INTERNATIONAL UNION
OF RAILWAYS

3ÈME CONGRÈS AFRICAIN SUR LE NUMÉRIQUE FERROVIAIRE

28 À 30 MAI 2024, YAOUNDÉ

Christian Chavanel
Director of Railway System Department & Coordinator of the Africa Region

28 May 2024

AGENDA

THE UIC

UIC’s INVOLVEMENT IN DIGITAL RAILWAYS

ARTIFICIAL INTELLIGENCE (AI) WITHIN RAILWAY SECTOR

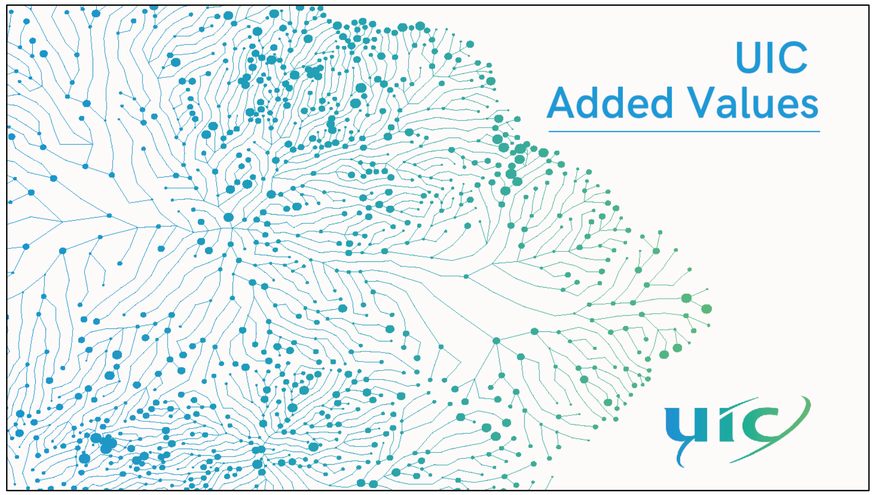
- HOW AI IS BEING DEPLOYED
- PERSPECTIVES

FOR FURTHER INFORMATION

QUESTIONS & ANSWERS

THE UIC

UIC ADDED VALUES



https://uic.org/IMG/pdf/added_values_-_membership.pdf

UIC provides to its members a technical support on:

- (1) **Safety and Interoperability**
- (2) **Telecommunications**
- (3) **Passengers**
- (4) **Freight**
- (5) **Labelling**
- (6) **Security**
- (7) **Cybersecurity**
- (8) **Energy**
- (9) **Regulatory Framework**

In addition, UIC has the capacity to **disseminate railway best practices** through more than 85 events per year (seminars, webinars) and publications (documents, websites).

The UIC **Sustainability Platform** provides focus and leadership for the **Environmental and Social sustainability agenda** in the global railway community

UIC 2030 VISION OF RAIL
DESIGN A BETTER FUTURE
INTEGRATING MAJOR TECHNICAL BREAKTHROUGHS

The UIC Railway System Forum **integrates major technical breakthroughs through its multi annual work programmes** based on:

- **Capacity**
- **Quality of service and continuous improvement of railway services**
- **Innovations**

uic.org/IMG/pdf/uic-design-a-better-future-vision-of-rail-2030.pdf

UIC AFRICA
REGIONAL PROJECTS

- **Safety Task Force**, Kick-off 22 May 2024
  - Peer Reviews in person
  - Safety Trainings online

- **Security Task Force**, Kick off 17 May 2024

- **Research Competence Hub**, Kick off 29 August 2024

- **Narrow Gauge Working Group**, Kick off 30 April 2024

- **Rolling Stock Task Force**, Kick off scheduled for December 2024

UIC AFRICA
WEBINARS, TRAININGS

Webinars

- **Security Task Force**: Organisational models to meet railway security challenges, 28 March 2024
- **Railway project management**, date TBC
- **Governance of railway undertakings**: a journey through organisational structures, date TBC
- **PRMs' mobility in the rail ecosystem**: issues and challenges, date TBC

Trainings

Coorganised with ONCF, Regional Office and UIC (in French)

- 12th Edition of **Safety Training**, Rabat, 15-26 April 2024
- 3rd Edition of the **Rolling Stock maintenance** course, online, 24-28 June 2024
- 11th **Track Maintenance** training course, Rabat, 14-25 October 2024
- 3rd **Project Management** course, online, 2-6 December 2024

UIC’s INVOLVEMENT IN DIGITAL RAILWAYS

UIC'S INVOLVEMENT IN DIGITAL RAILWAYS (1/5)
DISSEMINATION

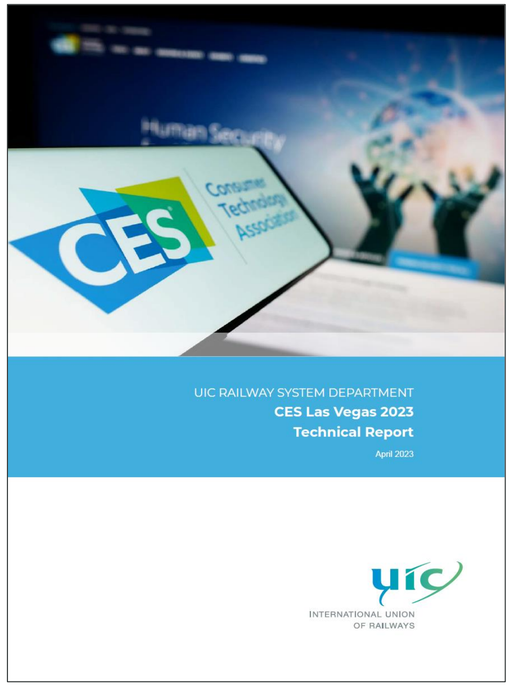
- **United Nations:**
  - *"High Level Regional Conference on Accelerating Rail Digital Transformation"*
    UNESCAP, Delhi, 6 April 2023

  - Workshop *"The use of satellite imagery and artificial intelligence to analyse critical road links"*,
    UNECA, Addis Ababa, 13 November 2023

UIC'S INVOLVEMENT IN DIGITAL RAILWAYS (2/5)
DISSEMINATION

- **CES Las Vegas 2023:**

  UIC Technical Report

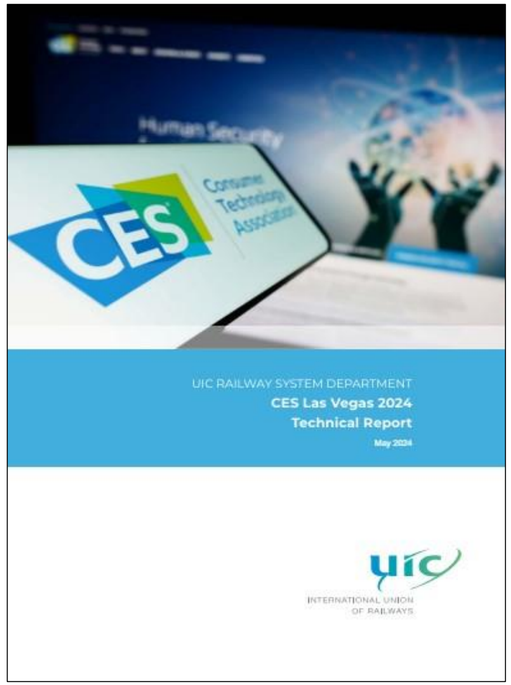


https://uic.org/IMG/pdf/ces_las_vegas_2023_uic_technical_report_en.pdf

UIC'S INVOLVEMENT IN DIGITAL RAILWAYS (3/5)
DISSEMINATION

- **CES Las Vegas 2024:**

UIC Technical Report



https://uic.org/com/IMG/pdf/ces_las_vegas_2024_-_technical_report_v6.pdf

Speeches

- *"Artificial Intelligence within the Railway Sector"*
- *"Railway Cybersecurity"*

UIC'S INVOLVEMENT IN DIGITAL RAILWAYS (4/5)

DISSEMINATION

UIC'S INVOLVEMENT IN DIGITAL RAILWAYS (5/5)

SPECIFIC PROJECTS

- Lead of the specification stream for **FRMCS (Future Railway Mobile Communication System)**
- Multimodality and international ticketing with **OSDM (Open Sales and Distribution Model)** program
- Define and put in place a set of digital solutions to improve the commercial context and the operations of freight with the **Digital Platform for Freight**
- Digital Modelling with **RSM (Railway System Model) and OntoRail (Ontology for Rail)**
- **OpenRail foundation,** UIC, together with three initial members, aims to put in place the first open-source foundation dedicated to railway industry
- The **railway system architecture** and the **relevant exchange of data for more efficient operations**
- **Energy Settlement**
- **Digital Automatic Coupling (DAC)**
- **Artificial Intelligence (Predictive Maintenance)**
- **Intelligent High Speed Railway** (UIC OPTIN Project PAS 689)

ARTIFICIAL INTELLIGENCE WITHIN RAILWAY SECTOR

ARTIFICIAL INTELLIGENCE WITHIN RAILWAY SECTOR

HOW AI IS CURRENTLY BEING DEPLOYED

HOW AI IS CURRENTLY BEING DEPLOYED

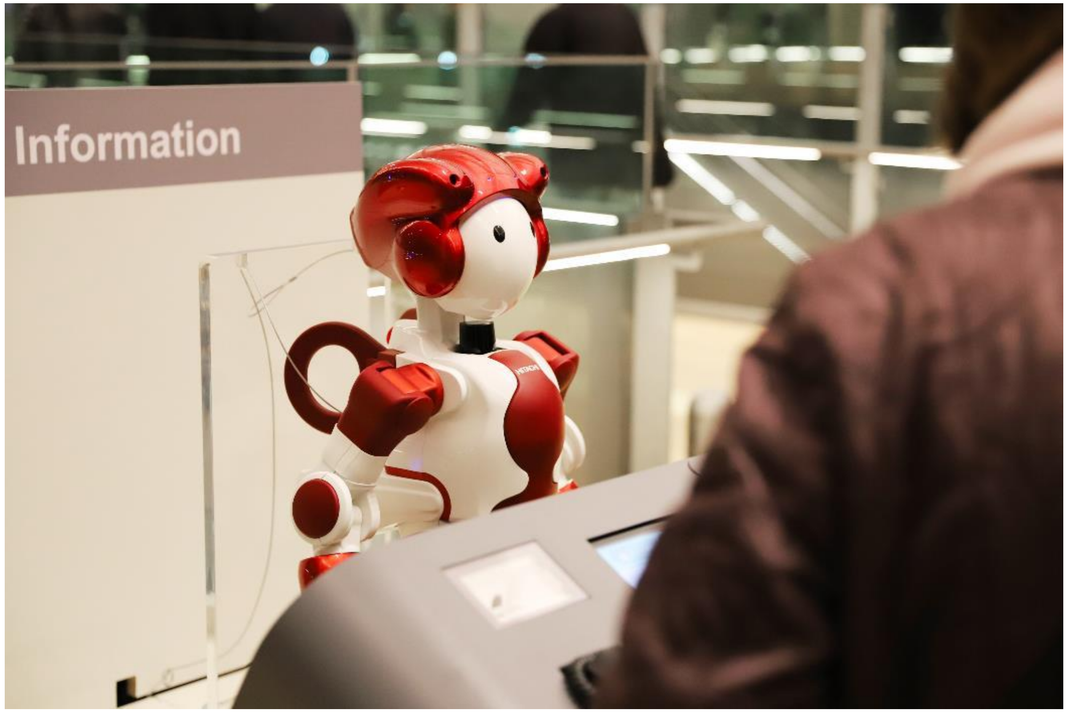
Image recognition in the fight against terrorism

Chatbots and virtual assistants for passengers

Sales prediction through ML

HOW AI IS CURRENTLY BEING DEPLOYED

Robotics in railway stations



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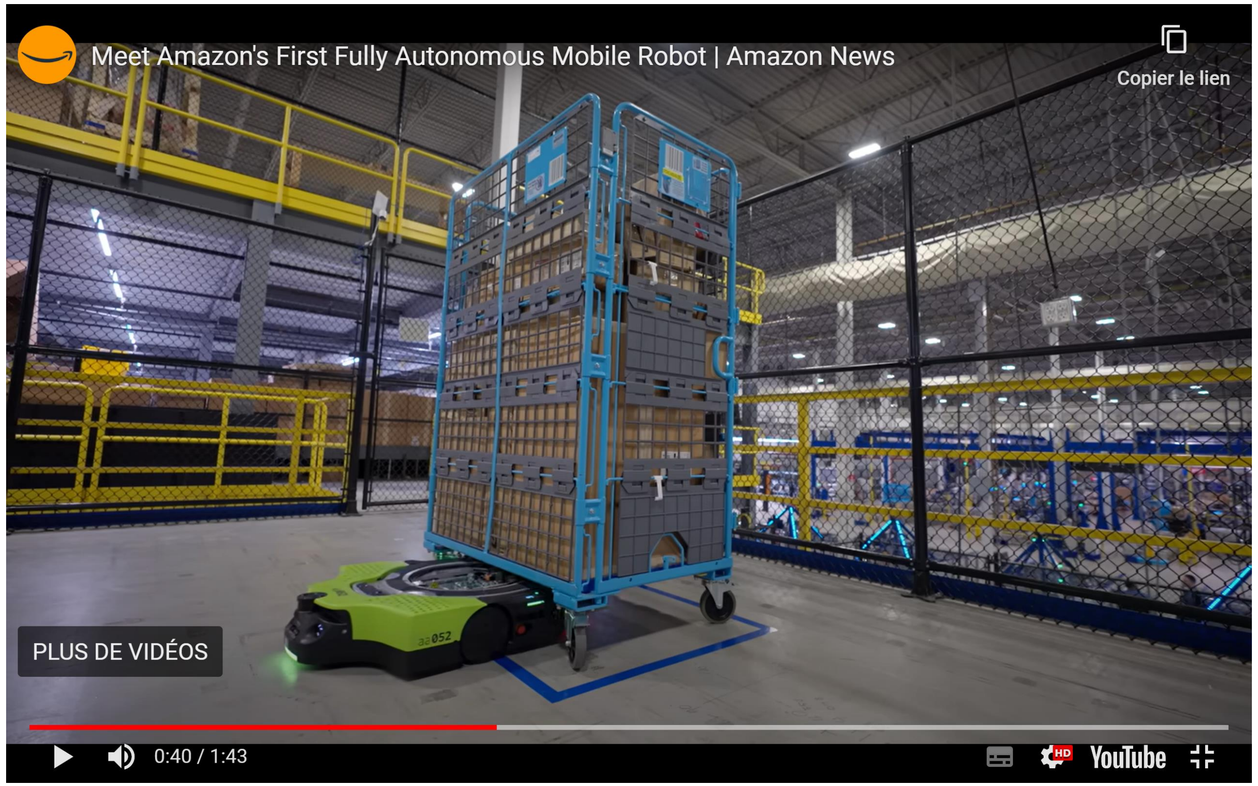
HOW AI IS CURRENTLY BEING DEPLOYED



Robotics in warehouses [1]

(1): https://youtu.be/AmmEbYkYfHY

HOW AI IS CURRENTLY BEING DEPLOYED

PREDICTIVE MAINTENANCE

Thanks to advanced statistical methods

such as Machine Learning

Possible to set up predictive maintenance
“Predictive maintenance predicts future breakdowns by giving you a probability, whereas condition-based maintenance prevents additional breakdown cost by telling you something is wrong now” [1]

(1): Neurospace (2019), ‘Condition-Based Maintenance vs Predictive Maintenance’, [Online], Available at: https:// neurospace.io/blog/2019/08/condition-based-maintenance-vs-predictive-maintenance/ (Accessed: 2 August 2019)

HOW AI ARE CURRENTLY BEING DEPLOYED

Automated tunnel examinations

Track machine vision systems [1]

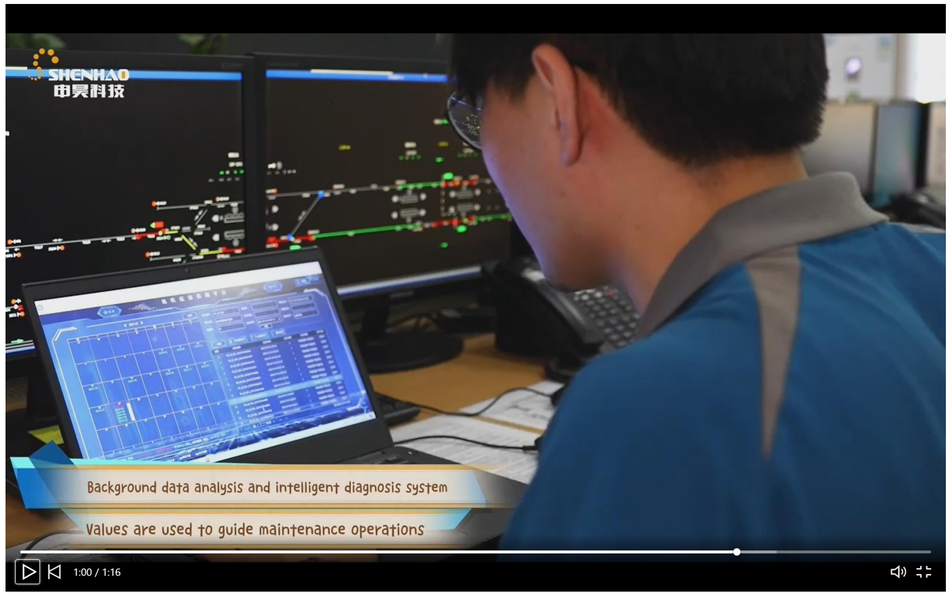
Robots to automate inspections (infrastructure and rolling stock [2])

Aerial monitoring of railways using drones [3]

Data analytics

(1): https://www.spanishrailwaysnews.com/noticias.asp?not=9411&cs=tech
(2): https://www.linkedin.com/posts/aaloui_aminea-rail-railway-activity-7067738687324786688-hMTA?utm_source=share&utm_medium=member_ios
(3): https://shop.uic.org/en/other-documents/14290-harmonised-methodology-for-drone-uav-uses-for-bridge-inspection.html

HOW AI IS CURRENTLY BEING DEPLOYED

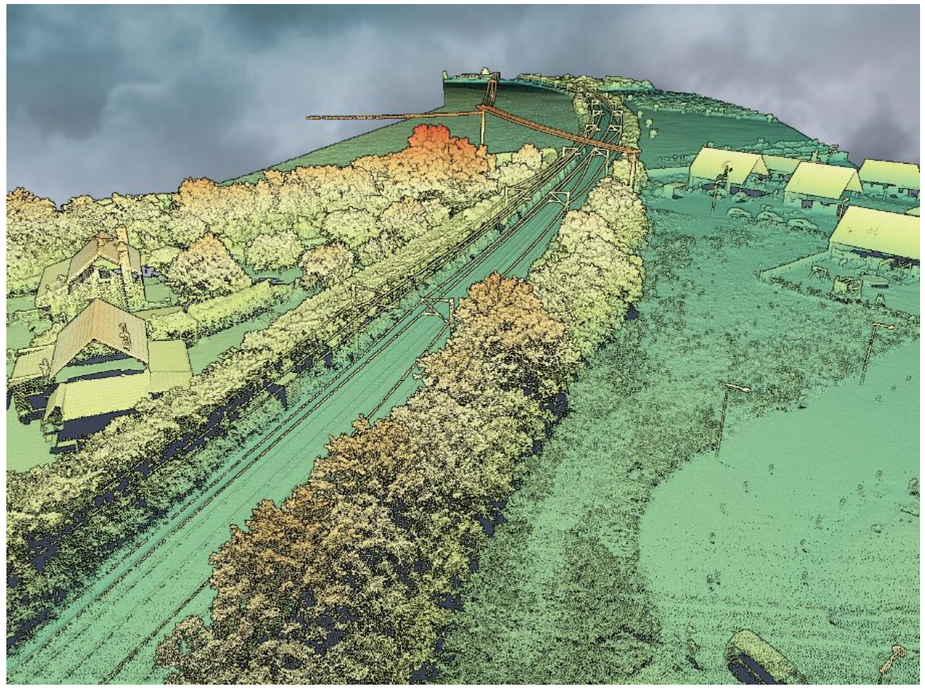


Robotics in rolling stock inspections [1]

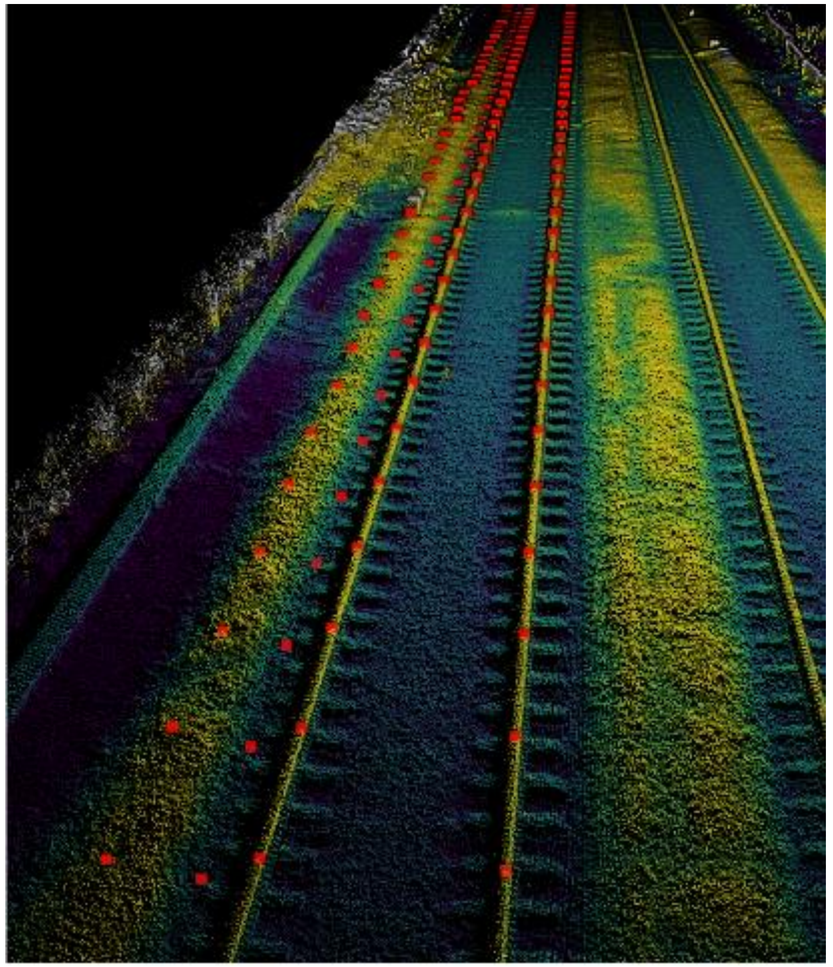
(1): https://www.linkedin.com/posts/aaloui_aminea-rail-railway-activity-7067738687324786688-hMTA?utm_source=share&utm_medium=member_ios

HOW AI ARE CURRENTLY BEING DEPLOYED

DATA THANKS TO DRONES



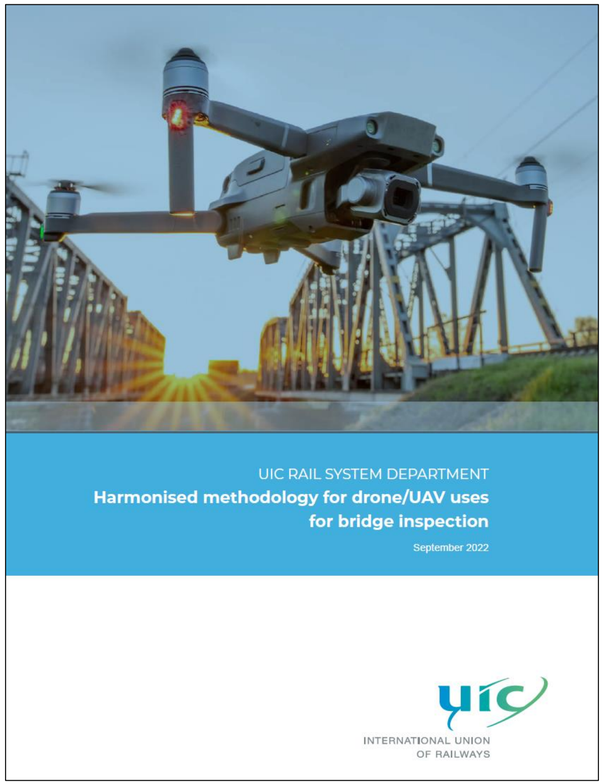
LiDAR imagery taken by a drone
Crédit photo: Altamétris



Rails and ballast ridges taken by a drone
Crédit photo: Altamétris

HOW AI ARE CURRENTLY BEING DEPLOYED

HARMONISED METHODOLOGY FOR DRONE UAV USES FOR BRIDGE INSPECTIONS



(1): https://shop.uic.org/en/other-documents/14290-harmonised-methodology-for-drone-uav-uses-for-bridge-inspection.html

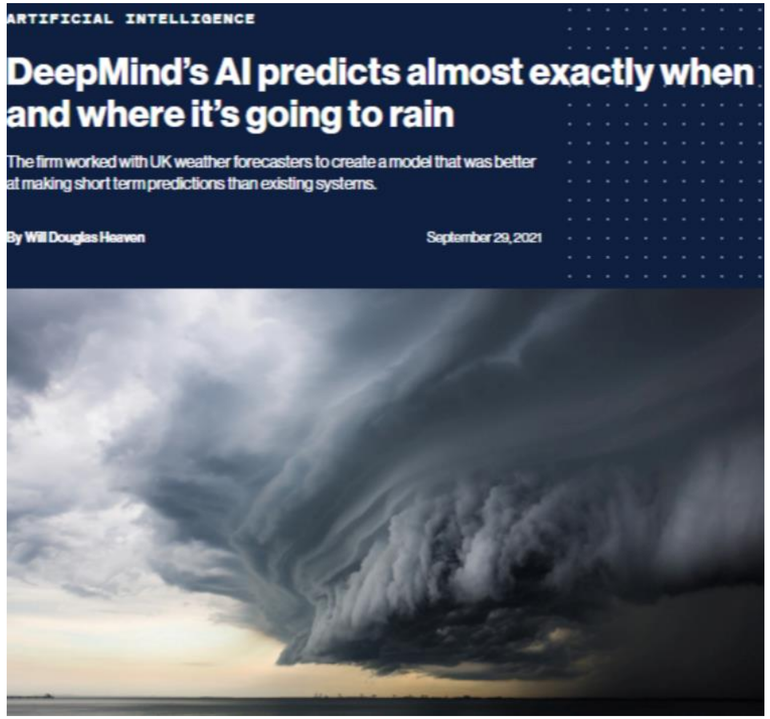
ARTIFICIAL INTELLIGENCE WITHIN RAILWAY SECTOR

PERSPECTIVES

PERSPECTIVES

DeepMind’s AI predicts almost exactly when and where it’s going to rain
MIT Technology Review – 29 September 2021

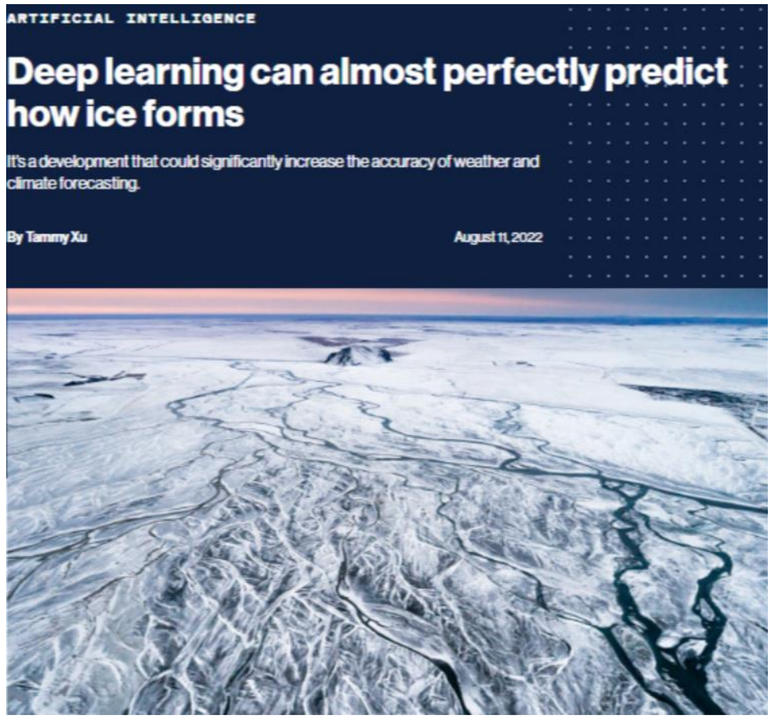
https://www.technologyreview.com/2021/09/29/1036331/deepminds-ai-predicts-almost-exactly-when-and-where-its-going-to-rain/



PERSPECTIVES

Deep learning can almost perfectly predict how ice forms
MIT Technology Review – 11 August 2022

https://www.technologyreview.com/2022/08/11/1057623/deep-learning-predicts-ice-formation/?truid=47be511725f269b7c2129009e84938a3&utm_source=the_download&utm_medium=email&utm_campaign=the_download.unpaid.engagement&utm_term=Active%20Qualified&utm_content=08-16-2022&mc_cid=a768fe069a&mc_eid=49e4896975



PERSPECTIVES

Passenger Counting
at Basler Verkehrs-Betriebe (BVB)

Predictive Maintenance of the
Pantograph-Catenary System
At Regionalverkehr Bern-Solothurn
(RBS)

AI in Rail-Inspect at SBB

applied sciences

MDPI

Article

On the Track to Application Architectures in Public Transport Service Companies

Stephan Jüngling [1,*], Ilir Fetai [2], André Rogger [2,*], David Morandi [3] and Martin Peraic [1]

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[2] Swiss Federal Railways (SBB), Competence Center on Machine Perception, 3014 Bern, Switzerland; ilir.fetai@sbb.ch
[3] Regional Transport Bern-Solothurn (RBS), 3048 Worblaufen, Switzerland; david.morandi@rbs.ch
* Correspondence: stephan.juengling@fhnw.ch (S.J.); andre.rogger@sbb.ch (A.R.)

Abstract: There are quite some machine learning (ML) models, frameworks, AI-based services or products from different IT solution providers available, which can be used as building blocks to embed and use in IT solution architectures of companies. However, the path from initial prototypical proof of concept solutions until the deployment of proven systems into the operational environment remains a major challenge. The potential of AI-based software components using ML or knowledge engineering (KE) is huge and the majority of small to medium enterprises are still unsure whether their internal developer teams should be extended by additional ML or KE skills to enrich their IT solution architectures with novel AI-based components where appropriate. How can enterprises manage the change and visualize the current state and foreseeable road-map? In the current paper, we propose an AI system landscape for the public transport sector, which is based on existing AI-domains and AI-categories defined by different technical reports of the European Commission. We collect use-cases from three different enterprises in the transportation sector and visualize them on the proposed domain specific AI-landscape. We provide some insights into different maturity levels of different AI-based components and how the different ML and KE based components can be embedded into an AI-based software development life-cycle (SDLC). We visualize, how the AI-based IT-solution architecture evolved over the last decades with respect to coupling and decoupling of layers and tiers in the overall Enterprise Architecture.

Keywords: AI architecture; AI maturity model; AI landscape; machine learning; knowledge engineering; software development life-cycle; domain-specific AI; AI in transportation industry; enterprise architecture; MLOps

check for updates

Citation: Jüngling, S.; Fetai, I.; Rogger, A.; Morandi, D.; Peraic, M. On the Track to Application Architectures in Public Transport Service Companies. Appl. Sci. 2022, 12, 6073. https://doi.org/10.3390/app12126073

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1. Introduction

When looking at the evolution of software architectures that started from mainframes and dumb 3270 terminals to N-Tier architectures, the distribution of specialized functionality to dedicated hardware-related tiers such as database servers or logical layers such as the presentation layer, which was triggered by a substantial technology gap between HTML as a markup language for the graphical user interface (GUI) and the object-oriented programming languages used to implement the application- and business-logic. With an increasing focus of organizations to business processes, workflow and rule engines were incorporated into the software architectures, leading to additional layers or tiers. With the increasing capabilities of artificial intelligence (AI), which in itself can be decomposed into machine learning (ML) and Knowledge Engineering (KE) sub-domains, additional layers and tiers slowly establish and need to be incorporated into the overall IT architecture and the software development life-cycle (SDLC) of all these different building blocks. In case of ML models, an additional challenge is added to the life-cycle management of components, which is equally severe as the gap between the markup and the programming

https://www.mdpi.com/2076-3417/12/12/6073/htm

PERSPECTIVES

Seen at WCRR 2022 in Birmingham (7-9 June 2022)

- Low adhesion prediction

PERSPECTIVES

Seen at WCRR 2022 in Birmingham (7-9 June 2022)

FUZZY LOGIC ARTIFICIAL INTELLIGENCE HYBRID APPROACH TO MITIGATION OF CLIMATE CHANGE DRIVEN RAILWAY TRACK BUCKLING

WCRR BIRMINGHAM UK 2022

FUZZY LOGIC ARTIFICIAL INTELLIGENCE HYBRID APPROACH TO MITIGATION OF CLIMATE CHANGE DRIVEN RAILWAY TRACK BUCKLING

Iwo SŁODCZYK[1], David FLETCHER[2], Inna GITMAN[3], Brian WHITNEY[3]

[1,2]University of Sheffield, Sheffield, UK
[2]University of Twente, Enschede, Netherlands
[3]Network Rail, London, UK

Abstract

Buckles in railway track can lead to derailments and result in safety risks and infrastructure repairs. To reduce their occurrence, information about the temperature at which a track has a high risk of buckling is necessary. However, calculating the buckling temperature of track can be a computationally intensive task, which demands precise knowledge of engineering parameters often not available without experimental work. Fuzzy models allow for computation using uncertain or vague variables, translating linguistic descriptions of properties into a format which allows for calculation and generating a precise, numerical output. In this paper, a fuzzy model is developed which can predict buckling temperatures. Here, it is trained using information generated by an analytical track buckling model but it is equally suited to training on field data on real events or a combination of these methods. The model is computationally lightweight and allows for use of uncertain variables based on qualitative assessments of the track. The model is tested against a second set of data, different to the training set, to gauge its predictive capability. A close fit is seen between fuzzy model predictions and the testing set, verifying the functionality of this methodology in the field of railway track buckling.

Keywords: Railway Track Buckling, Fuzzy Logic, Data Driven Method

1 INTRODUCTION

Figure 1 - Derailment near Huddlesford due to a track buckle

The buckling of railway track in hot weather presents a unique and challenging problem, being both difficult to predict and potentially severe in its consequences. In the UK, buckles have been reported as early as 1885 [1] and despite changes in the form of track and efforts made in the characterisation, prediction and mitigation of buckling events, buckles still occur. Historically, buckles have resulted in the loss of life [2] and still pose a derailment threat [3], while the damage caused to the infrastructure and delays due to speed restrictions incur significant costs [4]. An example of a buckled track is shown in Figure 1 from a derailment of a freight train near Huddlesford on 14th July 2003.

Experimental analyses, analytical and numerical models have been used to identify the key variables determining whether a particular section of track has a high risk of buckling. Following the critical survey of previous work in the field in 1975 [5], Arnold Kerr developed an analysis of lateral track buckling [6] which he improved on two years later [7]. The core concepts from these publications served to inform future analyses which introduced new characteristics such as vehicle loads, non-linear lateral resistance [8] and considered the track as a ladder-type structure [9].

Despite the work in identifying the main parameters influencing the temperatures above which a risk of buckling exists (the safe temperature increase), significant challenge is found in implementing that knowledge. Complex interactions between variables necessitate the use of intricate models for prediction of the buckling

PERSPECTIVES

- **Automatized dispatching AI algorithm for the tunnel between France and England [1]**
- **Obstacle detection at level-crossings**
- **Eco Driving: Pilot project of VIA Rail Canada (called EcoRail) [2] with start-up Rail Vision Analytics**
- **Management of the vegetation [3]**
- **Google to generate ads instantly thanks to AI [4]**
- **Emergence of Generative AI**

(1): https://www.linkedin.com/posts/aaloui_ai-aminea-rail-activity-7055052428135591936-G8BN?utm_source=share&utm_medium=member_ios
(2): *'VIA Rail Canada extends AI pilot for emissions reduction'*
https://www.railway-technology.com/news/via-rail-canada-ai-pilot/
(Accessed 25 November 2022)
(3): 'Artificial intelligence helps Britain's railway see the wood from the trees'
Railway Freight
https://www.railfreight.com/technology/2022/06/07/artificial-intelligence-helps-britains-railway-see-the-wood-from-the-trees/?utm_source=newsletter&utm_medium=email&utm_campaign=Newsletter%20week%202022-23&gdpr=accept
(Accessed 7 June 2022)
(4): *'Google va générérer des publicités instantanément grâce à l'IA'*
https://www.lesechos.fr/tech-medias/intelligence-artificielle/google-va-generer-des-publicites-instantanement-grace-a-lia-1946177
Les Echos
(Accessed 24 May 2023)

PERSPECTIVES

EXTRACT FROM UIC “INTELLIGENT HIGH SPEED RAIL” WORKSHOP 30 MAY 2023

The European Union has assigned over 2 billion in funding for the development of smart, green and integrated transport through the Horizon 2020 Initiative from 2014-2020

This funding led to the creation of the **Shift2Rail program**, which aims to develop and validate sustainable, cost-efficient, high-performing, time-driven, **digital and competitive train operation** standards **through railway research and innovation**, also related to the **application of AI in transport systems**

Objective

"The overall objective of the RAILS research project is to investigate the potential of Artificial Intelligence (A.I.) approaches in the rail sector and contribute to the definition of roadmaps for future research in next generation signalling systems, operational intelligence, and network management. RAILS will address the training of PhD students to support the research capacity in A.I. within the rail sector across Europe by involving research institutions in four different countries with a combined background in both computer science and transportation systems. RAILS will produce knowledge, ground breaking research and experimental proof-of-concepts for the adoption of A.I. in rail automation, predictive maintenance and defect detection, traffic planning and capacity optimization. To that aim, RAILS will combine A.I. paradigms with the Internet of Things, in order to leverage on the big amount of data generated by smart sensors and applications. The research activities will be conducted in continuity with ongoing research in railways, but the methodological and technological concepts developed in RAILS are expected to stimulate further innovation providing new research directions to improve reliability, maintainability, safety, security, and performance. With respect to safety, emerging threats and certification issues will be addressed when adopting A.I. in autonomous and cooperative driving, based on the concepts of ""explainable A.I."" and ""Trustworthy AI"". With respect to cyber-physical threat detection, innovative approaches will be developed based on A.I. models like Artificial Neural Networks and Bayesian Networks together with multi-sensor data fusion and artificial vision. Resilience and optimization techniques based on genetic algorithms and self-healing will be addressed to face failures and service disruptions as well as to increase efficiency and line capacity. All those techniques will pave the way to the development of the new ""Railway 4.0"".

Project Information

RAILS

Grant agreement ID: 881782

DOI

10.3030/881782

Start date 1 December 2019

End date 30 June 2023

Funded under

SOCIETAL CHALLENGES - Smart, Green And Integrated Transport

Total cost

€ 299 953,75

EU contribution

€ 299 953,75

Coordinated by

CONSORZIO INTERUNIVERSITARIO NAZIONALE PER L'INFORMATICA

Italy

PERSPECTIVES

EXTRACT FROM UIC “INTELLIGENT HIGH SPEED RAIL” WORKSHOP 30 MAY 2023

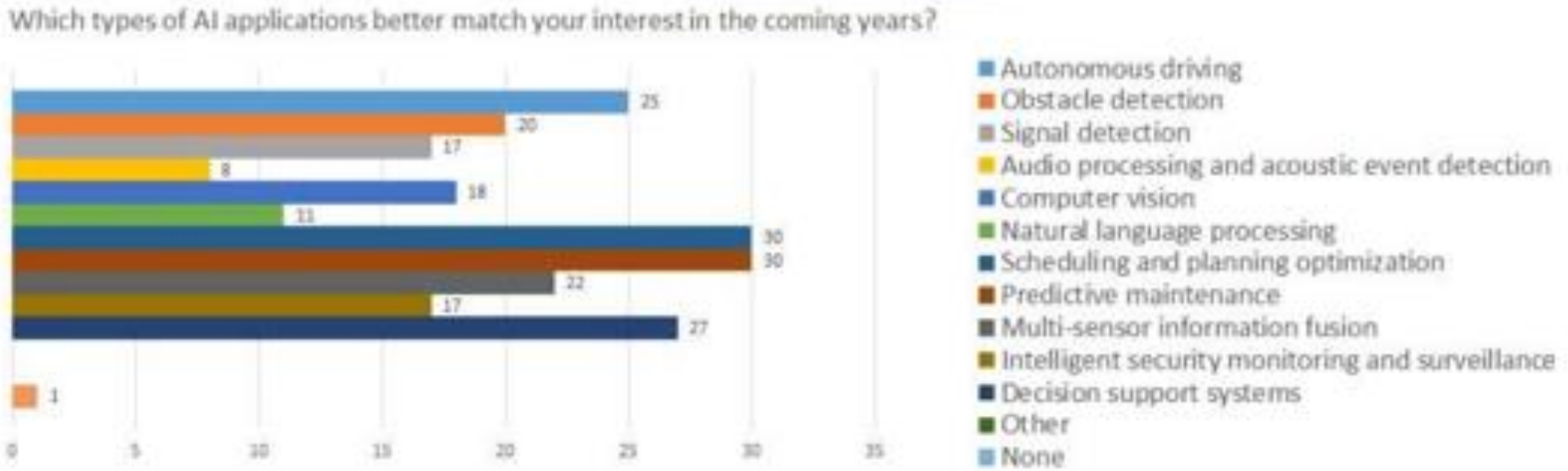


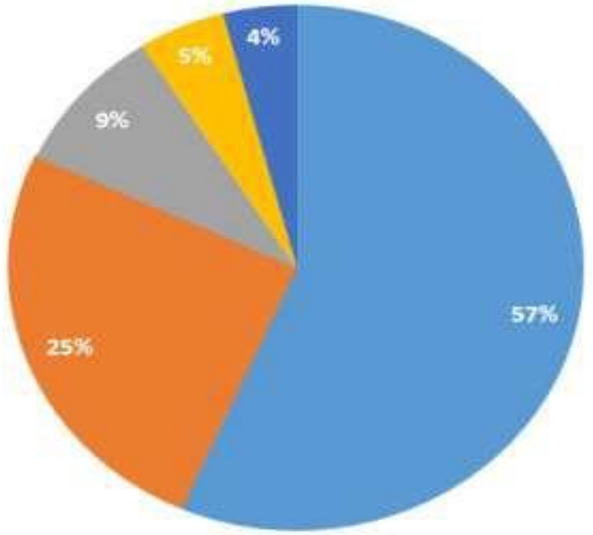
Fig. 5.14. AI application ranking: railways focus group

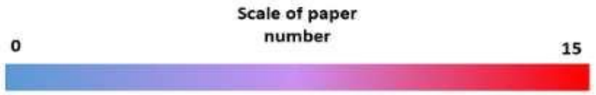
PERSPECTIVES

EXTRACT FROM UIC “INTELLIGENT HIGH SPEED RAIL” WORKSHOP 30 MAY 2023

The result has led to the identification of **7 subdomains**:

1. **Maintenance and Inspection**
2. **Traffic Planning and Management**
3. **Safety and Security**
4. **Autonomous Train Driving and Train Control**
5. **Passenger Mobility**
6. **Transport Policy**
7. **Revenue Management**

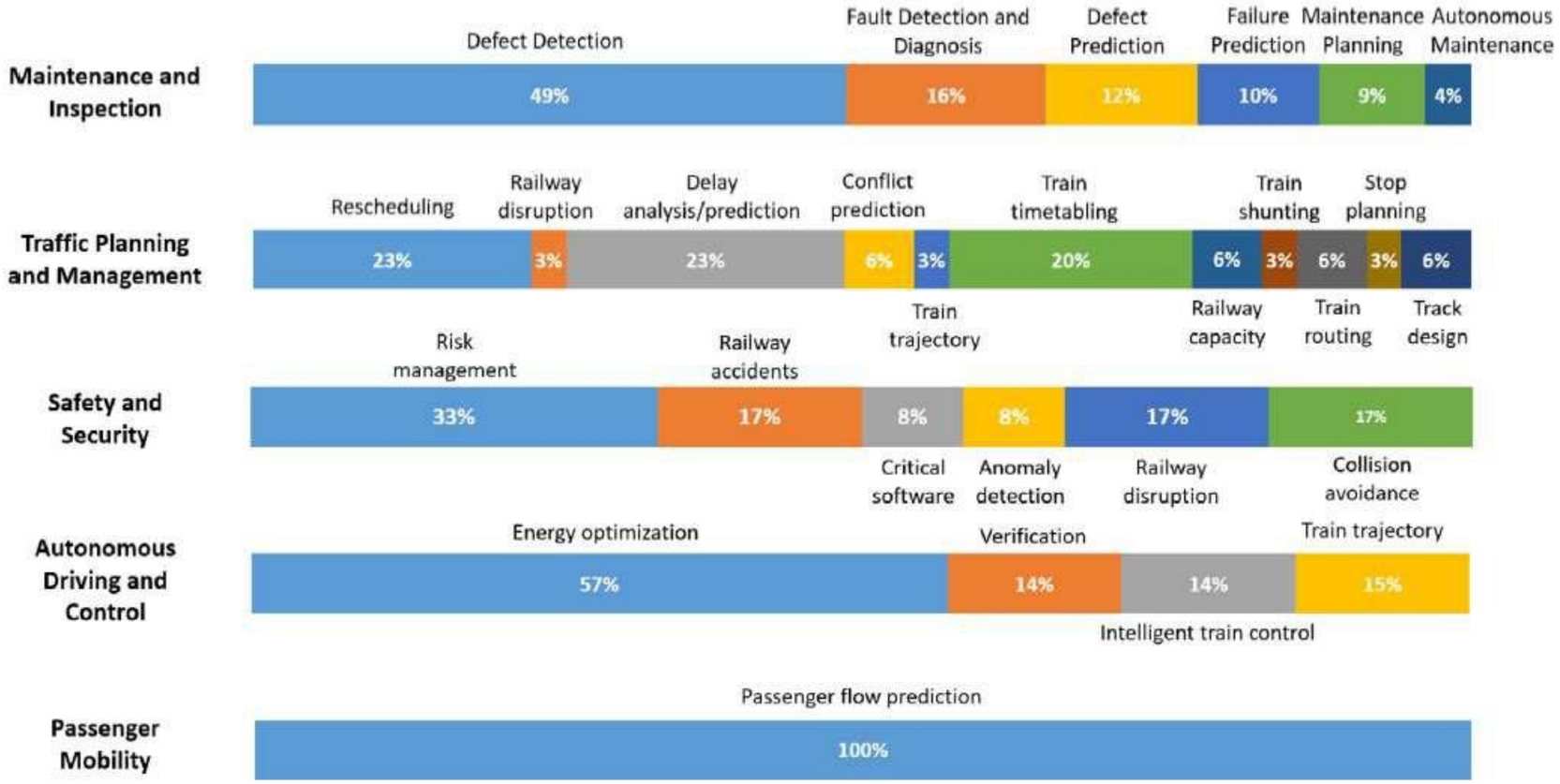




PERSPECTIVES

EXTRACT FROM UIC “INTELLIGENT HIGH SPEED RAIL” WORKSHOP 30 MAY 2023

Papers in railway sub-domains with respect to their focus



PERSPECTIVES

EXTRACT FROM UIC “INTELLIGENT HIGH SPEED RAIL” WORKSHOP 30 MAY 2023

. Railway Problems to investigate by AI approaches.

FOR FURTHER INFORMATION

1st REGIONAL COMPETENCE HUB
TSHAWANE UNIVERSITY OF TECHNOLOGY, 29 AUGUST 2024
SOUTH AFRICA, PRETORIA

IRRB International Railway Research Board

The UIC IRRB will develop **six Regional Competence Hubs** (one per UIC Region), facilitating:

- the **sharing of railway expertise** and **knowledge** the conduct of effective research,
- **collaboration** with innovators and future-thinkers through the involvement **on the entire value chain** (railway companies, universities, research institutes, innovators, future-thinkers and financial sector).

In the long term, the six Regional Competence Hubs will **pave the way from incremental to architectural, disruptive and even radical innovations**

QUESTIONS & ANSWERS

STAY IN TOUCH

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#UICrail

Thank you for your kind attention!