FINAL BROCHURE

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locate

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Shift2Rail

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CONTENT

Foreword

LOCATE is a 30-month Shift2Rail project which will contribute to the modal shift to rail freight by replacing the preventive or scheduled maintenance of locomotive bogies by predictive maintenance.

LOCATE aims to improve the competitiveness of freight rail transport by:

- increasing the freight reliability and availability.
- replacing manual inspection activities with cost-effective remote defect localisation and monitoring solutions.

Facts & Figures

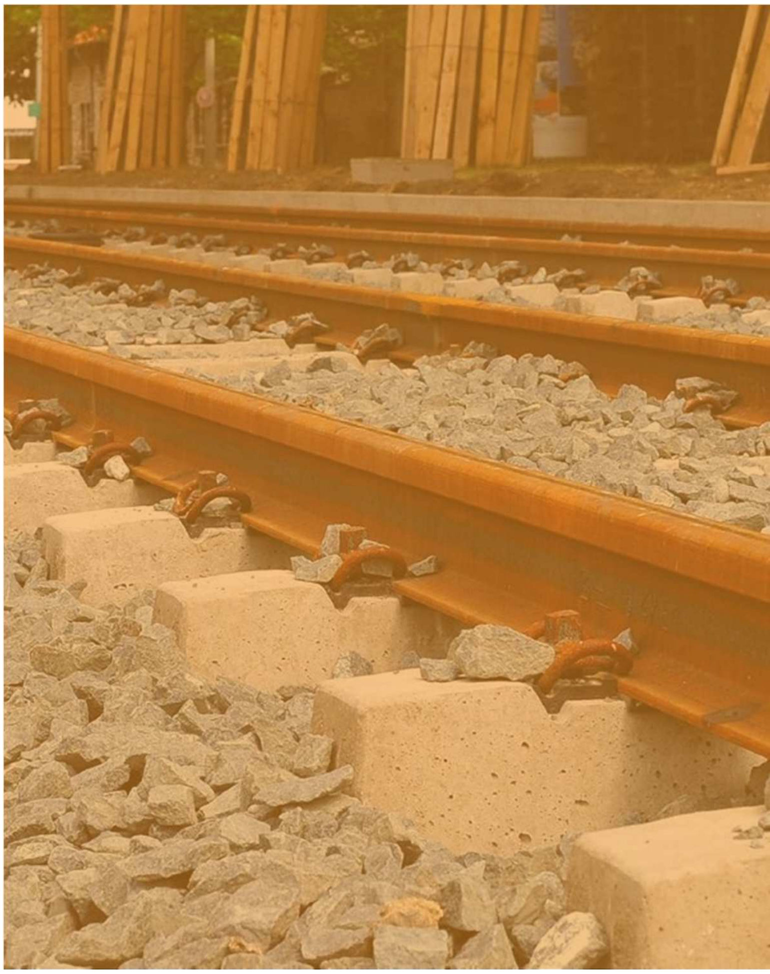
1.5 million€ EU Contribution	**30** months
6 partners	**4** countries

Objectives

From preventive conditional and scheduled maintenance of bogies to predictive maintenance through digitalisation.

LOCATE has:

- developed optimised condition-based maintenance strategies using dynamic tools to:
  - support maintenance scheduling,
  - localise faulty components bogies,
  - ensure appropriate inventory control of stocks and spare parts, . and assign maintenance staff;
- set-up and validated an open architecture to carry asset management data on the locomotive bogie;
- developed a digital twin for the bogie system, based on vehicle dynamic simulations and post-processing;
- applied a cost-effective and reliability-based sensor installation to locate defects and monitor structural integrity of bogies.

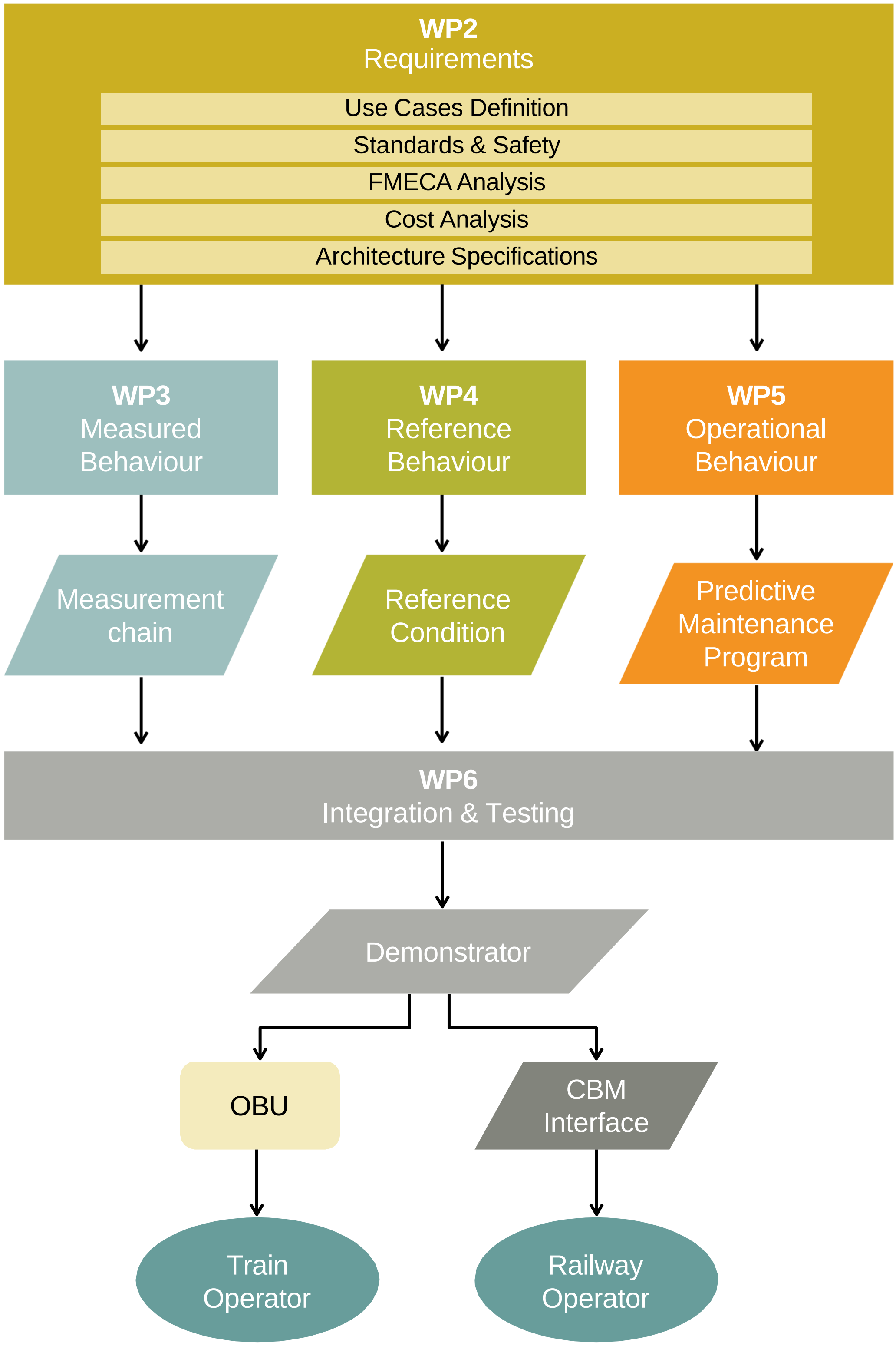


Structure of the project

The LOCATE project was divided into 5 main work packages:

- **WP2** Requirements
- **WP3** Measured Behaviour
- **WP4** Reference Behaviour
- **WP5** Operational Behaviour
- **WP6** Integration and Testing

The interaction between the WPs are highlighted in the following diagram, where the WP2 outcomes in terms of use cases, requirements and specifications are used by the parallel activities of WP3, WP4 and WP5. The overall technical results are then combined in WP6, which is responsible for the integration and testing and the execution of the LOCATE demonstrator.



The next paragraphs explain the activities performed and the key results from each work package.

WP2 Requirements

WP2 identified the candidate components and subsystems of the FGC operated series 254 locomotive which would be monitored as part of the LOCATE project. The candidate use cases included:

- Bogie frame
- Pivot bolster
- Wheelset
- Axle box
- Wheel flange lubricator
- Primary suspension
- Secondary suspension
- Traction engine suspension
- Electric traction engine
- Brake rigging
- Brake cylinder
- Parking brake
- Sander
- Pneumatic equipment

Based on the proposed candidate use cases, a failure mode effect and criticality analysis was performed to identify and prioritise the most relevant components and subsystems of the bogie. A Risk Priority Number (RPN) was used to rank the criticality of the identified failure modes to determine the three main subsystems of the bogie, namely:

- Wheelset
- Braking System
- Suspension System

In addition, the components and subsystems which cause problems from a maintainer's perspective (e.g., number of failures/warnings, time to repair) were identified by FGC. These were aligned with the FMECA outputs and research objectives to define the following most critical subsystems:

1. Wheelset subsystems
2. Axlebox
3. Bogie Frame
4. Brake System
5. Suspension system / elements
6. Electric Traction Motor

The FMEA analysis considering these subsystems identified 30 failure modes divided as follows:

- 7 failure modes for the Wheelset subsystems
- 3 failure modes for Axlebox
- 1 failure mode for Bogie Frame
- 13 failure modes for Brake System
- 3 failure modes for Suspension system / elements
- 3 failure modes for Electric Traction Motor

After the monitoring targets were identified, the requirements and specification of the system architecture capable of implementing the use cases were established. At this stage of the project, it was identified that the monitoring system would be composed of:

- OBU inside the cabin
- Conditioning system outside the cabin
- Analog sensors on the sub systems

Several Commercial suppliers were also evaluated for the acquisition systems, and DEWESOFT solutions was selected based on cost, robustness, ease of use and possibility to develop easily post processing tools with supplied libraries.

WP3
Measured Behaviour

WP3 started by performing an assessment of the available technologies in terms of sensors and monitoring approaches and organized an initial measurement campaign to support and evaluate the sensors selection. Additionally, an important knowledge was used from previous experience from industry leaders in the LOCATE Advisory Board Meeting, including members from Shift2Rail Project FR8Rail III.

The outputs from this first measurement campaign provided the data to allow this evaluation to take place, prior to selecting the sensors for use on the longer-term measurement campaign.

The post-processing resources and adequate on-board computational resources were also adjusted based on the field experience acquired during the first measurement campaign and work completed by the different work packages.

Initial statistical and frequency analysis of the measured data suggests that the selected sensors and sensor locations provided useful information for the monitoring of bogie stability (low frequency accelerometers) and detection of abnormal behaviour in suspension and wheelset (profile related conicity issues) components of the bogie system. Measurement of high frequency accelerations has been shown to provide useful information on the performance of the axle box and with future post-processing could be used to detect abnormal behaviour of related components, such as bearings, wheelset (tread defects) and gearbox.

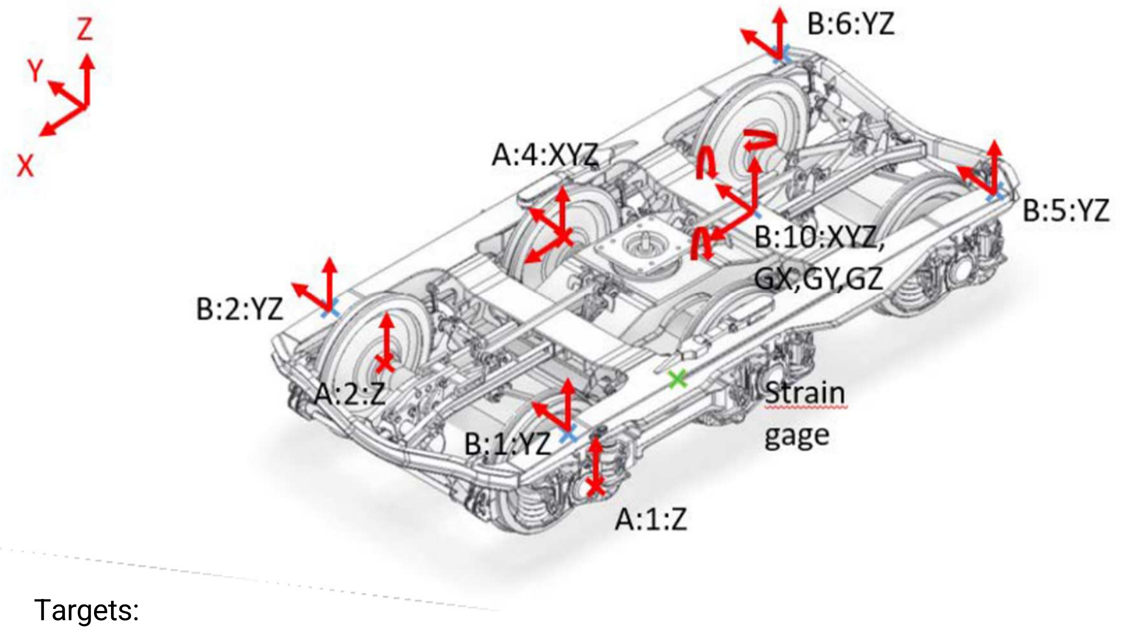
The data acquired during the preliminary measurement campaign was used to validate the dynamic response of the computational model in WP4 and support the development of the Digital Twins.

Overall, the preliminary measurement campaign was a success. It showed the ability to instrument the FGC locomotive with all the necessary sensors to address the different use cases defined in the project.

The different sensors have been evaluated and an informed choice was undertaken for the longer-term measurement campaign depending on the strategies defined in WP4 and WP5.

This preliminary measurement campaign has also helped to define for the specification for the longer-term measurement campaign and integration of the LOCATE system, for example powering, cable routes, and hardware integration.

It also showed that monitoring the global status of the locomotive is important such as velocity, motor current, GPS position as the measurements should consider the condition of the different sectors of the track, operating speed, and load. Instantaneous wheel speed is highly important especially when GPS signal is lost. The signal from odometer already installed on the wheel of the locomotive would provide a more precise and robust measurement of speed.



Targets:

- Rigid body motions of the bogie (0-50Hz)
- Deflection modes of the bogie (10-200Hz)
- Axle box vibration (1-10kHz) and temperature

A proposed strategy employed in the full measurement system was to enter the vehicle into a diagnostic cycle at given periods when the locomotive is within prescribed operational boundaries.

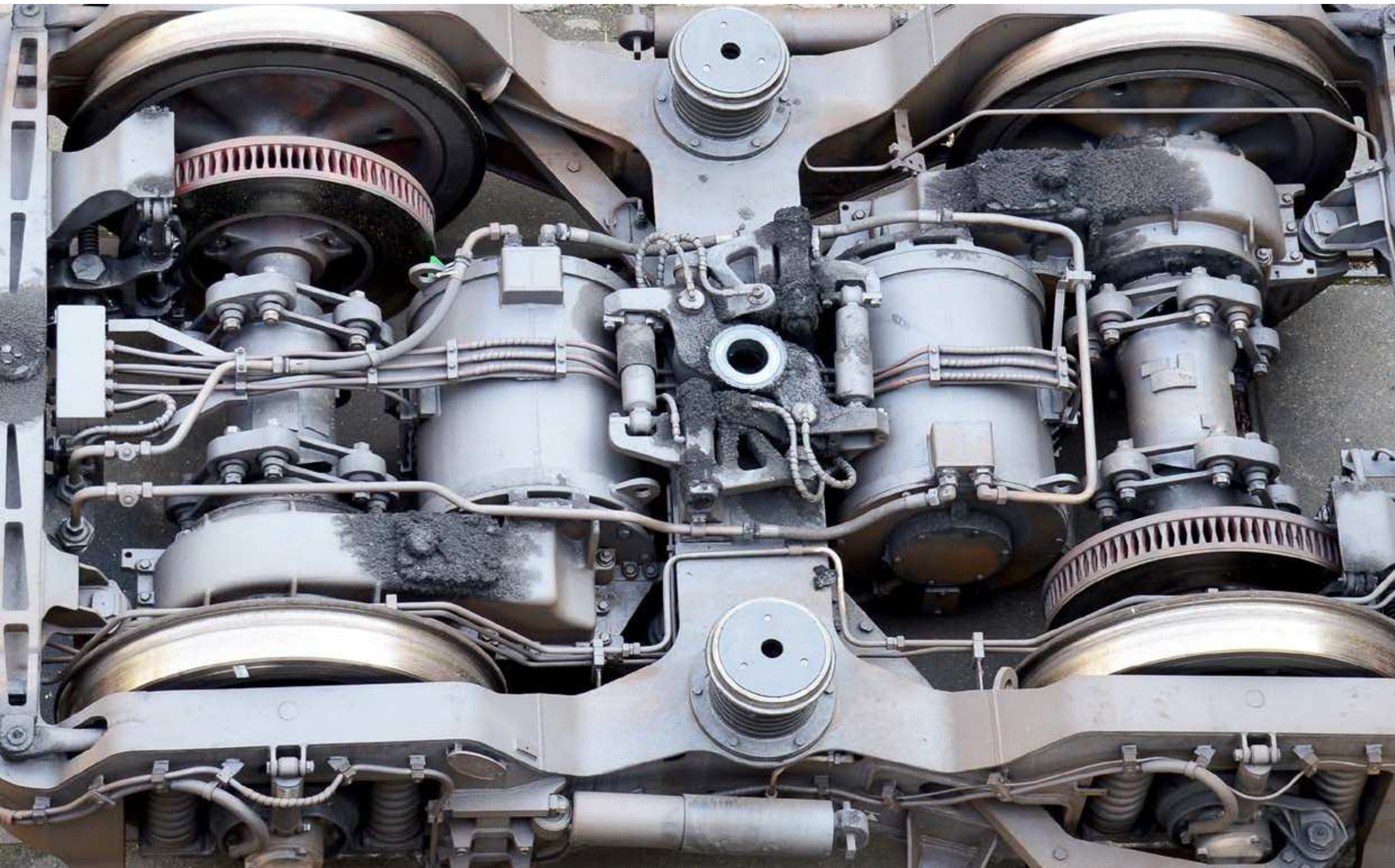
This will require prior available coordinate system maps of stations and points of reference when the vehicle will normally enter a diagnostic zone. The zone will be controlled by factors such as speed, GPS location, loading conditions and any other parameter that can establish baseline measurements from which critical repeated measurement for the failure modes will be recording by the monitoring system. A register will be kept for the baseline measurements from which thresholds will be assessed and stored.

WP4
Reference Behaviour

The Reference Behaviour Work Package started by assessing the available models and several solutions were presented to study the degradation of bogie components using numerical simulations. Railway axle cracks can be detected by taking advantage of the periodicity of the fault signatures, which is related with the velocity of rotation of the axle. Several methods exist that allow the study of fatigue phenomena in railway bogies.

Likewise, various techniques exist that are already in use to monitor the condition of mechanical structures such as bridges and planes. However, to the knowledge of the authors, there is no published solution to monitor the bogie structure regarding fatigue. There is the potential for project LOCATE to fill this open point. A great number of solutions exist to assess the damage and degradation of suspension elements, both in the context of the modelling of the defective components, as well as the signal processing techniques for fault detection and identification.

Project LOCATE has contributed with more advanced models to represent body flexibility and damage, such as fatigue cracks in the railway axle and bogie frame. This was achieved using a flexible multibody formulation that employs modal reduction techniques to allow the efficient simulation of complex mechanical systems. Additionally, the degradation of suspension elements was analysed using multibody simulations, taking advantage of imperfect kinematic joints to allow a realistic representation of friction, local compliances, and clearances.



The computational model's specification was established and the suitability of the experimental data from the preliminary measurement campaign for the validation of the vehicle dynamics model of the Series 254 locomotive has been reviewed and compared to relevant standards. Whilst the measured quantities do not include information on wheel-rail forces typically used to validate vehicle models, the measured bogie frame and axlebox accelerations provided useful information to validate the dynamic response of the vehicle model. In turn, the validated vehicle model simulation, in normal operation conditions, delivers the normal dynamic response of the systems.

By varying the selected bogie modelling parameters, suspension spring characteristics, bogie chassis crack locations and propagations, wheelset cracks, etc., vehicle abnormal dynamic responses were obtained and related to KPI. Key Performance Indexes (KPI) were determined from post-processing of the measured quantities and used to support model validation and component condition classification. These KPIs include statistical quantities associated to the dynamic responses, such as standard deviations, maximum and minimum accelerations, relative displacements of the bogie components, etc.

The systematic use of the simulation tools to analyse all the possible combinations of modelling parameters is unfeasible, as each simulation may take from several minutes to several hours, depending on the operation conditions, extent of the track covered by the vehicle and on other interaction conditions. Therefore, the use of a meta-models to estimate the vehicle response as a function of the health of the bogie subsystems has been introduced. A range of Design of Experiment techniques have been identified to estimate reliable metamodels and to develop the Digital Twin.

The decision was to define the DoE based on the Latin Hypercube Sampling and the metamodel based in Kriging.

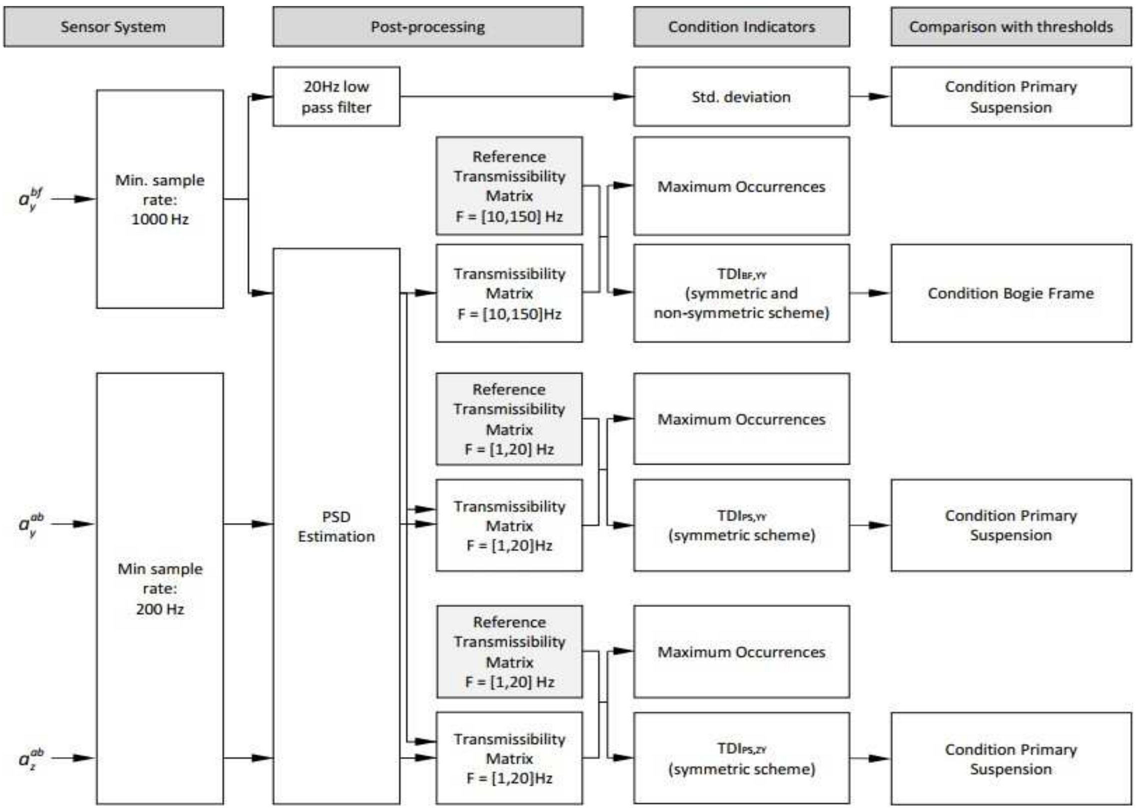
The models were developed, and the methods implemented to evaluate the condition of bogie components using dynamic simulations. The results of multibody simulations represent the nominal and abnormal response of the vehicle, providing a database of the locomotive reference behaviour. This database supports the identification of the health of the bogie components.

The failure modes addressed in WP4 are cracks in the bogie frame and wheelsets, and the degradation of elements in the primary suspension. Condition assessment is accomplished using damage detection methods based on the transmissibility concept, such as the Transmissibility Damage Indicator (TDI) and Maximum Occurrences (MO) methods. The degradation of primary suspension elements is also assessed using surrogate modelling.

The main conclusions of the research activities conducted in WP4 can be highlighted:

- A static analysis based on standard EN 13749 was used to define an appropriate location for a crack in the welded connections between the front transversal beam and the side frames. The lateral accelerations measured at selected points in the bogie frame were obtained from a set of simulations of the vehicle-track interaction considering different crack sizes and a constant speed of 60km/h. The transmissibility matrix of the measured response is computed in the frequency range of 10-150Hz, and the results show the TDI method is sensitive to damage if the crack area is at least 63% of the cross-section of the welded connection. Further increasing the crack area reduces the TDI value. The symmetric and non-symmetric schemes used to compute TDI suggest a threshold of 0.7.
- The results from the flexible multibody simulations rely on the sensitivity of the natural frequencies and vibration modes of the structure to the existence of damage. The modal analysis of the wheelset shows the natural frequencies are only sensitive to cracks perpendicular to the axle if their depth is higher than 25% of the axle diameter. Therefore, this method is unlikely to detect damage in the wheelset before the crack grows exponentially.
- The TDI method can measure changes in transmissibility caused by damage in the primary suspension. It is sensitive to a 50% reduction of the nominal value of spring stiffness and a 40% increase or decrease of the nominal value of the damping coefficient of the viscous damper. TDI is sensitive to damage in the primary suspension given the sources of variability in the simulations, i.e., track irregularities, speed, and uncertainty about the nominal values of the mechanical properties.
- After detecting damage in the bogie frame using the TDI method, the MO method identifies the entry corresponding to the highest difference between the nominal and measured transmissibility matrices. The indices of this entry correspond to the pair of sensors detecting damage. The sensitivity of the MO method depends both on the frequency range considered for the response and the position of the sensors. However, when damage is detected on springs it can only indicate if the damaged spring is in the leading wheelset or on the other two. The method cannot isolate damage in the middle and rear wheelset.
- Surrogate models of the standard deviation of the lateral acceleration of the bogie frames show good fit, low absolute percentage error, and sensitivity to spring damage. The stiffness values used in the simulations range from 10 to 190% of the nominal stiffness. However, it is not clear what values are acceptable before the spring can be considered damaged. Upper and lower stiffness limits were defined for discrete speed intervals based on the variance of the surrogate. Finally, the maximum and minimum of the surrogate within the stiffness limits constitute the threshold for the response.
- A Recursive Least Square method for the estimation of the primary suspension parameters is presented. The RLS method is suitable to monitor the condition of suspension systems that can be represented by linearised models. Since this RLS method is based on the parameter estimation with Input-Output model, the estimation result is not sensitive to the operational condition.

The following diagram captures the data flow and condition monitoring methods researched.



WP5 Operational Behaviour

The Operational Behaviour Work Package started by the identification of operational constraints and non-negativity restrictions associated with bogie maintenance. Typically, these consist of technical (e.g., associated with the type of locomotive, depot layout and capacity, resources and spares inventory) and non-technical constraints (e.g., personnel, depot management, competence/skills and working conditions). The general maintenance instructions, programs and failure records associated with freight locomotives and the actual maintenance practices at the FGC depot have been reviewed. The key constraints related to the maintenance of locomotive have been identified and summarised in this deliverable. These include a mixture of:

- Operational constraints – business model of FGC, service requirements, depot management, resource requirements and spares inventory policy
- Technical constraints – type of locomotive, regulations/requirements of maintenance related to the select component/sub-system
- Economic constraints – specific budget of maintenance

Although there are some variations in the maintenance planning due to the constraints of different international rolling stock maintainers; the adoption of international standards and interoperability means that they are similar.

The current maintenance regime for the FGC Series 254 locomotive has been reviewed to identify the specific constraints and dependencies for selected use cases. The current regime focuses on the safety and availability of the locomotive and includes the replacement and repair of components off the vehicle. This makes the planning of spares more important, especially when moving to a CBM approach (where components may be in-service for a longer period). Examples of typical maintenance threshold/rules and resulting maintenance activities have been provided.

Finally, specific data requirements have been identified which supported the definition of objective functions to describe these constraints for inclusion in the maintenance decision framework.

Currently, FGC adopts an on-condition based maintenance regime, where inspections are undertaken on specified intervals with defined thresholds. If one of these limits is reached an intervention to correct the problem should be made as soon as possible. The LOCATE project proposes to replace this with a predictive maintenance system of the bogie of the FGC's locomotives. This system continuously monitors the bogie and the performance compared to reference data obtained from a digital twin. Failures are anticipated and the time before the failure affects the locomotive operations estimated, based on the defined thresholds and rules. The scheduling of this operation must be done to limit the impact on the availability of the fleet.

To define the threshold and rules, it is initially proposed that the failure rates defined in the FMECA (WP2) and/or manufacturing data is utilised to provide the most accurate representation of the failure rates of the components (accounting for any variation between components/operation).

These should be combined with the condition data to provide an estimate of RUL. These can be combined with the operational constraints, to support the condition maintenance framework. The failure rates should be reviewed during long term measurement campaigns in collaboration with the maintainer to provide feedback on the accuracy of the LOCATE system.

Definition of thresholds and rules, such as the P-F curves, depend on the system/ component being assessed, failure modes and type of data monitored. In the LOCATE system, the measured and reference behaviour provide an indication of the health status (or performance) of the system/component. Thresholds/rules are required to provide an indication of when maintenance is required, with sufficient time for maintenance to be scheduled based on the health status of the system/component. This requires an understanding of the relationship between performance and degradation to support the prediction of the estimated-time-to-failure (or RUL) and definition of the P-F curve.

The type of thresholds used is dependent on the type and format of measured/reference behaviour data. For example, data could include physical measurements of the actual condition of a component/system (e.g., wear measurement of a wheel profile) and sensor data (e.g., vibration measurements) which require some form of post-processing to infer the component/system condition or functional performance. If the physical condition of the component/system is monitored, then changes in the measured data can be tracked to detect potential failure which can be linked to industry (safety) and company (performance) limits. In the latter case, features in system performance, e.g., peak frequencies which change with degradation (e.g., symptoms) need to be identified and there are challenges in terms of identifying the type and severity of a fault and recommending the most appropriate maintenance action.

To support the definition of initial thresholds and rules in the LOCATE project, existing standards and techniques for condition monitoring and prognostics were reviewed. Techniques, such as failure mode symptoms analysis, were shown to provide useful information for identifying the symptoms which potentially lead to a particular failure, the current means of detection and thresholds which trigger a maintenance action. In discussion with FGC and the LOCATE Advisory Board, this technique has been applied to each of the selected use cases to link the main failure modes identified in the FMECA developed during WP2 (D2.3) with the symptom(s) and proposed measured or reference data.

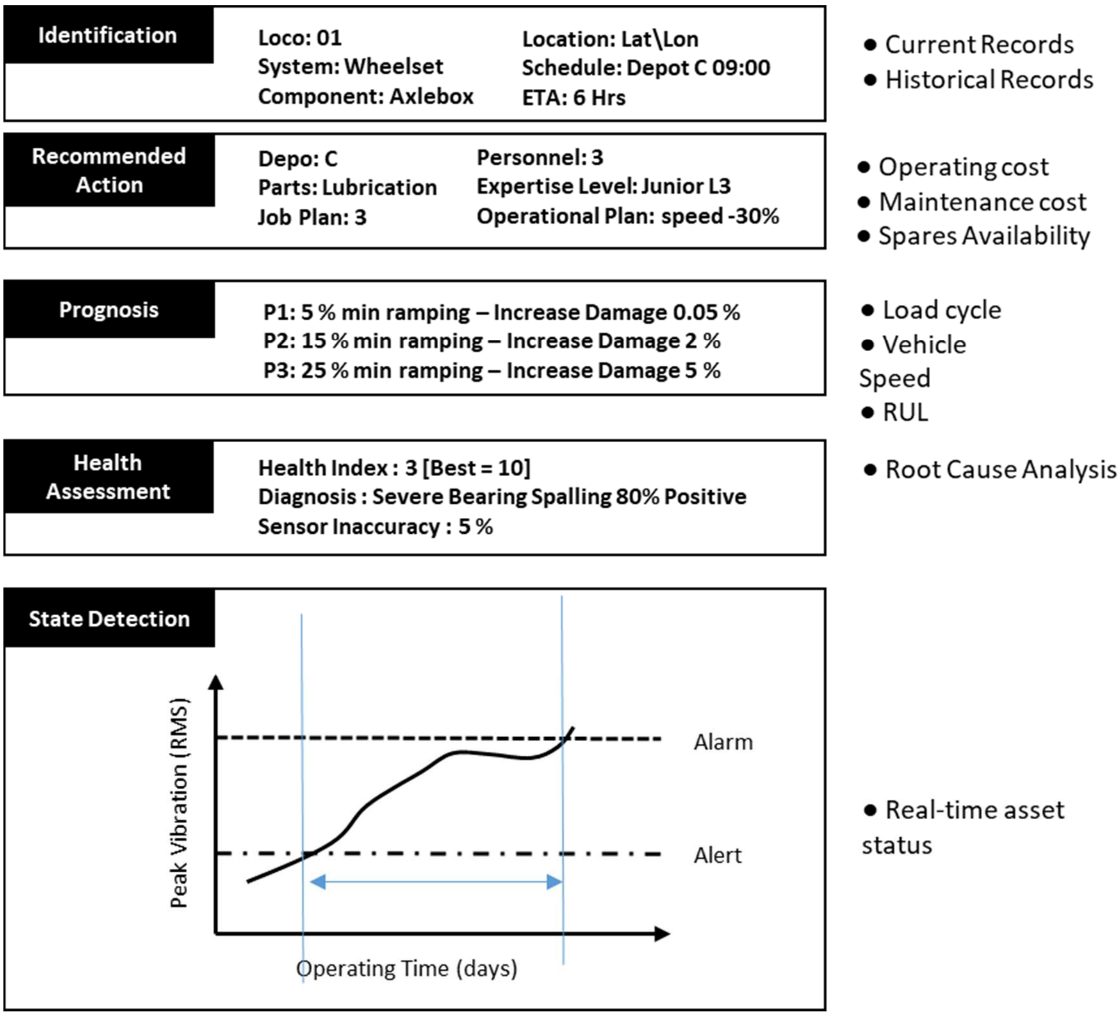
The expanded FMECA includes details of the current detection method and existing (or typical) thresholds and rules that are applied to each of the use cases. In LOCATE, these were replaced with information (either physical measurements or data features) from the measured or reference data developed during WP3 and WP4.

An estimate of the P-F interval, in time or distance, for all the identified failure modes would have been a valuable addition to the FMSA. However, in the current preventative maintenance regime adopted by FGC, the failure modes are not permitted to remain in the system past the potential failure point (P). This concept is not natural in the current regime therefore no records of extending RUL or scheduled maintenance intervals exist.

It is envisaged that once the CBM (Condition Based Maintenance) system is in place and the maintenance transitions to a Pd.M. (Predictive Maintenance) regime, failures modes will be tracked more closely and a better understanding of the limits and threshold to support the confirmation of the initial P-F intervals defined in D5.3.

The main goal of LOCATE was to deliver a framework, in the context of bogie maintenance and compatible with current FGC's maintenance practice and standards, for decision-making support and optimisation of maintenance plans. In particular, the optimisation tool should be flexible to incorporate changes related to the acquisition of sensor information.

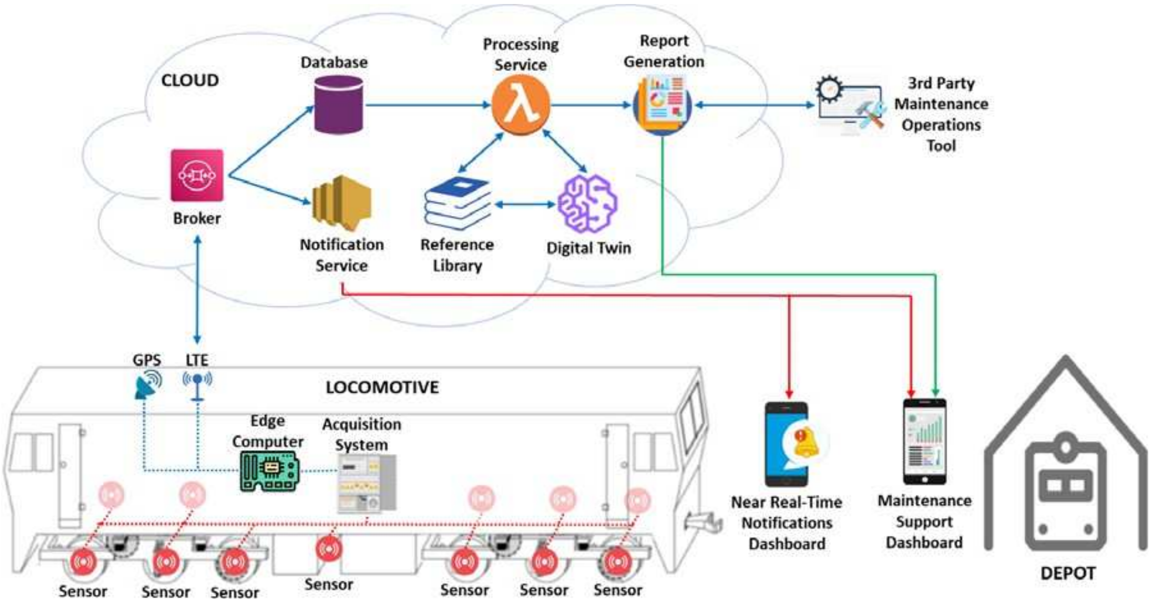
The key constraints and variables to the maintenance of the locomotive or, more specifically, the operational constraints defined on deliverable D5.1 and the monitoring thresholds and decision support rules defined on deliverable D5.2, were used and a simulation experiment was first proposed to assess the impacts of having models with different configurations and failure patterns for the various bogie's subsystems. The optimisation-based framework was constructed after the appropriateness of the main assumptions, including failure rates, were tested in the simulation model.



Although sensor information was not available at the time this activity was performed, a sample problem using simulated data was proposed to test the optimisation algorithm. The results showed good suitability of the model to capture the main characteristics of the current maintenance FGC's practice and, on top of that, to serve as a decision-making support tool to define short-term and long-term changes to the maintenance scheme, especially when sensor information is available.

WP6
Integration and Testing

The WP6 activities were focused on the integration and testing of the LOCATE framework, based on a demonstrator installed on a locomotive.



Concerning the architecture: WP6 validated that the requirements of the LOCATE system provided a flexible and adaptive system which integrated the constraints induced by retrofitting to an older locomotive. It necessitates to have a flexible architecture with the possibility to condition different sensors, which are able to withstand and resist the harsh operational environment.

On the other hand, the framework for predictive maintenance is applicable to all stages of the asset lifecycle; for example, at the design stage the reference behaviour can assist to evaluate future modifications to components for optimised running in operation; and in the early stages of the asset lifecycle, the measured and operational behaviour can inform adaptive and predictive changes to maintenance and tactical optimisation for resource management.

Regarding the measurement campaign, the following conclusions can be highlighted:

On the vibrations measured on the bogie, the averaging time to compute the PSD that represents the averaged vibration behaviour of the bogie should be long enough to smooth the effect of the track irregularities and operational condition of the bogie. Taking a longer averaging time allows to smooth the variation of load and track irregularities and converge to an averaged vibration level.

A strategy should be to compute PSD only when current is zero to remove gearbox excitation to focus only on bogie vibration response, or to compute the PSD only when the current consumption is a certain level to focus on the gearbox excitation.

The PSD computed from 0 to 250Hz for the 4 sections, showed that in the Z direction from 10 Hz to 80 Hz, the vibration levels are mostly due to rigid body motion and natural frequencies of the bogie frame. But below 10Hz, the differences in vibration levels can be explained by variation in track irregularities. .

In Y direction, the PSD levels are mainly associated with the characteristics of the track section and there is no common profile due to only bogie frame modal response.

Regarding the axleboxes, the PSD profiles are different between axlebox 1 and axlebox 2 but there are very similar for the 4 different sections of track. It means that the vibration profile is mainly made by local response of the axlebox and load on the electrical engines.

The PSD profiles can be used independently of the track section to monitor the vibration level and detect abnormal situations in Z direction on bogie frame and axlebox.

For the axlebox, the load on the engine influences significantly the vibration level and measurements shall be performed on same load condition, including similar speed of the locomotive.

On Y direction the PSD profile are mainly governed by phenomenon due to interaction between the locomotive and the track. The edition of a PSD profile independently of the section is not possible.

Regarding the use of the PSD profiles on different vehicles, we observed that the signals measured are representative of the rigid body modes of the bogie frame on primary suspensions and first bending modes of the bogie. The edition of PSD profile in Z direction can be a good and simple indicator to detect abnormal situation in terms of bogie stability or emergence of a new excitation due to wear on gearbox or flat on a wheel.

In what concerns the axleboxes, the accelerometers are much more sensitive to the sub-system and to the measuring point location, so the PSD indicator on an axlebox can only be used to monitor the instrumented bearing but a generic profile cannot be edited to use for all the axleboxes on the same type of locomotive.

As an overview, it was observed a very good adherence and correlation between the measurements and the reference behaviour, indicating interesting results from the sensors and monitoring system, and from the digital twin and computational models as well.

Regarding the reference model, the main conclusions can be highlighted:

- Duration of the time signals has an impact on the quality of the transmissibility-based damage indicators (TDI);
- Small sensitivity of the TDI to 20% cross section crack. However, TDI is sensitive to moderate to large cracks (63 to 100%);
- TDI effectively detects moderate to large spring stiffness reduction (-50%);
- TDI effectively detects moderate to large variation of the damping coefficient (+-50%);
- Maximum occurrences approach is globally sensitive to damage in bogie frame and allows damage location; the results are inconclusive regarding the failure of suspension elements.
- Surrogate models of the standard deviation of the lateral acceleration of the bogie frames show good fit, low absolute percentage error, and sensitivity to spring damage.
- Upper and lower stiffness limits were defined for discrete speed intervals based on the variance of the surrogate. The maximum and minimum of the surrogate within the stiffness limits constitute the threshold for the response.

Regarding the operational behaviour, the main conclusions can be highlighted:

- CBM framework has been developed based on FMECA.
- Condition monitoring, diagnostics and prognostics approach has been adopted.
- LOCATE CBM framework includes:
    - MSG3\RCM approach to development of functional failures modes,
    - Failure frequency distribution and conditional probability of failure,
    - P-F interval linked to maintenance task interval,
    - Proportional hazard model linked to condition data for prognostics,
    - Safety, environmental, operational and economic concerns observed to meet asset life cycle costs.
- Complete demonstrator on FGC locomotive was achieved.
- Validation of ‘digital twins’ and P-F intervals.
- Linear piecewise approx. model for scheduling optimisation based on demonstrator.

FUTURE developments

The project contributes to the development and implementation of strategies for online condition monitoring. However, there are a few points requiring further investigation and consolidation:

- Extended Reference behaviour / Modelling Validation for different degradation stages
  - Library of reference behaviour with experimental data (systematic methodology needed)
  - Fault detection methods analysis with simultaneous failures
  - Methods which consider tracks segments with curved geometry (rather than just tangent track)
- Operational behaviour
  - Linear piecewise approx. model for scheduling optimisation based on demonstrator
  - Validation of 'digital twins' and P-F intervals with longer deployments and larger datasets collection from different asset condition stages
- Measured behaviour
  - Integrated and more straight forward sensor installation methods and technologies would make the system easier to install, including miniaturization and energy autonomy.

List of acronyms

Acronyms	Description
AB	Advisory Board
CBM	Condition Based Maintenance
CFM	Call For Members
DoE	Design of Experiments
ECM	Entity in Charge of Maintenance
FGC	Ferrocarrils de la Generalitat de Catalunya
FMEA	Failure Mode and Effects Analysis
FMECA	Failure Modes, Effects and Criticality Analysis
FR8HUB	Real time information applications and energy efficient solutions for rail freight
FR8RAILIII	Smart data-based assets and efficient rail freight operation
GA	Grant Agreement
GPS	Global Positioning System
HUD	University of Huddersfield
IEEE	Institute of Electrical and Electronics Engineers
IP	Innovation Programme
IST	Instituto Superior Técnico
LOCATE	Locomotive bOgie Condition mAinTEnance
MO	Maximum Occurrences method
OBU	Onboard Unit
PdM	Predictive maintenance
P-F	Potential-Failure
RUL	Remaining useful life (period of time after which the risk of defect become intolerable)
S2R JU	Shift2Rail Joint Undertaking
STC	Steering Committee
TD	Technology Demonstrator
TDI	Transmissibility Damage Indicator method
TOC	Table of Content
TRA	The Transport Research Arena
UIC	Union Internationale des Chemins de fer
WCRR	World Congress on Railway Research
WP	Work Package

List of project deliverables

WP1	**Project Management**	
D1.1	Gender Strategy Plan	Public
D1.2	Quality Assurance Plan	Public
D1.3	Data Management Plan	Public
WP2	**Requirements**	
D2.1	Use Cases Description	Public
D2.2	Report on Standard and Regulations	Public
D2.3	FMECA Analysis	Public
D2.4	Requirements and Architecture Specification	Public
WP3	**Measured Behaviour**	
D3.1	Available technologies assessment report	Public
D3.2	List of Selected Sensors and Devices	Confidential
D3.3	LOCATE Monitoring System Specification	Confidential
WP4	**Reference Behaviour**	
D4.1	Available Models Assessment Report	Public
D4.2	Computational Models Specification	Confidential
D4.3	Behaviour Prediction, Simulation and Post Processing Results Report	Public

WP5	**Operational Behaviour**	
D5.1	Operational Constraints Identification Report	Public
D5.2	Monitoring and Thresholds Rules Specification	Public
D5.3	Scheduling Flowchart	Confidential
D5.4	LOCATE Software user manual	Confidential
WP6	**Integration and Testing**	
D6.1	System Test and RAMS Analysis Report	Confidential
D6.2	LOCATE Predictive Maintenance Framework	Public
WP7	**Dissemination and Exploitation**	
D7.1	Dissemination and Communication Plan	Public
D7.2	Dissemination Report and Exploitation Plan	Public
D7.3	Recommendations Brochure	Public

Public deliverables can be downloaded on the project website at:

locate-project.eu/#deliverables

Dissemination

Project final event

LOCATE project partners held their final event remotely on Friday 29 April 2022.

Recording of the event can be accessed HERE

All presentations delivered can be downloaded below:

Welcome	EVOLEO Technologies
WP5 – Operation Behaviour	University of Huddersfield
WP4 – Reference Behaviour	Instituto Superior Técnico
WP3 – Measured Behaviour	Vibratec
WP6 – Integration and Testing	FGC/UIC/EVOLEO
LOCATE vision and innovation	EVOLEO Technologies

Peer-reviewed papers

The project partners attended several conferences and published a series of papers to present the results achieved during project life. Below a selection of papers published by the project partners:

- Assessing the performance of different devices in railway wheelset inspection published in Science Direct, Elsevier in December 2020 (download HERE)
- A Framework for Locomotive Bogie Condition-based Maintenance (LOCATE) presented at the World Congress of Railway Research Conference in June 2022 (download HERE)

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Consortium

NAME	SHORT NAME	COUNTRY
EVOLEO Technologies LDA	EVOLEO	Portugal
Instituto Superior Técnico	IST	Portugal
University of Huddersfield	HUD	United Kingdom
Ferrocarrils de la Generalitat de Catalunya	FGC	Spain
Union Internationale des Chemins de fer	UIC	France
Vibratec	Vibratec	France

CONTACT

Project coordinator

Mr. Pedro Ribeiro – EVOLEO Technologies
pedro.ribeiro@evoleotech.com

Dissemination

Ms. Christine Hassoun – UIC
hassoun@uic.org

in www.linkedin.com/company/79762935

locate-project.eu