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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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Organizer
University of Zagreb
Faculty of Civil Engineering
Department of Transportation



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EDITOR

Stjepan Lakušić
Department of Transportation
Faculty of Civil Engineering
University of Zagreb
Zagreb, Croatia

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FUTURE CHALLENGES FOR THE ROAD ASSET MANAGEMENT

Denitsa Osichenko, Roland Spielhofer
AIT Austrian Institute of Technology, Austria

Abstract

Road Asset Management is a systematic process of maintaining, upgrading and operating assets, combining engineering principles with sound business practice and economic rationale (OECD). In fact, it is a high-level management activity conducted by road authorities that help balance cost, risks and performance and includes data acquisition, data analysis and resources and budget planning. Today's pavement managers meet the challenge to address their transportation needs with limited resources. Moreover, the legislative bodies have placed large demands on the highway agencies and more accountability for the expenditure of taxpayers' money. As a result, the importance of management systems is even more significant than ever. In addition, autonomous vehicles are being developed and it is expected that vehicles with conditional automation are driving on motorways from 2019. These vehicles use a variety of sensors and cameras, which inspect the objects around it and detect road signs and lane markings. Furthermore, vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) technologies are designed to allow automobiles to share information to each other and to the infrastructure and provide important information to improve the road safety. To date, several studies indicated that the environmental impact resulted from the road maintenance works or the operation of the road (congestion, noise, pollution, etc.) need to be considered in the asset management process. Furthermore, to make the final decision between alternative maintenance strategies road operators should take into consideration the impacts on socio-economic life. Moreover, new measurement systems are developed in the last years, which provide additional information for the road assets condition at traffic speed and improve the measurements with higher accuracy. This paper presents relevant topics and future challenges for the Road Asset Management. It summarizes latest issues related to the road infrastructure managing and maintaining and outlines new themes for future research.

1 Introduction

The number of motor vehicles in the world is growing rapidly over the past several years. The automotive trade journal Ward's Auto had estimated that the total crossed 1 billion vehicles sometime during 2010. Moreover, about 2 billion vehicles are estimated to be on the roads by 2035, according to a report from Navigant Research. In addition, autonomous vehicles are being developed and they are already driving themselves on roads, but they are still restricted to specific test areas and driving conditions (QUARTZ, 2017). However, it is expected that vehicles with conditional automation driving on the roads from 2019 (THE VERGE). Furthermore, Vehicular communication systems (V2V and V2I) are developed for providing vehicles and roadside units with information, such as safety warnings and traffic information. All these technologies lead to enormous changes and new requirements for the infrastructure and the road asset management.

In addition, several projects have shown that the environmental impact and the socio-economic issues should be included in the asset management process (EVITA – Environmental Performance Indicators for the Total Road Infrastructure Assets, ISABELA – Integration of social

aspects and benefits into life-cycle asset management). Advanced/ recent asset management systems are limited to road data and traffic data and in some cases, they include also weather data. Information about air quality, CO₂ emission, noise etc. is very often missing or limited. In recent years, the issue of fuel consumption and CO₂ emissions has received significant attention by the public, environmental and consumer organizations. In order for the world to stay within the safety threshold of a 2°C increase in average temperature agreed by virtually all governments, the transport sector needs to be decarbonized (Santos G., 2017). Furthermore, travel time and vehicle operating costs should be also included in the analysis. They are highly correlated to road conditions (ISABELA, D2.1).

Recently, new measurement systems with high accuracy were developed and added in the routine measurements at network level. Projects like HiSPEQ (High-speed survey equipment) and PREMiUM (Practical Road Equipment Measurement Understanding and Management) presents different measurement methods for measurements at traffic speed. Measurement of surface characteristics as skid resistance, evenness, texture and deterioration with high-speed systems and emerging equipment are well established, while others for monitoring and inventory of road signs and markings are not. However, the attention of these two assets has increased extremely in recent years with the development of autonomous vehicles and Vehicular communication technology. These systems use a variety of sensors and cameras to observe its surroundings, to locate itself on the road and help it to drive safely.

Furthermore, the information for the road structure is very often missing or limited. Surprises often occur during repair works – repairs have been done without historical records. This leads to a significant increase in costs for repair and maintenance.

In addition, the weather condition in recent years have been drastically changed – frequent phenomena are heavy rainfall and high temperatures, snow falls in places where this is not typical. These phenomena sometimes lead to the destruction of the infrastructure and additional costs. Therefore, road weather data is also very important puzzle piece of the asset management system.

So far, much attention is paid to autonomous cars, but very little is known about the information, that is needed. Moreover, several projects investigate the environmental impact and socio-economic aspects, but their implementation in asset management system is still under question. As previously mentioned, there are new measurements systems, which can provide data at traffic speed, but why is the information still limited or missing?

This paper provides an overview of relevant topics and future challenges for the Road Asset Management and tries to answer this question. In the pages that follow, it will be summarized latest issues related to the road infrastructure managing and maintaining. In addition, new topics and themes for future research will be outlined.

2 Vehicles and infrastructure

By 2035, the number of vehicles on the road worldwide will double to 1.7 billion (CNBC). The motorization rate per 1000 inhabitants according to ACEA is shown on Figure 1. The presence of so many vehicles also requires the construction of road infrastructure. One of the biggest road networks are: USA (6.58 million km), China (4.24 million km), India (4.1 million km), Brazil (1.6 million km), Russia (1.28 million km), Japan (1.21 million km), Canada (1.04 million km), France (1.02 million km), Australia (823,000 km) and Spain (683,000 km) (RTT). Maintaining road infrastructure in good condition is an important and responsible issue with many resources and costs. The fast-growing road network and motorisation rate make this task even more complex and difficult.

In addition, vehicles with advanced driver assistant systems (ADAS) were developed and are on the roads with specific restrictions (QUARTZ, 2017). However, it is expected that vehicles with conditional automation (i.e. SAE Level 3, “Highway Chauffeur”) are driving on motorways from 2019 (ERTRAC, 2017).

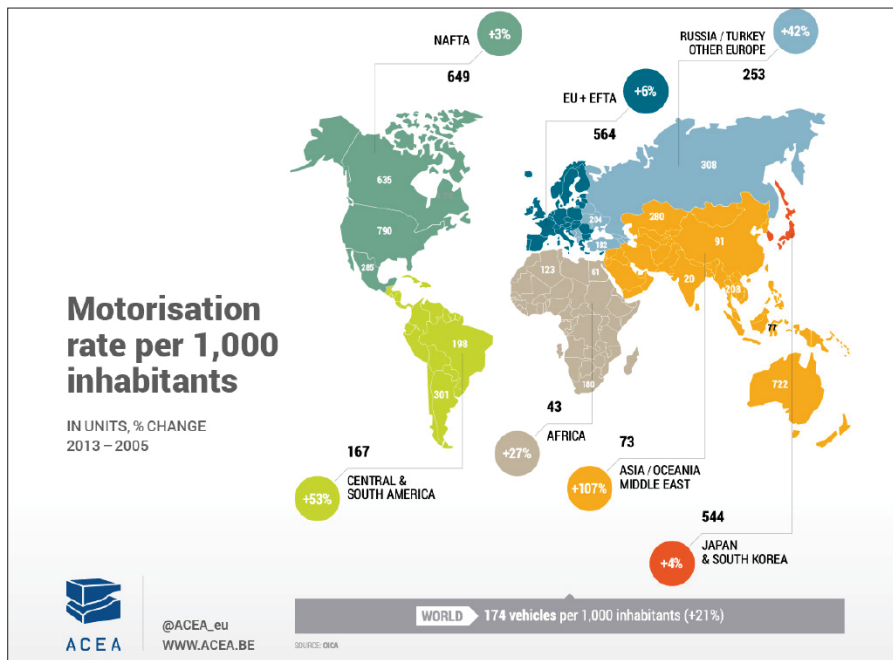


Figure 1 Motorisation rate per 1 000 inhabitants, worldwide
 (Source: ACEA https://twitter.com/ACEA_eu/status/943092058385997824)

As previously mentioned, ADAS systems use a variety of sensors and cameras to observe, navigate and drive safely. Cameras e.g. detect road signs and Lidar and Radar sensors help to detect the edges of roads and identify lane markings (Hsieh et al, 2007). Therefore, the inventory and condition data of road signs and markings take on a greater aspect of importance for ADAS – and even more for autonomous driving.

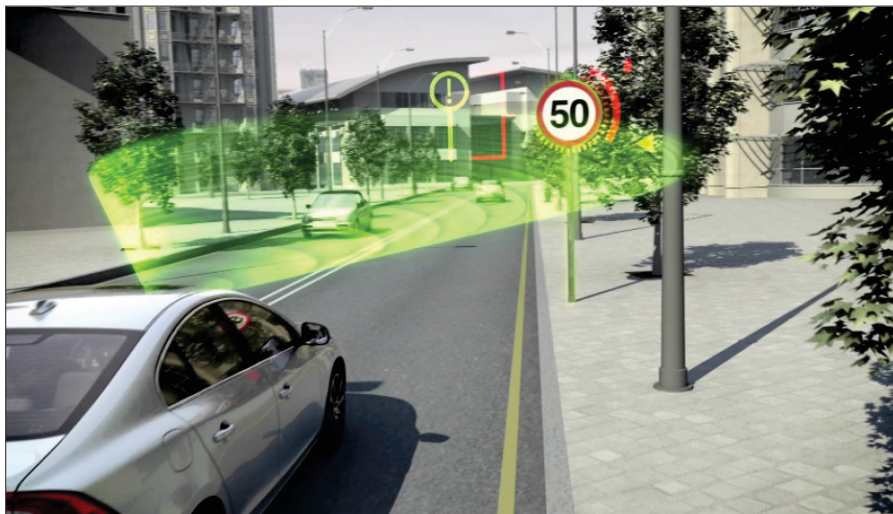


Figure 2 Vehicle with Vehicular communication systems
 (source: <https://www.youtube.com/watch?v=U-SBY9eJ-xc>)

The visibility of road markings and signs is crucial for the driving, both at day-time and night-time, in dry and wet conditions. Inventory information and measurements of road marking and sign characteristics will provide information for its condition and proper planning of the maintenance measures and reduce the costs. In PREMium were identified some measurement systems that have potential for data collection at traffic speed and cover the whole network. Image based methods and Lidar technology offer to automate the assessment process and reduce the manual work. Nevertheless, robustness and completeness of these systems are still in test phase and more investigation is needed.

3 Environmental impact and socio-economic aspects

To date, several studies have reported the importance of the environmental impact and socio-economic aspects for the road asset management: ISABELA (Integration of Social Aspects and Benefits into Life-cycle Asset Management), EVITA (Environmental Performance Indicators for the Total Road Infrastructure Assets), COST 356 (Indicators of Environmental Sustainability in Transport), SILVIA (Sustainable Road Surfaces for Traffic Noise Control); SILENCE (Quieter Surface Transport in Urban Areas). Table 1 presents the summary of existing technical environmental performance indicators, reported in EVITA:

Table 1 Summary of existing technical environmental performance indicators (Source: EVITA D2.1)

Area	Indicator / Technical parameter	Assessment ID
Noise	Equivalent continuous sound level, L_{eq} , $L_{Aeq,T}$	N1
	Day–Evening–Night equivalent level L_{den}	N2
	Night time level L_{night}	N3
	Sound absorption coefficient	N4
Air pollution	Concentration of pollutants ($PM_{2.5}$, PM_{10} , NO_x , SO_2 , NMVOC, CO, Hg, Pg, HC)	A1
Water pollution	Concentration of heavy metals (Cd, Cu, Pb, Cr, Zn, Fe, Ni, Na)	W1
	Concentration of total hydrocarbons (polynuclear aromatic hydrocarbons, PAH)	W2
	Concentration of de-icing salt (sulphate, calcium chloride, sodium, cyanide)	W3
Natural resources	Waste reduction (Use of recycled materials in construction)	R1
	Energy consumption	R2
GHG	Emission of CO ₂ equivalent (CO ₂ e)	G1

But, why environmental impact and socio-economic aspects are so important for the asset management? Worldwide, in 2014 transport as a whole was responsible for 23 % of total CO₂ emissions from fuel combustion and road transport was responsible for 20 % (Santos, G., 2017). The European Union’s 2030 climate and energy framework requires the transport, building and agriculture sectors to reduce greenhouse gas emissions to 30 percent below a 2005 baseline by 2030. Transport (including road, rail and inland waterways) is the largest contributor of GHG emissions. Radically reducing emissions from transport is essential to meeting the 2030 climate goals (ICCT). Miller J. describes several methods for achieving the 2030 target for non-ETS sectors. His paper focuses on CO₂ from light-duty vehicles (LDV), which include passenger cars and vans, and heavy-duty vehicles (HDV), which include medium trucks, heavy trucks, and buses. Together, LDVs and HDVs account for 95 % of GHG emissions from non-ETS transport and one-fifth of total EU GHG emissions, and CO₂ accounts for 99 % of GHG emissions from road transport. In detail are described following methods and strategies for reducing the CO₂ emissions in transport sector:

- Inclusion of road transport in EU ETS;
- Light-duty vehicle efficiency;
- Heavy-duty vehicle efficiency;
- Electric drive vehicles;
- Biofuels;
- Fuel taxes.

“Establishing stable policy will be crucial to encourage further investments and innovations in low carbon transport technologies, particularly in advanced biofuels and electric vehicle infrastructure” (<https://epure.org/media/1350/briefing-on-the-road-to-2030-decarbonising->

europes-road-transport-sector.pdf). Reducing emissions is an important and responsible issue for all users and road owners. The presence of emission data is essential for pollution control and better living conditions.

4 New measurement systems

Recently, new technologies were developed, that can provide data with high accuracy at traffic speed. Projects like HiSPEQ, PREMIUM, ROSANNE and TYROSAFE reported about these measurement systems, their advantages and limitation. A short overview of all these systems is presented on Figure 3.

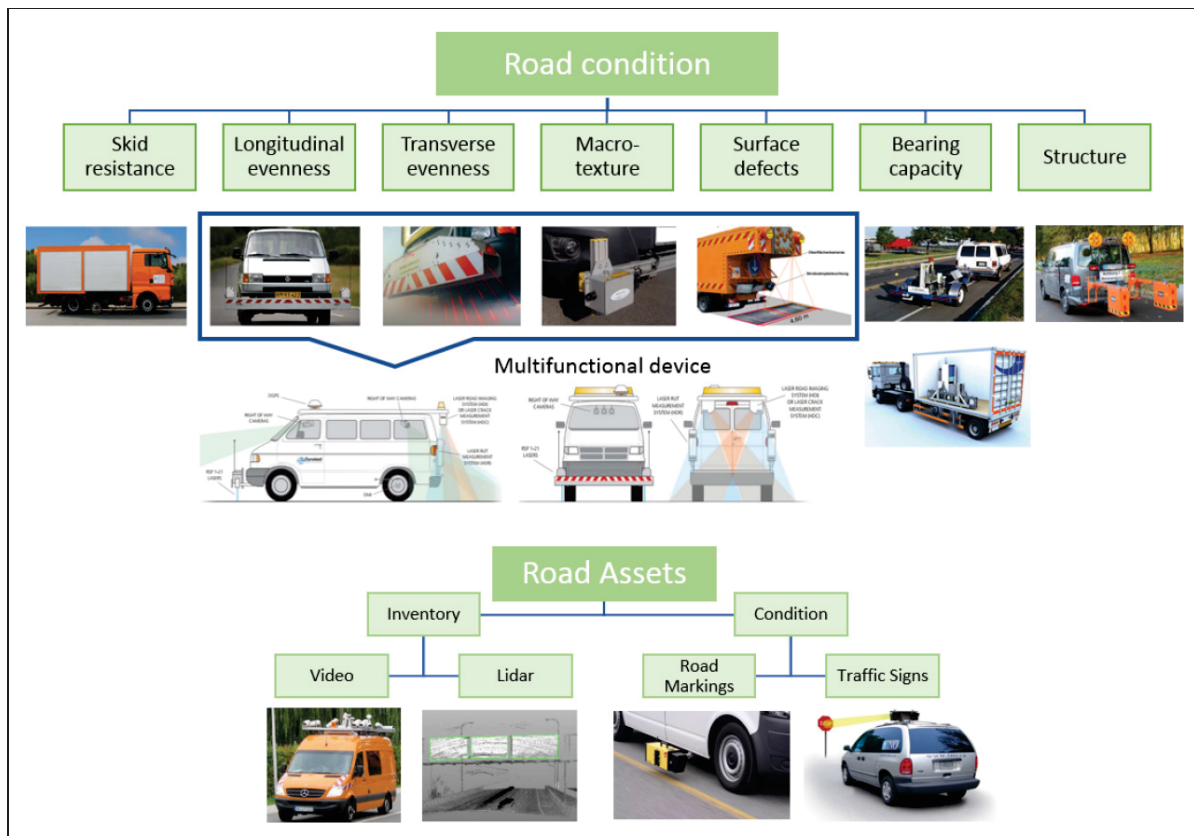


Figure 3 Measurement systems (summary of HiSPEQ, PREMIUM, ROSANNE and TYROSAFE)

These measurement systems can provide data for the road network, but vehicles with advanced driver assistant systems (ADAS) have also lasers and scanners and can collect inventory and condition data for the road. Is this data the same as this from the measurement devices? Can we compare the information? Moreover, ADAS vehicles can provide this information in real time. Can we use these data? Do we need new measurement devices?

The answers to all these questions are extremely important for the further development of Road Asset Management. Further research is needed to improve the measurement methods and devices and the implement the new technologies into the measurement process. In addition, the correlation between road data from measurement systems and vehicle with advanced driver assistant systems is under question.

5 Climate changes

One of the greatest challenges for the infrastructure in the past few years are the climate changes. More and more frequent rainfall and very high temperatures during the summer. They lead to serious destruction of road infrastructure and the closing of roads for a long time. The

main question is how to prepare for these phenomena and to prevent serious damage to road infrastructure. FHWA reports for three types of road weather information: atmospheric data, pavement data, and water level data. Atmospheric data include air temperature and humidity, visibility distance, wind speed and direction, precipitation type and rate, cloud cover, tornado or waterspout occurrence, lightning, storm cell location and track, as well as air quality. Pavement data include pavement temperature, pavement freezing point, pavement condition (e.g., wet, icy, flooded), pavement chemical concentration, and subsurface conditions (e.g., soil temperature). Water level data include stream, river, and lake levels near roads, as well as tide levels (i.e., hurricane storm surge).

To make road weather management decisions, transportation managers must access data on environmental conditions from observing systems and forecast providers. Observing system technologies include fixed environmental sensor stations (ESS), mobile sensing devices, and remote sensing systems. An Environmental Sensor Station (ESS) is a roadway location with one or more fixed sensors measuring atmospheric, pavement and/or water level conditions. Mobile sensors are deployed to observe environmental conditions from any type of vehicle. Vehicle-mounted sensor systems can be utilized to sense pavement conditions (e.g., temperature, friction) and atmospheric conditions (e.g., air temperature), which are transmitted to central locations via Automated Vehicle Location (AVL) and Global Positioning System (GPS) technologies. In remote sensing, a detector is located at a significant distance from a target. The sensor can be mounted on unmanned aerial vehicles or part of a radar or satellite system used for surveillance of meteorological and oceanographic conditions. Images and observations from remote sensors are used for weather monitoring and forecasting from local to global scales (FHWA).

6 Conclusion

This paper summarizes the following challenges for the road asset management systems:

- The fast-growing road network and motorisation rate
- vehicles with advanced driver assistant systems
- Environmental impact and socio-economic aspects
- New measurement systems
- Climate changes

The fast-growing road network and autonomous vehicles lead to higher requirements for the condition and safety of road infrastructure. Information for road assets (road marking, traffic signs, VRS) is crucial for vehicles with advanced driver assistant systems. Measurement of surface characteristics as skid resistance, evenness, texture and deterioration with high-speed systems and emerging equipment are well established, while others for monitoring and inventory of road signs and markings are not. Current methods are mainly locally limited or the data are reported on project-level. Moreover, the information is often outdated or still missing. This can reduce the road safety and increase the costs for maintenance.

In other hand, environmental impact and socio-economic aspects can optimize the decision-making process. In addition, decarbonizing the roads is our high-priority task for near future. The presence of road infrastructure information is the key for Asset Management System, but whether standard methods meet current requirements? What about data in real time from vehicles with advanced driver assistant systems?

All these issues are to be addressed in future projects and investigations. It is necessary to improve the Road Asset Management, paying attention to the issues discussed in this paper. The necessary information on Road Asset Management can be considered as building blocks, as shown on Figure 4. In future, it is vital to improve the methods of collecting information and their implementation in the asset management. New technologies are on the road and they need information for comfort and safe driving.

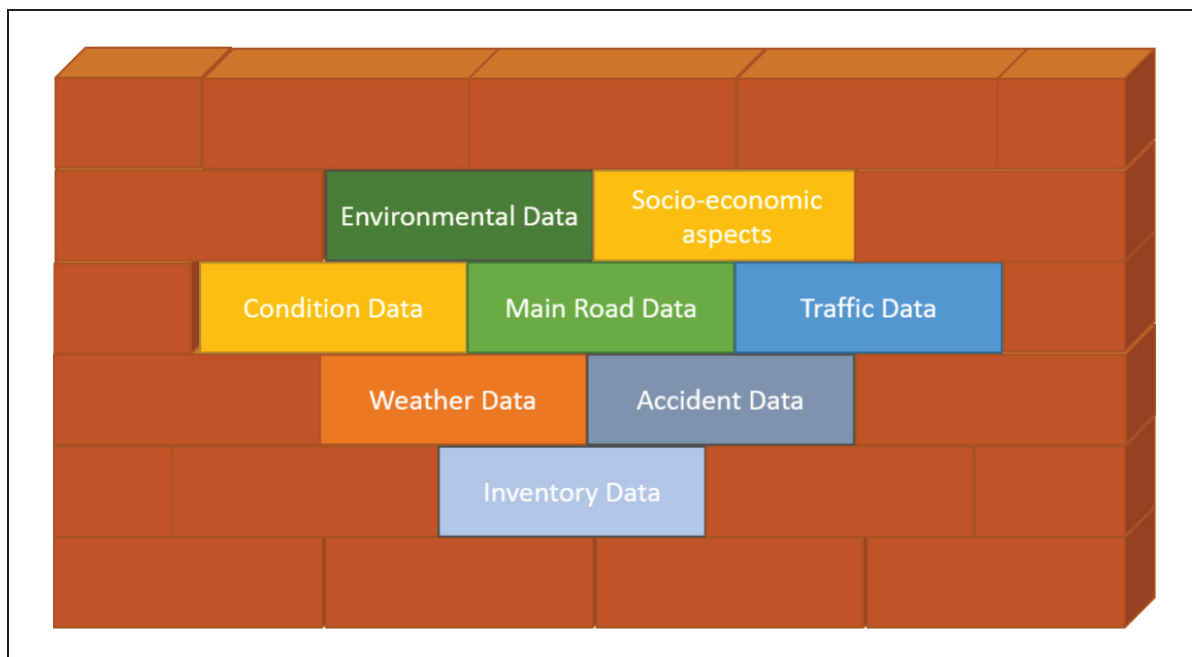


Figure 4 Building blocks for Asset Management System

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