EURAXLES

New European research project about railway axles starting in November 2010
One of the major challenges that infrastructure managers are facing in the last years is increasing inspection intervals of railway axles without reducing the level of safety. Various research projects have addressed this issue so far, but still there is no common approach to that subject. In principle, there is a need to benchmark the methods developed, compare them, validate and develop a commonly accepted procedure. Railway axles are one of the most critical factors affecting safety and the ultimate aim of designers and operators is to minimize the possibility of axle failure in service since it could lead to severe consequences including fatalities.

In order to ensure that axles are reliable and to promote innovative solutions ensuring their proper performance, fatigue limits shall be clearly defined. In addition, innovative methodologies and techniques are needed to allow fast and effective inspection of axles without stopping the train for some days which at present represents an important maintenance cost.
The aim of research is to find a practical solution to fatigue limit determination in railway axles, including new steel grades applied for high speed train axles, with a view to reducing the cost of maintenance without compromising safety requirements. Research activities will address the following main areas:

- **Design fatigue limit – innovative method(s)** to determine the fatigue limit for existing and new steel grades including safety considerations. These developments shall contribute to improvement of the European standards for railway axles and wheelsets.

- **Improved design of the axles for roughness including development of painting and coating innovative solutions with regard to environmental requirements.** These developments shall lead to improved fatigue resistance of railway axles due to paint adhesion problems.

- **Simplified non destructive testing (NDT) techniques** that will allow inspection under the train without any disassembly and train stopping. These methods need to be validated and shall facilitate the inspection and allow measurements with significantly raised safety level.

Activities will lead to a better design validation and inspection technologies of the wheel axle, which, associated with RAMS and LCC models and appropriate maintenance plans, will lead to the optimisation of the costs of the product and its safety characteristics.
### Status of the consortium

| 1.  | UNIFE       | 17. | UIC          |
| 2.  | CAF         | 18. | ENSCL        |
| 3.  | BONATRANS   | 19. | Fraunhofer Society (IWM + IZFP) |
| 4.  | GHH Radsatz | 20. | UNI Udine   |
| 5.  | VALDUNES    | 21. | Polimi      |
| 6.  | LUCCHINI RS | 22. | UC3M        |
| 7.  | RAFIL       | 23. | INEUM (consultant) |
| 8.  | ANSALDO BREA |  |  |
| 9.  | MER MEC     |  |  |
| 10. | INTERLAB (sme) |  |  |
| 11. | METALOGIC (sme) |  |  |
| 12. | ALSTOM (tbc) |  |  |
| 13. | SNCF        |  |  |
| 14. | RENFE       |  |  |
| 15. | DB          |  |  |
| 16. | TRENITALIA  |  |  |

**Defined Advisory Groups:**

1. Paint suppliers – important link with WP04
2. End users:
   - SNCB
   - RSSB
   - Turkish Railways
Figure 15 – Locations of EURAXLES partners in Europe (Lucchini’s branches in Poland, Sweden and the UK will be involved indirectly by LUCCHINI RS.)
EURAXLES Managing structure
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

Actors of the sector are in favour of promoting railways as the safest land transport mode and want to apply overall measure package further lowering risks of extremely rare fatal accidents. It has been previously proven that railway wheelsets are one of the most critical components for safety.

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.
WP 1. Management. (UNIFE)

**Task 1.1 Administrative, contractual and day-to-day coordination** (UNIFE, INEUM)

**Task 1.2: Assistance to the Steering Committee and Quality management** (UNIFE, INEUM)

**Task 1.3: Internal Communication** (UNIFE, INEUM)
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 wheelseat – 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 machined with higher roughness to improve painting adhesion
5. Metal coatings surface testing
Task 3.3: Modelling activity

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.
WP4: TOOLS, TECHNOLOGIES AND SURFACE PROTECTION SYSTEMS MINIMIZING THE NEGATIVE INFLUENCE OF CORROSION OR SURFACE DAMAGE ON THE AXLES SURFACE (GHH)

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
WP 7. Dissemination and standardization. (UNIFE)

Task 7.1: Project Identity, Website and major Meetings (UNIFE, UIC)
- ST 7.1.1 Project Identity
- ST 7.1.2 Public website
- ST 7.1.3 Dissemination meetings

Task 7.2: Dissemination and Exploitation
- ST 7.2.1 Plan for the use and the dissemination of foreground and dissemination strategy
- ST 7.2.2 Dissemination tools

Task 7.3: Contribution to standards and regulations
Interdependencies between EURAXLES WPs

- **WP1 Management**
  - 2.1: Characterisation of the in-service loading severity
  - 2.2: Axle calculation and risk analysis
  - 2.3: Validation of the design procedure

- 3.1: Definition of test methods
- 3.2: Material testing
- 3.3: Implementation of calculation models
- 3.3: Comparison between the existing procedures and the new one in connection with WP2

- 4.1: Development of new innovative painting, coating and protection systems and technologies and alternative design method for unpainted axles
- 4.2: Development & definition of appropriate quality test methods for painted/coated protection and unpainted systems

- 5.1: (NDT) and verification of the reliability of in service condition
- 5.2: New methods to inspect axles in real service condition
- 5.3: Diagnosis of flaw axle using new analysis and classification techniques
- 5.4: Verification of influence of surface damages and corrosion in service

- 6.1: Definition of RAMS/LCC models
- 6.2: Data collection & selection of reference cases
- 6.3: RAMS/LCC analysis of the innovative solutions
- 6.4: Summary & recommendations for standards

**Results**

**WP7 Dissemination and standardisation**
## EURAXLES deliverables having a potential impact for standardisation

<table>
<thead>
<tr>
<th>Del. no.</th>
<th>Deliverable name</th>
<th>Delivery date</th>
<th>Potential use for standardisation work</th>
<th>Reference to the corresponding standard/TSI if known</th>
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<tbody>
<tr>
<td>D2.1</td>
<td>Database of on-line load measurements</td>
<td>M18</td>
<td>Yes</td>
<td></td>
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<tr>
<td>D2.2</td>
<td>Report on the Equivalent-fatigue load methodology and the load severity distribution</td>
<td>M24</td>
<td>Yes</td>
<td>EN13103, EN13104</td>
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<tr>
<td>D2.3</td>
<td>Report on the Numerical analysis</td>
<td>M24</td>
<td>Yes</td>
<td>EN13103, EN13104</td>
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<td>D2.4</td>
<td>Numerical analysis recommendations</td>
<td>M28</td>
<td>Yes</td>
<td>EN13103, EN13104</td>
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<tr>
<td>D2.5</td>
<td>Report on the calculation of an axle risk of failure</td>
<td>M30</td>
<td>Yes</td>
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<tr>
<td>D2.6</td>
<td>Report on the reliability design method</td>
<td>M34</td>
<td>Yes</td>
<td></td>
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<tr>
<td>D3.1</td>
<td>Report on the testing methodology adopted with specific references to geometries and assemblies of components and testing machines</td>
<td>M6</td>
<td>Yes</td>
<td>EN13260, EN13261</td>
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<tr>
<td>D3.2</td>
<td>Report on small scale and full scale testing results</td>
<td>M30</td>
<td>Yes</td>
<td>EN13260, EN13261</td>
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<tr>
<td>D3.3</td>
<td>Report on modelling methods for helping design against fretting fatigue</td>
<td>M30</td>
<td>Yes</td>
<td>EN13260, EN13261</td>
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<tr>
<td>D3.4</td>
<td>Report on possible changes to be introduced in the present Standards and based on the results obtained in the task 3.2</td>
<td>M36</td>
<td>Yes</td>
<td>EN13260, EN13261, EN13103, EN13104</td>
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</table>
EURAXLES deliverables having a potential impact for standardisation

<table>
<thead>
<tr>
<th>D4.1</th>
<th>Technical report as a database of the analysis of the state of the art including new start up specification of requirements for new systems and technologies</th>
<th>M9</th>
<th>Yes</th>
<th>EN 132161</th>
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<tr>
<td>D4.2</td>
<td>Technical report including a description of the limitations of the requirements contained in the existing EN standards.</td>
<td>M12</td>
<td>Yes</td>
<td>EN 132161</td>
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<td>D4.3</td>
<td>Technical report of the comparison between the national requirements not listed in the EN standards.</td>
<td>M15</td>
<td>Yes</td>
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<td>D4.4</td>
<td>Technical report of alternative protection systems in other industries with an assessment if other methods be applied to the rail industry</td>
<td>M18</td>
<td>Yes</td>
<td></td>
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<tr>
<td>D4.5</td>
<td>Technical/test report of a procedure that defines the surface preparation of the axles including proposals for innovative solutions</td>
<td>M36</td>
<td>Yes</td>
<td>EN 132161</td>
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<tr>
<td>D4.6</td>
<td>Technical/test report that defines surface conditions of unpainted axles and alternative innovative treated solutions to avoid both corrosion and necessary painting.</td>
<td>M36</td>
<td>Yes</td>
<td>EN 132161</td>
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<td>D4.7</td>
<td>Technical/test report of the procedure that defines how to test and validate the different painted/coated and unpainted solutions in order to validate the protection</td>
<td>M36</td>
<td>Yes</td>
<td>EN 132161</td>
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<tr>
<td>D5.1</td>
<td>Questionnaire &amp; Conclusion reports</td>
<td>M6</td>
<td>Yes</td>
<td>EN 13103, EN13104</td>
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### EURAXLES deliverables having a potential impact for standardisation

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Description</th>
<th>Reference</th>
<th>Completed</th>
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<tbody>
<tr>
<td>D5.3</td>
<td>Gap Analysis Document identifying weaknesses and proposing methods of present methods and technologies</td>
<td>M12</td>
<td>Yes</td>
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<td>D5.4</td>
<td>Inspection Method Proposal</td>
<td>M24</td>
<td>Yes</td>
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<td>D5.5</td>
<td>Under-loading tests inspection report</td>
<td>M24</td>
<td>Yes</td>
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<td>D5.7</td>
<td>Report on the set of electrochemical and NDT techniques and their suitability for corrosion detection in in-service conditions</td>
<td>M30</td>
<td>Yes</td>
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<tr>
<td>D5.8</td>
<td>Inspection procedure for in service corroded axles</td>
<td>M36</td>
<td>Yes</td>
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<tr>
<td>D6.5</td>
<td>Summary and recommendations for updating the European standards</td>
<td>M36</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- **European standards for the design and fatigue strength assessment of axles**: EN 13103 (Railway applications - Wheelsets and bogies - Non powered axles - design guide) and 13104 (Railway applications - Wheelsets and bogies - Powered axles - Method of design)

- **European standards regarding product requirements among other things concerning protection against corrosion and mechanical aggression, fatigue strength and fatigue life of the axles**: EN 13260 (Railway applications - Wheelsets and bogies - Wheelsets - Product requirements) and EN 13261 (Railway applications - Wheelsets and bogies - Axles - Product requirements)

- **European standard for maintenance**: EN 15313 (Railway applications - In service wheelset operation requirements – In-service and off-vehicle wheelset maintenance)
The project has not started yet

The project total budget is around 5M€ and the EU funding request was 3M€ for a 3 years project

Evaluation results from the Commission very good: 14 out of 15 points and decrease of funding request to 2,9M€

Starting date: November 2010

The project can use some of the results of the following projects:
1. WIDEM FP6 (2005-2008)
3. EBFW II, started as DEUFRAKO project (2004-2008)
4. EBFW III (planned for 2010-2014)
5. SOR, financed by UIC