# Inspection Interval Software for Railway Axles

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**Abstract**

The inspection interval software is an easy to handle graphical user interface for the application of the software tools for calculating the crack growth during corrosion fatigue at the surface of railway axles. The stand-alone tools were developed by the research group of professor Beretta from the Politecnico di Milano (PoliMi), Department of Mechanical Engineering within the Project RAAI "Whole Life Rail Axle Assessment and Improvement Using Ultrasonic Phased array and Corrosion Inspection Systems", which has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 674231.

These tools provide the calculation of corrosion-fatigue damage and growth of microcracks in railway axles exposed to the synergetic action of fatigue in combination with mild rain corrosion. They are based on the results obtained with the projects RSSB-T728 and WOLAXIM which have led to the formulation of a model able to describe the development of the corrosion-fatigue damage in different phases for EA4T and EA1N steels. These phases are: “pit format”, “pit-to-crack transition” and “small crack growth and final growth for long cracks”. With this is it possible to estimate life-time predictions according to different failure probabilities.

Furthermore the tools consider an in-air fatigue crack growth model for railway axles exposed to variable amplitude load spectra and present a way to link POD concepts to the results obtained from the model. The software is aimed at performing calculation of crack advance and, through the analysis of prospective inspections of the axle, to determine the so-called probability of detection (POD) for a given inspection interval periodicity. This allows the user to introduce a certain inspection interval and to compute the resulting overall cumulative probability of detecting the crack during its development.

# Inspection Interval Software for Railway Axles




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# Inspection Interval Software for Railway Axles

## **RAAI** – Whole Life **R**ail **A**xle **A**ssessment and **I**mprovement Using Ultrasonic Phased array and Corrosion Inspection Systems

### Project Partners (SMEs)

**Applied Inspection**

Burton & Glasgow
UK

Corrosion Inspection System

**arxes-tolina**

Berlin & Dresden
Germany

Project Coordination and Software

**BTD Bureau for Technical Diagnostics**
Brandenburg
Germany

Phased Array Ultrasonics System

### Subcontractors (RTDs)

**BAM Federal Institute for Materials Research and Testing**
Berlin
Germany

**Poiltecnico di Milano**

Milano
Italy

**TWI The Welding Institute**

Cambridge
UK

**RAAI** – Whole Life **R**ail **A**xle **A**ssessment and **I**mprovement Using Ultrasonic Phased array and Corrosion Inspection Systems

## Objective

Development of improved inspection technologies for railway axles, based on knowledge about crack initiation and growth under corrosion conditions, for increased safety, extended lifetime and optimised inspection intervals.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 674231.

# Inspection Interval Software for Railway Axles

**RAAI system with two NDT monitoring techniques:**

**Corrosion Inspection System (CIS)**
for corrosion analysis at the axles surface.

Enables the characterisation and sentencing of degradation by corrosion and give robust and accurate 3D reconstructions to allow measurement of profiles, roughness, etc.

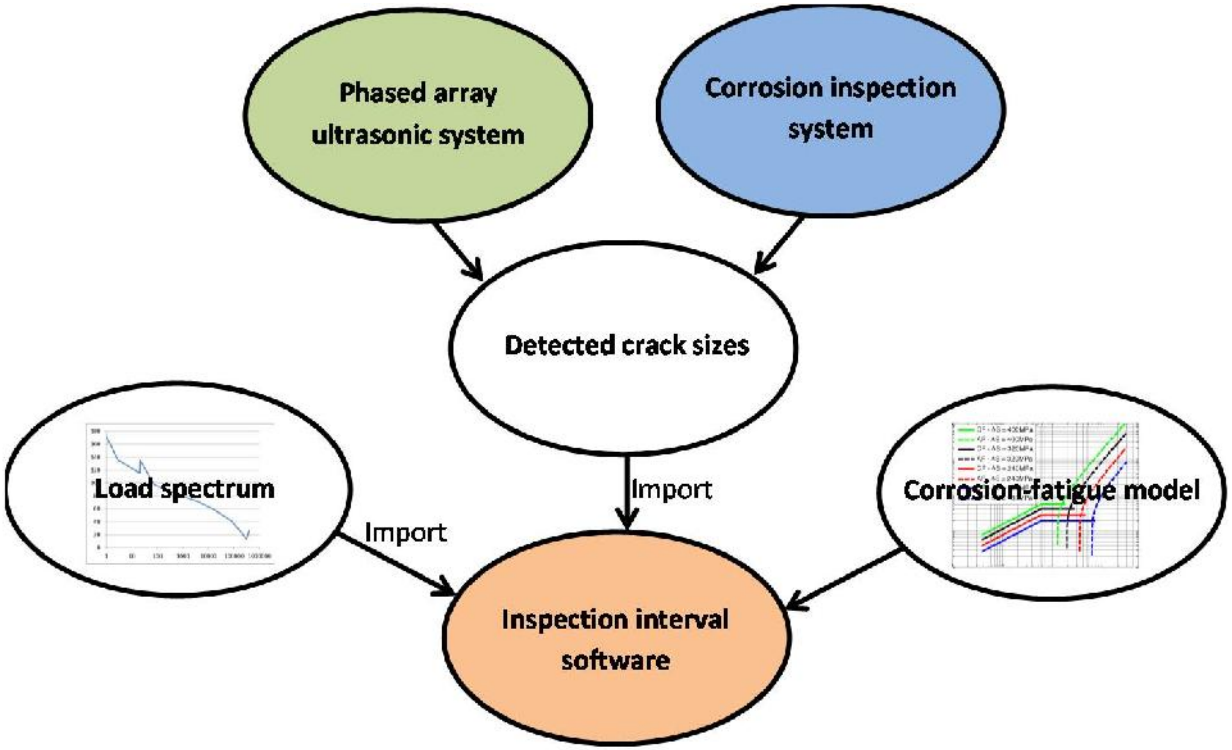
**Phased Array Ultrasonic System (PAUS)**
for hollow axle inspection for the detection of cracks at the surface.

Provides faster inspection by only one mechanical linear scan along the axle with full coverage.

# Inspection Interval Software for Railway Axles

The inspection interval software can predict the minimum inspection interval of a rail axle, in order to obtain a target failure rate.



# Inspection Interval Software for Railway Axles

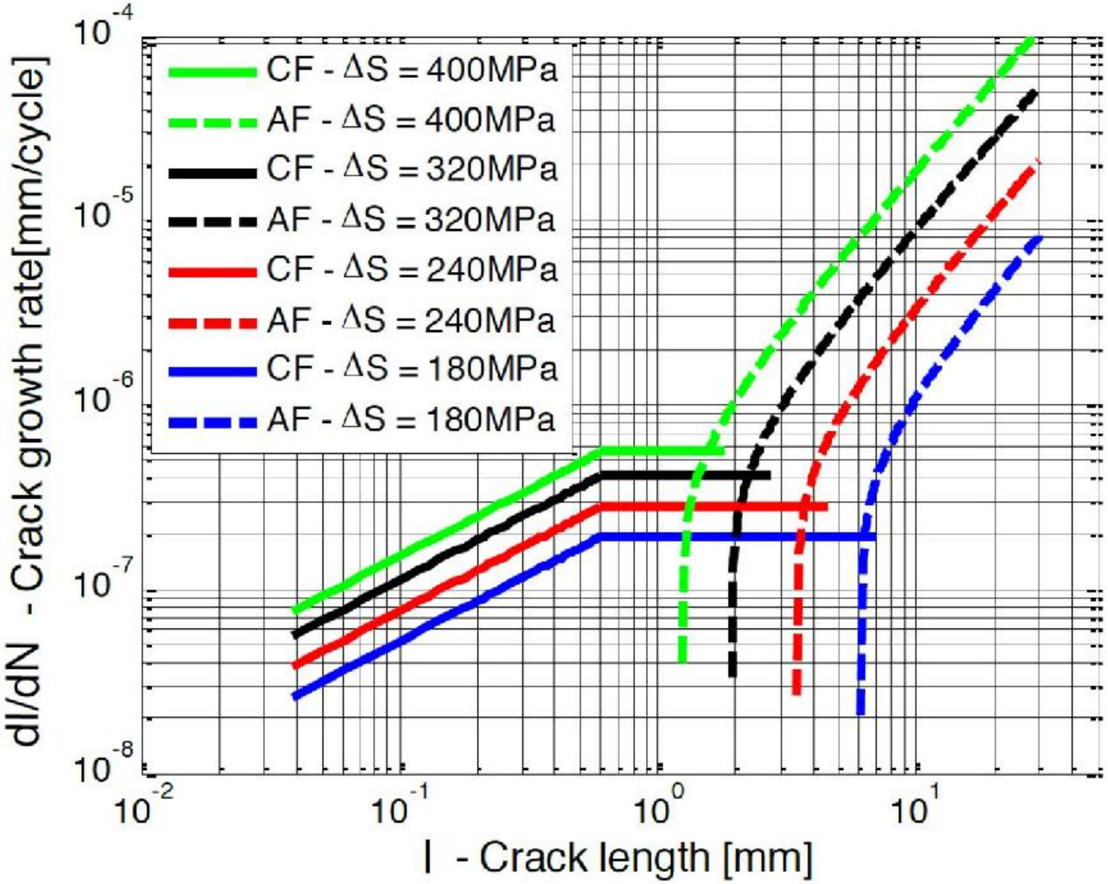
- Realised with LabVIEW® by National Instruments
- Easy to handle GUI for application of the software tools for calculating the crack growth at the surface of railway axles
- Tools = executables for calculation provided by PoliMi:
  - 50_Advance_A1N.exe
  - 50_Advance_A4T.exe
  - Corrosion_Fatigue_Propagation_A1N.exe
  - Corrosion_Fatigue_Propagation_A4T.exe
  - In_Air_Fatigue_Propagation_30NiCrMoV12.exe
  - In_Air_Fatigue_Propagation_A1N.exe
  - In_Air_Fatigue_Propagation_A4T.exe
- Protection by a Sentinel HASP® dongle
  - prevent the start of illegal copies
  - envelope protection for the executables for calculation
- Installation program including the LabVIEW®-Runtime

# Inspection Interval Software for Railway Axles

- The corrosion-fatigue process can be essentially seen as the propagation of tiny cracks, under the electrochemical action of corrosion, at stress levels much lower as for in air fatigue.
- The idea is to measure the onset and development of corrosion-fatigue in terms of the detection of the population of microcracks that grow from the initial pits.
- The tools provide the calculation of corrosion-fatigue damage and growth of microcracks in railway axles exposed to the synergetic action of fatigue in combination with mild rain corrosion.
- They are based on the results obtained with the projects RSSB-T728 and WOLAXIM which have led to the formulation of a model able to describe the development of the corrosion-fatigue damage in different phases for EA4T and EA1N steels.
- These phases are: “pit format”, “pit-to-crack transition” and “small crack growth and final growth for long cracks”.
- With this is it possible to estimate life-time predictions according to different failure probabilities.

# Inspection Interval Software for Railway Axles




(a) Corrosion fatigue cracks growth model (flattening at $l_t = 600\,\mu m$) and transition from corrosion-fatigue to in air fatigue for different stress levels

# Inspection Interval Software for Railway Axles

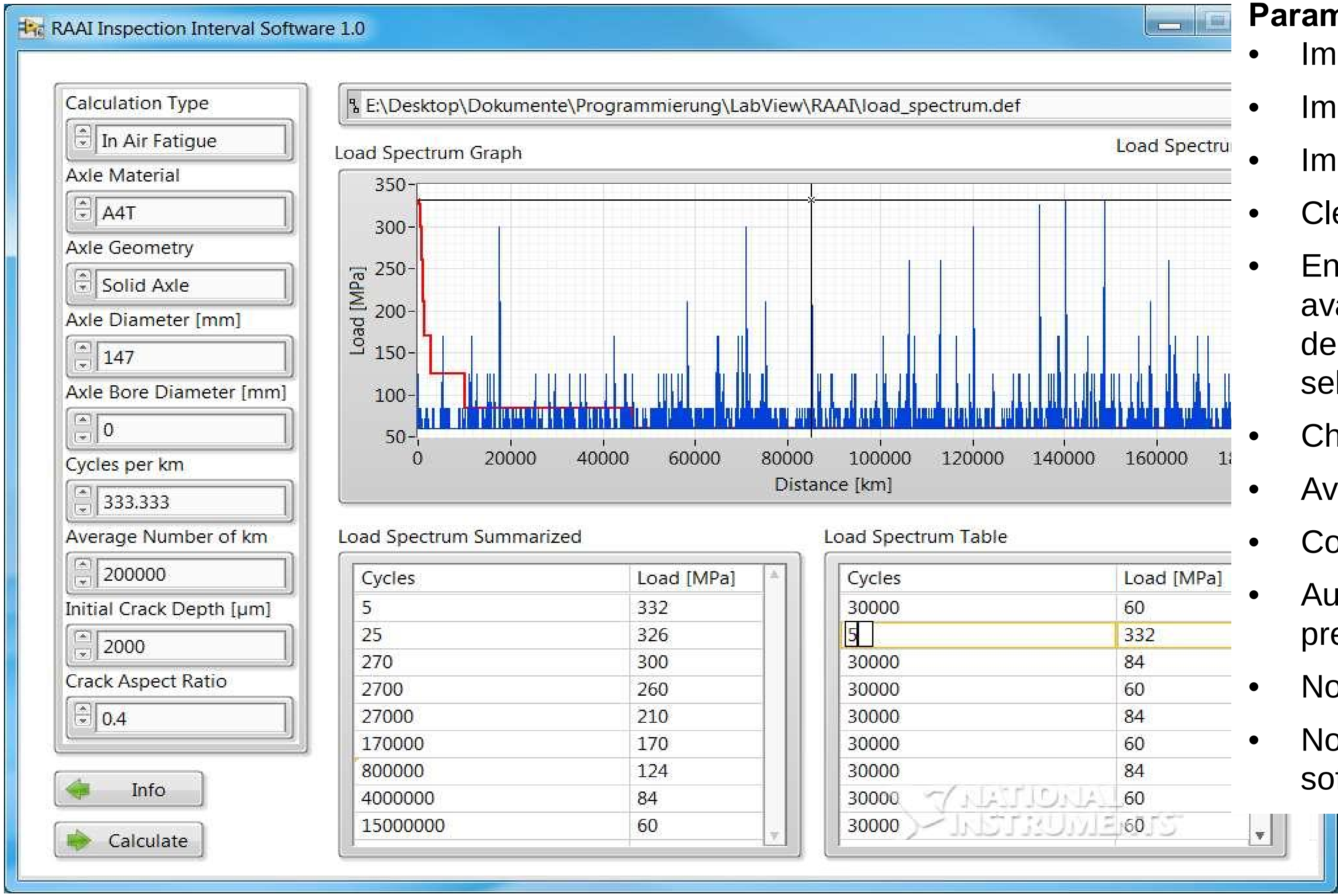
- Furthermore the tools consider an in-air fatigue crack growth model for railway axles exposed to variable amplitude load spectra and present a way to link POD concepts to the results obtained from the model.

- The software is aimed at performing calculation of crack advance and, through the analysis of prospective inspections of the axle, to determine the POD for a given inspection interval periodicity.

- This allows the user to introduce a certain inspection interval and to compute the resulting overall cumulative probability of detecting the crack during its development.

# Inspection Interval Software for Railway Axles




**Parameter mask:**

- Import data by CIS
- Import data by PAUS
- Import load spectra
- Clearly arranged
- Enables and disables available features in dependency of the selected options
- Checked for limits
- Avoid faulty inputs
- Continuously saved
- Automatic background pre-processing
- No multiple text files
- No other mathematical software tools needed

# Inspection Interval Software for Railway Axles

Import a load spectrum from two different file formats:

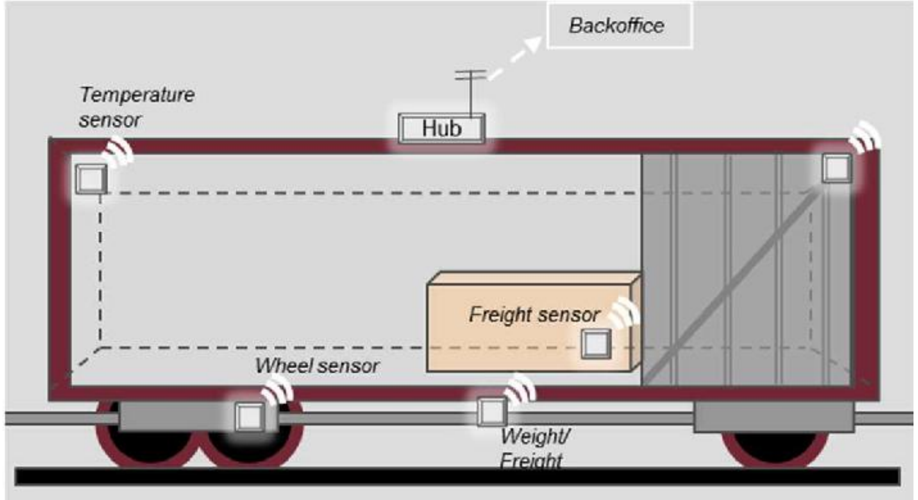
- Summarised spectrum
  - Can be interactively edited in the parameter mask.
  - A randomised full spectrum is calculated from these data and graphical presented immediately.
- Full spectrum
  - Real spectrum can be imported from other sources.
  - E. g. from the RailTM Telematic Monitor by arxes-tolina

# Inspection Interval Software for Railway Axles

## *Rail*TM Telematic Monitor

- Automatic logging of GPS tracked positions and different status data for rolling stock
- First approach was the immediate identification of derailments by acceleration sensors.
- Currently we work on different sensor systems for data acquisition, amongst others to determine the current load of a freight car.
- Low investment costs for wagon-mounted sensor equipment
- Robust design for operation under-floor
- 6 year maintenance free service

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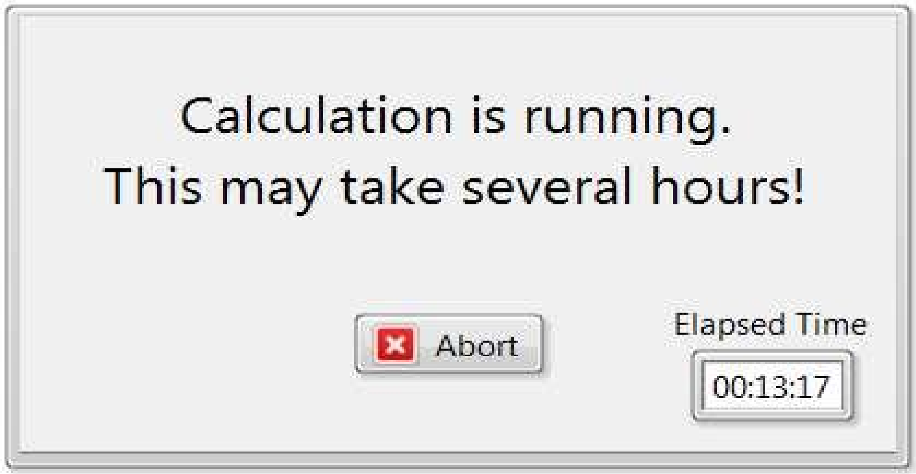
|---|
| Telematic |
| Sensoric |
| Derailment detection<br>Wagon mounted solution |
| Tracking<br>Geolocation |
| Tracing<br>By GSM radio railway communication network |
| Hub function<br>To external sensors |
| Predictive Maintenance<br>Based on mileage |

# Inspection Interval Software for Railway Axles

- Calculation start by the user opens the needed separate executables automatically.
- Software waits for completion of their work and a progress dialog is shown.
- Abort button for breaking the calculation
  by terminating the calculation process at any time

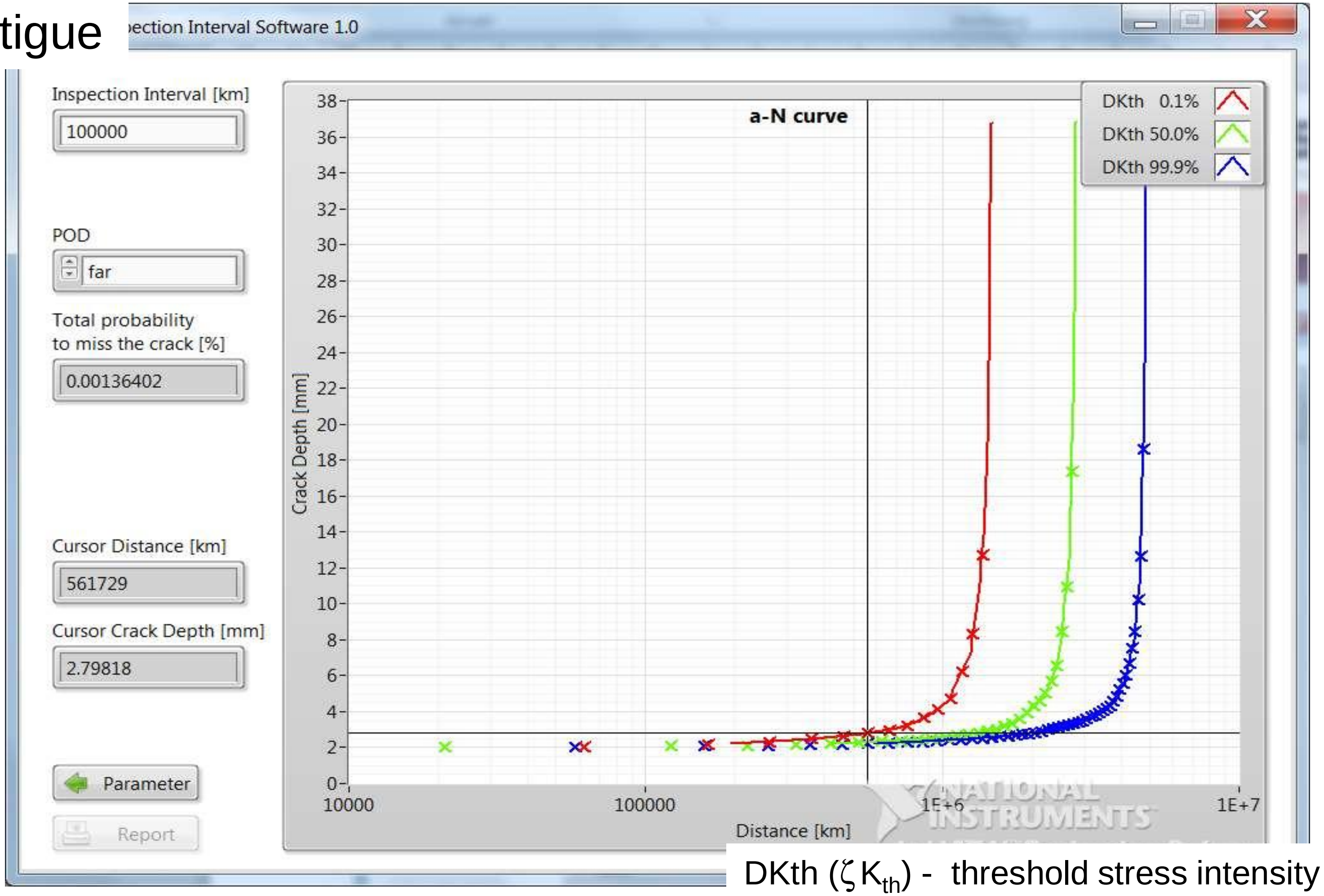



- When the calculation ends properly, the data will be pre-processed and visualised.
- The user can generate a customised report in Microsoft® Word format.

# Inspection Interval Software for Railway Axles

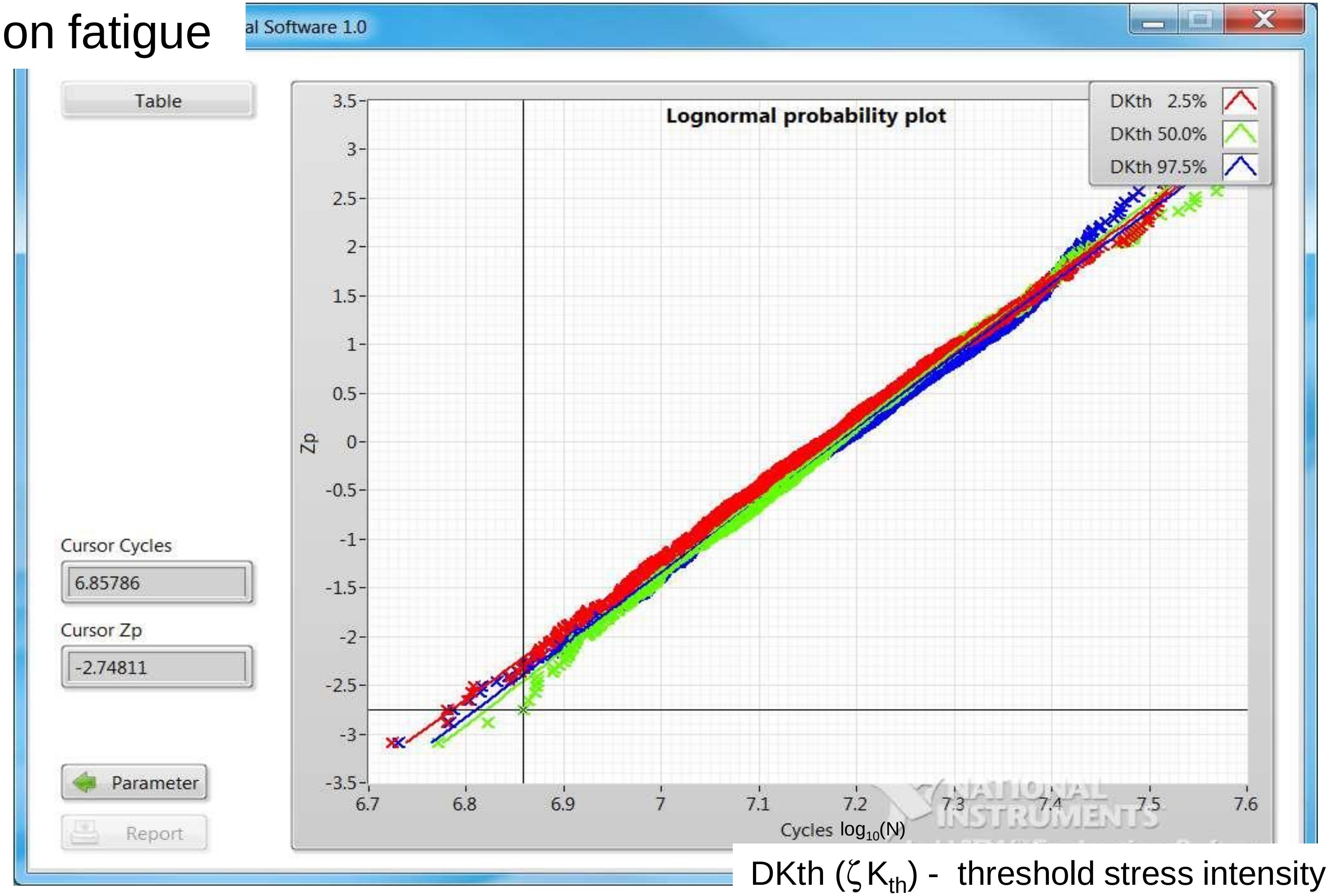
In air fatigue




DKth ($\zeta K_{th}$) - threshold stress intensity factor range

# Corrosion fatigue

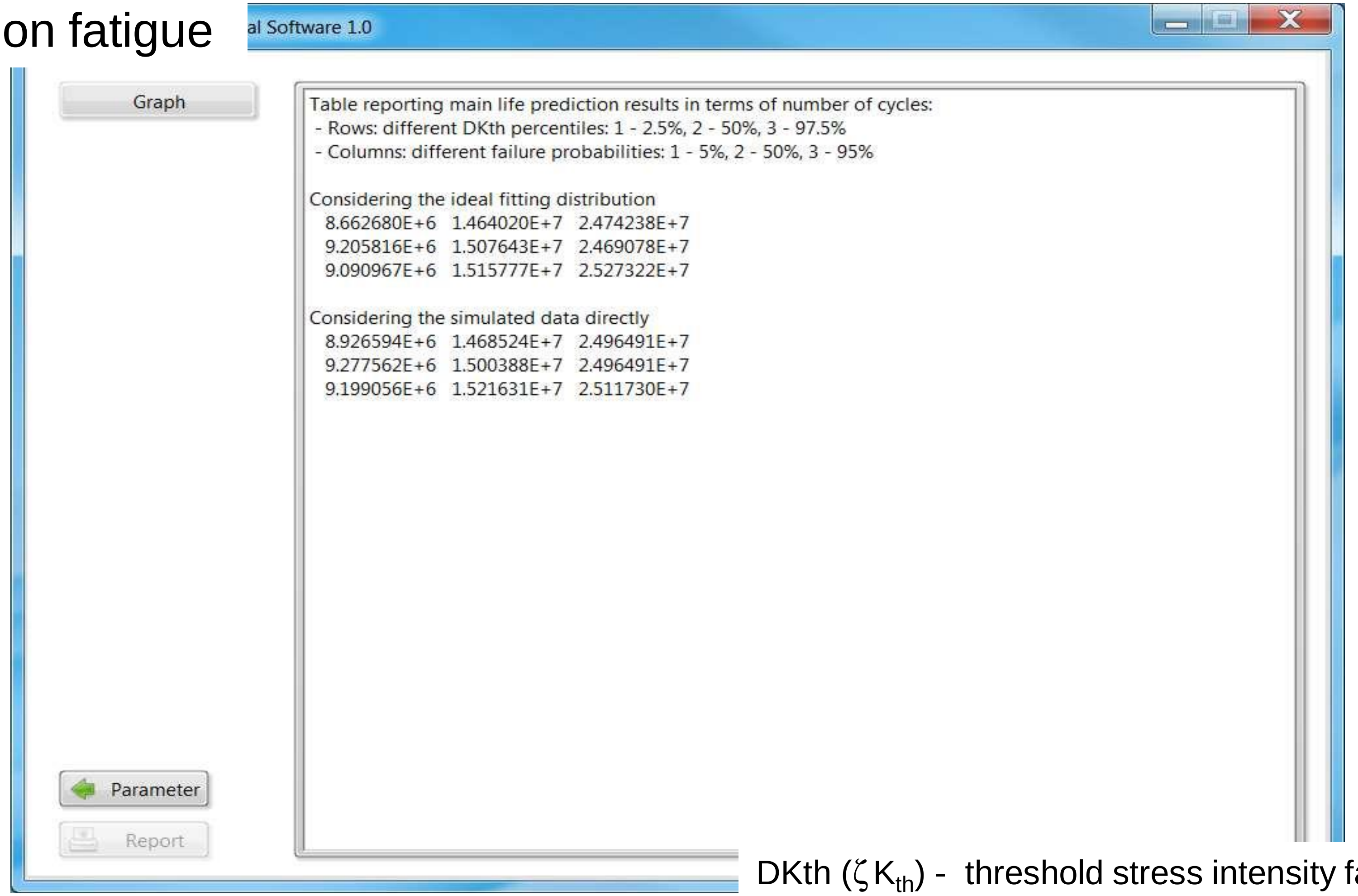



DKth ($\zeta K_{th}$) - threshold stress intensity factor range

# Inspection Interval Software for Railway Axles

## Corrosion fatigue




DKth ($\zeta K_{th}$) - threshold stress intensity factor range

# Thank you

**http://www.raai-project.eu**