SPEED RAIL : THE RIGHT SPEED FOR OUR PLANET ?

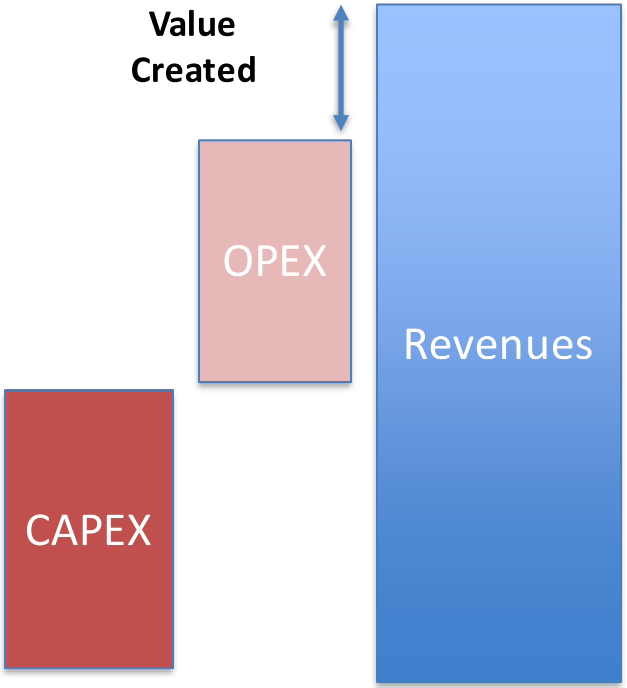
How to convince decisions makers converting the ambition into projects ?

Through Sharing positive track record :

Al boraq البراق

turning important investment in High Speed in Value Creation Projects

As any other investment, a HSR project has value creation expectations …



Value Creation comes from **clear and global Policy** based on **Principles of Operating** the system since **the very beginning of the Project**

Case : Alboraq Fleet Maintenance

Maintenance Performance is a **Key Success Factor** (KSF) for Operations Revenues and Costs **(OPEX)**

Maintenance Performance depends on factors that started since Rolling Stock Procurement stage **(CAPEX)**

The policy explained in 4 steps

1. Strategic Rolling Stock Sourcing
2. A strategic and balanced partnership for HST Maintenance
3. A global, anticipated and systemic Maintenance approach
4. An early focus on Innovation and Maintenance Engineering

A learning, agile organisation

A performant Alboraq Fleet, satisfying expectations

Step 1 - Strategic EuroDuplex choice and procurement process

- **Proven in use 'state of the art' technology :**
  - A choice between 2 HST variants which are technologically valid and satisfying requirements but with different Track Records and different fleet size
  - The choice of EuroDuplex allowed ONCF to have more options in Step 2

- **Procurement Process** based on a Strong engineering activities **focusing in gaps** with reference baseline through:
  - ILS methodologies,
  - Reliability and Safety methodologies and standards,
  - Manufacturing Control,
  - Testing through Product Life Cycle stages (from FAI to System Commissioning)

Step 2 - A balanced partnership with SNCF

Through a **JV scheme** based **on a (Cost + Fee) Business Model** and relying **on 4 structuring principles**

Know How Transfer	
Anticipated Hiring of 20 Technicians / Team Leaders who beneficiated from **immersive training in France during 2 years**	**Expatriates presence** covering various areas (logistics , maint., engineering, EHS, Quality, …) **each with adapted K-H transfer scheme**

Expertise and Data

Engineering Support

Benchmark / Data sharing

Logistic & Spares

Two logistic contracts :

- Repair of spares with **merge of stock** whenever relevant
- Spares procurement

A balanced Corporate and Executive Governance

- **A mixed Board of Directors** (SNCF and ONCF) and Executive Board
- **A mixed employee** profiles (ONCF, SNCF and direct Hirees)

Step 3 - A global, anticipated and systemic Maintenance approach

- From **reliability testing** to **maintenance**
- From **maintenance** to fleet operational **reliability improvement**
- **Supply chain :** spares sourcing and spares repair, initiation of local industrial ecosystem development
- **Human Resources challenge** : learning, skills and turnover management in a competitive environment
- A steering of the operational organisation through a full 'Client Focus' and ‘Home Made’ **Industrial Excellence Program ITKANE 4.0**

Step 4 - An early focus on Innovation and Maintenance Engineering

- **Asset Management System:** a progressive implementation to allow in depth process understanding and improvement

- **IA and IoT apps program launch** : Remote Diagnosis, Connected Glasses, SafAE: Computer Vision with IA, Shared Apps with Commercial …

Both topics being the backbone of Pillar n°6 of ITKANE 4.0 : Innovation and Digital

So … in a Nutshell Alboraq Fleet Maintenance in SIANA : What are the results ?

- **RST Procurement Cost**	at Contract
- **ITKANE 4.0**	reached stage 4 Excellence in 2023
- **Integrated Mgt System**	ISO 9001 / ISO 45001 Certification in 2022
- **FPMK**	above target
- **Fleet Availability**	at target
- **Punctuality**	above target
- **Costs**	better than target (less 20%)
- **Client Satisfaction**	above target
- **Knowledge Transfer :**	in advance, Y6 target reached in Y4 (currently 5 expatriates with reached maximum of 14 through **adapted format i**nstead of 24: focus support rather than expatriate format)
- **Supply Chain Contracts**	Active with Good and resilient performance
- **Innovation**	Own developed projects in Operation / AI project Safae selected for CES LAS VEGAS and reached a mature 'industrial' stage

"Someone's sitting in the shade today because someone planted a tree a long time ago"

Warren Buffet

THANK YOU

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Marrakech, 7-10 MARCH 2023

Agile Model-Based Systems Engineering of Passenger Train Operational Design

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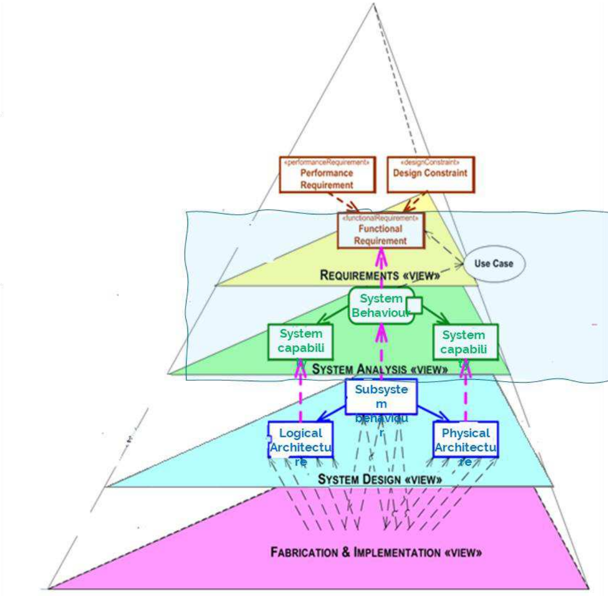
Session2-2.2 Rolling stock / Maintenance and RAMS

ONCF UIC

Introduction

This research proves the effectiveness in solving system requirements of train operational system, the model-based systems engineering method has been applied to generic railway uses cases to assess its feasibility, including a variability management approach.

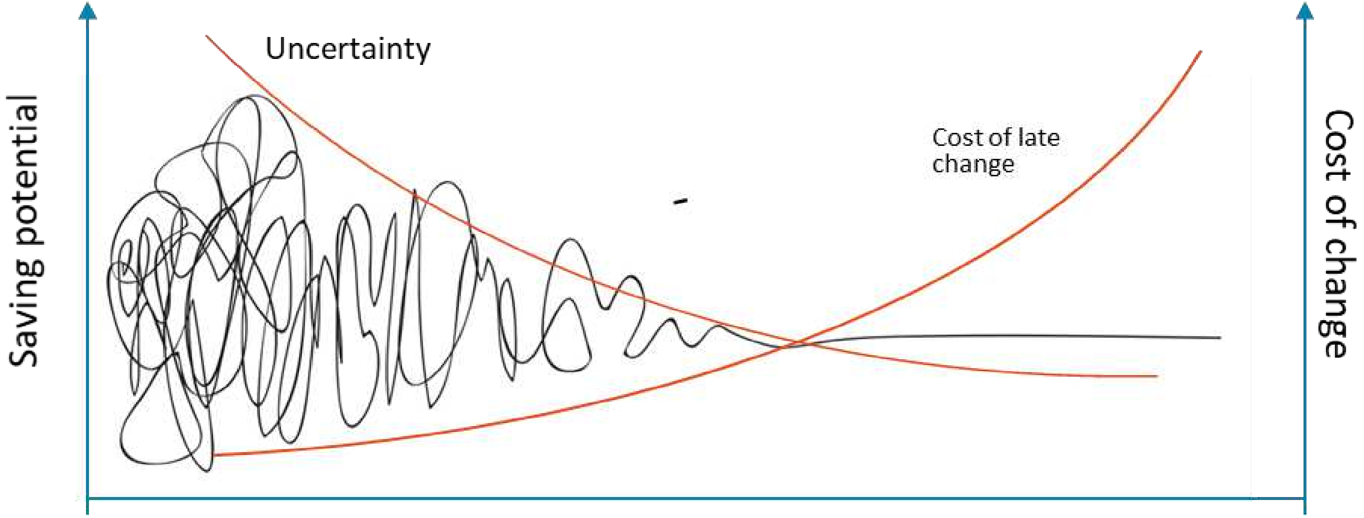


Objective	Today	Tomorrow
Why?	Understanding of Actors, constraints and business needs	Limited modeling possible / viable
	MBSE	
What is needed from the system for the target application?	**Limited modeling** requirement-based analysis.	**Executable model, high levels of re-use**
		Model in the loop (MIL)
How?	Reliance on modelling	Simulations…
Solution domain	Manual generation	**SW / HW in the loop (SIL/HIL)**

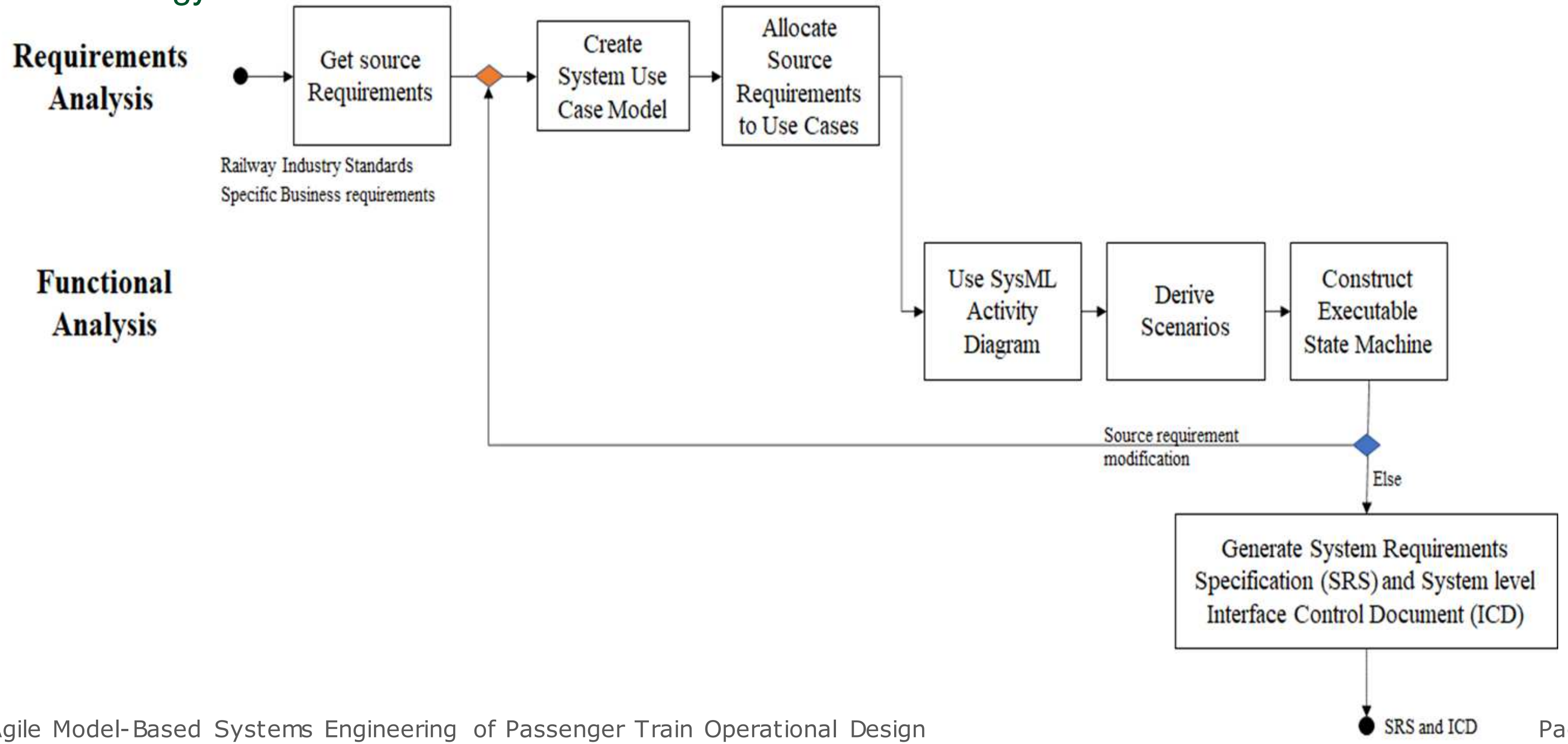
WHY a new agile MBSE framework for railway?

Modern rolling stock projects often face the efficiency issue for the delivery of new or modification of train:

- The large amount of documentation, drawings & requirements necessary to manage different engineering specialisms and information types.
- Difficulties in validating & verifying completeness and correctness.



Methodology



Methodology

1. Requirements Analysis—Use Case Model

- According to the source requirements and system scope, the use cases are created for train operational system.
- The graphic illustration of the interactions between the external actors and the use cases, is set up and how traceability is done.

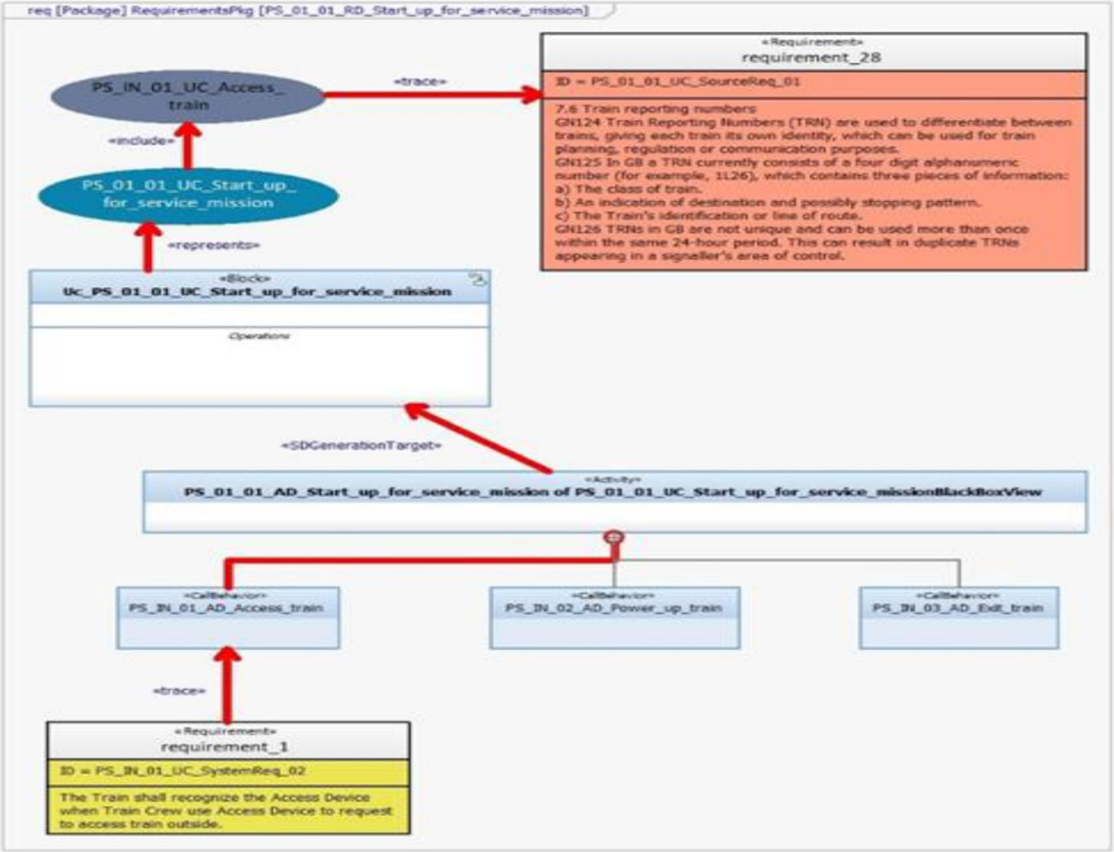
2. Functional Analysis--Detailed use case computable model (Black-box view)

- It uses activity diagrams, sequence diagrams and **state machine diagrams** to demonstrate the system's functionalities--behaviours, activities, and attributes of the system. Then derive system requirements during the modelling process.

3. Variability Management--Variability Matrix

- To detect & allocate new variants and pre-configure the model elements for a specific railway project.

Traceability from derived system requirement to source requirement



Results

- A **scalable method** to progressively develop the model including more variants and increasing the level of **reuse** for each new project.

- **Digital traceability** between the model design and system requirements.

- A **systematic digital modelling approach.**

Conclusion

This research provides confidence in the adoption of a tailored modelling approach to meet the objective of **improving the accuracy and speed of system requirement** specification of **rolling stock**.

Initial results also include evidence of **increased productivity** by minimising unnecessary manual transcription of concepts when coordinating the work of **large teams**.

It will also allow **manufacturers** to understand how to **adapt their product for the new railw**ay and **operators** to **understand impacts of their specifications** (given the traceability between the model and business requirements).

The limits today are to make the content grow and reach a sufficient size to be used in a quick way.

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DESIGN OF AN INTEGRATED MONITORING SYSTEM FOR A NEW GENERATION HS FREIGHT TRAIN: CONCEPT AND POTENTIALITIES

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Politecnico di Torino

ALSTOM · mobility by nature ·

Speaker: Simona Gurrì

PhD candidate, Politecnico di Torino

Rolling stock/Maintenance and RAMS

Session2-2.2 Rolling stock / Maintenance and RAMS

ONCF UIC

The need for a revolution in freight train concept

Modal share of railway freight transport declining in the last 70 years (around 17% in 2022 in the EU)

- EU objective is 30% before 2030 and 50% by 2050 -> decarbonization and sustainability: need for intermodality

Are traditional freight trains capable to reach these objectives? Evidence says no

New approaches to freight trains:

- Introducing the ***Freight-EMU***
  - Flatbed wagons for *intermodal transport*
  - Flexible ***distributed power*** layout
  - Diagnosability, monitorability and reliability for *HS lines*
- Reintroducing the ***P2F-EMU***: Passenger High Speed trainsets (ETR 675) converted for groupage cargo

Twofoldness of the need for exploitation of HS lines:

- HS lines still have some ***unexploited capacity***
  - Adequate performances (160 km/h) to run during soft hours
- **Faster service attractivity** to move modal share to rail
  - Possibility of carrying all kinds of goods (also high value, perishable etc. …)
  - Increased safety thanks to the monitoring system.

Also freight trains can be Cyber-physical systems

Need for a CPS perspective to fully address ***RAMS***:

- Railway systems are more and more *relying on ICT*.
  - This is true for passenger trains but not yet for freight ones which lagged years behind.

In the context of the F-EMU we propose an *integrated* concept for the design of the monitoring system starting from the BMS already in use in some of *Alstom* Passenger Rolling stock.

- Design, analyze and verify, components at *various levels of abstraction*, including the system and software architecture levels, subject to constraints from other levels;
- Analyze *interactions* between the monitoring systems and other subsystems
- Exploiting *economies of scale*: minimization of costs
- Ensuring reliability, monitorability and safety, keeping high availability: overall *higher performances*
- The sensing device installed can be used for *predictive maintenance*

Methodology: Systems engineering for Cyber-physical systems

Aim and scope:

- Design of a ***Bogie Monitoring Subsystem (BMS)*** for freight trains & implications on operation and maintenance

Proposed methodology:

- ***Mixed approach:***

1. Needs collected through qualitative analysis of supply/demand and expressed in natural language.
2. Needs are transposed in formal language to eliminate all the ambiguities.
3. ***Model-Based Systems Engineering*** is used for the design.
4. Establish traceability between system requirements and elements of the architectures.
5. Verification of requirement fulfillment at all levels.

Mathworks's *MATLAB-Simulink* suite is used, more specifically the *System Composer* plug-in.

Requirements and Needs

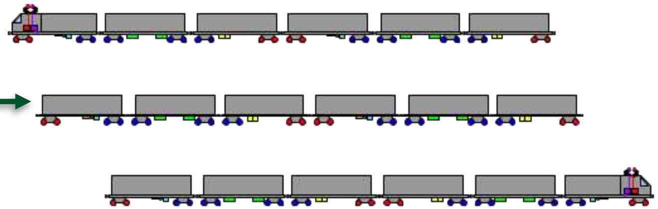
New platform’s requirements inherited from EU regulations and studies available in the literature:

- *TSI EU 1302/2014 High Speed Trains* mandatory equipment;
- Increase maintainability and availability using *continuous monitoring* of critical parts and components:
  - e.g.: motors, gearboxes, bogie structure, frame, oil level, temperature of axle box, etc.
- Widen the range of goods carried on board introducing sensors to *monitor the state of the cargo*;
- Optimize *energy efficiency* and *loading and unloading operation*

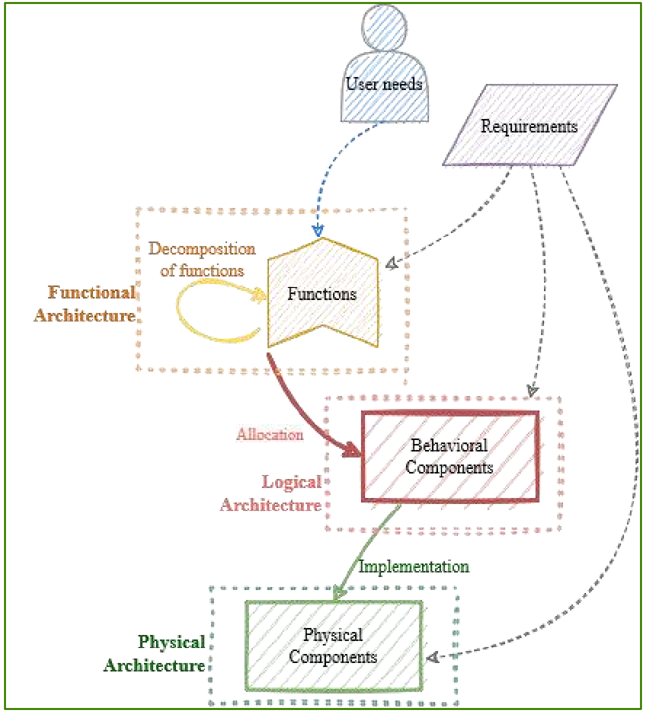
Electricity along the entire trainset becomes essential.

Subsystem suitable for:

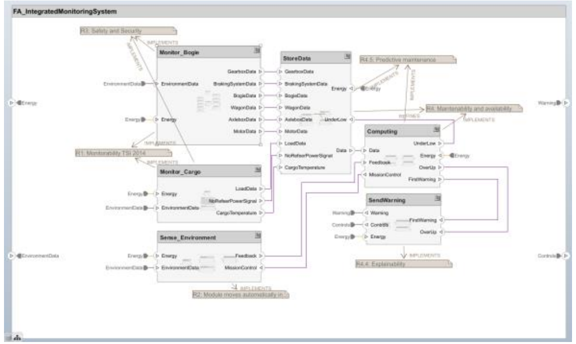
- the entirely new framework of the *Freight Electric Multiple Unit* (***F-EMU***)
- *Passenger-to-Freight converted high speed EMUs* (***P2F-EMU***)

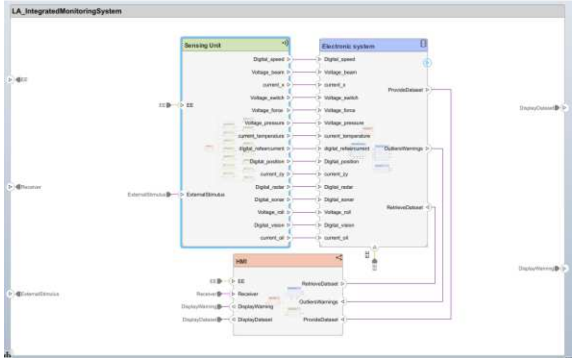


The MBSE approach



- **Functional** architecture
  - Functions are represented
  - High abstraction
- **Logical** architecture
  - Behavioural components
- **Physical** architecture
  - Sensors & other devices
- **Requirement traceability** at every level

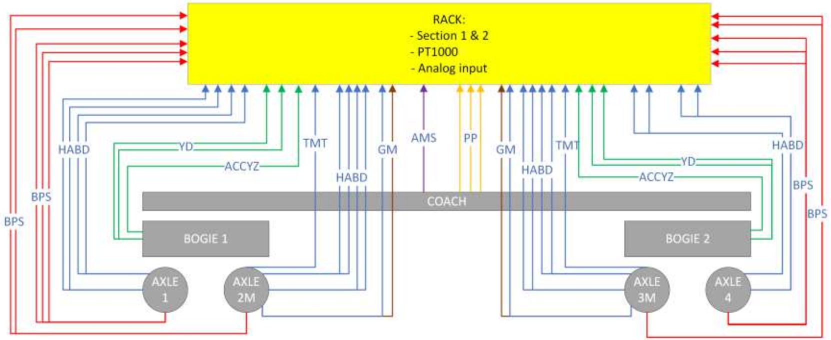




Architectures of the monitoring system

Subsystem layout:

- 1 rack per car
- 2 sections per rack (*redundancy*)
- racks communicate via *CAN* network



Subsystem features

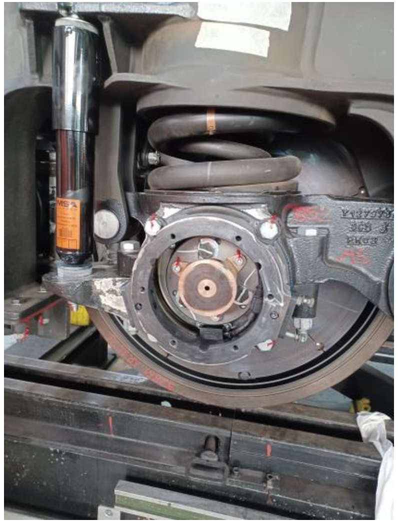
- *Bogie level*:
  - Axlebox Temperature Monitoring
  - Detect Excessive Bogie Hunting and Lateral and Vertical Bogie Dynamics
  - Detect if Motor is not Working as Expected
  - Monitor Gearbox Lubricant Status
- *Braking System*: Monitor Braking Phases
- *Wagon*: Monitor Wagon Roll
- *Cargo*: Check that the Cargo is Correctly Secured and in Place

Examination of the signals

The train is ***continuously monitored*** through sensors

- Spot events commanded by *TCMS* (es. time or km recurrence);
- Parameter beyond a lower threshold trigger a *warning*
- Parameter beyond a critical threshold trigger the *alarm*
  loop opening & TCMS takeover
- Train driver/engineer can investigate such aspects via *DMI*
  and take further action
- Alarm threshold can be *customized* by the final user or a railway manager
- Data transmitted via *GSM and GPRS* and collected in a *Control Room*
- Data can also be downloaded through hardware and exported
  manually – if needed
- *Data analytics* on the fleet in the Control room:
  - Statistics and processing are currently used for passenger trains

ALSTOM'S AXLE BOX SENSOR
AND RACK FOR BMS



DEPT. DIATI @POLITO'S EXPERIMENTS ON WAGONS

Potentialities

Run on HS line thanks to the *monitorability* of the rolling stock (RFI requirement)

Attraction of demand because of the higher safety for cargo:

- *Traceability* of cargo through GPS and odometry
- *Temperature control*
- Monitoring of any cargo *compromission*

Better performances: adaptation to actual mass of the train

- *Energetic efficiency* in all load condition

Improved maintainability: collection of more data helps in *identifying possible faults in advance*

Fleet monitoring to schedule availability

Data analytics with *AI techniques* to improve the design on factual data

Improving *track maintainability* giving some data to the infrastructure manager

- Solves the issue of high tolls in HS lines trading it with almost continuous data

How to optimize the use of collected data with Artificial Intelligence

- Many areas of transportation still *lack data* which are classified or not yet collected
- Decision-makers often have uncertain information
    - More data means *optimization of resources*
- Aiming for a design that fits into the future
    - Agile manufacturing, decarbonization throughout the whole lifecycle of the product, increased useful life, smart services
- Artificial Intelligence can *help* operators, infrastructure managers, manufacturers and maintenance personnel in reaching those objectives.

HOW?

- Digital Twins for reducing waste, software prototyping and testing and increasing GHG efficiency through the lifecycle
- Autonomous shunting and maneuvers in terminals safely without risk for personnel
- Explainable AI for forecasting and prediction of maintenance operations
- Automatic image processing with Convolutional Neural Network to speed up faults' identification
- Real time speed and acceleration control to minimize energy consumption or emissions given the mass of the train – power management systems improved with ML
- Optimizing routing of the train if it runs together with passenger trains and predict arrival time to increase multimodal efficiency
- Detect possible aerodynamically inefficient loading during the shipment and optimized train composition

New horizons and conclusions

New horizons:

- Build a ***prototype*** to be deployed on modified cars of conventional freight trains or P2F-EMUs for groupage to ***verify***, ***validate*** and ***test*** the monitoring system with all loads conditions.
- The TRL of this new concept of F-EMU is still low, but other subsystems are now under study

Conclusions:

- A Bogie Monitoring System can be considered a ***requirement*** for a high-speed freight train, in as much as it is for HS passenger trains.
- Fully *integration into the design* of a new generation F-EMU, giving it a CPS perspective
  - tracing requirements during the design
  - verification that every need is targeted both from the hardware and from the software and control side.

THANK YOU

For any question you can reach us at:
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The state-of-art research and implementation on Smart Maintenance and PHM for China Railway HSR

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Session2.2 Rolling stock / Maintenance and RAMS

ONCF UIC

Digitalization of High Speed Train

Smart HSR 1.0 Implementation

- Beijing-Zhangjiakou High Speed Railway for 2022 Beijing Winter Olympics.
- 8-cars trainset comprises 2718 monitoring points, including voltage, current, pressure, speed, temperature, etc.

Contemporary Smart HSR Applications

Smart HSR Train

C3+ATO

Smart Power Grid

Smart Disaster Prediction

Comprehensive Display

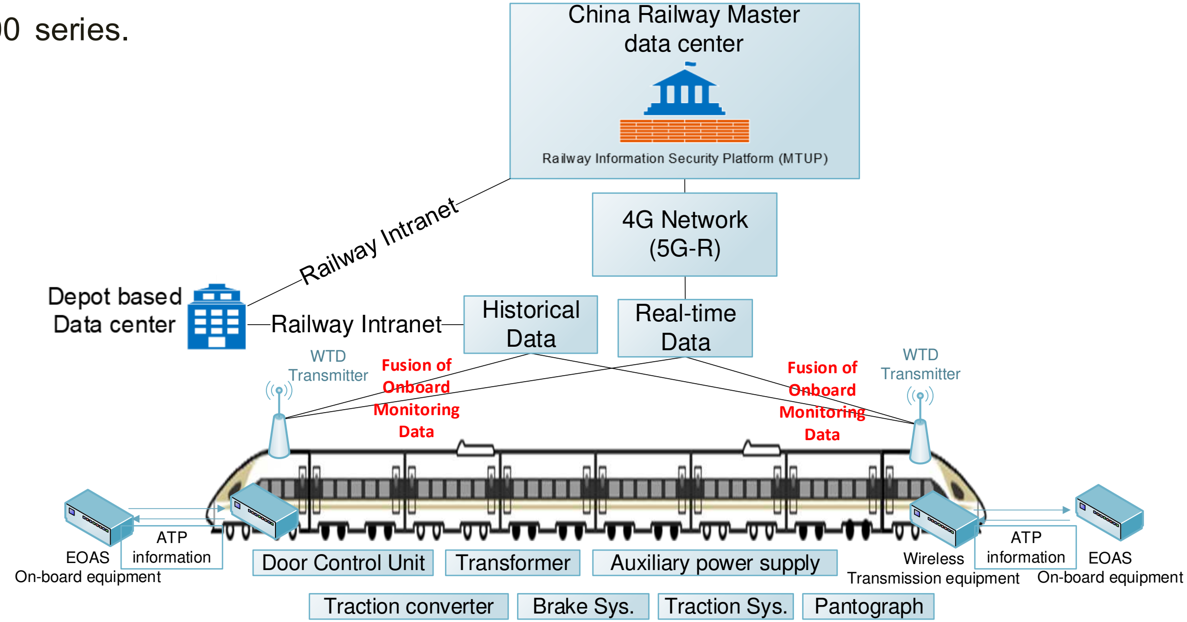
BIM-based Constructions

Digitalization of High Speed Train

Contemporary CBM data

- Along with the digitalization of high speed train, precise control, real-time monitoring, onboard data storage are realized in"Fuxing"CR400 series.

Infrared/Ultrasonic bogie detection system (depot based)



Wireless transmitted detection system (WTDS)

Data fusion enables…

Manufacturing, Operation and Maintenance data resources

❖ Multiple data assets including a bunch of static and dynamic data generated from different scenarios

Manufacturer data

- ✓ Manufacturing Profiles
- ✓ Bill of Materials (BoM)
- ✓ Hardware/Software Configurations of different batches
- ✓ (Stored in EMU Management Information System, **EMIS**)

……

Maintenance service data

- ✓ Operational & Senior Maintenance Records
- ✓ Fault Records
- ✓ Replacement Records
- ✓ Renewal and Upgrade information

……

Detection data (Depot based systems)

- ✓ Wheel Profile data
- ✓ Axle shaft detection
- ✓ Ultrasonic LU/LY wheel detection
- ✓ Pantograph detection data

……

Monitoring data (Onboard & Wayside systems)

- ✓ On-board Wireless Transmit Detection System (WTDS)
- ✓ Vision-based TEDS
- ✓ Acoustic-based TADS
- ✓ Wheel/rail force-based TPDS

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Operational Environment data

- ✓ Climate data
- ✓ Power supply data
- ✓ Construction and Maintenance data of bridge, tunnel & track
- ✓ Communication signal data

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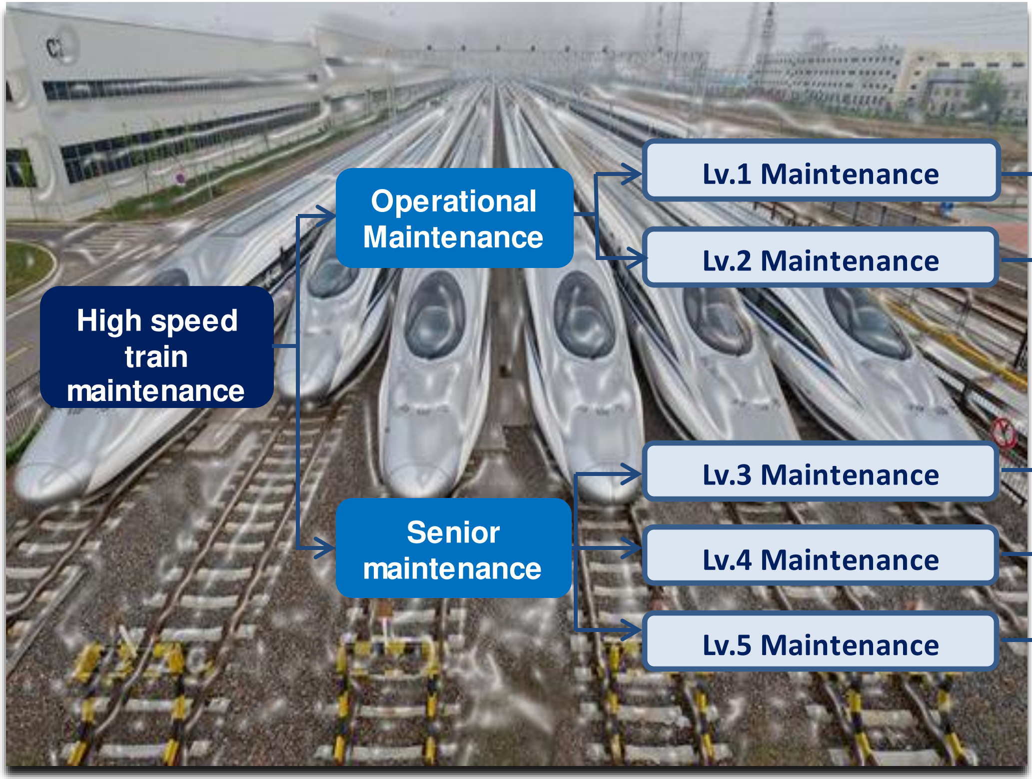
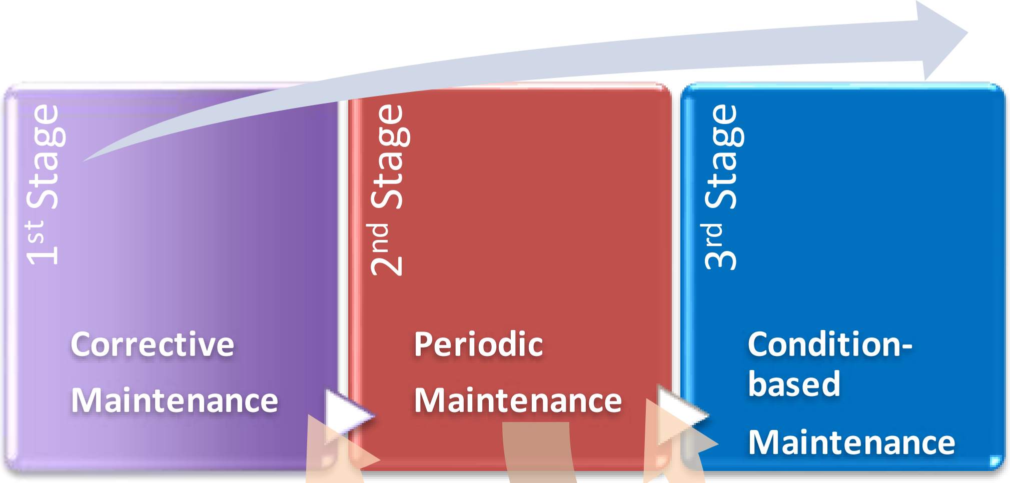
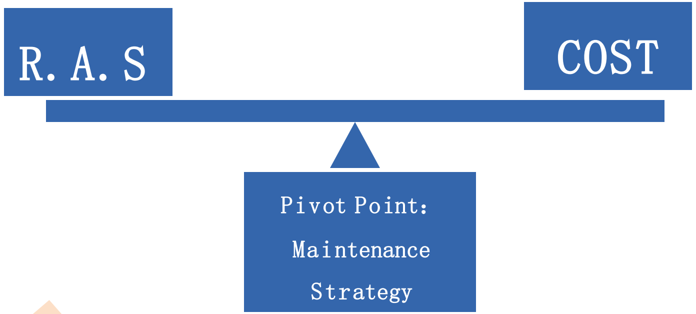
Current Periodic Maintenance Strategy



- **Lv.1 Maintenance** → Routine safety check before on-line operation. Commonly 5000km or 2 Days
- **Lv.2 Maintenance** → Periodic in-depth inspection, maintenance and functional testing: Cooling system functioning, Axle shaft flaw detection, wheel reprofiling, etc
- **Lv.3 Maintenance** → Bogie disassemble maintenance, function confirmation
- **Lv.4 Maintenance** → Disassemble check and maintenance of critical systems, especially Electronics
- **Lv.5 Maintenance** → Complete decomposition maintenance, upgrade and renewal for core subsystems

Change in Maintenance Strategy of HSR

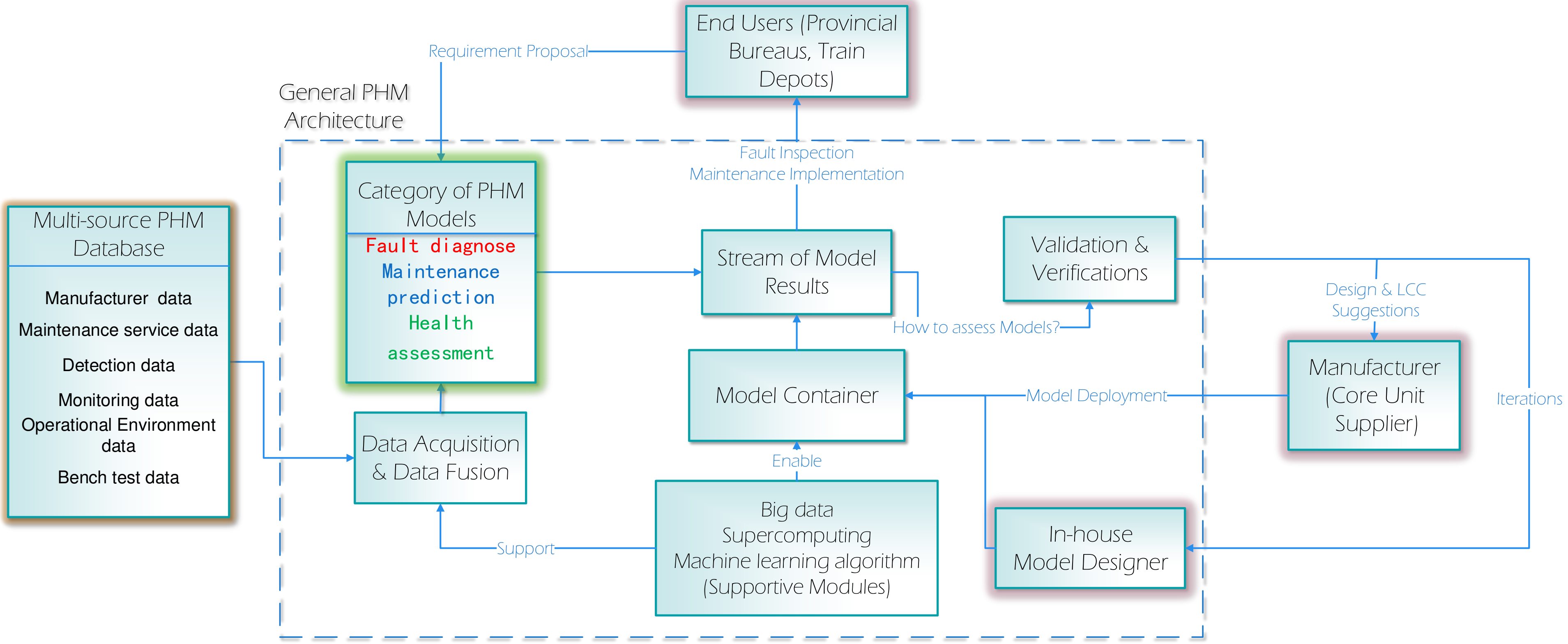




- ✓ Reliability Engineering
- ✓ Prognostic & Health Management

Main objectives of PHM:

- ✓ Guarantee Reliability
- ✓ Lower Life Cycle Cost (LCC)



China Railway PHM system architecture

Objectives of PHM Diagnostic Model

Fault Diagnostic Models for Core Units

Inspection

Correction/Remedy prior to Actual Fault

Higher Reliability

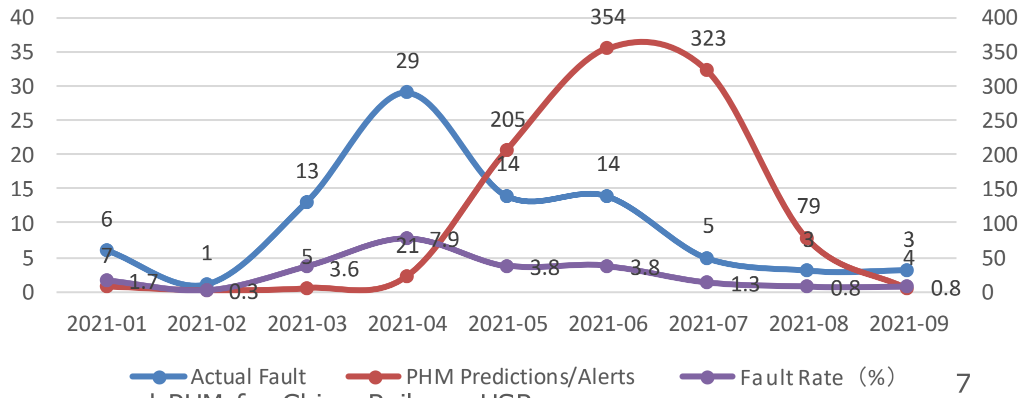
Safety Level Increased

Actual Fault Rate REDUCTION

Less Trouble

According to Statistics provided by the largest Subsystem Supplier for CR400 trains:

Trend of actual fault rate against number of PHM alerts/predictions (Ref. ZEMT ltd.)



Objectives of PHM maintenance prediction model

Periodic Operational Maintenance → Predictive Maintenance

Improved: Train Fleet Availability

Reduced: Maintenance Cost in Materials and Man Power

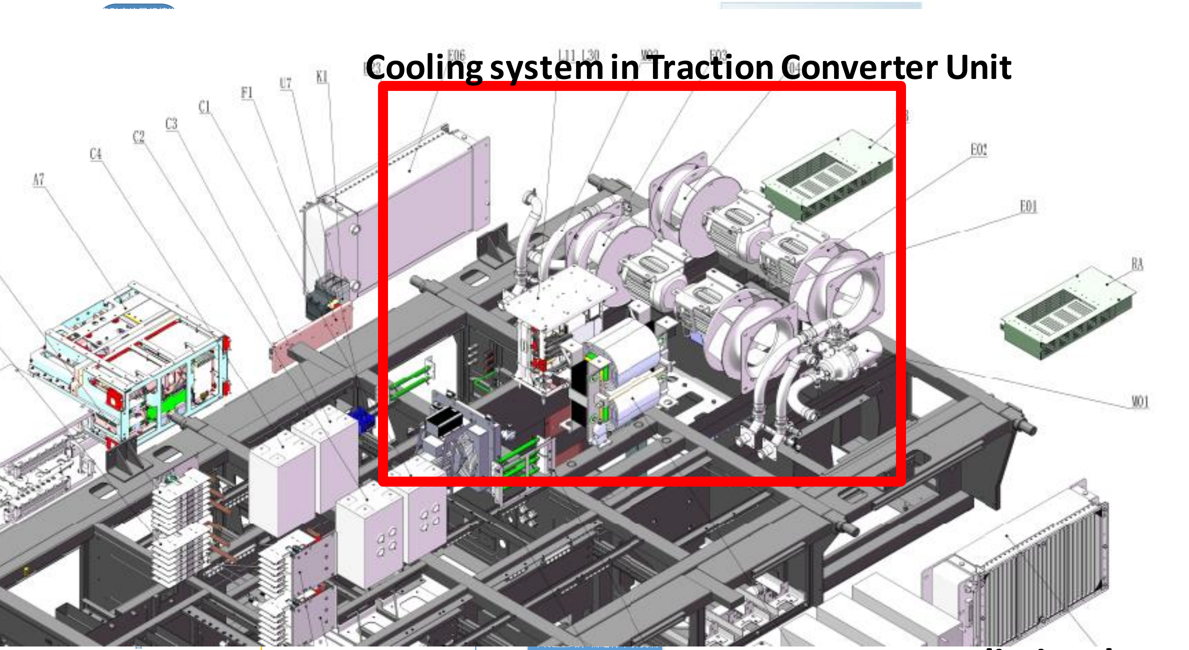
Compared against Current Periodic Maintenance rules For a 502-EMU fleet (CR400BF, CRH380B(BL), CRH380CL, 350km/h EMU):

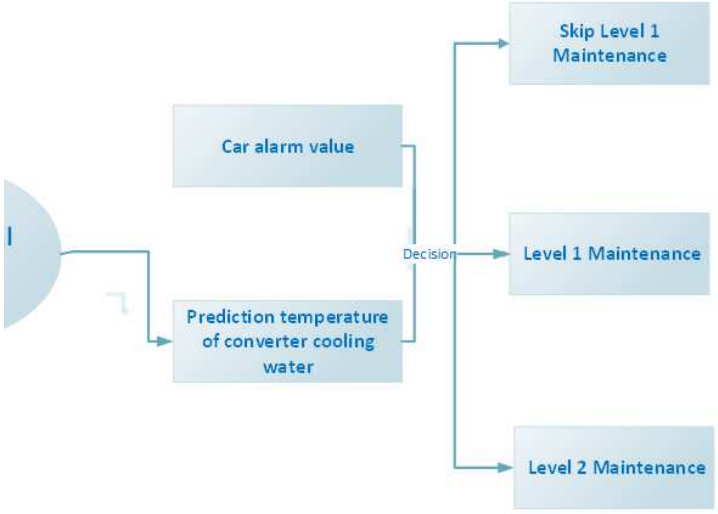
- ✓ For cooling system items only, reduce 20~30times per train of lv.1 maintenance.
- ✓ Save approx. 65,000man hrs/yr.
- ✓ Save approx. 70% in man power.
- ✓ Save overall costs 175M RMB/yr.(≈23M€/yr.)

(Source: Shanghai bureau of CR)

Case study: Predictive Maintenance in Converter Cooling System (Model prediction by PHM system)

Cooling system in Traction Converter Unit





neural network model:

Prediction based on onboard sensing data

Previous Rule-Based Reasoning (RBR)

The future outline of smart operations

Fully automatic operation

Condition-based monitoring,real-time analyze, prognostic and health assessment

Intelligence in operations and maintenance, higher efficiency

Deep integration with train core subsystems and multi-network to work comprehensively

Fusion with new energy, technology and equipment,

Health assessment & decision making, sustainable development of energy and optimized LLC

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