# CONTENT

Moderation: T. Heckel, Technical Committee NDT on Railway
J. Kurz, DB Systemtechnik GmbH

09:00 Opening

KEYNOTE

1 **How to transform railway infrastructure and operations for a sustainable future**
09:15 H. Diekmann [1]
[1] Konux GmbH, Munich, Germany

## STANDARDS

2 **Additional certificate – Wheelset Maintenance EN16910-1**
10:00 F. Bey [1], P. Martins [1], J.P. Gielen [1]
[1] COFREND, Paris, France

3 **NDT in ECM organisations in the Netherlands**
10:20 T. de Keijzer [1]
[1] DEKRA Rail, Utrecht, Netherlands

10:40 Break

## TRACKS

4 **Solutions for AI based assessment of high-resolution images as both, stand-alone**
11:00 **evaluation and base for automated comparison with continuous UT or ET rail testing**
S. Damm [1]
[1] P.U.T. GRAW SP. Z O.O., Gliwice, Poland

5 **AI-based Analysis of Eddy Current and Ultrasonic Measurement Data in Rail Inspection**
11:20 A. Simroth [1], R. Casperson [2], T. Heckel [2], A. Friedrich [2], T. Zhang [2]
[1] German Centre for Rail Traffic Research at the Federal Railway Authority, Dresden, Germany; [2] Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany

6 **Ultrasonic rail inspection at high-speed using Phased Array Ultrasonic Testing**
11:40 X. Harrich [1]
[1] SOCOMATE INTERNATIONAL, Crécy-la-Chapelle, France

12:00 Break

## Rolling Stock

**7** 13:00 **In-service ultrasonic wheel inspection thought beyond – New generation with focus on improved ergonomics, digitalization and operator support**

D. Werner[1], B. von Kirchbach[1]

[1] Waygate Technologies, Huerth, Germany

**8** 13:20 **Application of ultrasound-based residual stress measurement techniques on railway components**

I. Poschmann[1], M. Batur[1], A. Specht[1]

[1] W.S. Werkstoff Service GmbH, Essen, Germany

**9** 13:40 **ACFM innovations to promote more reliable and efficient maintenance programs**

M. Gündel[1]

[1] Eddyfi Technologies, Hamburg, Germany

**10** 14:00 **Mobile automated solid axle inspection in mounted condition using phased array technique**

T. Rehfeldt[1], S. König[1], A. Weber[1]

[1] Framatome GmbH, Erlangen, Germany

**11** 14:20 **Application of Ultrasonic Inspection Techniques and Solutions for China High-speed EMU Wheel and Axle**

E. Peng[1], Y. Zhang[1], F. Guo[1], S. Eisenreich[1]

[1] DTEC GmbH, Rosbach v. d. Höhe, Germany

14:40 Break

## New Challanges

**12** 15:00 **Inspection of fiberglass composites and bonding with terahertz waves**

J. Jonuscheit[1]

[1] Fraunhofer ITWM, Kaiserslautern, Germany

**13** 15:20 **Visual inspection in railway maintenance. Can this NDT-procedure be optimized through digitization?**

J. Raabe[1], J. Rasch[1]

[1] J.M. Voith, Kiel, Germany

**14** 15:40 **UT, PAUT and MT testing systems for railway components**

W. Deutsch[1], M. Maaß[1]

[1] KARL DEUTSCH, Wuppertal, Germany

16:00 Closing marks

LECTURE 1

## How to transform railway infrastructure and operations for a sustainable future

H. Diekmann[1]
[1]Konux GmbH, Munich

Railways are the safest mode of transportation, compared to cars, planes and others. The development of rail technology has increased a lot in the last years. Digitalization is playing a leading role in rolling stock and infrastructure modernisation. Railway networks have to cope with increasing load and aging infrastructure. I will talk about solutions to accelerate the infrastructure digitalisation e.g. with IIOT and AI.

LECTURE 2

## Additional certificate – Wheelset Maintenance EN16910-1

F. Bey[1], P. Martins[1], J.P. Gielen[1]
[1]COFREND, Paris, France

The standard EN 16910-1, entitled Railway applications Rolling stock - Requirements for non-destructive testing on running gear in rail maintenance Part 1: Wheelsets is built on four pillars. The ultimate goal was to define the necessary requirements in terms of non-destructive testing and to promote safety, interoperability and mutual acceptance between companies and countries performing wheelset maintenance. In order to promote the recognition of NDT personnel, the CFCM (Railway Maintenance Certification Committee) has endeavoured to adapt its processes to issue a recognition of skills in two standards (ISO 9712: Non-destructive testing - Qualification and certification of NDT personnel and EN 16910-1) based on a single examination, and to encourage regular monitoring of the authorisation to operate by the employer. At the time of publication of the standard EN 16910-1, the CFCM's identity and scope of activity seemed to fully meet the objectives identified in the personnel skills pillar of the standard. At that time, it was still necessary to offer the already certified personnel an additional certification to have their skills recognised beyond our borders. There then began a series of works in two stages. The first consisted of identifying the existing certifications referring to the wheelset product, and the second, of identifying the additions to each certification with a view to obtaining a certification relating to the standard 16910-1. As it takes future applications into consideration, the CFCM will enter a transition phase between already certified personnel and future certified personnel. All of these cases have been identified and taken into account for processing in stages. They will be implemented to satisfy all certified personnel and enhance their skills as well as those of their companies.

LECTURE 3

## NDT in ECM organisations in the Netherlands

T. de Keijzer[1]
[1]DEKRA Rail, Utrecht, Netherlands

In the Netherlands several rail companies have an ECM licence. Do they perform NDT on their rolling stock and how is that organized? This presentation is the result of a search of the world behind the licences.

LECTURE 4

## Solutions for AI based assessment of high-resolution images as both, stand-alone evaluation and base for automated comparison with continuous UT or ET rail testing

S. Damm[1]
[1]P.U.T. GRAW SP. Z O.O., Gliwice, Poland

Vision systems have been one of the fastest growing areas in recent years. Ideas for their use in motion control systems, production control or the automotive industry have resulted in the emergence of many new analytical models mainly based on deep neural networks, ideally suited to solving general cases in image analysis. Vision systems have also been implemented in the railway industry for over a decade. One development direction is visual inspection trains, capturing high-resolution images while inspection rides. With efficient LED lighting and the advanced mechanical construction of recording modules, the recorded images maintain high quality, regardless of external lighting and weather conditions. Various elements of the track infrastructure are recorded, including the rail head's surface and the rails' side view. Especially these two views are ideal for the verification of defects recognized during UT and ET tests, giving the possibility of additional confirmation or omission of the detected defects. However, all the methods mentioned above generate much data that, not supported by automatic evaluation systems, would require many specialists to process them. That is why it is not so important to collect data but to process and report it reliably. Increasing the number of available sources of information increases the probability of correct assessment. The presentation shows the software development results developed in the GOLDSCHMIDT group, aimed at integrating the results with the systems mentioned above. The developed models include classical digital data processing methods supported by artificial intelligence. Such an approach to the system allowed us to achieve high efficiency of the offered solution and develop an optimized design for automatic evaluation of measurement data, combined with a reporting system containing the best GOLDSCHMIDT experience from cooperation with domestic and foreign customers.

LECTURE 5

## AI-based Analysis of Eddy Current and Ultrasonic Measurement Data in Rail Inspection

A. Simroth[1], R. Casperson[2], T. Heckel[2], A. Friedrich[2], T. Zhang[2]
[1]German Centre for Rail Traffic Research at the Federal Railway Authority, Dresden
[2]Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin

Non-destructive testing of rail tracks is carried out by using rail inspection cars equipped with ultrasonic and eddy current measurement. The evaluation of test data is mainly done manually, supported by a software tool which pre-selects relevant indications shown to the evaluators. The resulting indications have to be checked on-site using hand-held testing equipment. Maintenance interventions are then derived on the basis of these on-site findings. Overall aim of the AIFRI (Artificial Intelligence For Rail Inspection) project - funded by the German Federal Ministry of Digital and Transport (BMDV) as part of the mFUND programme under funding code 19FS2014 is to increase the degree of automation of the inspection process from the evaluation of the data to the planning of maintenance interventions. The accuracy of defect detection shall be increased by applying AI methods in order to enable an automated classification of detected indications into risk classes. For this purpose, data from both eddy current inspections and ultrasonic inspections will be used in combination. Within the framework of this data-driven project, relevant defect patterns and artefacts present in the rail are analysed and implemented into a configurable digital twin. With the help of this digital twin virtual defects can be generated and used to train AI algorithms for detection and classification. With the help of reliability assessment trained AI algorithms will be evaluated with regard to the resulting quality in defect detection and characterisation. A particular aspect of the development of AI methods is the data fusion of different NDT data sources: Thereby, synergies are used that arise from linking eddy current and ultrasonic inspection data in a combined model. In the course of the project a demonstrator consisting of the developed IT-tool and an asset management system will be implemented and tested in the field using real-world data.

LECTURE 6

## Ultrasonic rail inspection at high-speed using Phased Array Ultrasonic Testing

X. Harrich[1]
[1]SOCOMATE INTERNATIONAL, Crécy-la-Chapelle, France

FAAST-PA is a worldwide patented phased array able to generate multiple ultrasonic beams at different angles in one shot. It removes PAUT technical constraints for Ultrasonic testing of railway track at low and high-speed and add some benefits compare to conventional ultrasonic.

LECTURE 7

## In-service ultrasonic wheel inspection thought beyond – New generation with focus on improved ergonomics, digitalization and operator support

D. Werner[1], B. von Kirchbach[1]
[1]Waygate Technologies, Huerth

Depending on wear behavior and use, railway vehicles must be tested non-destructively. Due to the high traffic density (over 150 million travelers in German long-distance traffic in 2019), sometimes high speeds, specified test intervals and the requirement for short downtimes, mechanical test technology is increasingly being used. The operational safety of the rolling stock, such as wheels, is particularly important here. The latest generation of the underfloor testing system »Krautkrämer UFPE WheelStar« is a fully mechanized ultrasonic testing system for the in-service testing of railway wheels (i.e. directly on the train, without prior dismantling). With increasing mechanization, time-consuming set-up work on the track is eliminated and ergonomics at the workplace are improved. Intuitive software helps to structure and optimize the test and workflow. The evaluation is supported by visual test data processing. In this way, increased test loads per layer (tread, wheel flange, inner and outer end face and additional (straight) web) can be managed with a reduced test duration or increasing mechanical complexity (test areas according to DIN 21207-7). The testing system is used, among other things, for testing the wheels of high-speed trains. Here the Krautkrämer UFPE WheelStar plays a key role in quality assurance during maintenance.

LECTURE 8

## Application of ultrasound-based residual stress measurement techniques on railway components

I. Poschmann[1], M. Batur[1], A. Specht[1]
[1]W.S. Werkstoff Service GmbH, Essen

Ultrasound-based residual stress measurement is well established for block-braked freight wagon wheels. Besides that, ultrasonic testing (UT) is virtually not used for stress measurement. The fact somewhat contradicts the numerous UT stress measurements techniques and the many potential fields of application. The presentation introduces physical fundamentals and application examples for different UT bulk stress measurement methods using longitudinal waves and polarizes transversal waves. Moreover, technical basics and engineering instances are presented for UT surface stress measurements utilizing horizonal polarized shear waves and creeping waves. Application examples will be given for UT stress measurements on wheels, axles, bolts and welds.

LECTURE 9

## ACFM innovations to promote more reliable and efficient maintenance programs

M. Gündel[1], C. Tremblay[2]
[1]Eddyfi Technologies, Hamburg, Germany
[2]Eddyfi Technologies, Quebec City, Canada

With more than 20 years of NDT application in the railway industry, Alternating Current Field Measurement (ACFM) has proven to be a valuable alternative to conventional methods when it comes to fatigue crack detection and sizing: enabling faster and more reliable inspections, without surface preparation, adding crack length and depth information in both ferromagnetic and Austenitic alloys. Even through thick coatings, around rough welds with complex geometries, or on unprepared axles and wheels, ACFM works and can help make operations safer, cleaner, and more sustainable. Eddyfi Technologies Amigo2 platform has recently been the subject of significant investments in innovations targeted at the railway industry. Among these, a fillet weld array probe ideal for the complex geometries found in railcar structures, has been developed. It provides faster inspections, requiring only a third of the usual ACFM detection scans. It also features an innovative mix of sensor and software technology to quickly estimate crack lengths. Another key advantage of this technology is that it doesnt use moving parts, making it easier to negotiate complex geometries and minimize the risks of failure. Another innovation originated from the ACFM user bases experience in carrying out inspections of railcars featuring several complex welded components. Given the high number of welds and their complexity, their inspection is prone to human errors and can be long to execute. To minimize the risk of operator errors and accelerate the overall inspection process, we developed an inspection planning tool in Assist, Eddyfi Technologies ACFM software platform. This tool can be used to pre-program the inspection sequence from specific railcar model drawings. When a railcar comes in for inspection, inspectors can simply load the right inspection plan and execute it. A detailed review of ACFMs history, recent innovations, and the opportunities it offers to the railway industry will be presented.

LECTURE 10

## Mobile automated solid axle inspection in mounted condition using phased array technique

T. Rehfeldt[1], S. König[1], A. Weber[1]
[1]Framatome GmbH, Erlangen

State of the art automated solid axle UT inspection requires to unmount the wheelset from the train, in order to inspect the axle using stationary UT inspection systems. This procedure becomes more and more cost intensive due to increasing inspection cycles, which are required by the authorities. Mobile UT inspection systems, using phased array technique, can be an alternative for a cost-efficient method to inspect solid axles in mounted condition. However, due to the limited accessibility and very rough surface conditions under the train, the mobile inspection can be very challenging, compared to state of the art stationary UT-inspection methods. This contribution introduces inspection results from in service solid axles, generated with a new mobile solid axle UT inspection system, developed by Framatome/Qualicon. The new mobile system will be introduced and the inspection results will be discussed. Advanced methods of data evaluation, using artificial intelligent algorithms, will be presented.

LECTURE 11

## Application of Ultrasonic Inspection Techniques and Solutions for China High-speed EMU Wheel and Axle

E. Peng[1], Y. Zhang[1], F. Guo[1], S. Eisenreich[1]
[1]DTEC GmbH, Rosbach v. d. Höhe

The Wheelset is the key load-bearing part of the train. Today ultrasonic imaging technologies are designed according to common failure modes of wheel shafts in China EMU, cloud detection and health management system. The system includes three automatic inspection parts: daily dynamic, regular online (remote) and offline (in person) maintenance. The electronic management of vehicle information, axle information and inspection results are realized based on the Internet of Things (IoT) technology. Ultrasonic imaging also realizes intelligent prompt and remote supervision based on deep learning algorithm. Big data models are used to analyse the operation rule of wheel and shaft for effective health status management. Application in several depots of China railway group co., LTD has been introduced, mainly from effects in security assurance, economy improvement and efficient management. This indicates that these systems can play an important role in the process of railway predictable maintenance, and raising the level of management information.

LECTURE 12

## Inspection of fiberglass composites and bonding with terahertz waves

J. Jonuscheit[1]
[1]Fraunhofer ITWM, Kaiserslautern

Fiber-reinforced plastic composite structures and bonding are commonly used in rail vehicles where a combination of low weight and high structural integrity is required. Such structures usually consist of several functional layers of different materials, e.g., aramid, foams, glass fiber material, and adhesives. As the structures are built up layer by layer, quality control is desirable in in-line production as well as in service and repair to detect possible delamination, structural defects, and other defects at an early stage. Frequency modulated continuous (FMCW) terahertz imaging systems have been shown to provide an excellent combination of spatial and depth resolution for typical defect sizes while providing large penetration depths into the respective materials. We present a terahertz imaging system for composites and demonstrate the performance of the measurement system on test panels with artificially introduced defects and on in-service rail vehicles.

LECTURE 13

## Visual inspection in railway maintenance. Can this NDT-procedure be optimized through digitization?

J. Raabe[1], J. Rasch[1]
[1]J.M. Voith, Kiel

At least 90% of all damage to rail vehicles is discovered through visual inspection. Nevertheless, visual inspection is not fully recognized as a NDT method in railway maintenance. In this contribution, visual inspection as a NDT method will be examined in more detail and recommendations for inspection planning and training will be given. The support of the personal through the use of digitization is presented using the example of the "OnCall Video" software by J.M. Voith.

LECTURE 14

## UT, PAUT and MT testing systems for railway components

W. Deutsch[1], M. Maaß[1]
[1]KARL DEUTSCH, Wuppertal

This paper discusses various examples for the inspection of train wheels, axles and wheelsets. Examples for inspection of new components and used components in the maintenance workshops are discussed. Two lines for the production and testing (PAUT / MT) of new railway wheels in Turkey and in India are presented. MT systems for special wheel sets at a maintenance workshop in Switzerland show the efficient inspection for surface cracks.