STEPHEN MARICH LECTURE

+ FROM FAR LEFT Monash University's Institute of Railway Technology hosts the 2019 Stephen Marich Lecture in Melbourne. + Professor Hannes Gräbe speaks on track infrastructure requirements and condition monitoring. + Professor Rebekah Brown, Senior Vice-Provost and Vice-Provost (Research) and Program Director, Monash University, addresses the audience. + Professor Hannes Gräbe delivers his presentation titled 'Track Infrastructure Requirements for the Digital Railway'. + IRT director Ravi Ravitharan takes his turn at the lecturn. + IRT director Ravi Ravitharan (left) and Dr Stephen Marich (right) present Professor Hannes Gräbe with a memento of his visit to Melbourne.

People still needed to shape railways

AMIR SHAMDANI

Professor Hannes Gräbe, chair in railway engineering at the University of Pretoria in South Africa, delivered the 2019 lecture in railway engineering honouring the 40-year contribution of Dr Stephen Marich to the railway industry.

The lecture has been hosted every year by Monash Institute of Railway Technology (IRT) in Melbourne since 2014.

The inaugural lecture five years ago was delivered by Dr Marich himself covering the principles behind wheel-rail interface, and the importance of management of the interface as well as the consequences when this is neglected.

In 2015 Harry Tournay, a senior scientist from the Association of American Railroads Transportation Technology Center, presented on 'Strategies to Counter Wheel & Rail Rolling Contact Fatigue in Heavy Haul Service'.

Professor Elias Kassa from the Norwegian University of Science and Technology showed in 2016 how to 'Improve Train Dynamics through turnouts by optimising track gauge and track stiffness'.

In 2017 Gary Wolf presented 'New Inspection and Detection Technologies for Managing Track and Vehicles – Improving Asset Life and Reducing Derailments'.

Dr Robert Fröhling from Transnet, South Africa, discussed 'Vehicle-Track System Dynamics and Long Term Behaviour' in 2018.

This year the lecture was focused on track infrastructure requirements and condition monitoring with an emphasis on advanced research, digital technologies and solutions. It covered examples of state-of-the-art digital technologies such as optical metrology, the internet of things (IoT), deep learning and augmented or virtual reality and explained how they have been used in condition monitoring of track infrastructure including bridges, track transitions, rail, ballast and track formation.

Professor Gräbe addressed the audience of railway professionals on how railways across the world were experiencing a digital revolution that challenged traditional methods and the proven technologies.

In his presentation, 'Track Infrastructure Requirements for the Digital Railway', he said the integration of systems and processes had certainly offered greater capability from existing assets and increased the capacity, performance and connectivity of the railway system. Taking into account the fact that, over two centuries, conventional track infrastructure consisting of ballast, sleepers and steel rails had successfully retained its position as the preferred track structure for freight and most passenger railways, Professor Gräbe raised the important question of what track infrastructure requirements would be in the future.

Professor Gräbe addressed some of the important topics relevant to the digital railway:

- smart infrastructure which incorporates sensors and integrated, digital communication networks as well as optical technologies to report on its current state and performance;
- new IoT devices that are now being developed at an exponential rate and can measure track parameters and asset condition, from simple temperature measurements to high frequency accelerations in three dimensions;
- big data in combination with machine learning models which enables engineers to replace reactive maintenance actions with condition-based and predictive maintenance interventions; and
- augmented and virtual reality which enables effective track inspection and simulations for training and incident investigations.

While outlining the requirements of the digital railway, he emphasised the people skills required for the era of digitalisation, or as he called it the "fourth industrial revolution". He named complex problem-solving, critical thinking, creativity, emotional intelligence and cognitive flexibility as some of the people skills that would be needed in the future, none of which could be displaced by computers.

He introduce a novel inertial measurement unit, Kli-pi – derived from the Afrikaans word for "small stone" – which could tell us more about track components' behaviour and what loads, accelerations and forces they experienced. He then pointed out some of the applications of Kli-pi, which he said were:

- measurement of the movement of rail with nine degrees of freedom; and
- investigation of ballast behaviour on a discreet, granular scale to understand ballast vibrations, forces experienced as well as ballast fabric and structure.

Professor Gräbe then talked about optical metrology and 3D scanning using white light LED with an accuracy of 25µm. He mentioned that various 3D scanning applications existed and included:

- scanning of welds and rail sections to determine local profile geometry;
- validation of ballast requirements in terms of shape and roughness specifications; and
- 3D model of ballast particles and superstructure components for discrete and finite element analysis.

Turning to the emergence of digital twins and photogrammetry, he said drone technologies were gaining significant momentum and were contributing significantly towards digital railways by assisting track infrastructure inspections, the creation of 3D infrastructure visualisations and the development of point cloud data for rail infrastructure asset management.

On the artificial intelligence (AI) and big data side, he stressed the AI boom and the flourish of machine learning. He used the example a process through which parameters of the permanent way and interacting systems were measured utilising acoustic, magnetic, electromagnetic and optical devices. These measurements alongside theoretical frameworks and big data and deep learning approaches could help in implementing real-time guidance as well as remedial actions on track infrastructure.

He then turned to condition monitoring, which he said was an excellent demonstration of track infrastructure requirements for the digital railway, and presented three examples of work he had carried out in South Africa:

- WILMA, or Wayside Intelligent Longstress (longitudinal rail stress) Management, which prevents blind rail destressing and provides continuous measurements linked to weather forecasting for derailment prevention and rail break detection;
- bridge condition monitoring using LVDTs, a weather station, temperature probes and strain gauges to predict bridge deck expansion and optimise the design of rail expansion joints; and
- formation condition monitoring to study unsaturated soil behaviour and mechanics and real time monitoring of soil conditions.

"Track inspectors performing visual inspections cannot readily or easily detect certain track defects and we know the limitations of trolley inspections and walking inspections" Professor Gräbe said.

"There are also difficulties linking what inspectors see with available condition data. To manage these issues and to prevent defects from causing incidents, we need to use automated inspection systems."

He then identified the solution: augmented and virtual reality systems with data source integration in which high-density, geospatial and visual components could be combined for an effective inspection. He also touched on another example of virtual reality simulations for derailment investigations and showed a video used for incident investigation training.

Professor Gräbe concluded that creating value at new frontiers and in core businesses relied heavily on proactive decision-making, contextual interactivity, global connectivity, journey-focused innovation, technology, real-time automation and, finally, linking people, ideas and things. He suggested that perhaps we should balance the billions of dollars invested in technology by empowering people who would embrace technology, connectivity and automation.

At the start of the evening, Professor Rebekah Brown, Senior Vice-Provost and Vice-Provost (Research) and Program Director, Monash University, welcomed the more than 280 railway professionals who were participating and outlined Monash's position in supporting the rail industry going forward.

Phillip Campbell OAM, past executive chair of the Railway Technical Society of Australasia, Engineers Australia's leading technical society and premier body representing rail professionals, acknowledged Dr Marich's contribution to the railway industry.

IRT director Ravi Ravitharan introduced Professor Gräbe and outlined his experience and contribution. He also announced that Professor Gräbe had accepted Monash IRT's invitation to join an important network of world leaders as an IRT rail research associate.

Dr Peter Binks, CEO of the Business Higher Education Round Table (BHERT) and chair of the IRT industry advisory board, provided the closing remarks and vote of thanks. T+S

+ Amir Shamdani is a senior mechanical engineer and data analyst with the Institute of Railway Technology, Monash University.