European research project about railway axles started in November 2010
### The consortium

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**Defined Advisory Groups:**

1. **Paint suppliers** – important link with WP04
2. **End users:**
   - SNCB
   - RSSB
   - Turkish Railways
Broken carrying axles have been reported since 2000 by different Railway Operators on passenger, freight and high speed trains. Last summer an accident occurred in Italy on a wagon transporting dangerous goods that conduct to injured people. In all cases, corrosion, service load definition, maintenance step operations have been point out during examination.

The calculation of a wheelset is only valid, if the corrosion protection is ensured over the lifetime of the axles EN 13103 – 2009. If corrosion protection is not ensured, an additional safety factor of 1.3 (proposal) must become part of the calculation. We know at the moment that European axles do not fulfil this requirement.

At the same time, axle suppliers have to face technical problems with the adhesion of paint coating due to low roughness required on axle machined surfaces. Surface conditions are linked with the fatigue limit of the axle and can not be modified even maintenance practices allow sandblasting of the axles.

Railway maintenance is not unified in Europe. The last accident in Italy has conducted European Railway Agency (ERA) to create a task force to establish common practice and recommendations. Maintenance needs also to define inspection steps that depend of the service conditions and vehicle loads. But usually, maintenance consists in heavy operations that must be done in specific shops. When axles are under the trains, it is clearly difficult to establish a non destructive examination of the running gears to validate a safe operation of the fleet.

Fatigue limits of railway axles have to be validated according requirements of EN 13261 and 13260 standards. Tests performed by axle suppliers have demonstrated that some errors occur in EN 13260 standard especially for the fatigue limit under the wheel seat.

Railway standards have been established on the basis of return of experience. Tests and limits only allow a verification of properties of existing material. New specifications and service conditions require new material for a weight reduction associated to an increase of the traction efforts needed on new vehicles. Standards do not give any recommendations or requirement for new developments.
EURAXLES objectives

Euraxles project combines different aspects to achieve these targets with:

- A design approach based on measurements from service and more accurate modelling of the wheelset. An improved knowledge of fatigue parameters in special conditions (presence of corrosion, special wheel/gear assemblies, press-fit condition, surface finishing, new materials)

- An improvement of the axle protection against corrosion adhesion improvement with a study of the roughness influence (adhesion and fatigue behaviour) and the development of innovative coating solutions based on benchmark analysis. New solutions have also to fulfil environmental requirements to avoid or limit COV emissions

- The application of new NDT inspection methods that allow an in-service inspection of axles in order to guarantee a safe service conditions with a low impact of the vehicle availability. This point is mostly based on a benchmark of existing, innovative solutions.

- A Rams/LCC analysis of the solutions. Railway transportation system requires a risk analysis of the safety components as for airway transportation system.
WP2. New axle fatigue design method (SNCF)

Objectives

- To develop a methodology to analyze on-line load measurements, in order to make a statistical description of the loads and determine the “fatigue equivalent loads” that have to be tested in calculations and experimental tests;
- To define requirements for numerical axle modelling using the finite element method;
- To develop a consistent methodology which estimates the probability of failure of an axle, taking account of the load variability and the components' strength scattering and to make a correlation with the standards EN13103/13104 as well as recommendations for its revision;
- To set-up a framework that will enable the introduction of innovations while allowing possible weight reductions and energy cost savings, without degrading the security.
WP2. New axle fatigue design method (SNCF)
WP2. New axle fatigue design method (SNCF)

Task 2.1: Characterization of the in-service loading severity.

- ST 2.1.1 Database on service loading measurements
- ST 2.1.2 Methodology to characterize the load severity and definition of the equivalent damage load
- ST 2.1.3 Load distribution for representative applications
- ST 2.1.4 Standardisation of representative loads – correlation between existing method (EN13103/EN13104) and the developed procedure.

Task 2.2: Axle calculation and risk analysis

- ST 2.2.1 Definition and test of FEA calculation methods
- ST 2.2.2 Definition of fatigue acceptance criterion for the FEA calculation
ST 2.2.3 Comparison of the FEA calculation method, the existing procedure (EN13103/EN13104) and the tests

ST 2.2.4 Determination of the main parameter that have to be fulfilled for the standardisation of the FEA calculation method

ST 2.2.5 Establishment of the risk analysis including a comparison between loads and strength calculation.

Task 2.3: Validation of the design procedure

ST 2.3.1 Reliability approach: Stress Strength Interference analysis

ST 2.3.2 Definition of test methods

ST 2.3.3 Comparison between EN 13103/13104 and the developed method

Comparison between safety margin and risk analysis method.
WP3. New testing methods of railway axle fatigue limit assessment (Lucchini RS)

**Objectives**

- To use predictive methods to verify that the empirical fatigue parameters described in the design and product specification European Standards for axles and wheelsets (EN13103, EN13104, EN13260, EN13261) are valid for new materials and axle types;
- To predict the probability of failure associated to the various fatigue limits on axles produced today by the European manufactures;
- To revise the stress concentration factors associated to various geometry grooves or transition sections subjected to cyclic fatigue.
- To determine the fatigue resistance associated with parameters regarding geometries and compositions of press fitted parts.
- To determine the influence of surface and coating quality on the fatigue resistance that is not clearly described in the Standards in order to facilitate the introduction of innovative materials.
- To obtain at the end of the project all the necessary information to revise the present Standards to enable a more optimized and safe design.
WP3. New testing methods of railway axle fatigue limit assessment (Lucchini RS)
WP3. New testing methods of railway axle fatigue limit assessment (Lucchini RS)

Task 3.1: Definition of test methods

- ST 3.1.1 Evaluation of influence of press/shrink fitted part on fatigue limit – determination of a new method for the assessment of the fatigue limit under the wheelset – benchmark of the existing methods and analysis of achieved with these methods)

Task 3.2: Material testing

1. Normal fatigue (F1)
2. Fretting fatigue (F3/F4)
3. Corrosion surface
4. Surface treatments that give higher roughness to improve painting adhesion
5. Metal coatings surface testing
Task 3.3: Modelling activity (fretting)

Task 3.4: Comparison between the existing procedures and the new one in connection with WP2
WP4: TOOLS, TECHNOLOGIES AND SURFACE PROTECTION SYSTEMS MINIMIZING THE NEGATIVE INFLUENCE OF CORROSION OR SURFACE DAMAGE ON THE AXLES SURFACE (GHH)

**Objective**
- Develop new reliable methods for improving the adhesion behaviour of water based painting systems applied on axles with various surface roughness conditions; new requirements for the paint process technology;
- Investigate innovative painting and coating systems, introducing more environmentally friendly technologies and reducing VOC pollution versus traditional methods;
- Define the design requirements for axles without corrosion protection systems.
- Investigate new protection systems against ballast impact, especially necessary for high speed applications; fulfilment of the conditions for high speed trains;
- Investigate the new quality test methods for the painting/coating and protection systems to meet a quality standard under consideration of the realistic operating conditions;
- Implement the results into the rules for new production and maintenance of wheelsets and act as a guideline for more cost/time efficient wheelset production, maintenance and repair;
- Reduce the number of complaints and repair work on wheelsets (frequency and length of routine inspections) and increase axle lifetime and safety level;
- Improve and revise the European standards for wheel-sets by deriving recommendations concerning design and product requirements.
Task 4.1: Development of innovative painting and protection systems and technologies for axles, and an alternative design method for unpainted axles

- ST 4.1.1: Data base on painting, coating and protection systems, process technology and its quality test methods.
- ST 4.1.2: Analysis and limitations of the existing coating technologies and the quality assessment test methods contained in the standards
- ST 4.1.3: Comparison of national requirements (also maintenance standards & practices) and in-service operating conditions of wheelsets.
- ST 4.1.4. Benchmark of alternative and innovative protection solutions used in other industries.
■ ST 4.1.5: Investigation of new improved painting and protection systems and their technology requirements

■ ST 4.1.6: Unpainted systems requirements/limitations and innovative treatment solutions.

**Task.4.2: Development and definition of appropriate quality test methods for painted/treated protection and unpainted systems:**
WP5. Non destructive testing and verification of the reliability of in service (Renfe)

**Objectives**

- Benchmark of the state of the art including existing and new NDT techniques and of current NDT practices;
- Define optimal technologies and methods for in-service preventive safe detection of critical defects in railway axles. Potential techniques can range from new to the improvement of pre-existing ones (e.g., US, EC, MFL, Laser based US, etc);
- Identification of predictive techniques and methodologies for on-board continuous measurement of physical parameters, enabling the establishment of effective conditioning based maintenance;
- Verification of the influence of surface damage and corrosion in service using standard electrochemical and other NDT techniques.
WP5. Non destructive testing and verification of the reliability of in service (Renfe)

**Task 5.1: Review of the current practice on NDT methods used for the verification of railway axles:**

- ST 5.1.1. Questionnaire on NDT
- ST 5.1.2. Testing benchmark
- ST 5.1.3 Analysis of the current US techniques used in service and manufacturing

**Task 5.2: New methods to inspect axles in real service condition**

- ST5.2.1. Identification of potential inspection methods
- ST5.2.2. Most suitable NDT techniques
- ST5.2.3. Results evaluation and final report
**Task 5.3: Diagnosis of flaw axle using new analysis and classification techniques**

- ST 5.3.1. Analytical and FE model of flaw in axles: mechanical behaviour in service
- ST 5.3.2. Axles bench (static and dynamic)
- ST 5.3.3. Signal process algorithm design and flaw pattern identification
- ST 5.3.4. Development of on board diagnosis system

**Task 5.4: Verification of influence of surface damages and corrosion in service**

- ST 5.4.1. Benchmark study of electrochemical and NDT techniques for corrosion of in-service axles
- ST 5.4.2. Inspection procedure for corroded in-service axles
WP6. RAMS and Life Cycle Cost Taking into Account Market Uptake (CAF)

**Objectives:**

- To define a set of RAMS/LCC models which will serve as a base for the comparison of the different solutions developed in the project.
- To perform a comparative analysis of the different innovative solutions based on RAMS and LCC parameters in order to determine the most promising solution for a particular desired application.
- To derive recommendations for future revisions of European Standards concerning the design and maintenance of railway axles.
WP6. RAMS and Life Cycle Cost Taking into Account Market Uptake (CAF)

**Task 6.1: Definition of RAMS/LCC models**

- ST 6.1.1. Survey of RAMS/LCC tools
- ST 6.1.2. Selection and definition of a common RAMS/LCC tool

**Task 6.2: Data collection and selection of reference cases**

- ST 6.2.1. Data collection from participants
- ST 6.2.2. Statistical analysis of collected data
- ST 6.2.3. Selection of reference cases
Task 6.3: RAMS/LCC analysis of the innovative solutions

- ST 6.3.1. RAMS/LCC analysis of the innovative solutions
- ST 6.3.2. Comparative analysis of the innovative solutions

Task 6.4: Summary and recommendations for standards

- ST 6.4.1. Summary of results
- ST 6.4.2. Recommendations for revision of the existing EN standards