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IRSC
INTERNATIONAL RAIL SAFETY COUNCIL
SOUTH AFRICA

IRSC 2023

INTERNATIONAL RAILWAY SAFETY COUNCIL

"Reshaping Railways in an Uncertain World"

CAPE TOWN, OCTOBER 1 - 6, 2023

HOSTED BY RSR RAILWAY SAFETY REGULATOR
RAIL SAFETY ON THE RIGHT TRACK

Prof. Hannes Gräbe, Paul Hume & Christiaan Mol
University of Pretoria, Department of Civil Engineering, Chair in Railway Safety

Technological Advancements and Digital Mapping for a Safer Rail Network

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CASUALTIES OF COMMERCE

Plea for Transnet to ‘slow down’ after train ploughs into four rhinos at Phongolo

DAILY MAVERICK

Content

- Digitalization of the Railway industry
- Smart Infrastructure & Track components
- Condition Monitoring and Mapping
  - Track geometry
  - Vehicle Dynamics
  - High-definition Video
  - Light Detection and Ranging (LiDAR)
  - UAV orthographic mapping
- Applications and Benefits
- Derailment Investigations
- Conclusions & Recommendations

The DIGITAL railway…

decision making

interactivity

global connectivity

innovation

technology

automation

linking people, ideas, systems & things

SMART Infrastructure…

A smart infrastructure is a smart system that uses a data feedback loop to **improve decision-making** regarding a matter. A system that can monitor, measure, analyze, communicate and act based on data collected by sensors*

Smart infrastructures are based not only on their physical structure (cabling, sensors, etc.) but also on four principles:

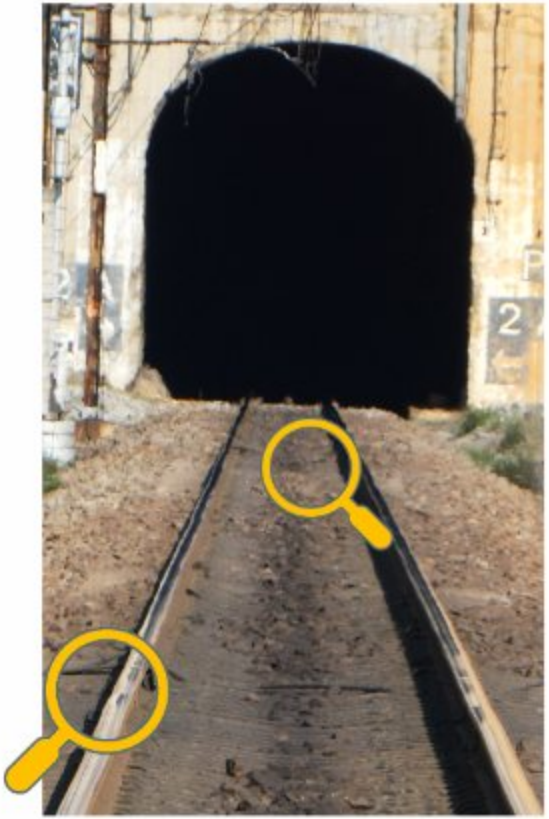
- Data
- Analytics
- Feedback
- Adaptability

*Ref: Royal Academy of Engineering of the United Kingdom

*Photo: Global Railway Review

Smart Railway Monitoring

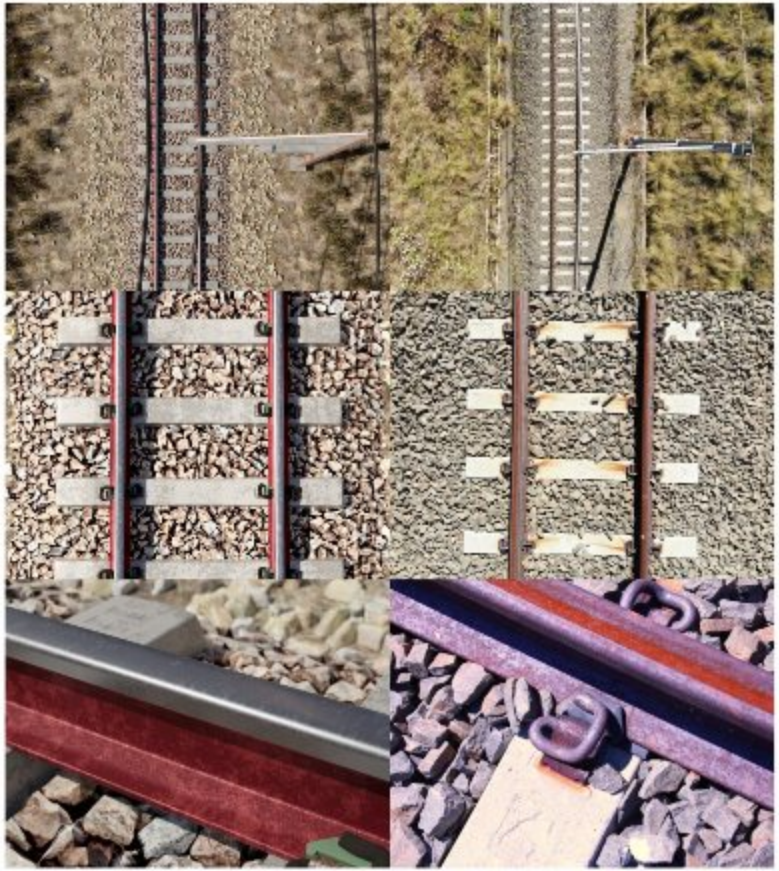
- The backbone of effective **maintenance and infrastructure management**
- If you cannot ***measure*** it, you cannot ***manage*** it
- Significant technological advances in **optics, sensors communication protocols, machine learning** and **artificial intelligence** has seen limited adoption in condition monitoring
- *How do we leverage these capabilities?*



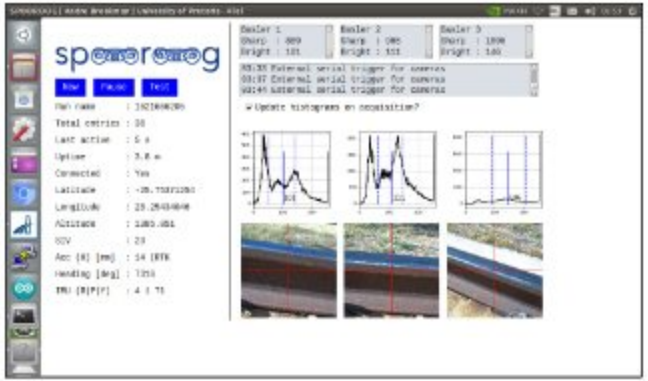
Track Geometry

From optics to track geometry?

* PhD student: Dr. André Broekman



Spooroog and Spoorpyp*

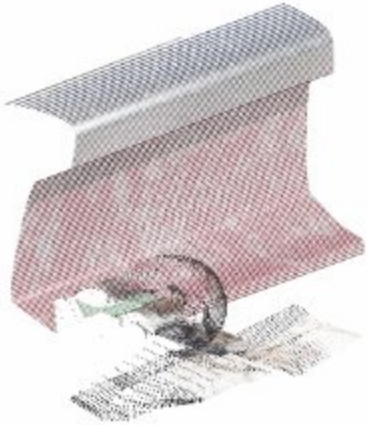


- Autonomous, non-contact optical measurement technique that rivals existing instrumentation performance
- Train neural networks on **synthetic railway data**
- Low-cost, cm-accurate **geolocation service**
- Accuracy ($|R|$): **3.90 mm** (μ=1.58 mm, σ=1.16 mm)

Photographic sequence (Bloubank)

4Tel

Neural network pipeline
"The Black Box"



Accurate 3D reconstruction

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Sub-theme: Rail Infrastructure innovation in a changing world

Case study: Olifantsriver bridge – Phalaborwa/Hoedspruit

Under- and postgraduate research students

Bridge harmonics and condition monitoring

- Improved Kli-pi
- Automatic triggering and manual data capturing
- Accelerations (x, y, z)
- Temperature
- Magnetic installation
- On-board data storage

UP Road/Rail Vehicle for Condition Monitoring

Sub-theme: Rail Infrastructure innovation in a changing world

Complete track condition monitoring

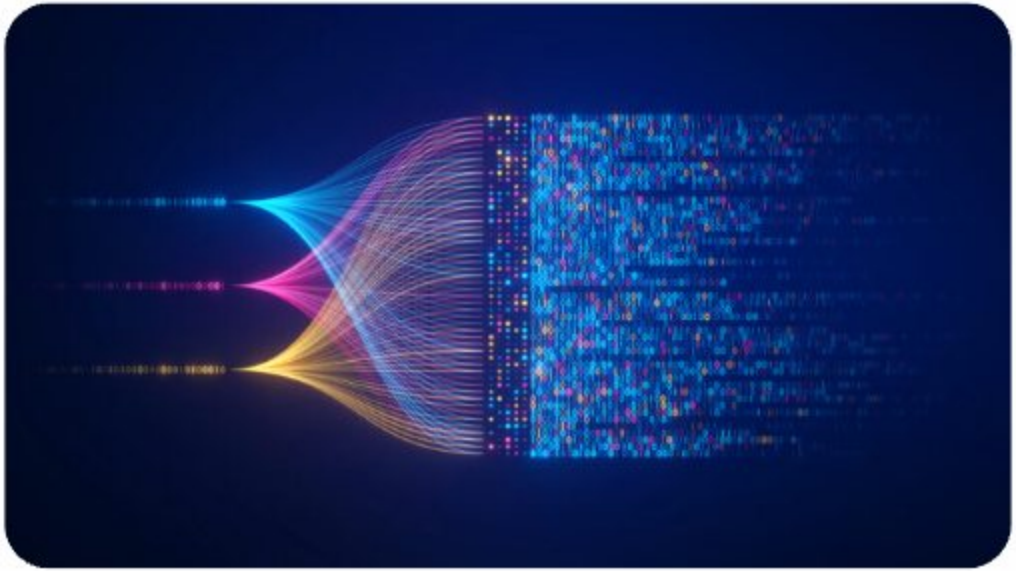
- Track geometry with KRAB
- LiDAR (Hovermap) for 3D point cloud
- Exact geolocation (mm-accuracy)
- GoPro video recording
- Vehicle and axle accelerations (OxTS & instrumented axles)

Machine Learning:

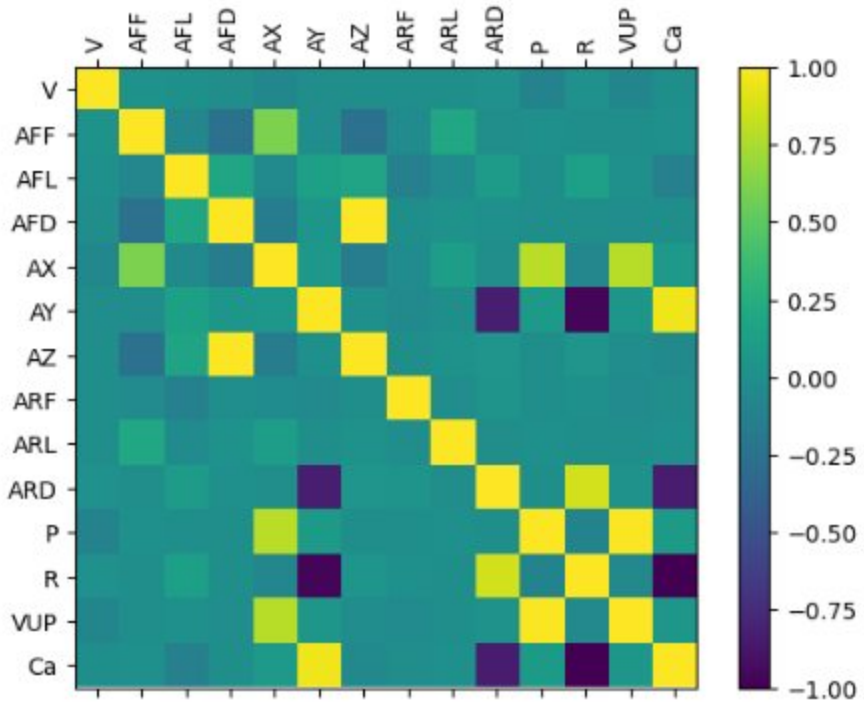
- Machine Learning methods:
  - Multi-linear regression*
  - Multi-nonlinear regression
  - Random Forest
  - XGBoost
  - ANNBN (artificial neural network by neighbours)
  - Deep learning

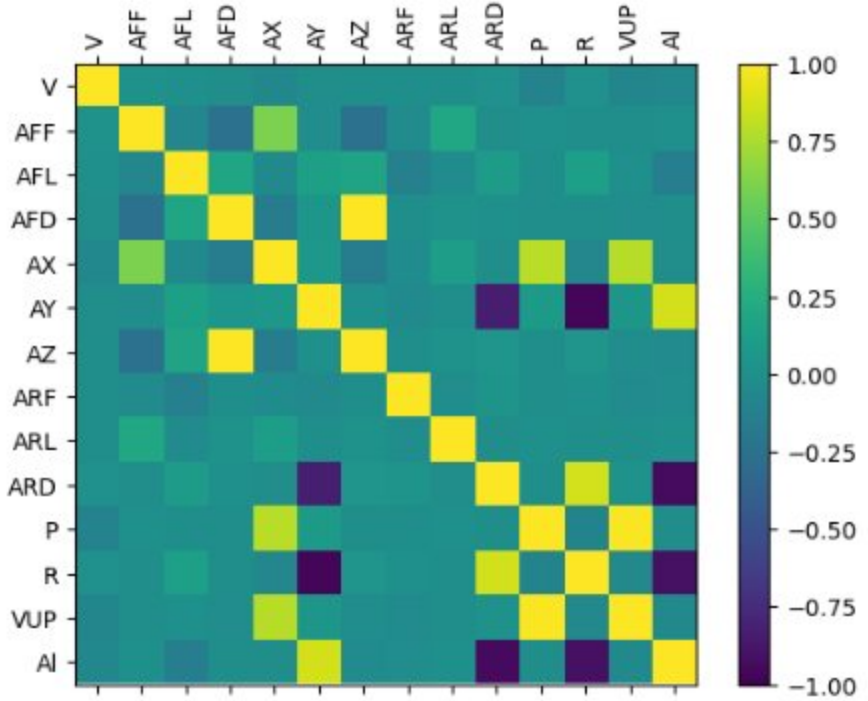
*Best performance

Track geometry from vehicle response measurements



Correlation Matrices





Ca=Cant, Al=Alignment, AX=acceleration in the x-direction, AFF=acceleration filtered forward, ARL=angular rate lateral, P=Pitch, R=Roll, VUP=velocity up

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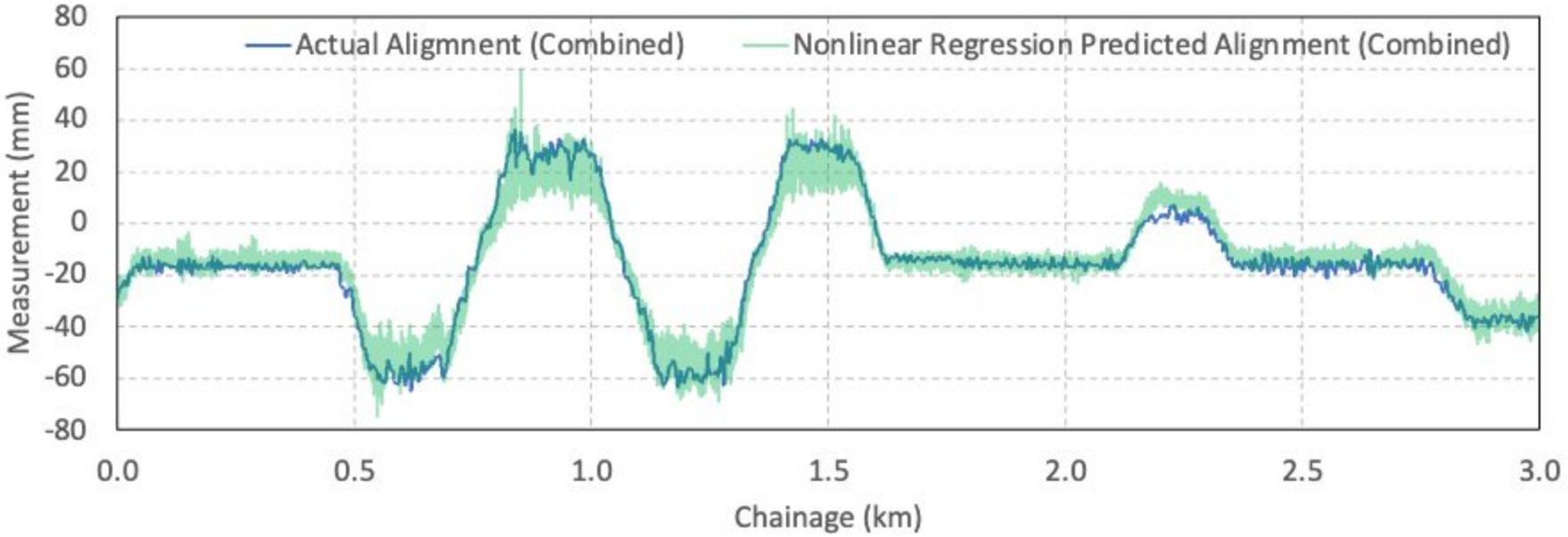
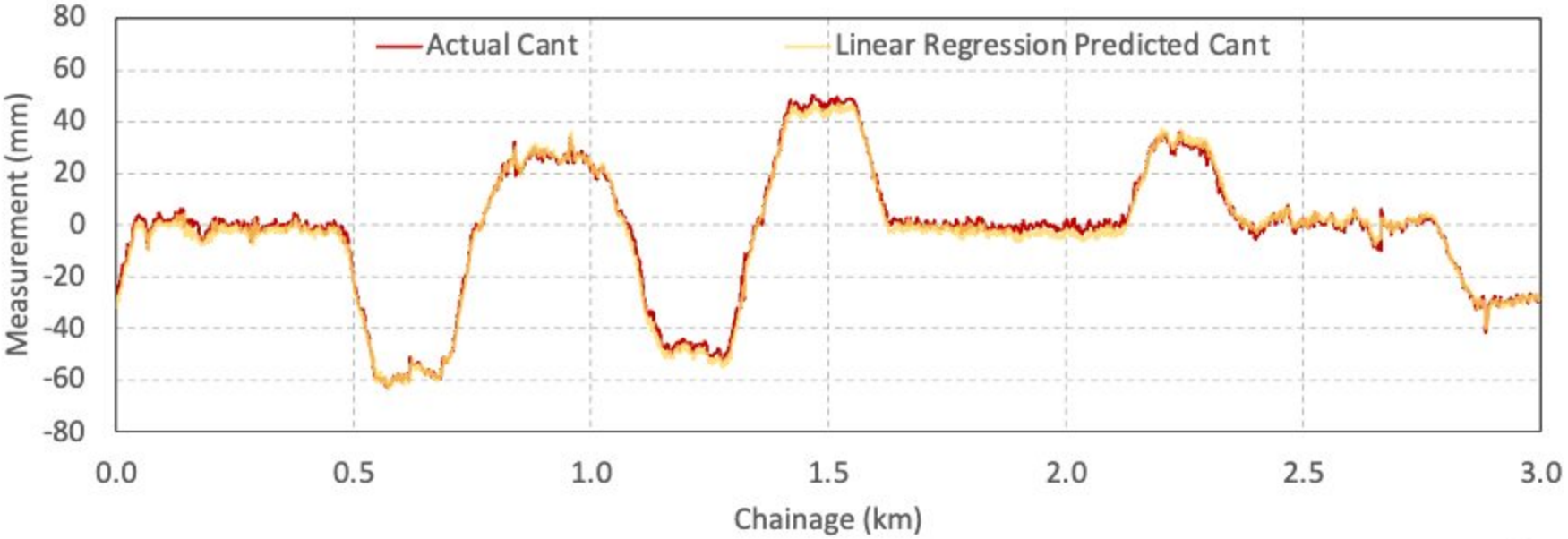
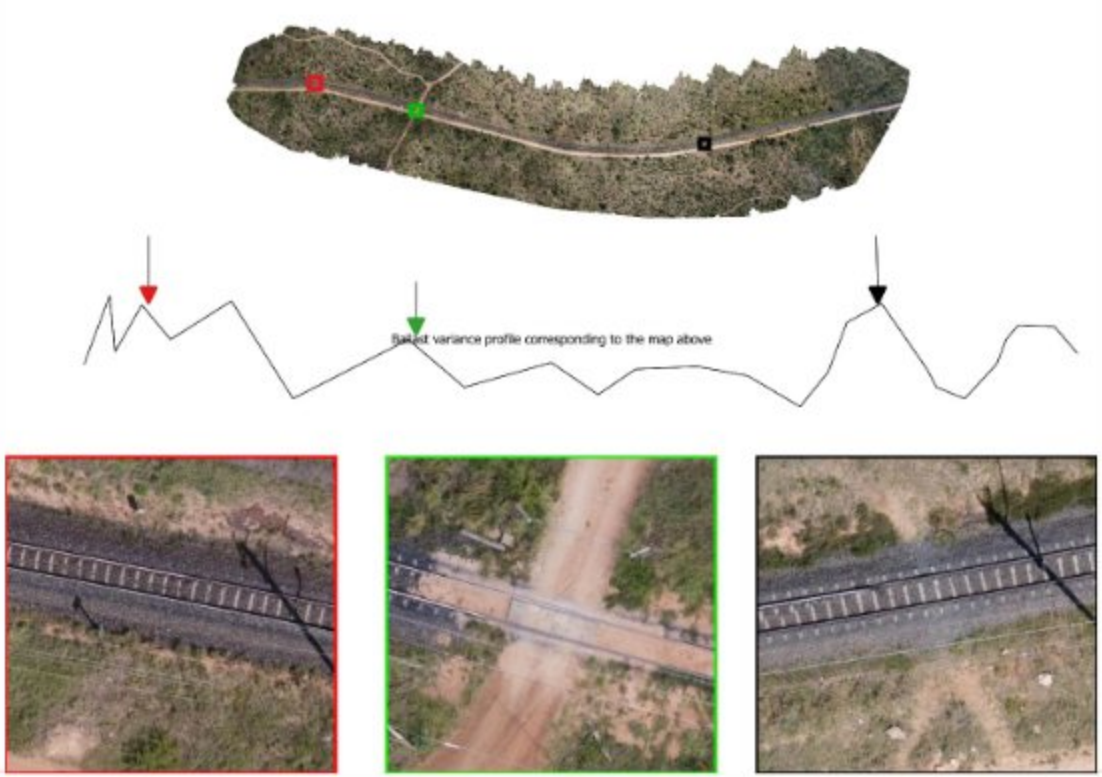
Alignment from vehicle response



Cant from vehicle response



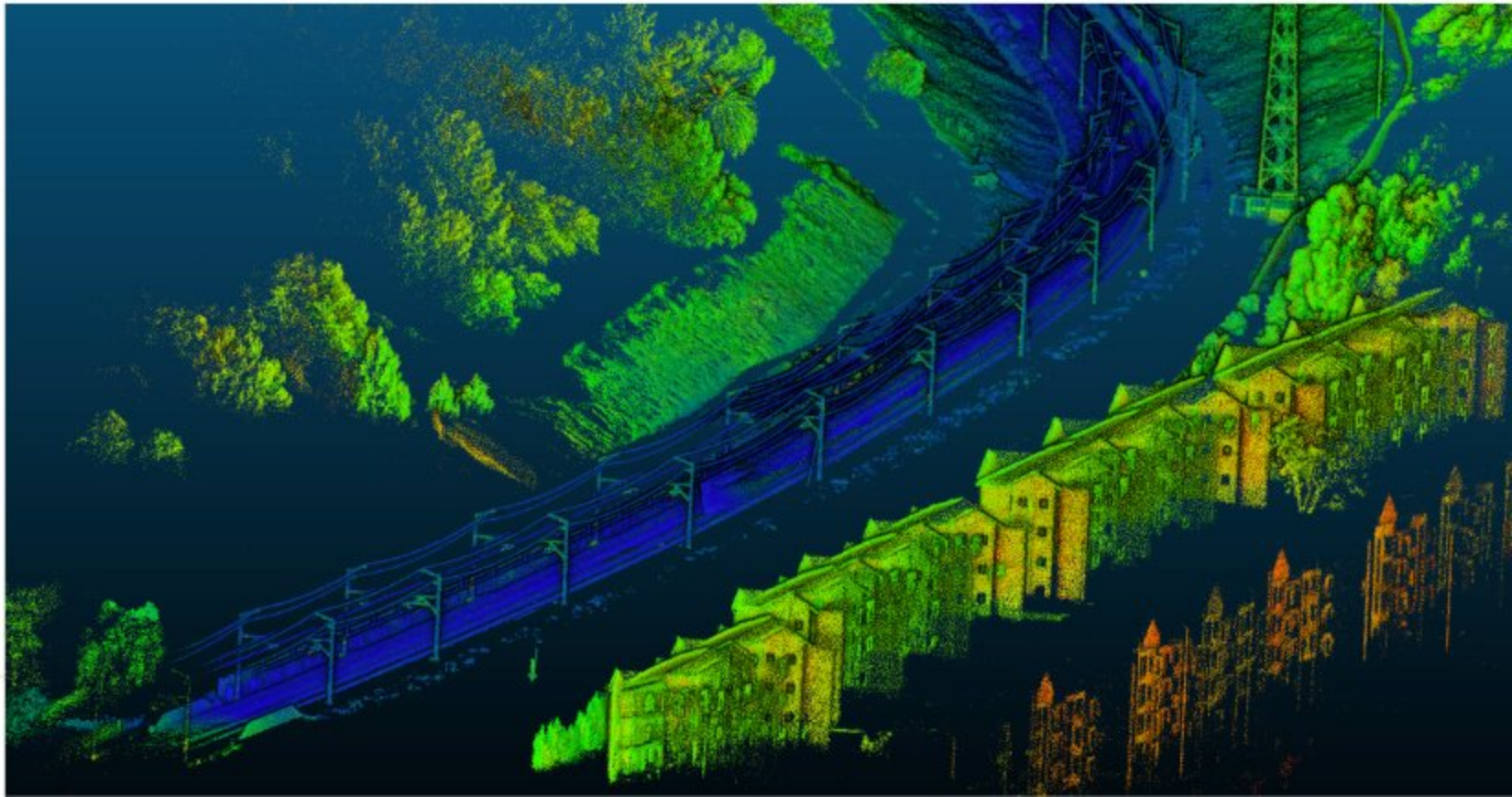
LiDAR derived ballast profile variance



UAV Applications in Railways

- Track infrastructure inspections
- Creation of 3D track infrastructure visualisations
- Development of point cloud data for track infrastructure asset management
- Digital track infrastructure scanning, remote sensing, levelling and high-precision measurements
- Incident investigations and derailment mapping

LiDAR scan of railway line



LiDAR and Photogrammetry

Orthographic mapping

Cutting
(Phalaborwa-Hoedspruit, April 2023)

Embankment
(Phalaborwa-Hoedspruit, April 2023)

Derailment investigations using drones

- Visualisation in the 360º cylinder
- 3D scanning of a derailment scene
- Derailment Investigation
- Incident Investigation Training

In Conclusion…

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