



travelspirit

Whitepaper

Autonomy

The role of Robotics and Artificial Intelligence in Public Transportation and Urban Mobility for Cities

July 2017

Summary

TravelSpirit is leading the debate on the role of autonomy in the emergence of new mobility services. A range of autonomous vehicles (AVs), enabled by Robotics and Artificial Intelligence (RAI), are necessary for the evolution of Mobility as a Service (MaaS) as a global resource. This white paper sets out our initial position and frames the debate around developments in autonomous mobility and how it can shape the new mobility frontier.

In this paper, we identify concerns about autonomous transport solutions being developed by technologists, without a broader public policy framework. We highlight the risks that this direction of business development poses and how technology-driven innovation may present a serious threat to the vitality of our society.

We then suggest a call for action from the public transport industries, and from cities, to act now and imagine a better future scenario. If we don't act there is the potential that public transport will be eroded, irreversibly, by private organisations with no moral or ethical obligation to provide universal, accessible and equitable transport. We call on likeminded businesses in the UK, and the rest of the world, to support or work directly with us.

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Autonomy

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The new mobility frontier

Around the world, new ways of providing mobility are appearing in our cities and towns each and every day. From autonomous vehicles (AVs) to e-bikes, new technologies are bringing our science-fiction dreams to life. At the same time, rapid adoption of mobile internet access is creating new business models and services, as well as changing the way we access existing modes. We can see the start of changing travel behaviour as car clubs in the UK have grown to 250,000 members across the UK in the last 10 years, whilst around 20 towns and cities have public bike-share schemes. There are several different models of ridesharing services providing transport options for people from festival goers to urban commuters.

Recently, Mobility as a Service (MaaS) has emerged to offer travellers a powerful new alternative to car ownership in the form of seamless multi-modal transport. It provides the means to plan and pay for journeys using different modes, all linked through an integrated user interface.

This is a real step forward. But MaaS also has the potential to upend existing business models and greatly disrupt local economies. We must ensure that the world of new mobility does not take substantial value and profits out of local communities. Instead it must add value and improve citizens' well-being. To do so, we need to challenge assumptions that the development of new mobility models will be proprietary, monopolistic, and closed to outsiders – whether they be from the public or private sector.

TravelSpirit is championing the role of “open” in the emergence of new mobility services and the evolution of MaaS as a global resource rather than an individualised business.

Autonomy in urban mobility services

The concepts around autonomy have captured the imagination of the transport industry, investors, government and academia, as well as innovative disruptors over the last few years. The need for a change to a range of historic business models in the mobility business becomes more apparent as the months go by and the frequency of new industrial, financial and academic partnerships increases.

Many of the key players in mobility are already trying to position themselves for this business revolution. All are looking to a changed mobility future, whether the acute need for change emerges in 5 years or in 20; and whether it emerges in our largest most dynamic urban metropolises, smaller niche innovative cities, or even in rural areas. The inevitable changes will be painful for some businesses while being transformational for others and to our opportunities and lives as users of transport.

Transport systems have so far largely required human control. We have moved a long way from the horse and cart to a broad range of mechanical systems. Human controlled ‘devices’ have been used to transport a single person, a few people, hundreds of people and goods. Without direct human control, almost no device has been deemed safe without rigorous segregation and other safety features.

However, we have already one template for transport which has become virtually autonomous in the past 50 years. In 1852, Elisha Otis invented the modern elevatorⁱ. The humble elevator transformed the modern city, enabling multi-storey buildings and the resulting extreme density at the urban core. Originally attendant controlled, elevators were eventually made automatic by the latter half of the 20th century. In effect, they are a form of autonomous transport.

There are distinct parallels between the impact of the elevator and the potential impact of autonomous vehicles. The arrival of the elevator changed the shape and skyline of cities. Their eventual automation ended a whole category of employment – the lift attendant. What remains is a device which conveys millions of daily passengers in automated vertical channels – lift shafts - barely without a second glance. Lifts are such an intrinsic part of the fabric of cities that they barely register on the consciousness of the travelling public.

As other vehicles have been developed with autonomous features, autonomy has become classified. Autonomy is now defined in a range of forms from level 0 to 5: each level providing increased computer control until, at level 5, no human interaction is required. ⁱⁱ

This can be briefly summarised as:

Human driver monitors the driving environment:

- 0 **No automation** – vehicle fully under the control of the human driver
- 1 **Driver assistance** – human driver performs dynamic driving tasks but is assisted in either steering, acceleration or deceleration in some driving modes
- 2 **Partial automation** – system performs key driving mode tasks of steering, acceleration and deceleration based on its monitoring of the driving environment in some driving modes with human driver performing all other dynamic driving tasks and ultimately responsible for monitoring the environment

Automated driving system monitors the driving environment

- 3 **Conditional automation** – system performs all key functions of dynamic driving based on its monitoring of the environment with human driver as fallback in response to a request to intervene in some driving modes
- 4 **High automation** – system performs all functions of driving in some driving modes
- 5 **Full automation** – system performs all functions of driving in all driving modes

The largest and best financed corporate players in mobility over the last 50 years in much of the world have been the car manufacturers (OEMs). They have established a thriving global industrial and consumer business in building, promoting, selling and maintaining tens of millions of vehicles each year. In fact, many local and regional economies depend on these industrial processes.

To a great extent, cities have been rebuilt to accommodate the car and the model of personal mobility that it offers. In addition, many suburban and particularly rural lifestyles in the developed world depend on this model.

However, this structure is now under disruption from many new players. This includes recent new automotive start ups such as Tesla, tech giants such as Apple, Google, Baidu and Tencent, transportation network companies (TNCs), car clubs, ride sharing models and niche players.

Implications for public transport

Personal mobility is also about public transport. Millions of people each day use public transport networks in and between cities as well as in suburban and rural areas globally. There are 60bn annual journeys by public transport in the EUⁱⁱⁱ This number is growing substantially as the world becomes more urban. Most of the world's population already lives in cities. ^{iv}

The nature of mobility in these large cities and their economic and social advantage as centres of growth are based on the density of population and the human interaction that this enables. Public transportation entails efficiently and effectively moving millions of people daily. This is the reality of mass public transport for the realistic functioning of cities.

Autonomy is not new to these large-scale public transport systems and, in fact, some of the earliest adopters of these original concepts are subway/metro systems around the world. London's Victoria Underground line has run on a form of Automatic Train Operation (ATO) from its opening in the late 1960s. The three largest fully automated metro systems in the world are currently in Singapore, Dubai and Vancouver. These systems have typically used autonomous systems to move trains between stations, with the passenger interaction at stations controlled through some human intervention. The deployment of these automated metro systems is now growing rapidly around the world as many cities see their cost and level-of-service advantages.

Autonomous interventions beyond metro systems – for instance in bus and light rail - has been more limited. However, local and regional buses and light rail/ trams at an intensive scale are at the core of the global public transport solution. They are critical to the operation of many medium and large cities. To give a sense of its importance, London's bus network carries far more of the daily demand than the Underground system.^v

There are also many models for providing "public transport" around the world, with the state taking different roles. This can be as a regulator, contractor, subsidy provider, service provider, actor of last resort, or co-ordinator. Depending on the cultural, financial and physical market, any of these roles may be most effective, and in an autonomous world an efficient "marketplace" will still be needed to provide for the complex set of transport needs, and in a sustainable manner.

Implications for cities

With cities consuming between two-thirds and three-quarters of the world's energy, their role in driving a clean energy future is inescapable.^{vi} Around 1.5 million people are added

to the global urban population every week, and the proportion of the world's population living in urban areas will be two-thirds by 2050.^{vii}

For cities to thrive, create a clean energy future and to take advantage of the technological revolution of autonomy, the bus and light rail systems must also be considered and developed as robust and mass-capacity autonomous transport opportunities.

As an autonomous use case, these systems are complex and difficult because, it can be argued, the cost bases and demands of public transport systems are more complex than private cars on a motorway.

The UK's Centre for Connected & Autonomous Vehicles (CCAV) is seeking to address this issue with the development of a test-bed facility in an urban and dense city centre environment. However, this will be focussed on enabling the testing of connected and autonomous technologies, rather than necessarily new business models and broad-based public policy development.^{viii}

Whilst autonomous private vehicles could easily fit the existing sales model – by substituting privately owned cars with privately owned autonomous vehicles – this is not necessarily the business model that will prevail by the time AVs enter the mass market.

Equally, much of the discussion in the mobility industry regarding public transport has so far focussed on essentially pushing the private car model into the world of public transport by using small autonomous pods or vehicles to provide tailored transport on demand.

However, our thriving cities are about millions and tens of millions of people moving daily in crowded and congested environments. In these environments, small pods, while an interesting technological intervention, will simply not provide anywhere near the scale of service that will make cities viable, especially in terms of peak flow, or tackle the issue of congestion.

In addition, there is potential for pods to conflict with walking and cycling. Active travel is being encouraged in cities all over the world, and requires safe road space to deliver sustainable mobility and health outcomes.

Further important questions about the role of autonomous pods need to be explored and addressed. For instance, if transport was provided by cloud-based private networks of shared autonomous vehicles, whose societal objectives would those pods be set to meet? Would it be possible to ensure that private fleets of pods met environmental standards or offered inclusive access across communities? How would advertising opportunities be governed and other such issues? Would a user or even a public leader even have any ability

to comment on and understand their dynamics, or would their control systems become a closed element of the proprietary system's technology?

And what if a city decides that these questions are simply too difficult to answer, and leaves its "position" on autonomy to private interests? How will this serve the city and protect the inclusivity and equality standards to which most public transport solutions across the world currently aspire?

In the absence of a broad-based public policy framework, the private sector will offer a version of the status quo with slicker technology; selling its standard offering of low-occupancy vehicles simply with higher levels of autonomy. This does nothing to address the problems of congestion but rewards travellers with in-vehicle entertainment and access to other productivity tools. This will be to the detriment of the overall economic performance of the city and to society.

Effective, successful and sustainable cities cannot be created through the model of the mass movement of millions of personal vehicles that replicate the congestion generated by private cars. This model also has the potential to exacerbate social divisions and societal conflict by being exclusive to certain "elites", because of price and locational access.

There are parallels in public transport where autonomous systems are extending beyond closed metro systems in places. For instance, the Thameslink project ATO system will enable 24 trains per hour in each direction over the standard ECTS north-to-south regional link (to be launched in 2018).^x

Trams in Ulm, in Southern Germany, are testing an intelligent driver assistance prototype system which guides tram drivers through the city traffic using a combination of radar and camera equipment. Such driver assistance technologies are a stepping stone to automatization, and assist with both safety and efficiency, optimizing speed and braking for fuel efficiency and emissions reduction.^x

Whilst increasing autonomy in the public transport sector is welcome, the current developments largely increase the levels of autonomy of existing services.

There is a further fundamental shift in thinking required. Combining the potentials of MaaS and autonomy could enable a phase shift in transport system design to be optimised, using better demand data to blend types of transport and integrate transport modes to deliver seamless and door to door solutions for real consumers.

The intelligent use of AVs in public transport will require greater levels of design in the business model – from how a passenger pays for a journey to how the solution is procured

and operated – however the opportunity this presents makes the additional considerations worthwhile.

Context is king

Conversely, a technology-led approach to automating our transport systems risks bulldozing through the spatial, demographic, economic, political and cultural contexts that have shaped transportation across the globe. This is a context that will confound technology-led players as they attempt to roll out standardised technological solutions across regions.

It is therefore essential that we inform, educate and encourage forward-thinking urban leaders and planners to become more involved in this broader societal debate. We also require our transport planners and economists to consider and determine what level of autonomy (from 0 to 5) is necessary to achieve a variety of different viable social and business models. For example, Daimler has identified that the added value of driver support on “big buses” is arguably the most significant improvement needed, over replacement of the driver.^{xi} This offers multiple benefits, including making the vehicles not only safer but feel safer to passengers.

Furthermore, we need to create a greater level of clarity over the relative benefits, and interdependencies, between the trend towards full automation and the towards full electrification of our transport fleet.

Transport planners and economists must be encouraged to take a holistic view of transport and consider the opportunities of an integrated transport system in which contextual data can automate transport mode decisions in real time. That is to say, taking a broader perspective not just on automation within a vehicle, but also on how an integrated system can be automated to react to weather, events, and changes in the movements of people and goods to benefit of the efficient operation of a city and the proactive management of transport solutions.

The test of autonomy and MaaS will be how we are eventually able to answer questions such as:

Can a passenger simply state an objective of needing to go from place A to place B by a certain time, taking into account their need to accommodate a wheelchair and a preference for as few transport mode changes as possible?

And:

Can the resulting service be met automatically and in a way that is creating a sustainable overall transport system?

This balance between the need for personalisation of service and integration into an overall sustainable system is the key.

Our call to action for bus, light rail and cities

We believe that the historic and successful earlier interventions in support of closed system rail-based autonomy needs to be brought to the broader bus and light-rail public transport markets.

This offers an innovation template that will bring new resource and cost models to public transport and will continue to make dense urban fabrics successful and viable. In addition, this offers the ability to bring the advantages of autonomy to the hundreds of millions rather than selected global elites.

How will autonomy, in its many forms, work within the bus and light-rail markets?

The user cases are widespread and need to evolve as the capabilities of autonomous systems develop.

These user cases would include: improved bus-stop docking for bus and rail systems to speed boarding and alighting; partial level 3 autonomy on certain sections of routes, perhaps in more suburban or rural areas; enabling drivers to have more ability to fulfil other customer roles within vehicles; much more precise route operation within physically congested areas; and better headway control.

Each of these small to medium-sized increments could have significantly multiplied benefits across entire public transport networks and on a global scale, as well as realistically address the needs of the public transport industry. These solutions should also be shared across the global mobility industry through open solutions that effectively allow cities to support safe and sustainable communities which empower humanity.

This approach also places integration at its core, rather than creating an overlay of a new and separate transport system. It seeks to make the existing systems work better and seeks to defend the substantial public and private investment that has already, and continues to be, put into public transport systems on a global scale.

Maturing and integrating Robotics and Artificial Intelligence

For the past year, TravelSpirit Foundation has been working closely with the National Advanced Robotics Research Centre (NARRC) in Salford University, which is celebrating the 30th anniversary of its foundation this year (2017).

We have, with support of a wider network of interested industrial partners (including Bosch, Cisco and the Northern Automotive Alliance), developed our thinking on how we can address the challenge of realising the full economic and pro-social benefit of Robotics and Artificial Intelligence (RAI) for tackling urban mobility problems.

This has resulted in the emergence of the ConcentriCity Alliance. The Alliance believes in the need for a focussed approach to autonomy that delivers benefits to the bus and light-rail industries in a way that delivers benefits for the realistic needs of our large conurbations and densely populated cities.

An integrated, connected and open ecosystem of autonomy that builds on the existing models of public transport and incorporates many of the sustainable lifestyle modes, such as walking and cycling, is what we believe will meet the needs of our growing world and challenging environment.

TravelSpirit Foundation is therefore seeking partners, both in development of RAI and Digital technologies and approaches, as well as funding partners that would enable this user case to be developed initially in a UK city, and then replicated worldwide.

We see this as an exciting and relevant challenge and seek to deliver this difference to the global mobility community. Please contact us to become involved and help us to drive these concepts forward and bring "open" to the world of mobility innovation!

What should happen next?

We aim to circulate this paper to key stakeholders in government, local authorities, the European institutions, industry and academia in the coming weeks to gain their feedback. We would like to have an open discussion about our views and proposals and use this to help refine our plans for the coming year.

Specifically:

- We want to explain, elaborate upon and debate our vision for the future of mobility in events, conferences, roundtables and forums throughout the UK, Europe and the world. Please contact us and engage with us.

- We will gather an ecosystem of interested partners around our open agenda at a conference in London, UK in Autumn 2017.
- We will support, however we can, mobility initiatives that embrace and champion our vision. We have already helped Simply Connect launch in Exeter (UK); we invite more businesses to come forward who are interested in being part of our ecosystem.
- We want to form active partnerships with other foundations, organisations, or government departments where we can work together to develop our concepts further, through activities such as whitepapers, events, research and advocacy. We want to enable overseas regional TravelSpirit boards to be established, lead local communities and thrive. We need local advocates to come forward and offer to drive these groups forward.

Fundamentally, we are now ambitious and want to challenge an actively changing mobility ecosystem. We are extensive in our network, but limited in our resources. We need support to enable us to meet our ambitions. We need government, business, academia, as well as partner foundations to consider our plans and, if they support them, see how they can assist us in making them a reality.

The Role of TravelSpirit?

The TravelSpirit Foundation was established in Manchester in 2016 to provide an open framework for the provision of new mobility services. To achieve our ambitious aims successfully for the emerging mobility sphere – within the UK and across the globe – we set out to build a global network of transport operators, software developers, businesses, policy makers, planners and activists across the mobility and technology sectors. Naturally, this global network is diverse, featuring a range of entities with different aims and objectives, so we are united by our four core values:

Universal Mobility as a Service: We believe that an integrated, connected, multi-modal MaaS system provides the needed path to sustainable and equitable transportation for all people and communities.

Open Innovation: We believe in an open innovation model, which rewards sharing of information that serves others, even our competitors, and brings benefits to all.

Global Community: We believe that by connecting coders, planners, activists, and policy-makers through a global network, we are better equipped to tackle the toughest mobility and transport challenges.

Local Benefit: We believe that our work must be grounded in its ability to demonstrate positive change by and for local communities and regions.

TravelSpirit is championing the role of “open” in the emergence of new mobility services and the evolution of MaaS as a global resource rather than an individualised business.

How to engage with us

We will be participating in and hosting a range of events across the UK and abroad in the coming months. Please come and speak to us and understand what we are doing and how we can support each other. This is one in our series of whitepapers and others, as well as short articles, will be prepared over the coming months. You will see and hear more widely about TravelSpirit, its activities and its views.

In addition, TravelSpirit is supported by a range of professionals in the UK and wider. We would be pleased to attend events to discuss our views on the future of mobility in panels and debates. We are also interested in partnering with other likeminded organisations where we might work together to progress these ideas. Again, please contact us to discuss any of these opportunities.

Acknowledgements

AUTHORS

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