

## WP3: – Digitization of railway transport

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MOST SP4 | riunione plenaria  
Politecnico di Milano  
5 July 2023



# Task involvement

T3.1: Learning formal models for predictive maintenance (**task leader: Alessio Ferrari, CNR-ISTI**)

Partners: UNIFI, UNINA, CNR, UNIPR, UNIROMA, ACCENTURE, LUTECH AS già ATOS, TRENORD

T3.2: On board monitoring systems for rolling stock and infrastructure (**task leader: Riccardo Licciardello, UNIROMA-SAPIENZA**)

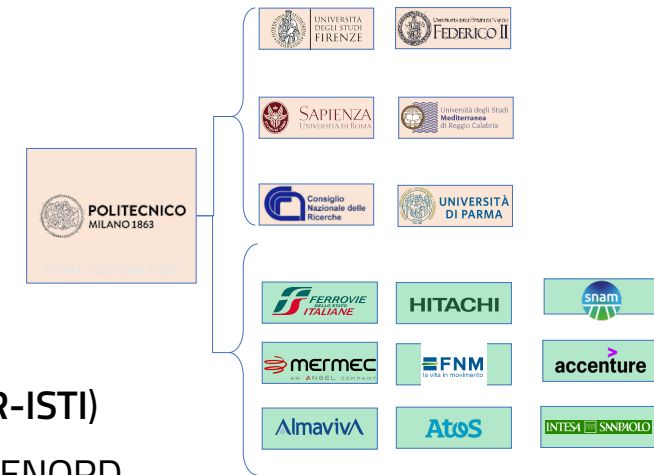
Partners: POLIMI, UNIFI, CNR, UNIROMA, MERMEC, TRENITALIA

T3.3: Way side monitoring systems for rolling stock and infrastructure (**task leader: Vito Renò, CNR-STIIMA**)

Partners: POLIMI, CNR, UNIPR, UNINA, UNIROMA, MERMEC, TRENITALIA, INTESA SANPAOLO

T3.4: Drone for autonomous infrastructure inspection (**task leader: Davide Tarsitano, POLIMI**)

Partners: POLIMI, UNIFI, CNR, RFI



## Status at M9

- 👍 **Defined:** partners' subtasks, expected collaborations and content of first deliverables
- 👍 **Identified:** first demonstrator for computer vision and typology of the drone (aerial)
- 👍 **Agreed:** backup plans for data (e.g., NDA with TRENORD) and test vehicle and track (MERMEC)
- 👎 **Slight deviation:** due to the limited access to data (e.g., no data about wayside systems)
- 👎 **Slightly behind schedule:** delayed personnel recruiting and equipment acquisition (primarily CNR, still lacking funds...)

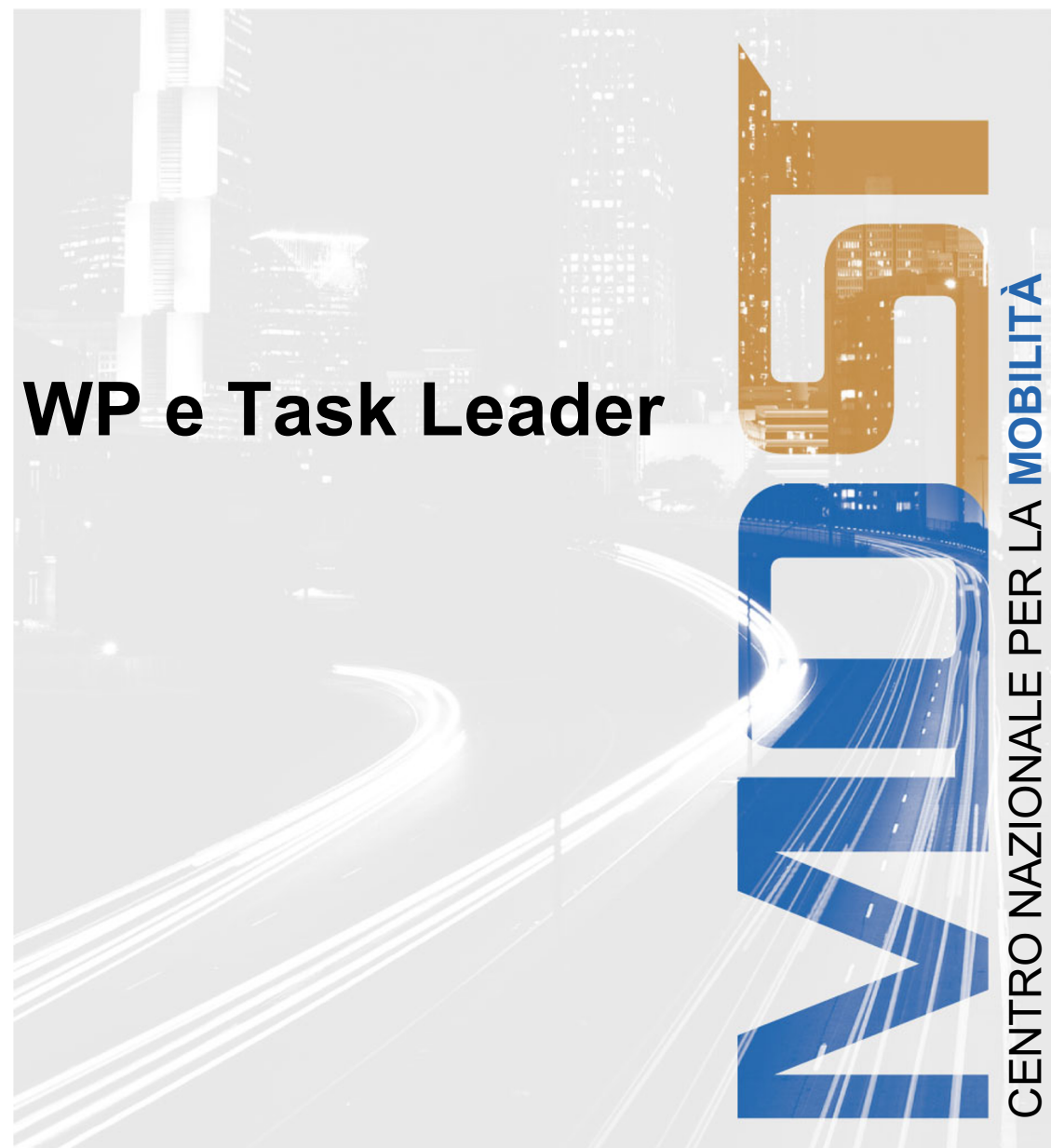


# MOST - Riunione Plenaria WP e Task Leader

Politecnico di Milano

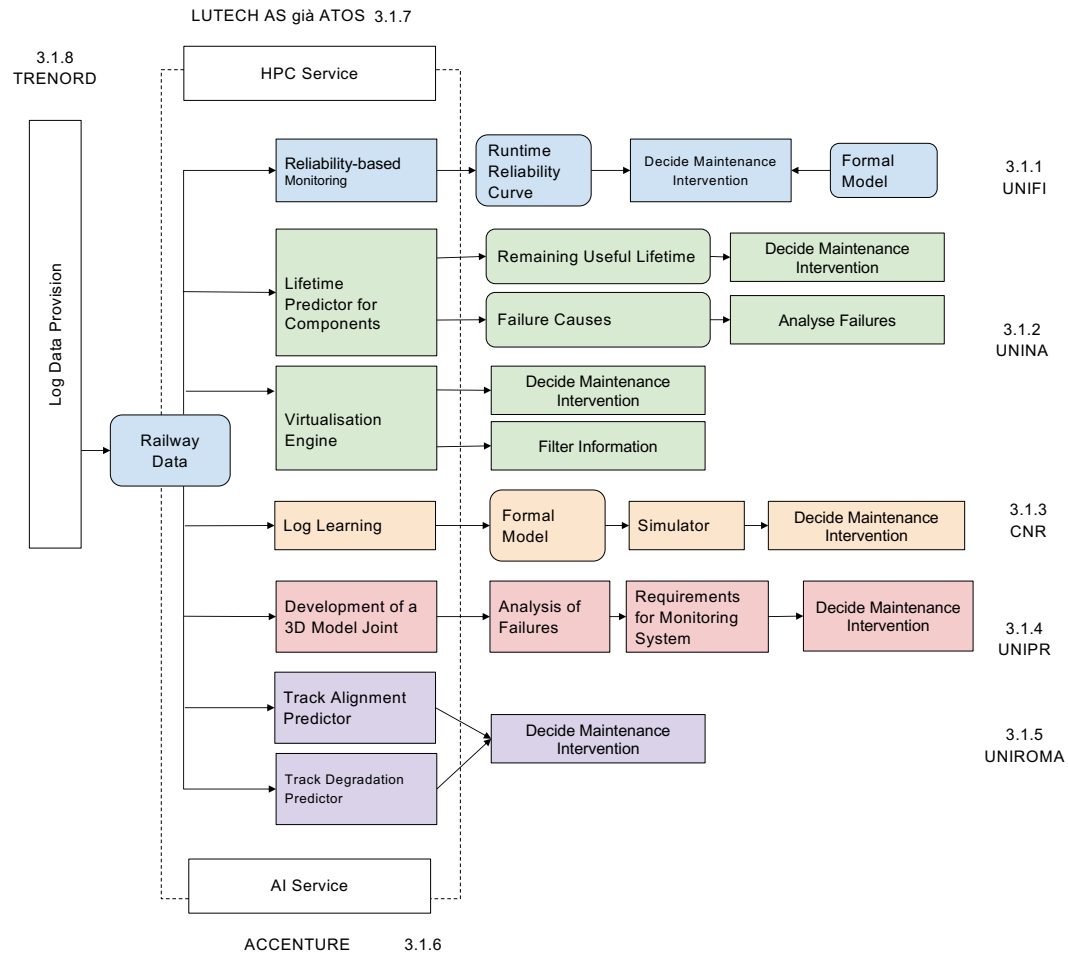
5 Luglio 2023

## TASK 3.1



# Overview e Struttura del Task

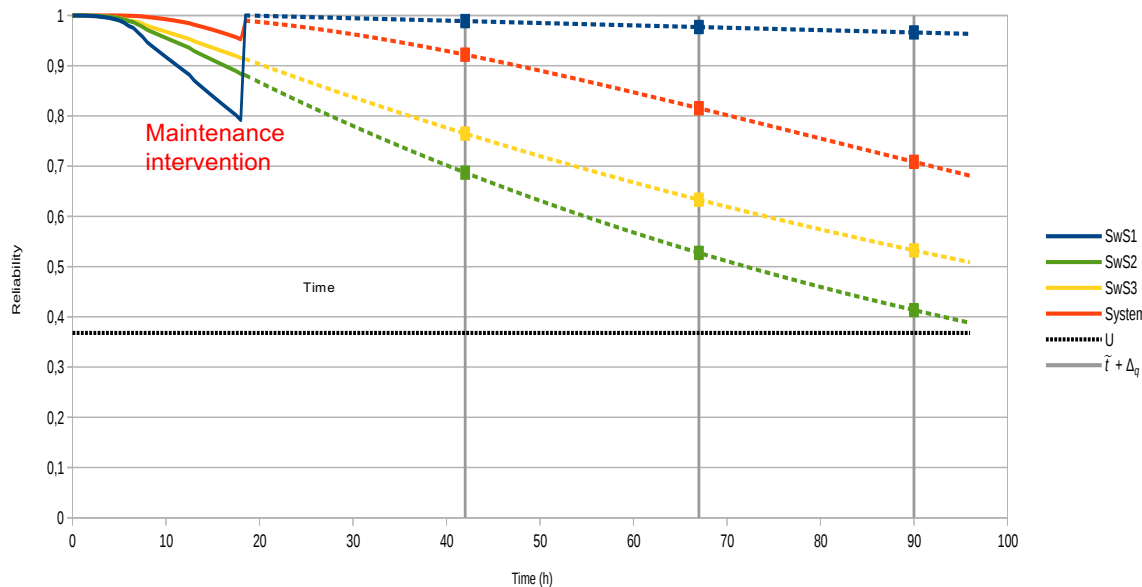
**TRENORD was added as a partner together with task 3.1.8**



# 1 UNIFI - Formal models for predictive maintenance

- Formal, model-based **quantitative analysis** techniques have the aim to predict specific dependability attributes (such as reliability, safety, availability, performability) in presence of **uncertainty sources**.

- Definition of a novel model-based preventive maintenance method, **Reliability Based Monitoring (RBM)**  
→ flexible runtime monitoring of reliability.



- exploits a **hierarchical reliability model** **periodically** applied to **runtime diagnostics data**

- **learning** is intended as the runtime update of the parameters of the reliability models on the basis of collected diagnostic data

- estimate at runtime the reliability curve of the monitored system

- perform prognostics, used to schedule maintenance interventions

- particularly suited to schedule software maintenance interventions, such as software rejuvenation

- ★ **UNINA** is working within the task 3.2 with **two lines of research activities**
- ★ **UNINA** is **collaborating** with **CNR, UNIFI** and **Trenord** for the development of machine learning and AI predictive maintenance algorithms.

**The first line of UNINA research** aims to leverage *virtualization technologies* (e.g., embedded hypervisors) in the context of the digitization of tramway and railway transport systems for applying *AI/ML techniques* in smart predictive diagnostics (RUL prediction, root cause analysis)

- **Currently**, a literature review of the most relevant studies and industrial solutions for integrating AI/ML algorithms and monitoring solutions into embedded systems
- **The next steps** will include the development of AI/ML predictive maintenance algorithm to be integrate with the most suitable virtualization solutions in railway/tramway industry

**The second line of UNINA research** is inherent the development of model-based algorithms capable of predicting with some accuracy the failure, synthesizing and filtering the information in order to reduce the amount of data to be processed.

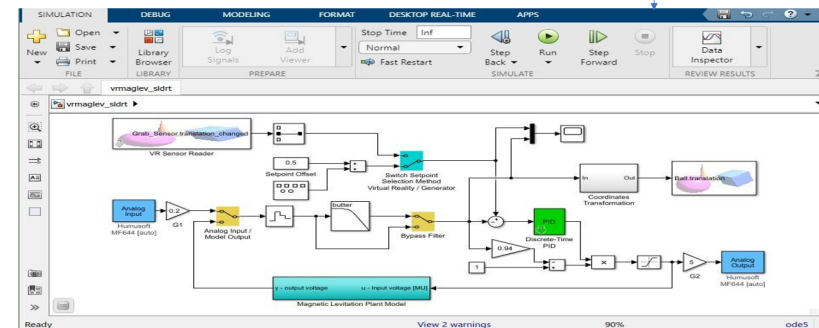
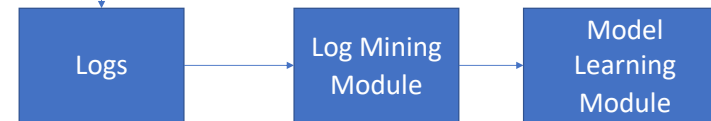
- **Currently**, a literature review of recent models developed for the SPD of electrical drives in industrial and traction applications is carried out.
- **The next steps** will include the development of the model-based algorithms and the start of the test bench design.

## Goal

- The CNR research activity is oriented to **formal modelling** and simulation of railway onboard and wayside systems.
- Within the project, we aim to develop a system to learn a **digital twin** from system logs to facilitate simulation and maintenance.

## Proposed Approach

- Log mining from train logs.
- Development of railway specific **model learning** techniques considering real-time aspects and a degree of uncertainty.
- Build and exploit digital twin models of trains to facilitate **predictive maintenance** by real-time monitoring and simulation.
- Development and industrial validation of a **prototypical** railway-specific predictive monitoring and maintenance system.



**Train Digital Twin - Simulator**

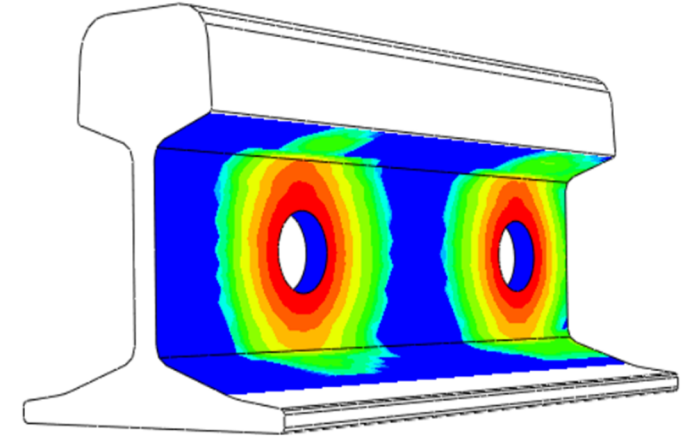
## Status

- Acquired data from TreNord.
- Preliminary evaluation on the feasibility of using ML techniques to predict maintenance events.

# Digitization of railway transport

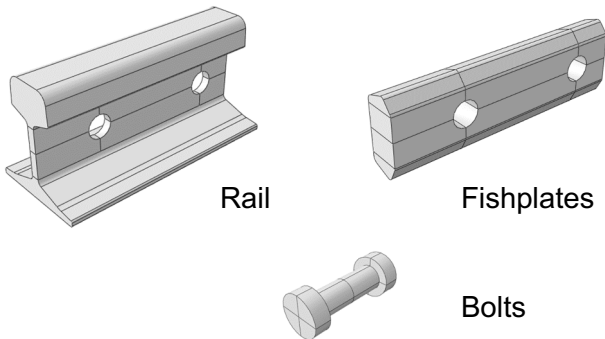
## Bonded Insulated Rail Joint (IRJ) monitoring

Evaluation of the types of degradation and ultimately failure of bonded insulated joints, identifying a cycle of failure that could lead to an anticipation of maintenance intervention. Development of a three-dimensional solid model for the analysis of the non-linear behaviour.



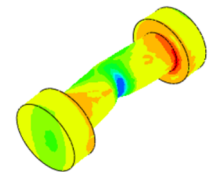
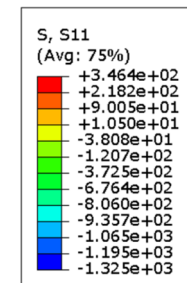
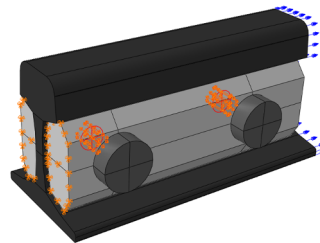
### The simplified model

#### Components



#### Boundary conditions

Fixed fishplates, bolt preloads, axial displacement of the rail (simulating the thermal effect)



## **5 UNIROMA - Applicable and robust learning models from operational and monitoring data for track maintenance management**

### **Gruppo di ricerca**

UNIROMA: Stefano RICCI (PO, MC), Riccardo LICCIARDELLO (RTDB), Nadia KAVIANI (PhD), due tesisti

UNIPR: Francesco FREDDI

Accenture: Cristiano LUNGHI, Emanuele MANFREDI, Sara CAVAGLION, Lorenzo BALLERINI, Silvia MORTARINO, Claudia BALLERINI

### **Attività**

4 riunioni plenarie: accordo di collaborazione, definizione dell'obiettivo, fondamenti del binario ferroviario, grandezze di influenza della geometria di binario, competenze IA  
nessuna variazione rispetto al programma iniziale

### **Acquisti**

Non necessari nell'immediato

### **Criticità/rischi**

Reperimento dati di evoluzione geometria. Canali: RFI, FNM, estero.



As a technical partner in the task 3.1, Accenture aims to support other academic partners in the development of their formal models. Accenture is currently collaborating with Sapienza and Uniparma with their models for **predictive maintenance**.



## GOAL & STARTING POINT

### **Shift from diagnostics to prognostics.**

In-depth analysis of various techniques to explore and evaluate prognostic modeling approaches for rail degradation, specifically focusing on the evolution of track geometry quality, in the context of predictive maintenance strategies.



## APPROACH

By leveraging advanced Machine Learning algorithms and harnessing the power of data-driven insights derived from the track geometry monitoring dataset, it is possible to achieve predictive track maintenance.

**How to approach detection to prediction based on data availability and the use of AI techniques.**

# 7 LUTECH Advanced Solutions già ATOS

Fornire un'infrastruttura di ricerca, basata su modelli HPC e AI, al fine di soddisfare le principali esigenze computazionali e di simulazione e per la realizzazione di laboratory ibridi (fisici/virtuali), di dimostratori e modellazione basate su operazioni più complesse.



Leader nei servizi digitali con know-how verticale



Forte presenza in tutti i settori e competenze uniche con una posizione di leadership nei settori Energy & Utilities e Telco & Media



Capacità di delivery in tutta Italia, con centri "near-shore" a Napoli e Bari



Customer base selezionata, consolidata e fidelizzata



Track record di crescita organica costante nell'ultimo decennio



Certificazione "Great Place to work"



Management altamente esperto e ambizioso per guidare la prossima fase di crescita



**140**  
clienti di cui 20 clienti chiave con ampie referenze in tutti i settori



**70%**  
dei 15 spender ICT(3) italiani sono primario clienti di Atos Italia

**60M€**  
investimenti in R&S in collaborazione con le top **6** università



**5**  
uffici in Italia



**1,600+**  
dipendenti



**c. 30%**  
In "near-shore" in Sud Italia

1

Energy e Utility  
(Worldgrid Italia)

2

Telecom

3

Media Digital  
Broadcasting

4

HyperAutomation

5

HPC and Quantum

~400 esperti cloud  
~200 esperti con certificazioni

Soluzioni di Cloud enabled

Oltre 20 clienti chiave con referenze estese in tutti i settori

# 8 TRENORD - Log data provision for development of rolling stock Predictive Maintenance

## TSR fleet



Remote diagnostics already in operation

## R-TAF fleet



Hardware installation to send diagnostic data to a ground server + remote diagnostics portal development


  
Consiglio Nazionale delle Ricerche

  
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FEDERICO II

Share of rolling stock data about:

1. on board diagnostic messages;
2. maintenance activities provided in Trenord plants.

These data will be used in models and research activities of the partner within the goals of Task 3.1 (learning formal models for predictive maintenance).



Results provided by the partners will be integrated into remote diagnostics systems, in order to introduce **Condition Based Maintenance** logics and algorithms for **Predictive Maintenance**. In this way, it will be possible to generate automatic alerts to activate maintenance interventions before the failure of a degraded device, with benefits on service regularity and on maintenance costs.

- **Changes** with respect to the original task structure:
  - TRENORD has been added as a partner
  - A new task has been introduced:
    - T3.1.8 - Log data provision for development of rolling stock Predictive Maintenance
- **Criticalities:**
  - Difficulties in hiring personnel
  - Part of the partners did not receive the funding
  - Wayside data, e.g., from RFI or Ferrovie Nord, currently not available

# MOST

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