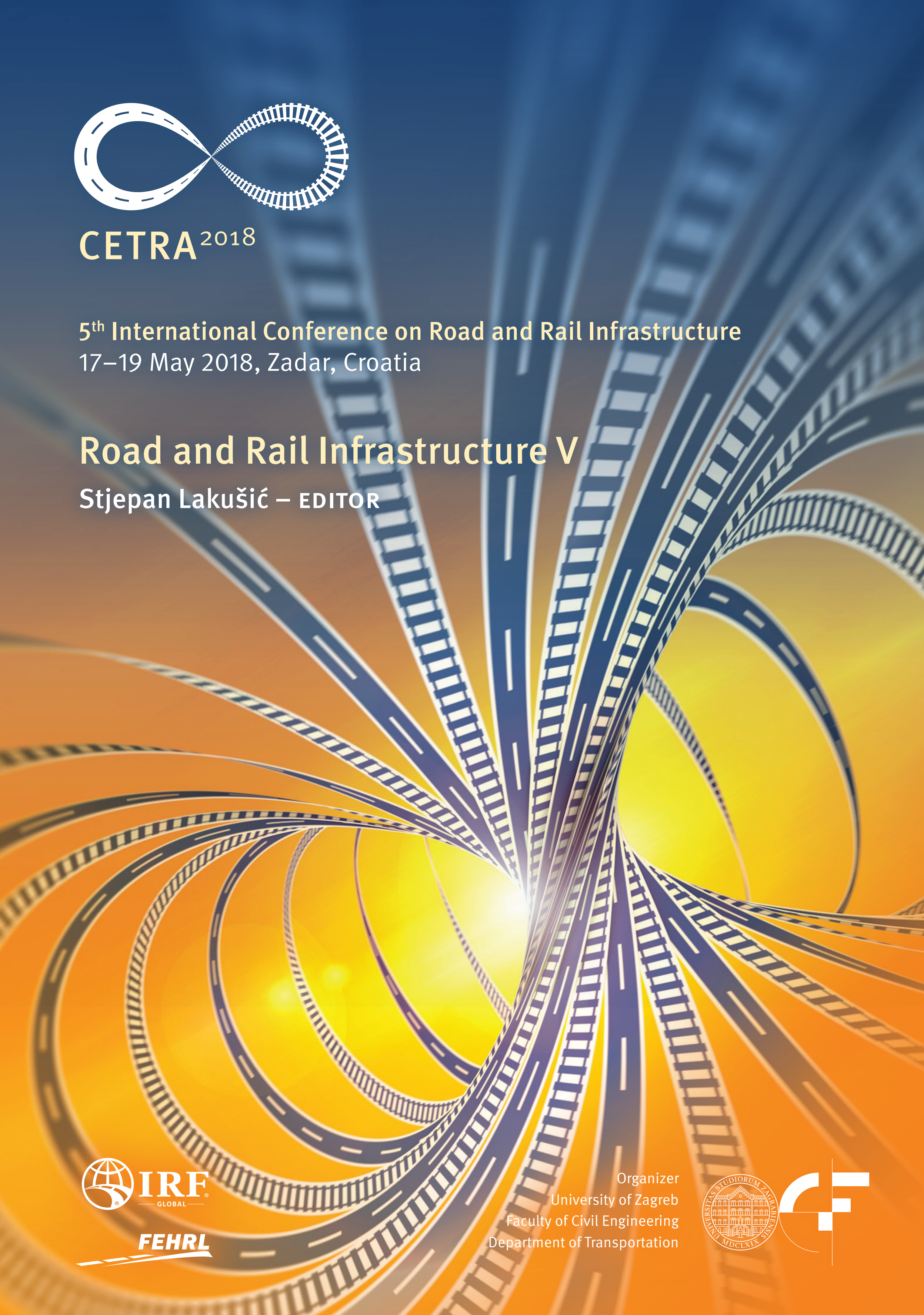

CETRA[2018]

5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

Stjepan Lakušić – EDITOR

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SAFE-10-T: SAFETY OF TRANSPORT INFRASTRUCTURE ON THE TEN-T NETWORK

Julie Clarke[1], Paul Doherty[1], Lorcan Connolly[2], Kenneth Gavin[3], Marieke van der Tuin[3], Pieter van Gelder[3], Stephen Wells[4], Rade Hajdin[5], Meho Saša Kovačević[6], Timo Hartmann[7], Irina Stipanovic[8], Ruediger Ehlers[9], Chiara Bianchizza[10], Miglė Paliukaite[11], Colin Sims[12], Dražen Vinscak[13]

[1] *Gavin & Doherty Geosolutions Ltd., Ireland*
[2] *Roughan & O'Donovan Innovative Solutions Ltd., Ireland*
[3] *Delft University of Technology, Netherlands*
[4] *VIRTUS IT, United Kingdom*
[5] *Infrastructure Management Consultants, Switzerland*
[6] *University of Zagreb, Croatia*
[7] *Technical University Berlin, Germany*
[8] *Infra Plan Consulting, Croatia*
[9] *University of Bremen and German Research Centre for Artificial Intelligence, Germany*
[10] *Institute of International Sociology of Gorizia, Italy*
[11] *Forum of European National Highway Research Laboratories, Belgium*
[12] *Network Rail, United Kingdom*
[13] *HŽ Infrastructura, Croatia*

Abstract

SAFE-10-T (Safety of Transport Infrastructure on the TEN-T Network) is a project funded by the European Union according to the Horizon 2020 Research and Innovation programme. The SAFE-10-T project is developing a global risk framework that will form the basis of an online Decision Support Tool (DST) to assist in decision-making regarding the management of transport infrastructure along the European TEN-T network. The DST is limited to road, rail and inland waterway transport infrastructure and will consider the multi-modality of these networks in terms of transport disruption due to asset failures. End-users will be able to assess the impact of interventions for infrastructure assets, including bridges, tunnels and earthworks and novel machine learning applications are being developed both at asset and network levels to provide real-time safety assessments for critical infrastructure assets. The targeted end-users are government authorities and infrastructure owners who will be able to use the outputs of the SAFE-10-T project to make strategic investment decisions regarding transport infrastructure. This paper provides an overview of the project, which commenced in May 2017. Further information is available at www.safe10tproject.eu.

Keywords: transport infrastructure, risk assessment, machine learning, transport safety.

1 Introduction

Transport infrastructure managers are tasked with ongoing maintenance activities, as well as long-term investment decisions regarding the upgrading and replacement of infrastructure assets. Decisions about where to implement investments are problematic due to the size and complexity of transport networks, and the vast quantity of infrastructure assets, inclu-

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ding bridges, tunnels and earthworks. A combination of ageing infrastructure, more frequent extreme weather events and increasing transport demand has led to a significant increase in the occurrence of asset failures along transport networks. Examples of recent failures include the occurrence of a landslide along the road and rail network in Switzerland in 2005 following a period of heavy rainfall (Fig. 1a) and the collapse of a rail viaduct in Ireland in 2009 due to the development of a scour hole around one of the bridge piers (Fig. 1b).

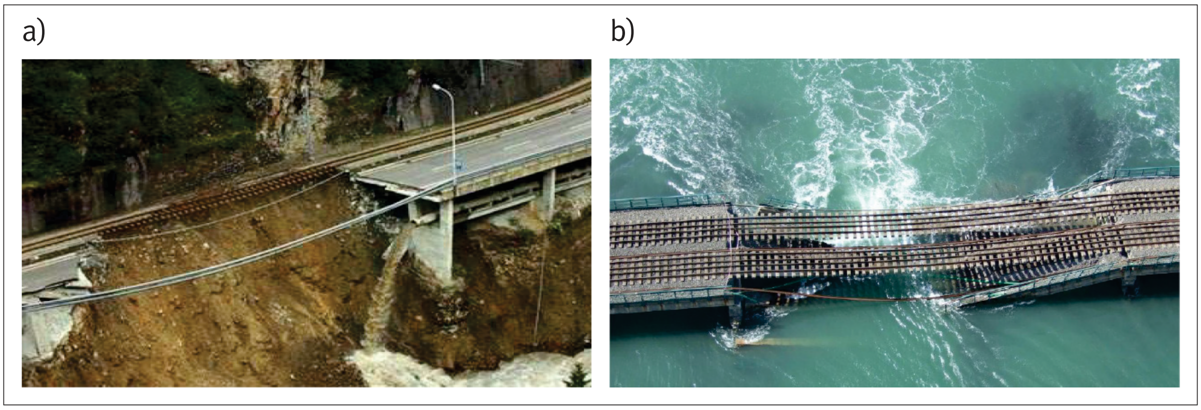

Figure 1 Examples of Recent Transport Infrastructure Failures a) Landslide in Switzerland, 2005; b) Viaduct collapse, Ireland, 2009

Current systems for managing transport infrastructure assets are heavily reliant on visual inspection, meaning that decision making is based on qualitative rather than quantitative data and, therefore, is highly subjective. To support reliable decision making based on quantitative data, the SAFE-10-T project is developing a global risk framework that will form the basis of an online Decision Support Tool (DST) to support decision-making in relation to the management of transport infrastructure along the European TEN-T network [1]. The project directly aligns with the objective of the European Union to increase safety levels across all transport modes, recognising that budgets are limited and that there are growing demands on infrastructure assets arising from increasing traffic levels and more frequent extreme weather events due to climate change.

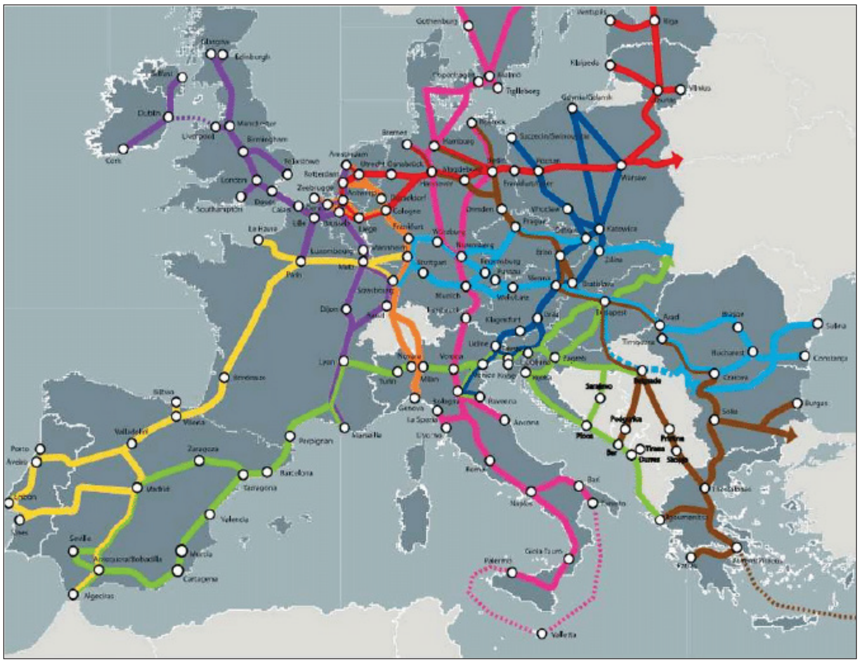

Figure 2 European TEN-T Network

The project will exploit the increase in the availability of asset monitoring data, arising from recent developments in remote monitoring technologies through the development of novel algorithms that enable infrastructure assets to become 'smart' by communicating their current condition. To do so, novel machine learning applications will be developed that use remotely monitored data to provide advanced real-time safety assessments of critical transport infrastructure assets. The ultimate objective of the SAFE-10-T project is to take advantage of the proliferation of transport network data currently available (through linked open data sources, smartphones, advanced vehicles, etc.) by implementing data analytic techniques that support transport infrastructure safety management.

1.1 European TEN-T Network

The European TEN-T network comprises nine core network corridors that form the backbone for transportation in Europe [2]. The demand for both freight and passenger transport in Europe is significantly increasing. By 2050, freight transport activity is expected to have increased by approximately 80 % compared to current levels and passenger transport is anticipated to grow by about 50 % [3].

1.2 Project Objective & Scope

The SAFE-10-T project is developing a global risk framework that will form the basis of an online Decision Support Tool (DST) to support decision-making in relation to the management of transport infrastructure along the European TEN-T network. These decisions primarily relate to medium- to long-term investment decisions for bridges, tunnels and earthworks on road, rail and inland waterway networks, to increase safety and to maximise network capacity. The targeted end-users are government authorities and infrastructure managers who are tasked with allocating budgets for transport infrastructure spending.

1.3 Project Consortium

The SAFE-10-T project brings together a consortium of 14 partners from across Europe, comprising experts in civil engineering, infrastructure risk management, big data management, social science, machine learning, and European transport infrastructure managers. The involvement of transport infrastructure managers in the project means that there is access to real-world asset and network data, which will be employed in three demonstration projects. Furthermore, there are five SMEs involved in the project, which will ensure commercial exploitation of the project outcomes and will also provide a significant contribution to the Europe 2020 strategy for economic growth and job creation [4].

2 Safety Assessment of Transport Infrastructure Assets

Novel methods are being developed in the project to evaluate the safety of individual critical infrastructure assets, including bridges, tunnels and earthworks. Probabilistic methods are being developed to evaluate infrastructure safety and resilience that incorporate monitoring data. The aim of this part of the project is to determine the probability of failure for individual assets, which will provide a key input into the global risk framework.

2.1 Bridges

Probabilistic modelling will be conducted for a number of bridges to determine their failure probability, which will incorporate monitored data. One bridge being examined in the project is the River Ebbw railway bridge in the UK. This single span, simply supported structure is composed of built-up sections carrying a ballasted track. A finite element model has been generated for the bridge (Fig. 3) and train weight data from Weigh-In-Motion (WIM) stations will be used to quantify the reliability of this structure. Crucially, algorithms will be developed to automatically stream data from WIM sites as it becomes available, providing an autonomous structural reliability platform.

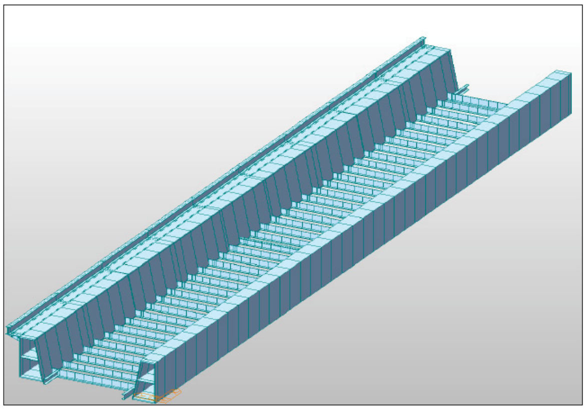

Figure 3 River Ebbw Bridge Model

2.2 Tunnels

A probabilistic displacement model will be developed to evaluate tunnel safety. As part of the project, the Heinenoord tunnel in the Netherlands will be instrumented using fibre-optic strain gauges to measure continuous longitudinal wall strains and to provide an indicator of localised capacity loss due to deterioration of the tunnel over time. The monitored strain measurements will be combined with a numerical model (Fig. 4) to estimate the failure probability of the tunnel.

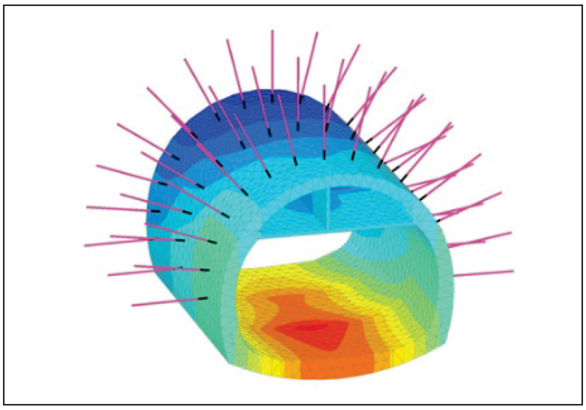

Figure 4 Tunnel Deformation Model

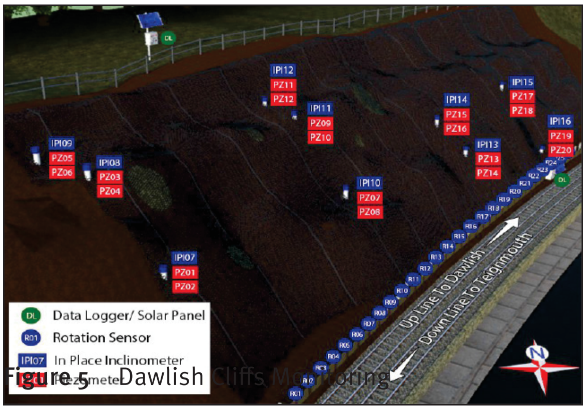

Figure 5 Dawlish Cliffs Monitoring

2.3 Earthworks

A probabilistic safety analysis is being performed for a number of earthworks assets along the railway network in the UK. Data has been obtained from Network Rail for several embankments and coastal assets. Numerical modelling will be conducted to evaluate the stability of these assets, which will consider the monitored data as inputs to the model. A probabilistic analysis will be conducted to account for the epistemic uncertainty associated with geological conditions due to limited site investigation and the analysis will consider environmental loading and its variation due to climate change.

3 Multi-Modal Transport Network Analysis

The project is considering current and future traffic demand in Europe, and is conducting a user demand analysis to quantify the demand for road, rail and inland waterway transport modes. Different population forecasting scenarios are being developed based on employment growth predictions and other demand forecasting techniques to identify major growth corridors in Europe. Alongside this, a multi-modal traffic model is being developed to quantify the consequences of asset failure in terms of transport disruption at network level. Both freight and passenger traffic will be considered across road, rail and inland waterway transport modes within the traffic model. As such, the model will facilitate the analysis of the consequences of the failure of an asset along one network mode on another mode type.

4 Global Risk Framework

The safety models for individual infrastructure assets, as well as the network traffic model, will feed into a global risk framework that will analyse the impact of asset failures in terms of traffic disruption and safety impacts. The global risk framework will be incorporated within an online Decision Support Tool (DST) that can be used to support decision-making regarding the management of infrastructure assets and will ultimately support increased safety and network capacity along the TEN-T network. The DST will also incorporate a whole lifecycle cost model that will enable end-users to determine the economic and environmental impacts of various decisions regarding infrastructure management. The various data inputs and outputs associated with the DST will be hosted on a cloud-based platform (Fig. 6). This will be capable of ingesting a variety of data sources in real time and will be used to implement the novel machine learning algorithms at asset and network level to enable risk-based, information driven decision making. Furthermore, end-users will be able to quantify and visualise network performance due to various traffic scenarios, and hazard events (including climate change effects). Ultimately, the DST assist infrastructure mangers and other stakeholders in making robust, cost-effective decisions that increase safety and maximise capacity.

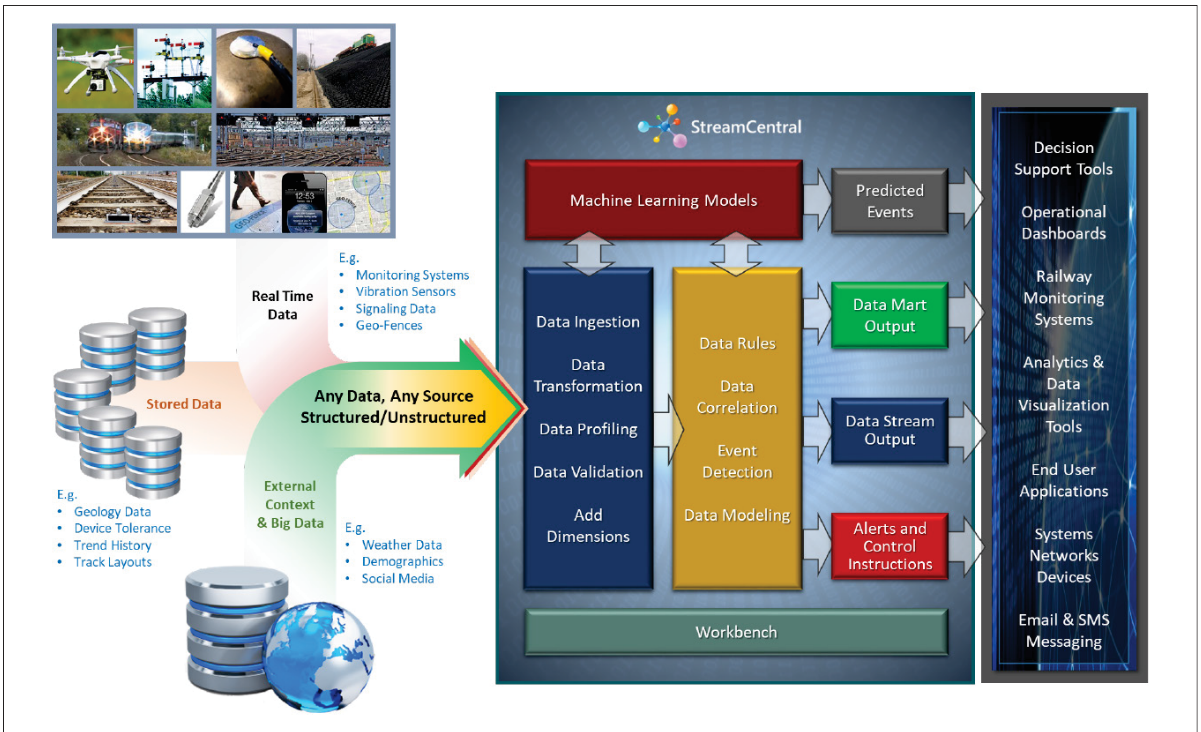

Figure 6 Big data management platform

5 Demonstration Projects

Three demonstration projects are being conducted in the SAFE-10-T project, whereby the methodologies and tools developed in the project will be implemented for real locations along the TEN-T network. These demonstration projects will comprise multi-modal networks, including a major freight corridor, a major tourism route and an urban interchange. The objective is to ensure that the project outputs can be implemented in practice for the purposes of infrastructure management.

5.1 Major Freight Corridor

The Port of Rotterdam (Fig. 7) is the busiest port in Europe and one of the busiest in the world. Goods are transported from Rotterdam via road, rail and inland waterways throughout Europe along the North Sea-Baltic corridor. A severe disruption due to the failure of an infrastructure asset in the vicinity of the Port of Rotterdam is expected to have significant consequences in terms of freight transport disruption across Europe. This demonstration project will quantify the impacts of the failure of a number of key bridges in the region of the Port of Rotterdam in terms of traffic disruption across Europe and safety impacts. To do so, a multi-modal traffic model will be used to quantify the consequences, which will be calibrated using real traffic data gathered during previous temporary bridge closures in the region of the Port of Rotterdam. Much of the data is provided by Rijkswaterstaat and ProRail for this demonstration project.

Figure 7 Port of Rotterdam (North Sea-Baltic corridor)

5.2 Major Tourism Route

Rijeka harbour provides an important gateway to the Mediterranean corridor, which forms an important tourism route in this region. There are a number of tunnels in the vicinity of the harbour that provide a critical connection between Rijeka and the main motorway connection to Zagreb. The project will examine the impact of a tunnel asset failure on passenger traffic during the tourism season, as well as demonstrating the use of monitored data as part of a whole lifecycle cost assessment model for optimised maintenance planning. Much of the data is provided by Croatian Railways for this demonstration project.

Figure 8 Rijeka Harbour (Mediterranean corridor)

5.3 Urban Interchange

The third demonstration project consists of the Severn crossing in the UK, which is a critical urban interchange connection between southern England and South Wales. This crossing is a heavily-trafficked route for daily commuters and freight transport. The project will consider the impact of the failure of earthworks, as well as the Severn tunnel and a nearby bridge in this region in terms of multi-modal transport disruption and safety implications. Much of the data is provided by Network Rail for this demonstration project.

Figure 9 Severn River Crossing

6 Summary

The SAFE-10-T project is developing novel machine learning applications that use remotely monitored data to provide advanced real-time safety assessments of critical infrastructure assets. As such, the project is moving from reactive management of transport infrastructure assets to proactive management. The integration of these safety assessment into a global risk framework that incorporates a multi-modal traffic analysis model will assist in decision making regarding the management and replacement of infrastructure assets along road, rail and inland waterway networks. It is anticipated that the outcomes of the SAFE-10-T project will be transformative for asset management in the transportation sector, and will support safe and reliable European transportation. The involvement of stakeholders and end-users is a key aspect of the project, and will be critical to the development of a novel Decision Support Tool that will support reliable decision making in relation to infrastructure safety and planning. Further information about the SAFE-10-T project is available at www.safe10tproject.eu.

Acknowledgements

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