The path towards digitalisation in road infrastructure

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contents

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The path towards digitalisation in road infrastructure

Editorial Introduction by the Guest Editor

This special issue offers an overview on digitalisation in road infrastructure. Digitalisation has a vertical impact across the several layers of the road system. This will bring, in the medium to long term, profound challenges and disruptions to the existing status quo in terms of construction, management, and particularly, operation of road systems. From technical design standards up to Mobility as a Service and digital platforms that allow the appearance of new services and mobility solutions, a new paradigm is emerging, able to extract added value from road investments.

The road infrastructure was traditionally the central element in the planning and management process of road transport. The focus is changing, and the service and users are now at the very center of the management process. Policy makers, regulators, infrastructure managers and road operators can extract significant benefits from the digitalisation, but to reap those full benefits, it will be necessary to have a clear view on the path ahead.

This special issue of the Network Industries Quarterly (NIQ) presents a set of five papers, developed by Researchers of Instituto Superior Técnico – University of Lisbon (Portugal), that provide a holistic perspective over the challenges, impacts, and risks of digitalisation in the road sector.

Neves and Velez developed a paper on the expected impacts of autonomous vehicles on road infrastructures of old urban centers.

Baptista and Duarte look into the trends of vehicle electrification and its challenges for infrastructure.

Sousa and Meireles analyse digitalisation of road infrastructure from a risk management perspective, particularly the possibility of implementing of a holistic quantitative risk management approach, allowed by the growing digitalisation.

Trindade and Almeida offer an analysis of digitalisation on the value realisation from infrastructure assets in asset-intensive organisations

Finally, Moura looks into digital platforms, particularly Mobility as a Service approaches.

Guest editor: Carlos Oliveira Cruz

The guest editor of this special issue is Dr. Carlos Oliveira Cruz, Assistant Professor at Instituto Superior Técnico (University of Lisbon) and Senior Researcher at the Civil Engineering Research and Innovation for Sustainability (CERIS), oliveira.cruz@tecnico.ulisboa.pt

dossier

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The impacts of autonomous vehicles on urban road infrastructures

José Neves[1], João Velez[2]

Autonomous vehicles are leading to a significant revolution in road transportation systems, with enormous challenges to mobility through several vectors, e.g., economic, legal, social, psychological, and technological. This paper deals with the expected impacts of autonomous vehicles on road infrastructures of old urban centres.

Introduction

Autonomous vehicles (AVs) are vehicles that can move automatically and independently of human intervention. There are five automation levels associated with these vehicles: Levels 1–5. Levels 4 and 5 are the highest levels of automation, corresponding to a complete automated driving system (SAE International 2016). The penetration of AVs in road traffic will be a major revolution in road transportation in general (Bunghez 2015, Meyer et al. 2017). Besides the uncertainty inherent in predictions, it is consensual that AVs will affect future mobility and accessibility through several vectors, e.g., economic, legal, social, psychological, and technological (Bunghez 2015, Litman 2018, Meyer et al. 2017). Most critical aspects of AVs implementation are currently related to either technology developments or road environment interactions that are generally complex and present additional risks and costs (Hulse et al. 2018, Rathore 2016). In the case of urban environment, the relationships between AVs and users (e.g., motorcyclists, cyclists, and pedestrians), equipment (e.g., barriers, signals, and other urban furniture), and infrastructure design (e.g., bus stops, parking areas, pedestrian zones, and street features) become more important to avoid issues with safety, efficiency, and performance (Duarte and Ratti 2018, Hulse et al. 2017, Montanaro et al. 2017). The particularities of old urban centres (e.g., high volumes of road users, high density of equipment, and reduced and irregular infrastructure geometry) lead to additional impacts on AVs and on the need for significant transport policies and planning to be accounted for by municipalities (Fagnant and Kockelman 2015, Metz 2018). This paper has the objective of making a reflection on the expected impacts of autonomous vehicles in road infrastructures of old urban centres in terms of planning and design, traffic management, equipment, users, and environment.

Methodology

A case study of an old urban centre was selected to model different realisations of AVs and consequently to overcome the impossibility and complexity of analysis in real conditions (Lang et al. 2017). The historical centre of downtown Lisbon was chosen, considering that its main characteristics are very representative of old cities of the south of Europe, with typical planning and design. This area, called "Baixa Pombalina," is the main tourism, shopping, and banking district of the city, characterised by intense vehicle and pedestrian traffic, with an enormous impact on traffic congestion and air pollution (Velez, 2018).

The model of this area was performed using PTV Visum software and considering the following transportation modes: private vehicle (car), AV, public bus (bus), and pedestrians (walking). The model considered different scenarios of AV penetration: Scenario 1 corresponded to the current traffic flows related to private and public transport modes (cars and buses); Scenario 2 was characterised by the total removal and replacement of the car mode, i.e., the transportation system consisted of AVs, with the same permissions as the car mode, and buses; Scenario 3 consisted of the total sharing of the same route between the AVs and the car mode, i.e., the AVs circulating in mixed traffic; in Scenario 4, the AVs mode was only allowed to travel in a special lane (in parallel with the bus lane), not crossing the same lane as the car mode. Only over ground modes of transport were considered in the model, regarding that in this area there are two underground subway lines. Velez (2018) describes the network (links, nodes, zones, and connectors) in more detail and demands a model of the case study zone.

The model intends to point out the challenges of AVs in the road infrastructures of the case study zone at different relationship levels: planning and design, traffic

[1]Assistant Professor, CERIS, Department of Civil Engineering, Architecture and Georesources, Instituto Superior Técnico, Universidade de Lisboa, Portugal, jose.manuel.neves@tecnico.ulisboa.pt
[2]Master Student in Civil Engineering, Instituto Superior Técnico, Universidade de Lisboa, Portugal, jps.velez@gmail.com

management, equipment, users, and environment (Figure 1).

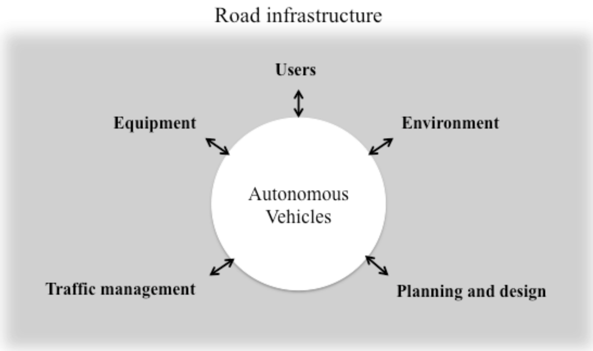

Figure 1. Relationships between AVs and urban road infrastructures

Source: Authors' own compilation

Results and discussion

Planning and design changes to road infrastructures will be necessary in order to ensure the efficiency and safety circulation of AVs in urban centres.

Two perspectives of including AVs in the traffic of urban centres can be implemented: the AVs have a shared or taxi function with the ability to pull over and safely pick up or drop off passengers and then return to the traffic flow with a new route; the AVs have a valet capability, and after leaving the passenger and avoiding wasting time for its user, will have to find a parking place and pick up its user again at the end of the workday. In both cases, unless the street layout is suitable for executing these maneuvers without disrupting the normal traffic flow, specific zones should be created for this purpose. This could be more critical in the case of intermodal interfaces.

AVs can move more accurately in narrower lanes. However, in a mixed traffic scenario, vehicles with a human driver will be conditioning. The presence of AVs will increase the street capacity, mainly due to the low speed and reduced headways of vehicles (more effective in platoons) in the traffic flow. AVs can also be managed with more efficiency in intersections and can perform curves with reduced curvature radii. However, the ability to detect the vehicles in proximity continues to be important. This will require the navigation and communication systems to be perfectly functioning, leading to a central physical and digital system that manages this information.

If an exclusive AV lane is intended, similar to a bus lane, it would be necessary to adapt the existing number and width of lanes on the street. Additional difficulties can emerge from this. It may be unacceptable to take away public space, limiting or even preventing the creation of an AV lane in that way. If it is decided that AVs will share the bus lane, problems and collisions with human drivers may occur, because there is no physical barrier, only a formal one (which is often not respected by other drivers).

Looking at the relationship between AVs and road infrastructure, a radical scenario characterised by completely closing roads off to regular car traffic, except for AVs or cars with a minimum of Level 3 autonomy, could induce great inconveniences and may appear as the most prudent scenario. In the short or medium term, depending on the importance and representativeness of services, businesses, housing, the enormous movement of people and goods, and the sweeping renewal of the car fleet by the residents, this could represent a huge inconvenience to the citizens and a profound economic impact with enormous negative repercussions.

For example, lanes for platooning on the freeways are stipulated. However, in an urban environment, the creation of isolated streets or neighborhoods that are exclusively for AVs can be considered. In these cases, a physical barrier to divide pathways should be created. To guarantee the current volumes of traffic, and regarding a long-term scenario, the need to replicate the infrastructure specifically for AVs seems reasonable.

In contrast, in a scenario where human and nonhuman drivers coexist or even vehicles with varying degrees of autonomy (Level 0 to 5), the possibility of collision is real, because humans have disruptive behaviors, and even the vehicles themselves have different capacities and degrees of autonomy. Moreover, to ensure the coexistence of these completely different types of drivers, a near duplication of the infrastructure or a substantial reinforcement of the existing one would be necessary to guarantee safe conditions for AVs.

The implementation of platooning on AVs driving could be very harsh on the road surface. The inexistence of a lateral wheel wander can induce significant damages to the road surface structure. The construction and maintenance of road surfaces that are more resistant to permanent deformations deserve more attention.

Classical traffic management will be changing with AV implementation, due to the need for connectivity between vehicles and infrastructures. Traffic signs, marks, and lights will undergo a great evolution, and change and will need to become more digital. Vertical signals would be redundant, complemented by a central traffic control system to support the navigation and communication with AVs. An irregular road network may be confusing for AVs and may result in collisions with other modes. The lines on the pavement surface need to be perfectly defined and in good condition to achieve the allocation and correct movement in the respective lanes. It is essential that the road surface is in perfect condition and that the horizontal markings are maintained regularly.

Numerous and diversified equipment (barriers, signals, and other urban furniture) in the proximity of AVs lanes should be analysed in order to always guarantee the efficiency and safety of the AVs. In a scenario in which electric cars are highlighted, as is already happening in several cities, it would be a good idea to associate parking spaces with charging points for vehicles.

Old urban centres are characterised by having several road users (motorcyclists, cyclists and pedestrians) in conjunction with traffic vehicles. The AVs could be circulating in dangerous conditions, because the road is shared with human drivers (vehicles, motorcycles, cyclists, heavy trucks, buses), and there is still a considerable number of pedestrians on the nearby pavements. With a great number of warning signals given by the various moving elements, the AVs would probably reduce their speed, and may even stop completely, potentially leading to an eventual accident. To avoid this situation, using physical barriers between vehicles and pedestrians can minimize the scale of alert.

The use of AVs as shared vehicles or as a taxi service leads to a significant reduction of the total number of vehicles circulating in the urban centres. This reduction and the fact that AVs will probably be mainly electric, will contribute to the general reduction of air pollutant emissions in urban centres, substantially improving the air quality.

The various scenarios modelled in the case study have confirmed general benefits on the AVs implementation in urban centers. There was a general tendency for the increase of AVs speed in congested traffic in Scenario 2. For the case of mixed traffic (Scenario 3), an increase of speed in both transport modes was obtained. For Scenario 4, AVs had a significant decrease in speed due to the AV corridor. Regarding CO2 emissions, the modelling has showed the most significant decrease, at 83%, in the case of Scenario 2.

The difficulty in implementing AVs in urban environments is still a reality. Changes and improvements to infrastructure will be necessary for the integration of AVs. While on the one hand it is difficult to change the existing infrastructure to create sharing conditions, it is even more difficult to guarantee safety for various participants. In the current state of technology, it would be a challenge to guarantee operational levels in mixed traffic, without too much caution also becoming a reason for congestion. Moreover, there would be a need for a strong initial investment in a digital infrastructure that guarantees centralised traffic management, making the navigation and communication of the vehicles in the city possible. The scenario that would allow for a greater space, for the benefits of AV to stand out, would be in an exclusive scenario for its movement, which for now is very difficult, if not practically impossible.

Conclusions

The current knowledge about AVs is still cause for uncertainty about the implications that AVs will have on the future of mobility and accessibility. However, technical advances that are in progress may predict major changes in the near future. It is expected that most of the current legal, social, psychological, and technological issues will be overcome soon.

In the particular case of old urban centres, the presence of AVs will have a positive impact on road infrastructures: the reduction of traffic congestion, the improvement of air quality, and the increase of traffic safety and infrastructure capacity. All these benefits are aligned with fundamental societal goals, such as decarbonisation or an inclusive and circular economy.

Despite the intention to objectively clarify the adaptations needed for road infrastructure for the use of AVs, this is still a difficult task at present. However, it is possible to confirm that the major changes in infrastructure will be at a digital level, not only in the physical infrastructure. In fact, the urban road infrastructures will be more digital, more connected to and from AVs, through intelligent traffic coordination at street intersections, and vertical and horizontal digital signals. The existence of a traffic management system will allow the aggregation and orientation of the various vehicles in a single stream of traffic. In fact, the connectivity of vehicle-to-infrastructure (V2I) and infrastructure-to-vehicle (I2V) allow for optimization of the traffic flow in comparison with the current reality.

These infrastructure changes will require public investment and planning. Because a period of adaptation of the market to the AVs is foreseen, it is also considered that there will be a redundancy in the infrastructure that will allow the coexistence of both AVs and nonautonomous cars. However, regarding the technological requirements of AVs to monitor the surrounding environment, the need for a well-maintained road network will be essential. In this sense, it is expected that in urban areas the adaptation may take some time, due to the greater fear of integrating the AVs into a more problematic environment.

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The challenges of vehicles electrification for road infrastructure

Patrícia Baptista[1], Gonçalo Duarte[1,2]

The transport sector has been evolving with the introduction of electricity powered vehicles, with associated requirements in terms of electric vehicle supply equipment (EVSE). Even if the deployment of EVSE started with less technological solutions mainly focused on urban environment, it has lately been expanding to long-distance trips with the deployment of a growing fast-charging EVSE network. This brings new opportunities for road infrastructure, namely highways, which must be adapted to accompany these trends of new vehicle technologies.

The transport sector has been rapidly facing a new paradigm, mostly related to how the user interacts with different mobility products and with the need to mitigate their externalities. One of these options has been diversification of vehicle technologies and of energy sources by the steady electrification of vehicles' powertrains. If this electrification started with hybrid electric vehicles in the 1990s, without requiring a recharging procedure with associated electric vehicle supply equipment (EVSE), the last 5 years has seen a wider adoption of battery electric vehicles (BEVs) and of plug-in hybrid electric vehicles (PHEVs), increasing the need for a complimentary EVSE network. In more detail, the European BEV and PHEV has increased significantly, approximately 180 thousand vehicle sales in 2017, having surpassed the 1% share of sales in 2015 [1][2].

The initial adoption of BEV and even PHEV was focused on urban use. It is in urban context that the potential for local pollutant mitigation and noise reduction is more significant, so the promotion of electric mobility has been pursued mostly focused on this environment. Furthermore, the majority of vehicles available in the market regard the B-segment, more directed to a quotidian, commuting use. In fact, contradicting the general belief that vehicle range would be insufficient for BEV use, several studies show that electric mobility is highly feasible for weekday urban trips [1,3,4], while weekend trips, due to their higher average distance, are less suitable to be performed by EVs. A study for the city of Lisbon, Portugal, showed that the percentage of eligible real-world trips for BEV was found to be equal to or higher than 94% and 88% on weekdays and weekend days, respectively. The same study showed that lower electric mobility feasibility would be associated with considering only daytime charging, while if considering night charging, electric mobility eligibility would improve significantly [3].

All these facts have justified that the first investments in EVSE have been centered in cities, directed at a daily use of vehicles, mostly to the home-work-home commute. Also, vehicle users have shown a clear preference for home and workplace recharging, namely stated in surveys for Nordic countries, stating that a large majority of EV owners perform their charging routine daily or weekly at home [5]. Consequently, in the last decade, around 60 thousand EVSE have been deployed in Europe with countries such as France, Germany, the United Kingdom, and Norway being leaders in the implementation of this infrastructure [1]. This deployment was accompanied by complimentary studies regarding the optimal location for the EVSE, with different approaches regarding home, work, or street charging [6][7].

Additionally, the deployed EVSE started with less technological solutions that within time have evolved into more integrated and robust solutions. Even if a simple socket can be used for recharging a BEV or PHEV, matters of safety and of current limitation (resulting in higher recharging times) have justified more developed options. The most significant barrier to the wider deployment of EVSE has been its cost, justifying economic feasibility studies for quantifying the tradeoff between economic and energy/environmental impacts for deployment of EV parking spaces. One example focused on urban context by comparing cities such as Lisbon, Madrid, Minneapolis, and Manhattan concluded that the maximization of the parking premium and the minimization of the equipment cost lead to higher net present value results [8].

Currently, urban centers have reached a point that already have some offer of standard EVSE and where an opportunity arises for solving the range anxiety problem associated with electric mobility. If on a daily basis, the current battery capacities are proving to be enough for most of home-work-home commuting mobility patterns, the occasional long-distance trips are on the verge of being possible with the deployment of a growing fast-charging EVSE network.

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[1] IN+, Center for Innovation, Technology and Policy Research – Instituto Superior Técnico, Universidade de Lisboa, patricia.baptista@tecnico.ulisboa.pt
[2] ADEM, Mechanical Engineering Department - Instituto Superior de Engenharia de Lisboa (ISEL)

The recharging types and modes differ significantly, according to the level of control and protection, as well as the voltages and current involved. These different levels can be found in both the infrastructure and vehicle, identified by three main characteristics, which include level (the range of the power output of the EVSE outlet), type (the type of socket and connector used for recharging), and mode (the type of communication protocol used between the vehicle and the EVSE). In the European context, slow charging is typically dominated by modes 2 and 3 (wall socket and wall box, respectively) and type 3 connector (the standard connector in recent BEV vehicles manufactured in Europe). This configuration can handle 3 to 22 kW, if charging from a socket or a wall box, respectively [9]. Therefore, if charging occurs in public parking, the occupancy rate of parking places with charging infrastructure is high, and rotation is low.

Fast charging mainly uses CCS Combo and CHAdeMO plugs, ranging from 43 kW AC to 120 kW DC [9]. This is a potential solution to overcome the high occupancy and low rotation of parking places. It is also the best solution to deploy a roadmap towards the battery range limitations on long-distance trips. The choice has been to deploy fast EVSE in the most important highway corridors, enabling a 20- to 30-minute stop to reach the 85% state-of-charge required to continue the trip.

Due to the importance of deploying EVSE along the major road networks to enable the long-distance driving of BEV and PHEV, the main markets have ramped up their goals for EVSE along highways. This ambition is reflected in the targets for number of EVSE (set at 800 for China, around 600 for the EU, and 900 for the USA), and in the target distance between EVSE in these corridors (45 km for China, 60 km for the EU and 115 km for the USA) [1]. These are ambitious values for which emerging market opportunities arise, possibly requiring regulatory and fiscal policies that support this EVSE expansion.

Moreover, the expansion of the EVSE network is also highly dependent on local market circumstances, resulting in national policy frameworks that influence the regulatory framework and the mobilization for funding for direct investment and for other types of financial support. The existence of such conditions, at least in some markets, is triggering private sector stakeholders, including vehicle manufactures, and utility companies as well as oil companies, to more actively begin entering the EVSE market, which in a longer term will be a positive sign for more competitive products and prices associated to recharging.

Additionally, the rapid technological development observed in recent decades may also rapidly change the paradigm in the recharging of electric vehicles. Aftermarket suppliers and OEMs have tested inductive recharging as a seamless solution regarding the interaction of vehicle and road. This solution has been tested on parking places (eliminating plugs), but most interestingly on roads. In this case, the road is not only a base to provide vehicle adherence and traction, comfort and roughness, but also an energy vector that provides continuous energy supply, changing the current paradigm of a discrete “fill-the-tank” system [10].

Inductive charging allows for overcoming the BEV barrier around charging compared with conventional vehicle refueling. This recharging alternative must be suited for low-ground-clearance sport cars, as well as high-ride SUVs and be comprised of a primary coil installed on the pavement and a secondary coil installed on the vehicle, which is connected to the vehicle battery charging control. SAE J2954 standard has already introduced practices regarding automated wireless charging up to 11 kW, underlining the importance of this system in the near future, particularly for long-range trips or shared mobility vehicles or taxis, where low stoppage rate is usually required [11].

Connected to this possibility is the fact that most vehicle manufacturers are planning and making considerable R&D investments in fully autonomous transportation. In the possibility of vehicle automation, inductive recharging may be complementary because if a vehicle is able to drive itself, it must be able recharge itself.

To sum up, the challenges associated with electric mobility are being transformed in opportunities, namely regarding the supporting highway infrastructure, which must be designed to accompany the trends in new vehicle technologies on the road.

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Risk management prospects with the digitalisation of road infrastructures

V. Sousa[1*], I. Meireles[2]

The digitalisation movement in general, and in road infrastructures in particular, open exciting prospects for implementation of a holistic, quantitative risk management. A framework for integrating risk, performance, and quality in a sustainability-oriented management of roads is presented. The potential benefits for risk management from digitalisation are discussed, both for the road assets and service.

Introduction

Since the 1950's, risk management have been moving from a research topic or area/case specific topic to an embedded, widespread formal professional practice in various fields. The publication of the ISO 31000 family of standards in 2009, which was recently revised (ISO, 2018), represented the culmination of international consent. On 2014, the publication of the ISO 55000 family of standards (ISO, 2014) linked the importance of risk management on (physical) asset management. These standards set out an internationally consensual framework for risk-informed performance-base asset management, particularly relevant for asset intensive organisations such as road administration or departments of transportations.

According to the ISO 31000 (ISO, 2018), risk is the "effect of uncertainty on objectives" and is often quantified as the combination between the likelihood and the consequences of an event. Uncertainty is "the state, even partial, of deficiency of information related to, understanding or knowledge of an event, its consequence, or likelihood" (ISO, 2018). In its essence, the source of uncertainty can be epistemic or aleatory (Walker et al., 2003). Epistemic uncertainty derives from the information/knowledge limitations about the systems and contexts. This type of uncertainty can be divided into model and statistical uncertainty (van Gelder, 2000) and can be reduced by knowledge increase. Aleatory uncertainty reflects the natural random nature of many natural and man-made phenomena and behaviour. This type of uncertainty can be divided into space-related (where) or time-related (when) (van Gelder, 2000) and can only be quantified.

In this conceptual context, there are motivating prospects for risk management from the digitalisation of road infrastructures. Digitalisation will, among other benefits, provide more and better information that may contribute to reduction of epistemic uncertainty and accurately quantify the aleatory uncertainty. The present contribution presents a framework for integrating risk and performance concepts in a sustainability-oriented asset-management framework and illustrates some of the potential benefits for risk management from digitalisation of road infrastructures.

Sustainability-oriented management framework

Historically, organisations and institutions guided their projects and operations by balancing cost, conformity/scope and time, the so called "Iron Triangle" in project management. The emergence of sustainability and sustainable development concepts has been promoting the change for a more holistic set of drivers that take into consideration a wider contextual perspective. As a result, various organizations already explicitly and quantitatively balance economic, environmental, and ethical (or social) aspects in their decision-making processes, both by internal option and by external demands (e.g., regulations, standards).

Still, a fully sustainability-oriented management is not yet embedded, not event in an ideal world guidance. Focusing on asset management, the ISO 55000 (ISO, 2014) definition of asset management as the "coordinated activity of an organization to realize value from assets", complemented by the statement that the "realisation of value normally involve balancing costs, risks, opportunities and performance benefits", reveals a financial-oriented management perspective. The externalisation of cost as a separate vector attributes a distinct level of relevance when compared to other vectors of the decision-making process.

Conciliating the definition of quality set in the ISO 9001 (ISO, 2015) – "degree to which a set of inherent characteristics of an object fulfils requirements" with risk and performance, a possible perspective is that quality can be measured by the balance between performance and risk (Figure 1).

Adapting the management model proposed by Spedding and Rose (2008), a sustainability-oriented, performance-based, risk-informed management framework is

[1] CERIS; Department of Civil Engineering, Architecture and Georesources, IST-University of Lisbon, vitor.sousa@tecnico.ulisboa.pt
[2] RISCO; Department of Civil Engineering, University of Aveiro,

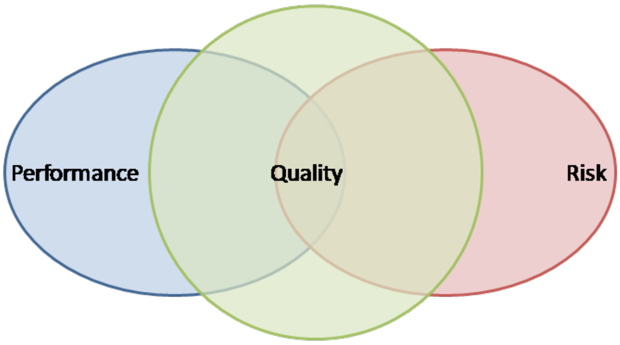

Figure 1. Conceptual integration of quality, performance and risk

Source: Sousa (2012), p. 28,

proposed in Figure 2. For asset-intensive organisations, such as road administrations, management of the physical assets will drive the core of the organisational decisions, projects, and activities.

In this framework proposal, a risk-informed approach is adopted, rather than a risk-based alternative. Contrary to the ISO 55000 (ISO, 2014) recommendation for implementing "risk-based, information-driven, planning and decision-making processes," it is the author's opinion that decision-making processes in the majority of business sectors should be performance based and risk informed. In the specific case of road assets, their management should be oriented towards sustainability (promoting greener, safer, and cheaper equitable transportation) based on estimated performance, and informed about the associated risks. Making a decision based mainly on the level of risk seems only adequate in specific sectors of activity, such as insurance or investment banking. This does not imply the nonexistence of performance and risk thresholds that automatically exclude alternatives. There are and always will be constrains in all vectors of sustainability that cannot be violated, regardless of the final overall balance between performance and risk.

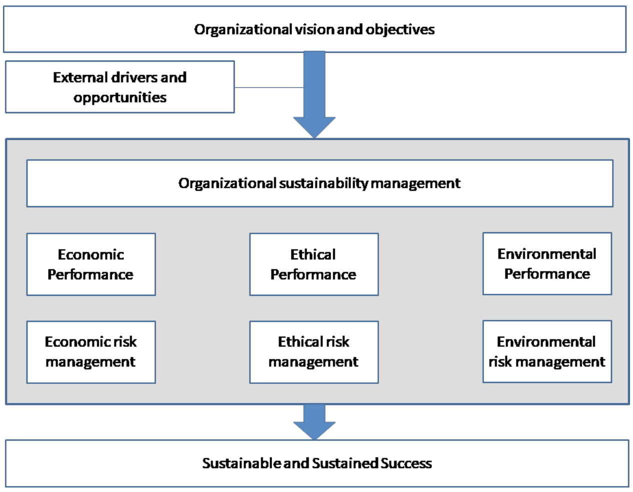

Figure 2. Sustainability-oriented, performance-based, risk-informed management framework

Source: Sousa (2012), p. 29

Risk management in digital road infrastructures

The digitalisation of road infrastructures can be grouped into two main groups (Cruz and Sarmento, 2018): i) assets-related; and ii) service-related. Within asset-related, digitalisation is taking place in the processes for designing (e.g., Chong et al. 2016 - building information modelling), building (e.g., RazaviAlavi and AbouRizk 2017 - construction site simulation), and using (e.g., Agnisarman et al. 2019 - automated inspection systems) the assets. The within asset-related digitalisation is also taking place on the assets directly (e.g., Alavi et al. 2016 - embedded continuous health monitoring sensors). Service-related digitalisation of road infrastructures is driven by the evolution in the transportation paradigm, implying also a change in the supporting infrastructures. Digital payment systems are already a reality in many toll roads around the globe, along with various communication and safety-related features. A recent example are the "smart" highways awarded by Highways England that will provide real-time management of traffic flow capability (https://www.vinci-construction-projets.com/en/realisations/m5-smart-motorway/). Sensors will send traffic information, enabling modulation of speed limits via dynamic signage. The emerging paradigm shift towards electric and autonomous vehicles will demand a new dimension of digitalisation of road infrastructures in the near future. In Sweden, a section of 2 km of a public road has been electrified by embedding an electric rail in the pavement to enable charging of the batteries of electric cars while in movement (https://www.theguardian.com/environment/2018/apr/12/worlds-first-electrified-road-for-charging-vehicles-opens-in-sweden). While the technology used in the Sweden case requires contact, there are various initiatives to build wireless inductive charging pavements (e.g., García-Vázquez, 2017). Within the important relation between transportation and energy, the digitalisation of road infrastructures may also include using it for energy harvesting (Venugopal et al. 2018).

Service-related digitalisation represents new features for the road infrastructures. With it, new different assets will be required in addition to the existing that entail their specific level of uncertainty. These new assets may not increase the level of risk of the existing road infrastructure assets but will certainly enlarge the risks portfolio for road management. An important question herein is the role of the road infrastructures on autonomous driving and its relation to safety-related issues. Assets-related digitalisation adds new functions to road infrastructures (e.g., electric vehicle charging, energy harvesting).

On the other hand, assets-related digitalisation will tend to reduce the level of risk in the management of road infrastructure assets. The digitalisation of the road infrastructures assets life-cycle will provide more and better information about them. Combining technologies such as BIM, GIS, autonomous inspection, and continuous health and traffic monitoring in current digital platforms will provide an unprecedented level of spatial and temporal resolution. These platforms allow for integration of this information with complementary data relevant for road infrastructure assets (e.g., climatic data from satellites, geotechnical profiling, identification and characterisation of underground and limiting infrastructures). This integrated information will enable a better understanding about how endogenous and exogenous variables interact and affect road assets and transportation service performance. In particular, physical-based models use constraints due to knowledge limitations, and the inexistence of the information needed for running them will be mitigated. Combined with the plethora of artificial intelligence tools developed (e.g., artificial neural networks, support vector machines, genetic algorithms, simulated annealing, ant colony optimization), there is significant potential for developing hybrid models. These models combine physical-based approaches with statistical-based approaches to increase the accuracy of the performance forecasts. As a result, the level of risk from epistemic uncertainty will decrease. Additionally, the road digitalisation movement enables building up of data to inform quantitatively the uncertainty left unexplained and/or the naturally random. This represents an improvement in informing the magnitude of the aleatory uncertainty.

Final remarks

Digitalisation of road infrastructure will have a dichotomous effect on the risk management. The digitalisation derived from the evolution of the transportation paradigm and the accumulation of functions demanded in road infrastructures will certainly expand the list of risks associated with the road infrastructures. This expansion may not represent an increase in the overall level risk but will certainly change the nature of risk. For instance, interaction between cars and with the road infrastructure in the scope of autonomous driving will transform the nature of safety-related risks. Assets-related digitalisation prospects are for the reduction of the level of risk traditionally associated with road infrastructures, as a result of the decrease in epistemic uncertainty. Even for the remaining level of risk, the digitalization process will provide better information for the decision-making processes because of more accurate quantification of the aleatory uncertainty.

Finally, the digitalisation of road infrastructures contribute to a holistic management approach required by a sustainability-oriented context. In Europe, the sustainable development principles are being progressively embedded at various levels and sectors of society and require more integrated and complete performance and risk assessments. Digitalisation is a relevant tool to identify, analyse and evaluate the complexity of the economic, ethical, and environmental dimensions of the man-made infrastructures and activities.

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The impact of digitalisation in asset-intensive organisations

Manuela Trindade[1] ; Nuno Almeida[2]

With the beginning of the breakthrough innovations of Industry 4.0, digitalisation is expected to enhance value realization from infrastructure assets in asset-intensive organizations. This article provides an outlook of the impacts of digitalisation in a large public organisation managing the Portuguese main road and rail networks.

Introduction

The aim of this article is to share the experience of a Portuguese asset-intensive organisation that manages the main road and rail networks while engaging in a digitalisation process by the asset management department.

The digitisation and automation have become widely available due to the fourth Industrial Revolution in terms of cyber-physical systems. Industry 4.0 is a confluence of trends and technologies that reshape processes, services, and products delivered by organisations of all types and sizes. But there are still challenges to overcome; for example, in order to combine "information technology" (IT) and "operational technology" (OT) (Woodhead et al., 2018).

Industry 4.0 may also be seen as a confluence of disruptive digital technologies driven by an astonishing increase of: i) readily available data, computational power, and connectivity; ii) the emergence of advanced analytics and business intelligence capabilities; iii) new forms of human-machine interaction, such as touch interfaces and augmented-reality systems; and iv) improvements in the transfer of digital instructions to the physical world (McKinsey & Company, 2016).

According to McKinsey & Company (2016), to capture emerging opportunities and keep pace with the rapidly advancing technological frontier, industrial players need to act in three dimensions: i) reach the next horizon of operational effectiveness; ii) adapt business models to capture shifting value pools, and; iii) build foundations for the organisation's digital transformation by developing digital capabilities, enabling collaboration in the ecosystem, managing data as a valuable asset, and coming to grips with cybersecurity.

Organisations managing physical infrastructures face the challenging task of maintaining, preserving, and improving infrastructure assets for current and future generations, while grappling with limited funding. Because assets such as pavements, railway track, and bridges have long, useful lives, sound asset management requires a long-term approach (FHWA, 2016). Adding to this challenging context, generically all transport infrastructure managers around the world are dealing with worn out assets that at the same time are required to deliver higher performance levels.

Industry 4.0 can add value to these types of organisations and there is the need to carefully monitor the coming changes and develop strategies to take advantage of associated opportunities (Baur & Wee, 2015).

Digital maturity of Portuguese organisations

EY & Nova SBE (2018) recently surveyed the levels of digital maturity of Portuguese companies and the expected levels of confidence in a world so greatly influenced by technology. A total of 102 participants took part in this survey, of which 80% hold management or top management positions.

The results of this study show that: (i) there is widespread optimism and reliance on digital transformation, and participants think they are well positioned in their processes; (ii) in the opinion of the participants, digital transformation has already begun; it is at an early stage, and only some believe they are behind competitors (Figure 1); (iii) there seem to be clues of ideas and leaders capable of thinking about the digital transformation in their businesses and their companies, but there is a significant gap between the strategy formulation and its implementation; (iv) the investment and adoption of technology seems to follow first an imitation of other actors, and only after adjustment of the technology to the specific organisational context; (v) the digital technologies most adopted by companies are social networks and digital marketing, big data and analytics, cloud computing and IoT (Internet of Things), with sectorial differences in the level of implementation.

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[1] PhD candidate, University of Lisbon; member of the research unit Engineering Research and Innovation for Sustainability, Portugal. manuela.trindade@infraestruturasdeportugal.pt
[2] Senior lecturer, University of Lisbon, nunomarquesalmeida@tecnico.ulisbos.pt

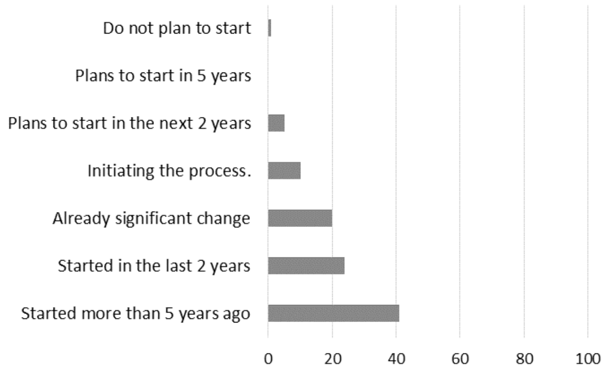

Figure 1. How long ago did digital transformation begin in your organisation?

Source: Adapted from EY & Nova SBE, 2018

Digital transformation is not new for Portuguese companies, but the impacts of change are still not clear (EY & NovaSBE, 2018).

Digital strategy for infrastructure asset management

Asset management in an asset-intensive organisation such as public infrastructure organisations are used to identify how an organisation deals with the management of its physical assets through their life cycle to achieve its strategy (El-Akruti & Dwight, 2010).

When used effectively, engineering asset infrastructure (EAI) can create benefits for both the asset-intensive organisation and their stakeholders/customers. However, the complexity of handling different types of budget-constrained EIA with varying capacity presents challenges for many asset-intensive organisations when planning, acquiring or constructing, operating and maintaining this EIA. Infrastructure asset managers must optimise the use of available resources within existing infrastructure and business constraints. A fully integrated technical, financial, and stakeholder/consumer-focused approach that leverages digital solutions is expected to enable asset managers to reach their benefit potential.

However, financial restrictions affect the availability of public sector funds, and subsequently this impacts asset-intensive organisations in different ways, namely by reducing the number of major capital projects and therefore hindering the disruptive effect of technology-based development projects.

Another critical issue to consider in asset-intensive organisations is the impacts of disruptive technologies in human resources, where adaptation and the risk of potentially significant loss of expertise and experience needs to be planned and factored in.

In light of this, an important question to ask is: how can infrastructure asset managers develop digitalisation strategies to build a holistic, fully integrated, and flexible asset management (AM)? An answer to this question is proposed based on the current digitalisation strategy within the largest infrastructure organisations in Portugal. This asset-intensive organisation is Infraestruturas de Portugal, S.A. (IP-SA), a state-owned company resulting from the merger of Rede Ferroviária Nacional – REFER, E.P.E. (REFER), the former rail infrastructure manager, and EP - Estradas de Portugal, S.A. (EP, S.A.), the former national road network manager (IP-SA, 2016). The following Q&A offers the current view on digital transformation focused on asset management being carried by Infraestruturas de Portugal (IP). The authors appreciate the contributions in dealing with these questions by Rui Coutinho (IP's Director of Asset Management) and João Morgado (Information Modelling unit of IP's Asset Management Department).

1) Is the digital strategy of the organisation in line with the AM Strategy?

If you consider the fundamentals of asset management, the answer to this question will be for sure "it has to be." The successful implementation of an asset management strategy must be fully coordinated with the digital strategy of the organisation, and both resulting from the strategic objectives of the company. Regarding the context of IP, it should be noted that it is a relatively young organisation, resulting from a merger process of two large organisations, REFER (rail) and EP (road). As an immediate result, the priorities within the digital development roadmap were focused on corporate systems such as accounting and document and process management. Currently, and after these initial efforts, relevant steps are being made to align the digital strategy and the asset management strategy, by mapping all systems, applications, and processes related to asset management, identifying gaps and priorities, and finally designing a mid-term plan to implement an asset management strategy fully supported in a corporate digital strategy.

2) How can asset managers develop digitalisation strategies to build a holistic, fully integrated, and flexible AM?

The first step shall be to understand that a digital strategy is not an IT strategy, the first focuses on automating processes and productivity and the last treats technology individually. Successful digital strategies focus on specific business or processes and not on a global or unified strategy.

One of the key goals to bear in mind within the development of digitalisation strategies in the context of asset management of asset-intensive organisations such as an infrastructure manager is the proper alignment between the physical and technical management of an asset, and its financial dimension. As an infrastructure management organisation, IP provides mobility services based on the contracted performance of its infrastructure and each asset must be managed as a physical entity with all the challenges related to the effective management of its condition, but also as a source of revenue that must be managed in order to maximise its value to the organisation. That is why asset managers need to strive for coordinated strategies, enabling the organisation to assess the financial impact on its objectives, when a decision to postpone a specific investment is considered. Given the potential fast-changing decision contexts, regarding for instance budgetary frameworks, integrated and flexible asset management systems are key, and this can only be sustainably achieved through a business digitalisation approach.

3) The digital era will require quick responses to emerging challenges and opportunities – is IP-SA prepared for this?

As mentioned in the first question, IP is giving relevant steps so that it can be prepared and respond to those challenges and opportunities. However, for asset-intensive organisations and considering IP's specific context, it is difficult to act quickly in a practical way. IP's asset portfolio includes more than 15,000 km of roads, 2,600 km of railways, more than 7,500 bridges as well as many other sub-systems (such as earth retaining structures, road furniture, switches and crossings, signaling systems, catenary, power supply installations, communication systems, and telematics). This very complex and diverse asset portfolio constitutes necessarily a considerable management challenge, where only a well-discussed and supported digital strategy can prosper. We should add that aged assets include specific challenges such as condition and inventory issues, as opposed to newly built assets. In any case, transport infrastructure companies for roads and rails have been around for more than 150 years, dealing with social progress, technology evolution, and economic trends. How could a company with this background not be ready for the digital era?

4) We must be able to handle and process more data to efficiently make AM decisions. Have we a strategy for this?

One digital strategy of the organisation is currently addressing the data acquisition and management processes, identifying opportunities for a more efficient approach. While in some areas paper-based inspections still occur, these are being replaced by mobile equipment, allowing real-time data to be fed to corporate databases, immediately generating alerts whenever needed. In other areas, such as structural condition monitoring, real-time data transmission is also a reality. These joint efforts are trying to complete a puzzle where constantly available and reliable data for all asset types is the final objective. However, technologies as the IoT and big data can also play a relevant role to this end and may significantly accelerate it, as there is a huge potential for it in the monitoring of such a diverse group of physical assets.

We must understand that there is no one digital strategy to solve all issues related with data collection, information delivery, and decision-making. Asset management relies in coordinated digital strategies that maximise value extracted from assets.

5) Does IP's AM system include accurate performance metrics, deliver accurate data, and enable well-informed decisions?

As a result of the diversity of IP's asset portfolio, each technical area felt the need to develop dedicated systems, applications, and databases, supporting the technical management of each asset type. However, the communication between different platforms is not always possible, making it hard to compile, analyse and correlate data. Business intelligence started to be applied in some areas but is still limited by these types of constraints. The ongoing efforts on the alignment of the digital and asset management strategies are also dealing with these missing links and, in some cases, with potentially inadequate processes that may lead to nonefficient data handling and, in further extent, to decisions not supported in reliable data.

Of course, those missing links are filled by human actions, and progressively those actions will also become automated. Digital transformation is essential to human performance, creating a more productive path to value creation and well-informed decisions.

6) In your opinion, what will be the main future impacts and challenges of digitalisation for AM functions in an asset-intensive organisation like IP-SA?

In our opinion, three types of impacts or challenges can be mentioned. First, we believe that digitalisation will transform the organisation in its entire value chain, from data acquisition and management, supporting tools such as machine learning and business intelligence, and ultimately allowing the organisation to make better decisions. Second, it will be a key enabler of the long-term strategy of the organisation. Digitalisation will provide tools to support the definition of a sustainable asset management approach accurately, improving the assets' performance, not only in their physical dimension but mainly in their financial aspect as a source of revenue to the organisation and its shareholders, which in the case of IP is the Portuguese state. Last, digitalisation can also be the source for new business opportunities for the organisation. The existing systems and the ones being implemented shortly are providing big data that can be processed, becoming relevant and valuable information in the mobility business. This also means an opportunity for cooperation with other entities in the mobility industry, in order to provide better services to its users. In asset management, decisions are never taken in isolation but always aligned with the company's strategic objectives.

Conclusions

While it is hard to predict how the future will unfold, we can see that some trends and the fast-approaching digital transformation will involve an array of technologies that promise to reshape the way things are made today. Several evolutionary waves of strategic innovation had been seen many times before. What is happening today has happened before in other industrial revolutions. Asset-intensive organizations must understand the changing context and operate within it. They need to manage their transformational adaptation to better fit with emerging strategic priorities. It must consider: i) the emerge of new "smart" products that provide greater insight into uncertainties that link to long-term costs; ii) different services based on data from sensors through an innovative technology that links to real-time analytics engines, to tackle problems such as asset tracking, predictive maintenance, and new processes that change workflows and use information flows to create more value; and, iii) more expectations and demand of customers. However, in the other hand, it is also necessary to approach the sphere of technology considering the human factor, especially when we move on to the business of deriving and implementing action plans, tracking progress, and changing the way people work.

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Making urban mobility more efficient with Mobility-as-a-Service and Mobility Service Companies

Filipe Moura*

Mobility-as-a-Service (MaaS) aims to integrate various forms of urban transportation into a single mobility service accessible on demand, which is possible due to the digitalisation of urban mobility. We explain how the concepts of MaaS and MObillity Service COmpanies (MOSCO) can overcome households' car-centered and inefficient mobility planning and may contribute to a more sustainable urban mobility system.

Are our current household mobility plans efficient?

Important societal transformations have happened over the last decades and will continue to be pursued in the future. Households evolved from a relatively standard four members to a set of diversified structures (e.g., single-parenting) with strong implications in the interpersonal relationships and daily organisation. With the increasing complexity of daily activities, personal mobility is progressively more complicated, where regular daily commuting is no longer the standard "home-work-home" trips. In turn, individual and household mobility plans vary from day to day, over weeks, seasons, and years.

Moreover, urban mobility systems have shifted dramatically from the dichotomous options of private car versus conventional public transportation (bus, underground, train, and taxi) to an intricate set of alternatives (public transportation plus vehicle sharing or pooling, minibus, transport-on-demand, short-term car rental), and their intermodal combinations, which increase the range of possibilities for the daily set of interconnected trips. The great revolution that urban mobility has undoubtedly suffered over the last decades thrives from the technological development and innovation, in particular of information and communication technologies (ICT) and the corresponding digitisation of the transport system, and the electrification of vehicles.

Information on urban mobility alternatives has also become ubiquitous, principally with the Internet of things and its mobile forms (e.g., smartphones). For short-term mobility decisions (e.g., going to a restaurant), resources such as route planners (e.g., Google Maps) are standard now and are commonly used, especially by younger generations. Conversely, it is not always straightforward to make adequate choices for longer-term household mobility planning that includes structural decisions such as house/work/school locations, private car acquisition, or choosing a public transportation monthly card, despite myriad information sources. In the face of this complexity, the final decision is too often buying one or several private cars and resorting to mobility ownership, instead of using services of mobility. Inter alia, the dominating modal share of cars, is responsible for much of the unsustainable urban evolution (e.g., air pollution, noise, urban space deprivation, inequity of access to opportunities, accidents, run-overs, time losses, and climate change).

We hypothesise that many households manage their mobility inefficiently, collectively contributing to that unsustainable path of current urban mobility systems. We argue that families should be more rational when planning their mobility and compare their current mobility options with more efficient alternatives that are growing in number and diversity. However, they often do not do it.

The reasons for not opting for more efficient mobility alternatives can be grouped into five broad categories:

1. Lack of awareness or knowledge to make the full cost accounts and compare mobility options (e.g., "I did not include depreciation of car in total car ownership expenses");
2. Lack of information regarding the existing transport alternatives (e.g., "I wasn't aware of car-sharing systems, costs, and potentialities");
3. Social ties that interfere with mobility plan of the household (e.g., "I have to take my kids to school before work");
4. Personal constraints or resource limitations (e.g., "I work until late hours, and there aren't good public transportation options at that time"); and
5. Other benefits for the household (or household members) compensate for the lack of efficiency identified strictly from a transportation perspective (e.g., "I love to drive my car").

Solving for the first four potential sources of inefficiency can be achieved through the mediation of households

*Associate Professor of Transportation Systems; CERIS, Department of Civil Engineering, Architecture, and Georesources, University of Lisbon; fmoura@tecnico.ulisboa.pt

and the complex urban mobility system, where the bundling of urban mobility services into one contract could make the overall mobility endeavors of users more seamless. Such mediation services already exist in the energy sector with the energy service companies (ESCOs) (Vine, 2005) or telecommunication sector. This paper aims to explain how MaaS providers already offer packages of urban mobility services (e.g., Whim; https://whimapp.com/), while a new concept of mobility service companies (MOSCO) is put forward to mediate the household mobility planning and decision making.

What is MaaS and what is left to do?

Mobility-as-a-service (MaaS) was a natural evolution in the mobility sector from the everything-as-a-service (XaaS) thinking (Rimal and Choi, 2009). Among many available in the literature (Expósito-Izquierdo et al., 2017; Giesecke et al., 2016; Goodall et al., 2017; Jittrapirom et al., 2017; Karlsson et al., 2016), just to mention a few, one of the first definitions of MaaS was proposed by Sampo Hietanen (Hietanen, 2014), the current CEO of MaaS Global (https://maas.global):

“Mobility as a Service (MaaS) is a mobility distribution model in which a customer’s major transportation needs are met over one interface and are offered by a service provider. Typically, services are bundled into a package – similar to mobile phone price-plan packages.”

A more complete definition is proposed by the MaaS Alliance: “MaaS is the integration of various forms of transport services into a single mobility service accessible on demand. To meet a customer’s request, a MaaS operator facilitates a diverse menu of transport options, be they public transport, ride-, car- or bike-sharing, taxi or car rental/lease, or a combination thereof. *”

While Hietanen (2014) highlights the digitised approach of MaaS where mobility users are met through an interface, the MaaS Alliance (2018) brings relevant specifications to the concept:

1. Integration of various forms of transportation into a single mobility service;
2. The service is accessible on demand; and
3. The service facilitates a diverse menu of transport options.

Other authors bring valuable clarifications to the concept. Leviäkangas (2016) specifies that transport providers can be either public or private, and König et al. (2017) refer to that MaaS is paid via a single account (or digital wallet).

Whim (https://whimapp.com/) is the first MaaS provider deployed in the market (Figure 1), operating currently in Helsinki (Finland), Antwerp (Belgium) and West Midlands (UK). Other options are being developed in the EU, such as the UbiGo project in Sweden (http://ubigo.se).

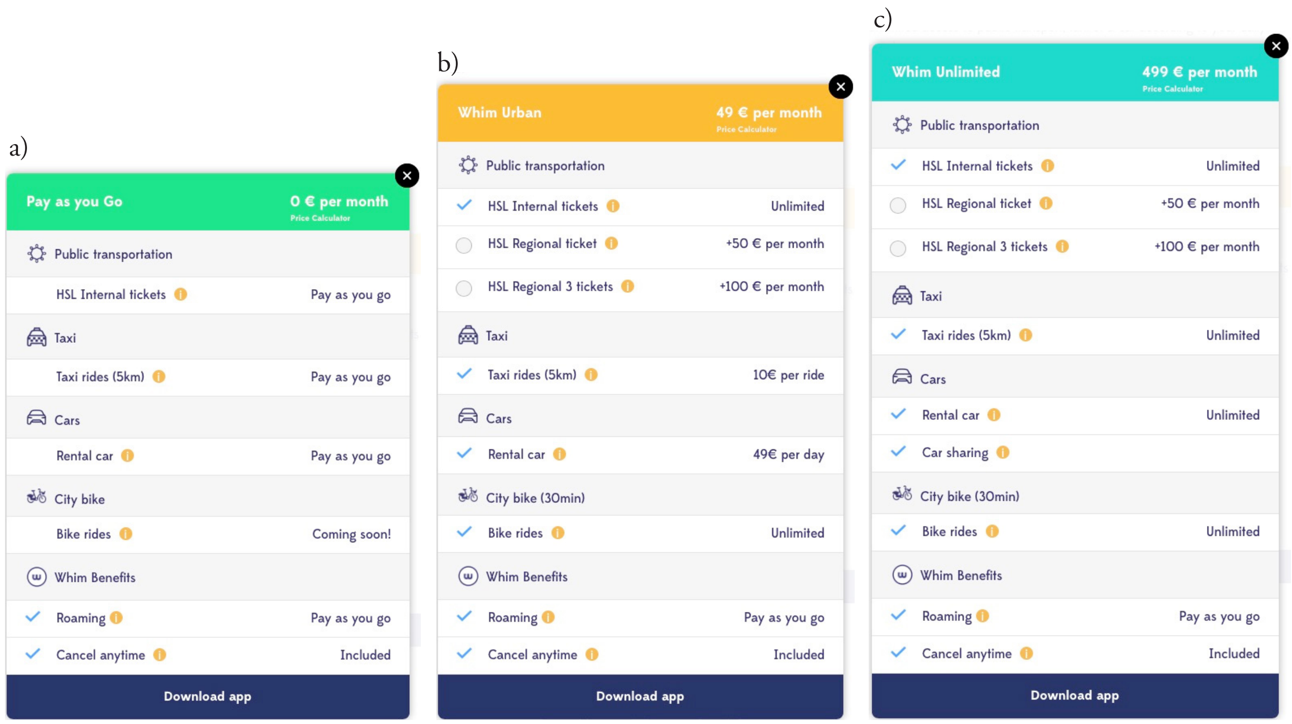

Figure 1 . Whim MaaS packages in Helsink:i a) “Pays as you go”; b) “Urban”; c)”Unlimited”

Source: https://whimapp.com/

*https://maas-alliance.eu/, last accessed November 2018

Although variable, total car ownership costs per kilometer average 0,30€ (refer to total car ownership cost calculators available on the Internet – e.g., http://www.ev-app.eu/TCO-results.php). For an annual mileage of 15.000 km, the monthly costs round up to 300€ to 500€ per month. Household car ownership in western countries averages 1 to 2 vehicles per family, meaning that an important part of these families dedicates 300€ to 500€ of their budget to the 2nd car, which might not be obligatory. Instead, the willingness-to-pay for the 100% availability of an often-oversized car (i.e., cars stopped and idling more than 95% of their lifetime; 80% of 5-seat unused capacity), could be allocated to MaaS packages and possibly save money. For example, the "Whim Unlimited" (Figure 1) offers unlimited trips in urban public transportation, taxi rides (up to 5 km), car rental and car sharing, and bike sharing. Ultimately, households could allocate the 600€ to 1000€ of car costs and shift away from car ownership to MaaS only and possibly save money.

MaaS providers are still taking off. Sochor et al., (2017) proposed a 5-level topology of MaaS services:

- Level 0 – No integration of transport services, where operators provide mobility services separately, as we knew it until a few years ago.
- Level 1 – Integration of information of multimodal travel plan and information of the tariffs for separate legs of the multimodal trip, which was made possible with the digitisation of transport activity and widespread smartphones.
- Level 2 – Integration of multimodal information, booking, and payment through e-wallets, but services are still not bundled together, and payments are made directly to each operator;
- Level 3 – Bundling of transport services into a single contract (but with different possible packages) integrated by a MaaS (this is the case of Whim or UbiGo); and
- Level 4 – Integration of societal goals, whereas policy makers can use MaaS services to implement car restriction policies to provide a more accessible and livable city.

Level 2 focuses on single-trip requirements, provides easier access to mobility services, and is a natural extension of route planners. Level 3 is a full alternative to car ownership and, as noted by Sochor et al., (2017), it "focuses on the total need of a household – it is about getting from morning to evening, Monday to Sunday, and spring to winter, rather than single trips from A to B." Level 4 is the last step to full integration of MaaS into transport and mobility policy making, serving as a tool to provide good quality alternatives to current car-centered mobility organization.

MaaS can make daily mobility of individuals more seamless, in a way that trip-specific requirements are met (for example, traveling from one origin to one destination at a specific hour of the day, and not using bike-sharing systems), and the only choice users would need to make is how many minutes in advance they would need to order each ride. However, some problems remain unsolved.

Although quite straightforward for individuals, the MaaS concept assumes that households can fully calculate their total costs of mobility, which is not true, particularly when complex mobility relationships of dependents are involved. This type of analysis requires more complex approaches when structural decisions other than mobility are involved, for instance, those related to the location of work, home, and schools.

Furthermore, the outcome concerning urban mobility sustainability will always depend on the decisions of the user, in the face of options provided in each MaaS package. Ultimately, the user can opt for a car always if the package is designed in that way. As such, by itself, the MaaS concept does not guarantee a collective improvement of urban mobility sustainability, unless it is regulated to limit the low-occupancy usage of cars or to better match more adequate modes to the different trip lengths.

What could be the role of a MOSCO?

The concept of a MOSCO was first proposed by Moura et al., (2016). To describe this concept, I use the analogy of medicine. MOSCO is a "doctor of mobility" who makes a diagnosis of the current household's weekly mobility management; identifies potential problem and proposes a "therapy" to correct less-efficient mobility with options and possibilities.

To address the issue of household activity and mobility patterns, a diversified set of variables is collected simultaneously through detailed face-to-face interviews (where mobility survey apps in smartphones are the natural follow-up of this methodology, e.g., based on Google Maps' timeline feature). The interview characterizes the household's typical weekly activity and mobility plans while incorporating social network analysis to identify dependencies among alters (for example, grandparents who pick up kids at school), as proposed by Pritchard et al. (2016).

The interviewer initially begins with questions regarding the a priori knowledge and information that households have about their monthly mobility costs and possible alternatives to their current organisation. For example, one fundamental issue is to ask the total monthly costs of car ownership that can be determined, and to consider other mobility options, as seen previously. Then, the interviewer collects information about the weekly set of activities and mobility decisions of all household members, determines their regular mobility requirements and the network of subordinations, namely with elicited alters, notably those considered "very close". Current mobility key performance indicators (e.g., weekly travel costs, travel times, CO2 emissions) are then calculated and compared with those potentially obtained after presenting alternative mobility plans that resort to more efficient mobility solutions.

Although with a smaller sample of five households (namely, single-person household and four families with several dimensions, all having different mobility options), Moura et al. (2016) tested the approach for a proof-of-concept exercise, and results suggest that different types of households could all potentially and significantly reduce their annual mobility budgets (from 45% up to nearly 90%) and the corresponding environmental footprint (up to 30%).

These results sustained the assumption that households plan inefficiently their mobility agendas, as none knew the total costs of their car ownership and had an obsolete or inadequate knowledge of alternative mobility options, in particular such as the more recent shared-mobility solutions lik bike-sharing systems that can solve the "first and last mile problem" of public transportation connections (Shaheen and Chan, 2016).

Conclusions

The ultimate and futuristic scenario of all private cars being replaced by public transportation, taxis, and shared or pooled vehicles is now closer. Many mobility options have rolled out in many cities worldwide. Urban mobility has suffered a revolution with the technological development of ICTs and electrification of vehicles. However, many inefficiencies have yet to be overcome. For instance, households are not always aware of or do not know how to take full account of their mobility options. When the complexity of mobility organization increases (typically, when children are involved), resorting to a private car is an option with long-lasting effects, both on an individual basis and collectively speaking. MOSCO could help households in the task of making the right budgeting comparisons of competing for mobility plans, while MaaS is becoming a comprehensive and most competitive urban mobility solution to drive families away from cars.

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EUROPEAN UNIVERSITY INSTITUTE (FLORENCE), 20-21 JUNE 2019

8th Florence Conference on the Regulation of Infrastructures

DIGITAL PLATFORMS – THE NEW NETWORK INDUSTRIES?

How to regulate them?

Introduction

Digitalisation is transforming all industries, including the network industries. It is creating a new model of industrial organisation using online platform as intermediaries for multisided markets. As a matter of fact, digital platforms display all characteristics of the traditional network industries: network effects, efficiency, scale, concentration, market power, etc.

The involvement of online platforms in the network industries benefits consumers by fulfilling unmet needs, often efficiently and at low cost. Platforms do this partly by exploiting access to existing network infrastructures that are often vital for national economic growth and wellbeing. However, if online platforms are allowed to sideline traditional network operators, it may mean that vital investment in building and maintaining the infrastructures on which these markets are founded becomes unsustainable in the long-term.

Another pertinent issue concerns the regulatory approach to platforms, as the success of online platforms is achieved, in part, by exploiting regulatory environments that place incumbent firms at a disadvantage. There is a debate as to whether platforms should be subject to the same regulatory obligations as traditional network players, and whether platforms should have access to network services under regulated terms.

This 8th Florence Conference on the Regulation of Infrastructures aims to:

- identify the key challenges of digitalisation for traditional network industries,
- discover various regulatory approaches to platforms,
- determine benefit scenarios for consumers and to the platforms itself.

Papers will be presented in parallel sessions dedicated to the following infrastructure sectors:

- **Communications and media**
- **Energy and Climate**
- **Transport and mobility**
- **Water distribution**
- **Wastewater and waste management**

We encourage contributions that link **different infrastructure sectors.** Contributions utilizing **multidisciplinary as well as interdisciplinary approaches** to regulation are welcome. Papers **linking academia and practice**, as well as policy research papers are particularly encouraged.

The conference is intended for **academics** such as PhD students, PostDocs and Assistant/associate/full Professors as well as **academically minded practitioners.**

Conference structure

The format of the Florence Conference on the Regulation of Infrastructures is unique:

- Each presenter has 45', which includes 20' of presentation, 10' of qualified feedback and 15' of discussion with the audience (there are only 2 papers per session, guaranteeing high quality discussions);
- Feedback will be given by senior professors associated with the Florence School of Regulation who are specifically knowledgeable about the topic at hand;
- Papers retained for publication will receive additional feedback beyond the Conference.

Timeline

- Submission of the abstract by **13 January 2019** (word format download the guidelines) using the online form. For any issue regarding the submission, please contact Ms Irina Lapenkova at FSR.Transport@eui.eu;
- Notification of acceptance by **22 February 2019**;
- Submission of the full paper by **26 May 2019;** participants who fail to submit a full paper by this deadline will be automatically removed from the programme;
- Conference on **20-21 June 2019 in Florence (Italy).**

Conference fee

- 150 EUR - Partial fee waivers for PhD students are available. Please contact Ms Irina Lapenkova at FSR.Transport@eui.eu for further information.

Guidelines for the abstract

- 600-1000 words
- Title of the paper & keywords
- Name of the author(s) and full address of the corresponding author
- The aim and methodology of the paper
- Results obtained or expected

Publication opportunities

- Papers will qualify for the Journal Competition and Regulation in Network Industries, which is published by Sage as of 2017.
- A summary of the 4-5 best papers will have the chance to be published in the dedicated issue of the Network Industries Quarterly (Issue 21, Vol 3, September 2019).

Organizing Committee

- Prof **Simone Borghesi** (EUI, Part-time professor and Director of the Climate Area of the FSR. Siena University, Professor)
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iglusQUARTERLY

INNOVATIVE GOVERNANCE OF LARGE URBAN SYSTEMS

IGLUS Quarterly is an online quarterly publication dedicated to the analysis of Governance, Innovation and Performance in Cities and is edited at École Polytechnic Fédérale de Lausanne (EPFL), Switzerland. IGLUS Quarterly aims to facilitate knowledge and experience sharing among scholars and practitioners who are interested in the improvement of urban system's performance in terms of the service efficiency, sustainability and resilience.

IGLUS Quarterly applies the highest academic standards to analyze real world initiatives that are dealing with today's urban challenges. It bridges the gap between practitioners and scholars. IGLUS Quarterly therefore adopts a multidisciplinary perspective, simultaneously considering political, economic, social and technological dimensions of urban systems, and with a special focus on how governance affects and is affected by the use of technologies in general, and especially the pervasive application of the ICTs.

VOL. 1, ISSUE 1

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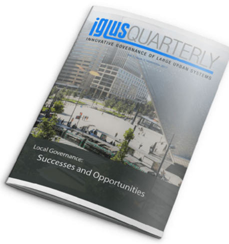

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We invite interested scholars and practitioners to write short analytical articles (4-6 pages) for the IGLUS Quarterly or to become a guest editor for an issue. For more information about IGLUS Quarterly, please contact us by sending an email to Umut Alkım Tuncer.

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Network Industries Quarterly
Vol. 21, issue 1, 2019 (March)

Regulation of the Railway Industry

Across the world, railways are poised to face new challenges, as all transport modes are transformed by technological innovations, liberalization, competition with other modes of transport and most recently by digitalization. Consequently, the railway industry is required to increase efficiency while ensuring security and safety, as it has to address multimodality, such as buses, as well as compete with new transport modes such as car-sharing. Regulation of the railway industry and its various dimensions, not the least competition, is central factor in the process of its transformation and will ultimately decide whether railways will or will not increase their modal share.

The next issue of the Network Industries Quarterly (NIQ) will be dedicated to some of the best papers presented at the Florence Conference on the Regulation of Railways, which took place on November 16 and 17, 2018. Selected academics and practitioners have been invited to Florence to discuss the latest developments in the field of railway regulation, such as competition in the market, role of regulatory agencies and economic perspectives.

You can get more information about the conference here:

http://fsr.eui.eu/event/florence-conference-on-the-regulation-of-railways/

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Open Call For Papers

Implementation of the liberalization process has brought various challenges to incumbent firms operating in sectors such as air transport, telecommunications, energy, postal services, water and railways, as well as to new entrants, to regulators and to the public authorities.
Therefore, the Network Industries Quarterly is aimed at covering research findings regarding these challenges, to monitor the emerging trends, as well as to analyze the strategic implications of these changes in terms of regulation, risks management, governance and innovation in all, but also across, the different regulated sectors.
The Network Industries Quarterly, published by the Chair MIR (Management of Network Industry, EPFL) in collaboration with the Transport Area of the Florence School of Regulation (European University Institute), is an open access journal funded in 1998 and, since then, directed by Prof Matthias Finger.

Article Preparation

The Network Industries Quarterly is a multidisciplinary international publication. Each issue is coordinated by a guest editor, who chooses four to six different articles all related to the topic chosen. Articles must be high-quality, written in clear, plain language. They should be original papers that will contribute to furthering the knowledge base of network industries policy matters. Articles can refer to theories and, when appropriate, deduce practical applications. Additionally, they can make policy recommendations and deduce management implications.
Detailed guidelines on how to submit the articles and coordinate the issue will be provided to the selected guest editor.

Additional Information

More Information

- *network-industries.org*
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Questions / Comments?

Irina Lapenkova, Managing Editor:
irina.lapenkova@eui.eu
Ozan Barış Süt, Designer:
ozanbarissut@gmail.com

Published four times a year, the **Network Industries Quarterly** contains short analytical articles about postal, telecommunications, energy, water, transportation and network industries in general. It provides original analysis, information and opinions on current issues. Articles address a broad readership made of university researchers, policy makers, infrastructure operators and businessmen. Opinions are the sole responsibility of the author(s). Contact *fsr.transport@eui.eu* to subscribe. Subscription is free.

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