General Presentation

PM'n'IDEA

Predictive Maintenance employing Non-intrusive Inspection & Data Analysis

- **Budget:** 4,9 M€
- **16 Partners :** Operator / Industry / University
  - Coordinator → **UNIFE**
  - Technical Leader→ **Tata Steel**
- **Objective:** Further development and deployment of:
  - Novel inspection and sensor technologies to enable safe and objective assessment of the track infrastrucure
  - Development of self-monitoring track components
- **6 Key Innovations**

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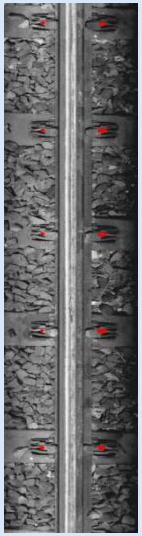
Key Innovation 1: Intelligent image acquisition analyses system for track inspections

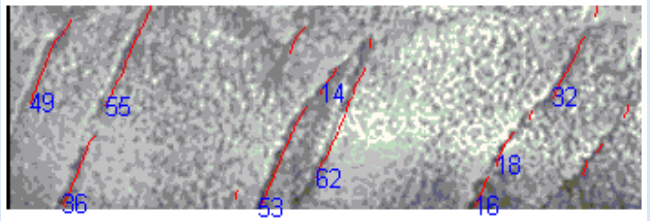
- **Objective:**
  - To develop a robust, yet simple, image acquisition system that can be mounted on a tramway or metro vehicle to provide consistent images for automatic recognition of selected features and defects;
  - To develop innovative automatic image analysis techniques to identify key track components, and running surface defects so as to minimise the need for subjective and unsafe walking track inspections

- **Advancement of the research**
  - A image acquisition system employing specialist cameras and lighting system has been critical assess in the laboratory and first demonstration trials have already been undertaken on the commercial tramway network of Stagecoach Supertram in Sheffield
  - Automatic image analysis techniques have been developed for key track components, track features, and rail head defects. These algorithms are now being assessed on images acquired from trial runs on commercial networks

- **The finished product**
  - An image acquisition system capable of being mounted on a service vehicle to undertake non-intrusive visual inspection of entire networks and eliminate/minimize the need for subjective track waking inspections.
  - The acquired images will be analyzed automatically to monitor degradation of track components and facilitate predictive maintenance



Line Scan Camera

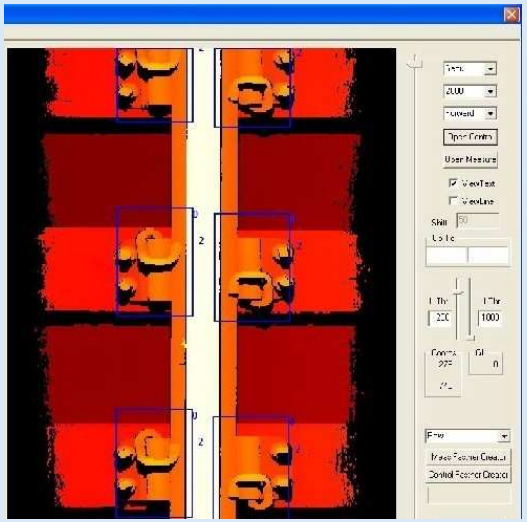


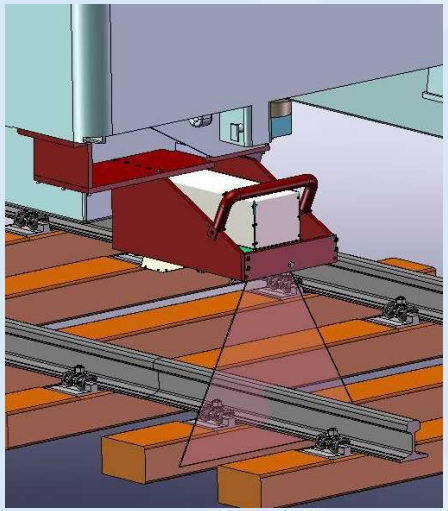
Key Innovation 2: Laser sensors dimensional measuring system with onboard diagnostics

- **Objective: To develop a novel optical profilometry method, based on laser-sensor dimensional measuring system, applied to the measurements of the main components of metro's and tramways infrastructures.**
  - An evolutionary technique will be assessed that will starting from linear measurements reconstruct the three-dimensional shape.
  - New approach of image processing to include the third dimension within the 2D image approach.
  - This technique allows to distinguish objects with low contrast relative to the background or covered by dust.

- **Advancement of the research**
  - Different approaches of component positions (couple laser-camera) have been done to determine the best integration on one box. This box has defined regarding tramway and metro availability and triangulation base imposed by this method. A integration on ATAC metro has been defined in order to improve constraints according to vehicle installation and odometer connexion.

- **The finished product**
  - The system will be able to analyse the components near the rail line with high accuracy in spite of worst environmental condition as dust. Further developments until end of the project will include the identification of each component on track and localisation defects according to 3D model learning by the system. The box is installed near the bogie and the PC installed inside the coach used the encoder information to trig the acquisition and locate the defect.



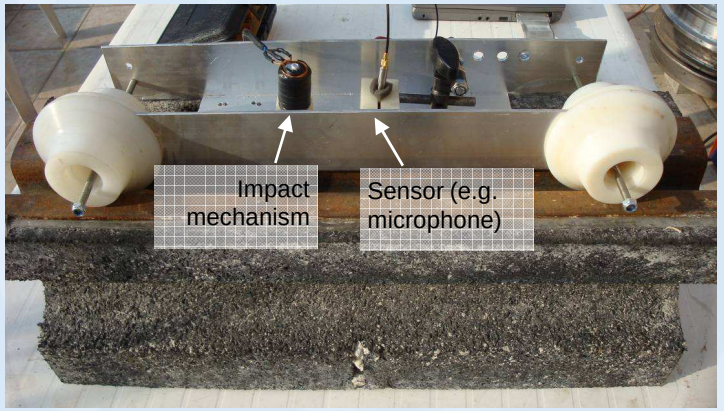


Key Innovation 3: Assessment of internal integrity of embedded rails

- **Objective: To develop a technique for the identification and localisation of electrically corroded rail foots of the embedded track.**
  - Existing technologies such as ultrasound inspection techniques and eddy current inspection techniques are not applicable for girder rails since the complete surface of the rail is not accessible and since the rail geometry is not symmetrical.
  - No technique is available today.
  - The technique selected is based upon the injection of a high frequency large band vibration at the rail top using a small impact hammer. The reflected waves are measured using a high-frequency accelerometer and post-processed to identify corrosion of the rail foot.

- **Advancement of the research**
  - An inventory of suitable methods and selection of the most suitable inspection method were made. Measurement and analysis tools have been selected and successfully tested on laboratory rail samples, provided by STIB: detection based on analysis of the autopower spectrum and cepstrum analysis. Building of a prototype inspection system and validation is ongoing. Validation measurements on STIB network (Chaussee De Gand).

- **The finished product**
  - The system will be able to localise corroded rails embedded in the street. This will be of use to all the tramway infrastructure managers. Further developments in a later phase will include the identification and localisation of other possible rail defects selected to be important by the infrastructure managers.

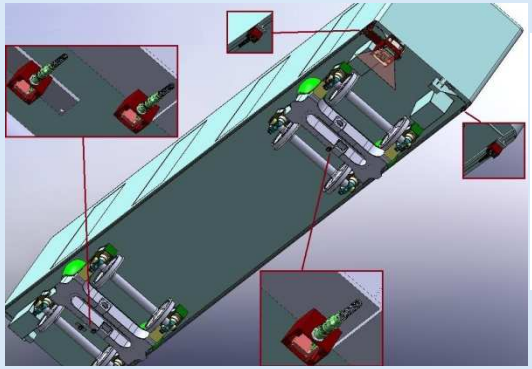


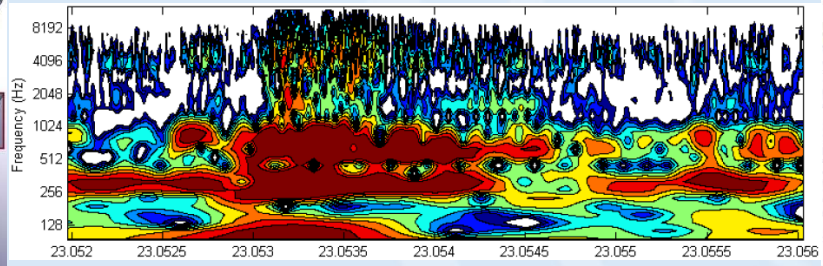
Key Innovation 4: Inspection technologies for the assessment of track quality

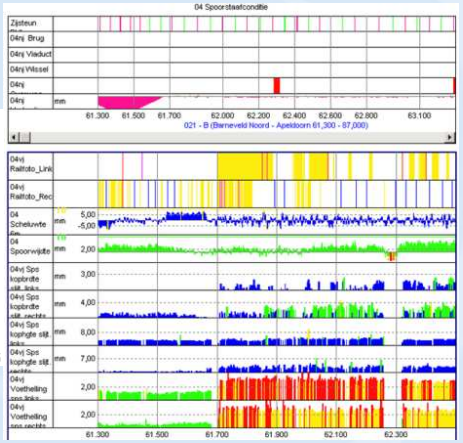
- **Objective: To design an innovative system for continuous monitoring of track quality, through measurements taken on service vehicles during standard operation**
  - Extract valuable information on track quality from vibration measurements taken on-board the vehicle with possible approaches: “track signature” approach, model-based techniques for input reconstruction.
  - The rail vehicle is seen as a MIMO dynamic system whose dynamics is excited by the random input coming from track irregularity.
  - The proposed methodology applies to "long wavelengths“ in track irregularity (from 5m to 30m, i.e. frequencies up to 5Hz, for 0<V<80km/h); the effects of wheel flats and rail corrugation can be easily separated, since they occur at higher frequencies.

- **Advancement of the research**
  - The current solid outputs are the methodologies and algorithms for data processing and the technical specifications (number and location of sensors, data acquisition system characteristics, etc.) for the prototype system.
  - The approaches of component positions have been done to determine the integration on 5 small boxes for 9 sensors. A integration on ATAC metro has been defined to minimize the interaction with service vehicles.
  - The methodology for data storage and analysis has been applied to experimental signals: Fourier Transform to identify the frequency contents of time series data, so that predominant wavelength may be isolated from track irregularities; Wavelet diagrams can show the frequency content of the accelerations as function of the position at the track and give ideas about the nature of the track defects

- **The finished product**
  - The system will be able to analyse the components of track quality. Further developments until end of the project will include the final version of data analysis. The small boxes allow an easy integration on service vehicle.





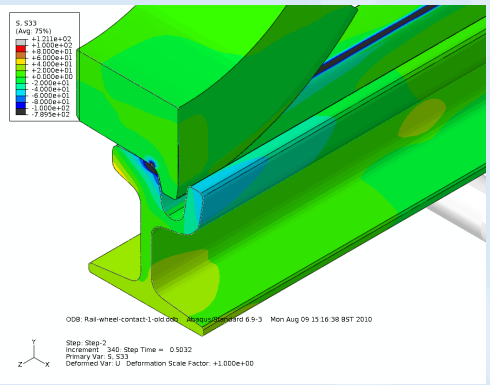


Key Innovation 5: Establishing actionable boundary limits for the wear of rails

- **Objective**
  - Establish the actionable boundary limits of vertical, gauge corner, and side wear as a function of a range of loading conditions
    - For grooved rail sections, and
    - For light flat bottomed rail sections (Vignole)

- **Advancement of the research**
  - Modelling and simulation are ongoing, starting from a global model and now focusing on a local model. Meanwhile, lab testing on rail samples have been initiated for calibration purpose and rail samples equipped with strain gauge have been implanted for measurement in track

- **The finished product**
  - A scientifically validated methodology to allow the determination of actionable boundary limits for wear for selected common rail profiles. The validated methodology can then be employed to determine the limits for the full range of rail sections and loading conditions and lead to the formulation of commonly agreed European Standards
  - The advantage will be to provide scientifically validated wear limits and enable the adoption of a predictive maintenance practice.
    - With a minimum investment
    - Without waiting for historical data gathering



Key Innovation 6: Automatic assessment of degradation and the integrity of intelligent track components

- **Objective:**
  - To develop techniques for the automatic assessment of degradation and integrity of selected track sub-components:
    - Fish plated and insulated block joints
    - Switch blades
    - Stretcher bars.
  - To develop appropriate data transfer and analysis techniques for the data collected from sensors
  - To validate the application of sensor technologies through laboratory testing prior to design and field testing.
  - To undertake field testing of developed systems.

- **Advancement of the research**
  - Development of MEMS sensors for the monitoring of stretcher bars under laboratory conditions
  - Development and installation in commercial track of a Fibre Brag Grating sensor system for the monitoring of Switch Blades and Fish plated joints
  - Use of accelerometers mounted on service vehicle to monitor degradation of track components such as rail joints

- **The finished product**
  - Selected key track components equipped with novel sensors capable of monitoring their degradation behaviour
  - A vehicle mounted accelerometer based system to monitor degradation of track