INTERNATIONAL ENERGY AGENCY

WORKSHOP REPORT 2018

Automation, connectivity, electrification, and sharing (ACES)

Transforming road transport services

Kate Palmer

Jacob Teter

George Kamiya

INTERNATIONAL ENERGY AGENCY

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Executive summary

The International Energy Agency (IEA) is undertaking a new project on the future of road transport and the implications of automation, connectivity, electrification, and sharing (ACES). The project will explore the potential trajectories, interactions, and impacts of these transformations, and provide policy insights to steer developments that advance energy, climate, air quality, and other socioeconomic objectives. The key output of the project will be a policy insights publication in early 2019, as well as enhancing the modelling capabilities of the IEA Mobility Model.

The IEA convened a two-day expert workshop in June 2018 to solicit strategic and expert input to the upcoming analysis. Over 70 invited experts and decision makers from industry (automakers, service providers, tech, etc.), academia, government, and civil society provided input through presentations and discussions.

Workshop (13 June)

The main workshop aimed to facilitate debate around the key levers and topics that could have the biggest impacts on the long-term energy and emissions consequences of ACES. The day was organised into four themes:

1. **The future of highly automated vehicles:** When and how autonomous vehicles (AVs) are deployed will have an impact on long-term energy and emissions trends in road transport. The session featured presentations from diverse perspectives: DiDi (ride-hailing/tech), University of South Carolina (legal/regulatory), TomTom (maps), and UNECE (regulatory). In the ensuing moderated discussion, participants shared their perspectives on plausible development/deployment pathways, as well as the key remaining technical, social, and regulatory barriers to their broader adoption.

   For cars, experts agreed that high utilisation services such as taxis and ride-hailing fleets are likely to be early adopters (particularly along fixed routes). High-cost AV technologies are also more likely to be readily adopted on larger, more expensive vehicles such as buses due to the lower proportional cost. In trucks and road freight, AVs offer labour, fuel, and safety benefits.

   Adoption rates across different cities and regions will vary, depending on a variety of factors (e.g. built environment, demographics, regulations, public acceptance). For example, with an aging population in Japan, vehicle automation is a political priority. Dense urban centres, e.g. cites, will be the first places for deployment.

2. **Implications of automation for sharing and electrification:** Whether AVs are shared and/or electric will have implications for vehicle activity (vkm), energy use, and emissions (as well as impacts on the grid). The session included presentations on the experience of electrifying fleets (Uber and car2go) as well as ongoing research at the University of Virginia on modelling the operations and energy impacts of fully autonomous electric ride-hailing fleets.

   In the ensuing discussion, participants shared their perspectives on the range of barriers around electrifying fleet vehicles today, and the policies needed to drive the electrification over the near-term and for AVs of the future. For instance, the deployment of public charging infrastructure can help to spur adoption of EVs in mobility service fleets today and set up a network for electric AVs of the future. The electrification of ride-hailing fleets could constitute a powerful market signal to spur the roll-out of public charging infrastructure, with potential spillover benefits to private EV owners. City-level regulatory and incentive policies can also have substantial impacts for mobility service providers considering ways to electrify their fleets. Policies like London's ultra-low emission zone and congestion charging cordon, as

well as incentives for EVs to charge and park can change cost considerations in favour of EVs over ICEs for various mobility service providers.

3. **Impacts of ACES on modal choice and urban form:** Highly automated vehicles could drastically cut the cost of ride-hailing services and displace public transit services. Opening presentations and interventions from the International Association of Public Transport (UITP), Renault, and MaaS, and Lime explored the potential impacts of AV adoption on public transport, walking and biking, and its integration with these modes.

   The moderated discussion explored possible technical and policy tools that companies and governments could implement to encourage ACES developments that support an integrated multi-modal mobility ecosystem which provides reliable, affordable, and diverse options and access to all. The discussion centred on how policies, technologies and patterns of mobility will all vary across different urban contexts, for instance as a function of population density. This diversity implies for a need to apply context-specific or targeted policies to ensure that outcomes are aligned with goals.

4. **Policy priorities:** The impacts of ACES on future mobility patterns, energy use and emissions could be revolutionary. But they are also highly uncertain – in pace, direction, and magnitude. This final session brought together the issues and themes from earlier sessions to focus on the policy aspects of ACES.

   A keynote presentation from Robin Chase highlighted the critical role of government policy in steering developments in technology and behaviour toward a more sustainable and equitable future. Specifically, physical infrastructure and pricing policies are key: road space re-allocation and fair pricing schemes can shape a fairer transport system that focuses on moving people and/or goods rather than cars.

   Case studies from Japan and Europe, followed by a moderated discussion focussed on how governments could support AV development and deployment, as well as the policies that could steer ACES developments towards sustainability and equity objectives.

Modelling Meeting (14 June)

A select group of experts gathered on the second day of the workshop to present relevant research and engage in critical discussions on how to model elements of the transformations around automation, sharing, and electrification. Presentations helped to facilitate a dynamic discussion among all participants to help inform the upcoming IEA modelling effort.

Following an introductory presentation from the IEA on the Mobility Model (MoMo), the meeting was organised into four sessions, covering key modelling considerations:

1. **Surveys:** Surveys and empirical analogies to existing transport patterns (such as chauffeured rides) can inform our understanding of how behavioural patterns may adapt and evolve with new mobility services and technologies. Presenters showed how current travel patterns and preferences vary within and across global cities. Together with stated preference surveys that elicit travellers' judgments on how they would prefer to get around, these pre-existing differences in modal split, together with differences in the cost, convenience, and quality of service provision across modes are likely to influence the impact of automation and vehicle sharing as they roll out.

2. **Microsimulations:** Detailed activity-based and network models can help to examine changes in city-level traffic patterns resulting from system-level policy and technological change. Such simulations can provide insight into how disruptions might vary regionally, how they might

evolve over time, and what policies might be well-suited to meet a variety of policy objectives in different urban settings. Presenters further showed how microsimulations can be used to compare among policy options. For instance, by comparing the modelled impacts on congestion, air pollution, trip costs faced by end users and revenue streams collected through taxation, various alternative fiscal policies (such as congestion charging, occupancy-based vkm charging, or curb-side pricing) can be comparatively evaluated. General insights on promoting shared use of AVs also emerges; for instance the need to promote shared usage through regulatory or pricing instruments, to feed activity to mass transit and ensure line and station capacity along high-capacity transit lines, and the value of targeting early adopters (and in particular, private car owners).

3. **Cost comparisons:** Comparisons of per-km costs of passenger and freight mobility services using various combinations of technologies can inform the pace and extent of technology or service adoption. For instance, capital and operating costs -- including vehicle purchase, fuelling / charging, insurance, and maintenance and servicing (including cleaning of fleets) -- and even hedonic costs of driving versus engaging in other activities) can be compared between privately owned versus fleet operated ICEs, PHEVs, and BEVs. Sensitivity and 'what-if' analyses can be used to explore assumptions of the impacts of cost reductions (e.g. in automated vehicle software and hardware) and policy impacts (e.g. of occupancy-based or congestion charging). Analyses that disaggregate vehicle purchase, fuelling, and hedonic costs across socio-economic groups show that the relative competitiveness of private AVs improves at higher income levels, as the additional costs of AV technologies become a smaller share of overall costs and are offset by the gains to value of time for vehicle owners who no longer have to drive (or pay for a chauffeur). Consideration of the convenience benefits of private vehicle ownership – for instance through monetising them – suggests that a few key elements such as the reliability and easy access to mobility afforded by private vehicle ownership may continue to pose hurdles for shared mobility service business models, whether automated or not. Finally, participants offered considerations on the question of whether higher utilisation, which will be a defining characteristic of mobility services, may shift toward the competitive advantage of vehicle electrification.

4. **Modelling energy and emissions impacts:** Adapting the IEA Mobility Model to explore some of the impacts of mobility disruptions will require building upon insights from the modelling frameworks outlined above. It will further require adopting certain assumptions and simplifications. In this final section, participants discussed how insights from external researchers' modelling efforts can inform the IEA's upcoming modelling efforts. Participants discussed the various modelling frameworks that have been developed to date to model the mechanisms for ACES to lead to changes in activity demand, energy consumption and emissions. Key levers for reducing all three emerged, including: congestion pricing, policies restricting the allocation of road space within cities (and reallocating it to other modes or purposes), vehicle 'rightsizing', promoting and improving access to and ease of use of alternative modes (including smaller, shared modes such as scooter and bikes), and prioritising vehicle connectivity (V2V, V2I) and traffic flow in advance of and over automation. Modelling approaches shown were able to capitalise on technical efficiency data of real-world vehicle operations, city-level microsimulations, consumer preference and cost modelling, stock-turnover accounting, vehicle activity simulations, or some combination of the above elements. A consensus emerged for the IEA to focus on key dynamics, leave room for model refinement, and explore 'what if' scenarios to examine the energy and emissions consequences of alternative policy and technology pathways.

Introduction

This document provides a summary of the presentations and discussions from the IEA Expert Workshop on "Automation, connectivity, electrification, and sharing (ACES): transforming road transport services", held in Paris on 13-14 June 2018.

Over 70 experts and decision makers from industry, government, and NGOs participated in the two-day event, representing organisations from Asia (China, Japan, Korea), Europe (Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom), New Zealand, and the United States:

- Agora Verkehrswende
- AXA Group
- Bloomberg New Energy Finance (BNEF)
- Bosch
- BP
- Bruegel
- C40 Cities
- car2go
- CEiiA
- Clean Energy Ministerial (CEM)
- CleanTech Group
- COWI
- Danish Ministry of Energy, Utilities and Climate
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- ETH Zurich
- European Commission, DG Connect
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- Korea Transport Institute
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- POLIS Network
- PSA Group
- Renault
- RISE Viktoria
- Shared Mobility Principles
- Shell
- Stanford University
- TomTom
- Total
- Uber
- UITP (International Association of Public Transport)
- UNECE
- University of California, Davis
- University of Leeds
- University of South Carolina
- University of Virginia

The workshop agenda, participants list, and presentations can be downloaded from the workshop webpage: http://www.iea.org/workshops/automation-connectivity-electrification-and-sharing-aces-transforming-road.html

Day 1: Workshop

Welcome and workshop objectives

IEA Chief Economist **Laszlo Varro** welcomed participants and asserted the importance for the IEA in bringing together global experts for a candid discussion on how emerging mobility technologies could impact long-term energy and emissions trends. Laszlo provided an overview of the IEA's mission and modernisation agenda, as well as its role in convening all stakeholders across industry, government, and research communities. The new IEA project on automation, connectivity, electrification, and sharing (ACES) builds on the IEA's first report on *Digitalization and Energy* (2017).

Lead transport analyst **Pierpaolo Cazzola** provided additional details on the new ACES project, and the key questions to explore at the workshop: 1) how quickly will autonomous vehicles be deployed; 2) how they will be used (including extent of sharing and rebound effects in activity); 3) how will AVs impact other modes (e.g. public transit, cycling). Pierpaolo underscored the critical role of policy to steer ACES developments towards more sustainable and equitable outcomes.

Session 1: The future of autonomous vehicles

Session 1 focused on how, when and where autonomous vehicles will be deployed. The discussion focused on the different use cases and potential geographic locations where initial deployment may be more profitable. The session was moderated by **Tom Vöge** (ITF).

- **Zhang Xu** summarised **DiDi**'s mission of connecting all modes to make travel more convenient. In China, there is strong collaboration between map developers, OEMs and ride-hailing companies. However, development of autonomous driving regulation is difficult as it

falls under the jurisdiction of over ten government ministries that must all coordinate to form AV legislation.

- Professor Bryant Walker Smith from the **University of South Carolina** outlined how development of AVs could be encouraged to fix current issues within our transport system, for example crash fatalities and social exclusion; on the other hand, without sufficient policy direction AV deployment could entrench these issues. Expectations, timelines, and forecasts for future AV pathways will inevitably be wrong, but policymakers can emphasise necessary vs. desirable steps to resolve issues/challenges. The introduction of AVs presents a unique opportunity to raise the bar for all road transport.
- **Hervé Clauss** outlined how **TomTom** is developing HD maps for autonomous driving, adding to existing functions like fleet management, telematics and leveraging existing data points like traffic, weather, fuel, parking etc. Mapping is crucial for autonomy: allowing not just navigation, but also localisation, perception and path planning. Sensor data from AVs will be critical to update HD maps but the scalability of this data collection is challenging.
- François Guichard discussed how **UNECE** is developing regulation for mass market AVs with the understanding that in the future AVs could help countries meet UN Sustainable Development Goals and mitigate issues such as congestion, pollution, CO_2 emissions and the road safety crisis. Other regulatory challenges (beyond safety) could be addressed at the same time, such as cybersecurity, data protection and over-the-air updates (as well as artificial intelligence / machine learning).

The ensuing discussion centred on the following topics and questions:

- **What is the status of automated driving technologies?** Automated driving technology is not fully developed and could follow a number of different development pathways: increasing driver assistance, enhanced safety features or truly driverless systems. Level 3 automation may pose serious safety risks given the time it takes for human take-over (6-7 seconds) greatly exceeds the minimum required warning time. By 2030, a mixture of vehicles on the road are expected (not just L5), resulting in challenges around how vehicles with different levels of automation will interact. Depending on the remaining barriers, adoption could happen very quickly once mass-market options are available. Artificial intelligence and deep learning were identified as potential key areas to accelerate AV development.
- **What are the key policy and regulatory challenges?** Law is often cited as the barrier to AV deployment, but some experts believe that the technology is still not sufficiently mature for mass deployment. The introduction of AVs could be an opportunity to raise the regulatory bar for all road transport, such as lowering speed limits and incorporating other AV types such as delivery robots and drones. A key question is who should lead on AV regulation: cities, national governments, or inter-governmental bodies? Regarding liability, similar to the flight recorder utilised in aviation to facilitate with the investigation of accidents and incidents, a regulation is being prepared for a similar device for AVs. One of the challenges around liability is the lack of global harmonisation in the insurance and telecom sectors (unlike the auto sector). The remote control of AVs faces two key challenges: cybersecurity and data/connectivity latency. Data standardisation and access are important for future development and deployment of AVs.
- **What use cases will be early adopters of AVs?** For **cars**, high utilisation services such as taxis and ride-hailing fleets are likely to be early adopters (particularly along fixed routes). High-cost AV technologies may be more readily adopted on larger, more expensive vehicles such as buses due to the lower proportional cost. Autonomous shuttles could be a solution for the last-mile problem. In **trucks and road freight,** AVs offer labour, fuel, and safety benefits. The

hype surrounding autonomous trucking is still growing, with increasing investment across the US, China and other parts of Asia.

- **In which geographic regions will we see earlier (or later) adoption?** Scenarios will differ from city to city across the world. With an aging population in Japan, vehicle automation is a political priority. In other regions such as California where platooning trials were vetoed, the political will is not as strong. Dense urban centres, e.g. cites, will be the first places for deployment; however, we may never have autonomy across all road transport everywhere.

Session 2: Synergies between automation, sharing, and electrification

Session 2 focused on how to promote sharing of autonomous vehicles (AVs), and how to ensure that AVs, when rolled out, are electric. The session was moderated by **Lew Fulton** (UC Davis).

- Alan Clarke summarized **Uber**'s efforts to reduce air pollution impacts of their operations (via promoting hybridisation and electrification) as well as to ameliorate congestion (via promoting pooling). Uber has already completed 1 million miles on EVs in the UK to date, and has ambitions to transition to fully electric operations in London by 2025. To get there, the company charges a clean air fee all on journeys within the UK, which is then allocated to offset up to £5000 off Uber drivers' purchases of (at first, both) conventional hybrid and electric vehicles (EVs) (and later, gradually phasing out subsidization of hybrids). To support the further electrification of fleet vehicles, it will be crucial to roll out publicly-accessible rapid charging stations in and around major cities in the short term, and of building up networks of charging hubs in urban areas in the longer term.
- Professor T. Donna Chen from the **University of Virginia** summarised an ongoing research project that focuses on the operations and energy impacts of fully autonomous electric ride-hailing fleets in an urban setting (namely Seattle). Her research illuminates the interdependencies among key technical and operational parameters – battery size and EV range, charging time and speed, share of pooled rides, and electricity pricing structure (i.e. a constant price versus time-of-use [TOU] pricing) – and how these factors jointly determine the optimal fleet size, costs, and operational strategies for serving passenger mobility demand.
- Mathieu Bernasconi outlined the scale and scope of **car2go**'s free-floating app-based car sharing services across cities in China, Europe, and North America. He focused on three European cities (Stuttgart, Amsterdam, and Madrid) where car2go offers EVs. These EVs currently make up about 10% of car2go's fleet. Mathieu went on to summarize how analysis of car2go's operations (taking the examples of demand prediction and intelligent charging) could be leveraged to manage the transition to AV fleets.

The ensuing discussion centred on the following topics and questions:

- **The eventual convergence of mobility service business models** (e.g. app-based ride hailing, car sharing, and other modes) in an era of highly autonomous vehicles. But providers may continue to differentiate themselves from one another on the basis ownership of assets, the range of modes and services offered, and other specifics.
- **How to promote electric operations in current ride-hailing operations.** The purchase price premium of EVs relative to new ICE vehicles is a major hurdle for wider market adoption. Since drivers for Transportation Network Companies [TNCs] typically own and operate second-hand vehicles, this challenge is all the more acute, making EV adoption among TNCs that much more difficult. These drivers are also unlikely to be able to afford home charging.

Short- and long-term leasing models, which have already been trialled by some TNCs, may prove to be an effective way to address this issue.

- **Range anxiety issues are even more acute for ride-hailing operations than for private EV owners.** But TNCs are well-positioned to use their data analysis capabilities to alleviate drivers' concerns over range by providing suggestions on how to improve and balance recharging.

- **Energy consumption of back-end sensors and data processing** for current trials of AVs is considerable (though highly variable depending on technologies), and near-term energy requirements for such operations will likely exceed 20% of the tractive energy of a vehicle (although current energy requirements tend to be much higher).
- **The importance of cities deploying public (on-street and other) charging infrastructure to spur adoption of EVs in mobility service fleets.** If TNCs can electrify city-level operations, the constant and reliable energy demand could constitute a powerful market signal to spur the roll-out of public charging infrastructure, with potential spill-over benefits to private EV owners, and with broader (potentially positive and negative) implications for grid stability and demand shaping. Over the near-term, charger availability may be limited overnight.
- **City-level regulatory and incentive policies can have substantial impacts for mobility service providers considering ways to electrify their fleets.** Policies like London's ultra-low emission zone and congestion charging cordon, as well as incentives for EVs to charge and park can change cost considerations in favour of EVs over ICEs for various mobility service providers. With such policies, payback periods can be substantially shorter, and since TNCs have greater access to capital and a strong understanding of the technical and economic aspects of their operations, they can be more effective than in the case of private vehicle purchase decisions.
- Currently, the **surges in demand for ride-hailing services are typically on weekend evenings and nights,** and not concurrent with typical weekday morning and evening congestion peaks associated with commutes.
- **Grid impacts of substantial and/or rapid deployment of EVs providing mobility services in cities** (and operating for a significant portion of the day) were highlighted as a key concern. Various 'fixes' were discussed, including:
  - The potential for V2G to enable using EV batteries as a mobile, diffuse stock of dispatchable energy storage;
  - The importance of TOU pricing, and the opportunities under TOU pricing for TNCs to improve demand prediction to manage grid impacts;
  - The possibility for PV solar generation to complement EV battery storage in space in time to provide a more responsive and flexible grid. The mismatch between peak PV generation and peak ride-hailing demand may limit this synergy;
  - The possibility of battery swapping, though challenges in standardization among automakers, high cost of overcapacity, and the need for temporal and spatial matching could limit interest in this option.

Session 3: Implications for modal choice and urban form

In the third session, participants explored the potential impacts of AV adoption on public transport, walking and biking. The discussion further sought to delineate potential bidirectional impacts between the built environment and transport infrastructure, on the one hand, and the ways that autonomous and shared mobility might affect how people get around and goods are moved, on the other.

- Mihai Chirca of the **International Association of Public Transport (UITP**) introduced the UITP, an organisation that unites over 1 500 diverse stakeholders from 96 countries in the sustainable mobility community (public transit operators, industry, associations, research institutes, and policy makers) to enhance quality of life, economic well-being, and sustainability. As evidenced by ongoing AV pilots, fixed routes and clear operational specifications make public transport an attractive use case for demonstrating and refining AV technologies. Eventually, AVs could become part of a diversified public transport ecosystem wherein robo-taxis and on-demand shuttles feed into high capacity transit networks. On the other hand, cheap and convenient AVs could displace transit and active modes while increasing vehicle activity, for example though empty vehicle travel and induced urban sprawl. To address these issues, the UITP advocates policies to encourage sharing (implemented before widespread AV deployment), large-scale repurposing of liberated on-street parking, and efforts to integrate shared AV fleets with public transport as well as walking and cycling. By strategically tackling these three issues, cities can ensure that AVs improve an affordable, space-efficient, and diverse range of mobility options. Policies that encourage sharing must be rolled out before AVs become a reality on the roads. Best practices in municipal planning, such as integrated land use and mobility planning, and policies that promote transit-oriented development, can converge with the evolution of MaaS to lay the foundation for AVs to contribute to social and environmental goals.
- The vision of future mobility in cities presented by Clément Dupont-Roc of **Renault** bore striking similarity to the one presented by the UITP. Clément drew upon consumer choice modelling based on surveys on current travel behaviour and stated preferences of people living in Los Angeles, greater Paris (Ile-de-France), Beijing, and Tokyo. Based on projected technology costs and consumer preferences, he showed how mobility patterns and modal shares might shift with the availability of automated cars and shared AV shuttles. In Los Angeles and greater Paris, for instance, the study found AVs would substitute for private car trips, while in Tokyo, they might draw more riders from public transport. Clément closed by summarizing the impacts of the modelled potential changes on congestion and local pollutant and CO_2 emissions in greater Paris. By reducing reliance on cars and shifting to shared AV trips in cars and shuttles, lower resulting road vehicle activity (vkm) leads directly to lower emissions, though the magnitude of these modelled impacts was never more than a reduction of about 20%.
- To illustrate the value proposition of **MaaS Global,** Krista Huhtala-Jenks used an analogy of a heavy-metal band. Like an obscure band, the concept of multimodality has thus far yet to break into the mainstream. By providing all the key elements to satisfy users' desire for reliable, affordable, simple and convenient mobility on demand, MaaS Global aims to compete with private car ownership and sustain the flourishing of an open and diverse mobility ecosystem. MaaS Global's **Whim** app, already operating in Helsinki, the Western Midlands of the UK, and Antwerp, provides a palette of mobility options – integrating modes, schedules, payment, and preferences. Finland's Act on Transport Services has played a key role in enabling a diverse mobility ecosystem and MaaS by requiring open data sharing across private and public mobility providers and discouraging exclusivity between mobility services and MaaS aggregators. To strike it big, a heavy-metal band (MaaS) needs to have all the pieces in place – the solid bassist (the regulator, in the analogy to Mobility-as-a-Service [MaaS]), the drummer (public transport operator), the virtuoso lead guitarist ('new mobility' services), and the enticing vocalist (MaaS platform provider).
- **Emily C. Warren** of **Lime** discussed the current modal shift impacts of shared mobility, how these impacts could change with shared AVs, and how policy could incentivise the use of convenient, reliable, space- and energy-efficient modes in high- and low-density contexts. According to available research, TNCs currently are not, by and large, being used as

substitutes for public transit. But as their usage grows, the extent to which ride-hailing/TNCs (Transport Network Companies) draws riders from public transit depends on the quality of public transit services (i.e. high capacity mass transit isn't threatened by TNCs, but low frequency / low ridership bus services are). This indicates that people are responding rationally and that TNCs are providing a useful and valuable service. 'Dockless' shared mobility services such as bikes, e-bikes, and e-scooters could help reduce congestion and local air pollution in high-density urban areas.

Several important elements should be considered in the design of policies to steer new mobility trends in the public interest. Emily advocated for a policy regime that is uniformly applied regardless of whether vehicles are privately owned or not. Further, policies should be able to differentiate between geographies, and take into account the fact that, for instance, dockless services are well-suited to high-density urban areas, while ride-hailing is best-suited in low-density areas. For their part, public transit operators could better incorporate insights from user behaviour, for instance by learning what aspects of public transit riders value most and incorporating these key elements. Public transit operators should aim to leverage shared mobility services to feed high capacity fixed lines (i.e. first- and last- mile) while focusing on more viable, high-quality service provision (which tends to be closer to profitability in the first place).

Discussion centred on the following topics:

- **Congestion pricing** was cited by a number of participants as a key policy in promoting the sustainable use of shared/autonomous cars (e.g. as a feeder for high-capacity public transit, and in contexts where transit, walking, cycling, and/or dockless modes are not viable).
- **Promoting responsible use of dockless shared modes** (such as scooters and bikes). Technology is available to monitor the operations and conditions of vehicles to hold users accountable for their treatment and use (e.g. parking location). The novelty of these dockless modes obstructing sidewalks was contrasted with the everyday bad behaviour of cars and motorcycles, such as parking in bike lanes, aggressive driving, and texting while driving (which tend to be more often overlooked or tolerated, as they has long been part of the urban fabric).
- **How automakers might position themselves for a world in which shared mobility services would translate directly to reduced sales volumes**. A shift from private car ownership to mobility services could lead a shrinking sales market for automakers, but at the same time to the emergence of a far larger market for mobility services. While the timing and extent of these changes is disputed, Automakers are positioning themselves to be among the first to exploit and master the potential future market (recognizing the fact that other companies are already established in this space), while at the same time continuing to compete in their core competencies. One participant warned that the **size of the market alone is not a sufficient criterion for judging the potential for profits** in that market. Operating margins, it was argued, tend in many sectors to be higher in product manufacturing than in service provision.
- **The degree to which cheap and convenient shared mobility services could replace/displace high-capacity low-quality public transit (e.g. crowded and dirty metros).** Participants cited evidence of consumers choosing travel modes primarily based on trip speed, price, and reliability. Other considerations, such as cleanliness, noise, etc. tend to be secondary. Other participants noted the high costs and operational challenges of ensuring cleanliness in shared mobility fleets (e.g. in car sharing services today, as well as in future shared AVs).

- A participant raised evidence that TNCs have already reduced peoples' willingness to walk and bike, and that these shifts away from 'active' modes do and are likely to continue to have negative impacts on people's health, as well as on congestion and air pollution.
- **Viable public transport, ride-hailing, and infrastructure making active modes safe and convenient are needed for MaaS to succeed**. It was noted that different urban transport modes tend to be optimised for a certain subset of use cases, but in contrast to the personal car, no single service/mode is able to fulfil the spectrum of consumer needs. Hence, in the absence of a wide range of flexible, redundant, and reliable alternatives, car owners will be reluctant to give up the security and reliability of their default option. Once a complete mobility ecosystem has been established, MaaS operators could incentivise trip choices that have lower societal and environmental impacts than the personal car, while at the same time providing a superior level of service.
- **Would a (monthly or annual) flat rate, subscription pricing for MaaS incentivise more travel?** MaaS Global does not yet have a reliable baseline or counterfactual against which to measure the impacts of fixed subscription rates. The commercial viability of a subscription package for ride-hailing is likely very limited when people are driving cars, but in a world of AVs, there may be times of day when excess fleet capacity might make it attractive for ride-hailing companies and/or MaaS providers to offer rides at no additional cost to MaaS plan subscribers.
- For MaaS to be viable, an open ecosystem allowing with open data that is standardized to enable APIs to do trip matching would be needed, and MaaSs platform services would ideally also compete.
- The possibility of MaaS apps providing behavioural nudges that extend beyond (inter-)modal choice to deciding when and whether to make trips. This extends to making MaaS apps provide broader 'lifestyle' management services that go far beyond mobility.

Session 4: Policy priorities

Session 4 brought together the issues and themes from earlier sessions to focus on the policy aspects of ACES. Discussions focussed on how governments could support AV development and deployment, as well as the policies that could steer ACES developments towards sustainability and equity objectives.

- In her keynote presentation, Zipcar and Veniam co-founder **Robin Chase** summarised possible visions of contrasting urban futures, largely dependent on how policy implementation shapes AV ownership and usage. In a "Heaven" scenario, appropriate policies and pricing ensure AVs are electric, used judiciously, and with incentives for shared use, resulting in cities that are more sustainable, equitable and just. In the opposing "Hell" scenario, AVs travel under inadequate existing tax and regulatory regimes, are privately owned, used for low value trips, ghost vehicles contribute to increasing mileage, and congestion is an even greater problem than today. Robin concluded that physical and tax policy infrastructure are key to future development: road space re-allocation and fair pricing schemes can shape a fairer transport system that focuses on moving people and/or goods rather than cars.
- Naoshima Hashimoto from the **National Institute of Advanced Industrial Science and Technology** discussed ambitious targets for AV deployment in Japan, including operation on expressways by 2020 and truck platooning by 2022. He introduced key government actions in Japan to develop and deploy automated driving technologies and systems: namely around technology development, Field Operation Tests (FOT) and legal considerations (Charter of Improvement). Key benefits of AV deployment were identified, for example, AVs could

provide mobility services to an aging population while revitalising rural communities. Also, the first/last mile project (one of the FOT projects) was introduced, which includes experiments/trials and the use of automated EVs.

- Zoi Sagia from **DG Connect** outlined the **European Commission's** third Mobility Package, "Europe on the Move III", presented in May 2018. The package covers safe, autonomous, and clean mobility, and includes a range of measures to support, incentivise and regulate AVs across the EU. It is supported by a call for proposals under the Connecting Europe Facility (CEF) with €450 million available to support projects in the Member States. Under the CEF Telecom programme there will be an additional €6 million available with €2 million of this set aside for projects concerning Cybersecurity for Connected and Automated Mobility. Five digital cross-border corridors have already been established with an additional corridor under development. The incremental deployment of 5G will be a key enabler to the advancement of AV technology.
- **Suzanne Hoadley** outlined the role of **Polis Network** in facilitating peer-to-peer discussions on current and future city issues, including mobility. With so many uncertainties surrounding the development of AVs, we may be distracted by a future that we may never reach. Instead, policy should focus on the challenges of today's transport system, such as supporting high capacity public transit and active modes without viewing AVs as a panacea.

The ensuing discussion centred on the following topics and questions:

- **The role of policy and regulation to enable trials and demonstrations in the near-term and deployment in the longer term.**
  - Many delegates recognised the critical role of governments in enabling and supporting the deployment of AVs. Clear policy intent and implementation signals a government's support for AVs, and can help inform the car designs of the future. For this reason, proactive policy is crucial.
  - 27 European Member States (plus Norway and Switzerland) signed a letter of intent in March 2017 acknowledging the need for AV testing in the short-term. Some of these countries have already signed memorandums of understanding to establish cross-border corridors for testing connected and automated vehicles. The European Commission will set out recommendations for legislation of data, cybersecurity and connectivity by the end of 2018. In addition, the Communication on Connected and Automated Mobility (part of Mobility Package III) states that in 2018 the Commission will establish a single EU platform for all relevant public and private stakeholders to coordinate open road testing and pre-deployment activities. In Japan, affordability and user acceptance are very important, therefore policy needs to address these issues to stimulate AV deployment.
- **Policy options to encourage sharing, interoperability and integration across different modes and mobility service providers.**
  - Availability and access to infrastructure is a constraining factor for the provision of mobility. In this context infrastructure signifies physical assets (road space, kerbside access, charging infrastructure and so on) as well as (ideally, real time) data about the entire system. In recent history the design, use, and allocation of infrastructure has centred upon enabling the ease of use of personally owned cars, and in most instances there has been little attempt to discriminate according to the nature of the journey (e.g. short vs long trips, single occupancy vs multi-occupancy shared trips, time and geography of travel). The lack of extensive and granular mechanisms and political will to price in the true impact on air pollution, congestion and access to the kerb in conditions of scarcity all

mean that, in effect, journeys made by personally owned cars are a disproportionately attractive option.

- It is more politically acceptable to regulate 'pioneering' shared mobility services (corporations / organisations) than it is to regulate personally owned cars (individual citizens). But taking just one approach in isolation is unlikely to be sufficient to achieve the desired policy outcomes. Constraining personal car ownership and use must therefore go hand in glove with policies to encourage and promote shared mobility services.
- With the advent of AVs, there are concerns that car trip costs could drop further, resulting in mode shift from public transit to low occupancy (or empty) autonomous cars. Dynamic (or surge) pricing was identified as one method of changing how people make mode-choice decisions. This has already been introduced in ride-hailing services with general positive feedback. While congestion pricing has been political unviable to date, increasing gridlock, the resulting economic pain, and new technology options might change this.
- Another key policy could be the introduction of road pricing, which would replace lost fuel taxes due to transition to zero emission or low emission vehicles. Political timelines play a significant role in planning and policy design and implementation. In many countries, officials are only in government for 5 years, and therefore long-term change is intangible; whereas in China, with 15-20 year political targets, the pace of development and planning takes a longer-term view.
- Urban development over the past several decades in many cities has led to worsening social inequality and mobility access. Appropriate policies could help guide AVs to help address (rather than exacerbate) this inequality.

- **How energy and transport models could help inform policy and planning decisions.**
  - Although energy and transport models are generally recognised to be useful, several key issues have been identified in their utilisation in this field. In many organisations, there is often a struggle with having internal expertise to interpret advanced transportation model. Because of this, within these organisations it can be difficult making recommendations and broad conclusions that policy makers can act on.
  - As with most modelling, there are challenges regarding the quantity, quality, and reliability of data for these model inputs and calibration, mandatory data sharing was identified as a key necessity for improving this area.

Closing remarks

Pierpaolo Cazzola and **Jacob Teter** (IEA) provided closing remarks, summarising key themes from the day. He emphasized the clear and considerable economic opportunities that could in theory be realised by making travel cheaper and more convenient. From this vantage point, it is clear that for AVs to enter the market at a level beyond demonstration projects, there is a need for technologies and business models to prove not only their technical viability – in terms of safety, reliability, and functionality – but also their economic superiority over human drivers.

Another point of apparent consensus was the existence of synergies between both vehicle automation and sharing, on the one hand, and electrification, on the other. This consensus is not absolute, and is conditioned by certain barriers such as availability of charging infrastructure, time requirements of charging, and the high energy consumption of on-board automation hardware and algorithms.

But these points of consensus stand in sharp contrast to the uncertainties surrounding many other elements of the potential for mobility disruptions. First, no consensus emerged on when

AVs might become available, nor on the speed with which they might begin to penetrate different settings and use cases. Second, it became clear that "automated vehicles" were not a single thing but rather that this catch-all term obscures a broad range of potential technology solutions, capacity or levels of automation, and use cases.

Another point of debate was on the role of bus systems. Sharing and automation may end up favouring certain bus services, likely depending on policy context and urban form. More generally, there seems to be potential for MaaS and ACES to open up mobility to a more diverse set of multimodal and intermodal options, but this again depends on many unknowns.

Given the uncertainties, and the huge potential for rebound (which was hinted at but largely remained unexplored in the main workshop discussions), there is a clear role for policy. It is clear from looking at the issues faced by cities today, such as congestion and air pollution, that there is a policy gap. Continuing challenges in providing reliable, affordable, and convenient mobility and access to goods and services and in facing negative externalities show that policy is already currently not sufficiently effective nor proactive. Road use charges like congestion charging or distance-based pricing were mentioned on several occasions as a critical and primary policy instrument, and indeed declining revenues from gas taxes could help bolster the case for these.

Other issues, such as cybersecurity, privacy, and equity, were not discussed in much depth, but are also important to consider in the context of mobility disruptions.

Day 2: Modelling Meeting

A select group of experts gathered on the second day of the workshop to present relevant research and engage in critical discussions on how to model elements of the transformations around automation, sharing, and electrification. Presentations helped to facilitate a dynamic discussion among all participants to help inform the upcoming IEA modelling effort.

Introduction

- Jacob Teter (IEA) provided a brief introduction to the IEA Mobility Model (MoMo). This tool integrates global historical data across all major motorised transport modes with policy, economic and technology drivers, and is used to explore potential energy and emissions impacts of alternative policy and technology futures. The presentation focused on the current modelling assumptions and methods, and how these would need to be updated to attempt to capture the key elements that would change if passenger and freight services in road modes were to shift away from current usage to shared usage of connected, automated, and/or electric vehicles.
- Questions raised during the introductory discussion include: How to balance trade-offs between model resolution and complexity, and detailed casual links between technologies, prices, policies and behaviour with the need to simplify for tractability, limitations in the available data in most cities and countries, and irreducible complexity? With a focus to date on the costs and attractiveness of alternative services to the end-user, what new or additional insights could be gained by modelling the competitive behaviour or comparing the profitability / risk and strategic behaviour from the perspective of firms (e.g. mobility service providers, car and truck manufacturers, shippers and haulers)?

Session 1: Surveys

- **Clément Dupont-Roc** (Nissan-Renault) went into further depth on the methodology of the consumer choice modelling work presented at the workshop. The online survey collected data from over 7 500 survey respondents. The survey assessed consumers' mobility choices and preferences across a range of characteristics such as journey length and type, wait times, parking availability, and price (though no variable/attribute for comfort was included). The findings across the study cities (in EU, US, China, and Japan) indicates that modal preferences differ between cities/regions, but there were two convergent trends across the cities. First, preferences for cars were below its actual mode share, reflecting the hassle of owning a private car in large cities. Second, preferences for ride-hailing and taxis were above the actual mode share of these options, indicating the need for lower-cost ride-hailing options.
- Sebastian Hörl (ETH Zurich) presented on several of his research laboratory's recent and ongoing research projects. After briefly introducing the mesoscopic simulation framework used to model road and rail activity in and around Zurich, he proceeded to show the preliminary results: how this simulation is used to estimate the impact of AVs over space and time on vehicle activity. He next introduced how costs are incorporated into his modelling; compared the costs of rail, bus, individual and pooled taxis, and private cars; and how costs could be expected to change if AVs were to roll-out. Finally, he explained how stated preference survey responses are translated into inputs for simulations of the impact of introducing AVs. He closed by summarising ongoing research areas. These include studying the impact of operational constraints (e.g. availability of charging infrastructure); spatial

constraints (e.g. parking availability); intermodality (and coordination among modes); and the impacts of externality and congestion pricing.

Session 2: Microsimulations

- **Luis Martinez** (ITF) presented ITF's work on shared mobility and policy implications from Lisbon, Helsinki, Dublin, and Auckland using agent-based simulation models. Several scenarios and targeted policies were modelled to test the impacts of policy on a range of outcomes, including modal shares (including heavy public transit ridership), CO_2 emissions, and average mobility costs. The comparisons across the cities suggest four key factors affecting impacts: current modal share, public transport quality, population density, and trip patterns. Targeted policies tested include car use restriction, electrification policies, and high deployment of autonomous taxis and shuttles. Key policy recommendations include: 1) Enable shared mobility as part of policy package; 2) Introduce at a sufficient scale; 3) Feed to mass transit; 4) Target potential early adopters, particularly car users; and 5) Ensure line and station capacity.
- **Panagiotis Angeloudis** (Imperial College London) presented the methods and results from two modelling streams: traffic & dynamics and logic & interactions. A range of inputs (e.g. emissions, acceleration, GPS) informs a vehicle behaviour model to simulate AV traffic and emissions at a range of penetration rates. Results show improvements in CO_2, PM, ad ride comfort with a 100% penetration of connected AVs. He also presented on an ongoing case study on pricing strategies between competing TNCs to look at the impact of ride-matching, adaptive pricing and other strategies on wait times and total AV TNC mode shares.

Session 3: Cost comparisons

- **Zia Wadud** (University of Leeds) began by sharing results from a survey of how chauffeured riders currently spend their time in cars and how they would prefer to spend their time. He then focused on a recent TCO analysis for different income groups and personal vs. commercial use. The results indicate bigger potential cost savings from automation of commercial vehicles (taxis, trucks) compared to privately-owned AVs. Among private vehicles, privately-owned AVs could yield lower TCO for the highest income groups (80^{th} and 99^{th} percentiles).
- **Lew Fulton** (UC Davis) discussed an array of out-of-pocket costs as well as hedonic costs that could impact adoption/use of AVs in different use cases. Hedonic costs include travel time (which differs for drivers and passengers), parking search time, walking time, lack of privacy of shared trips, etc. Including hedonic costs such as parking search costs and travel time costs, automation could make electric AV taxis cost-competitive even on a variable basis compared to private vehicles. Other hedonic costs (e.g. value of storing things in your personal vehicle) need to be further explored, but surveys and other considerations suggest they are unlikely to be game-changers.
- **Nikolas Soulopoulos** (BNEF) discussed recent progress in cost reductions for EV batteries, which is underpinned by technology improvements as well as economies of scale. Continued costs reductions coupled with improvements in battery energy density and durability will make EVs more and more competitive on a TCO basis compared with private ICE vehicles. Higher utilisation that would be a defining feature of mobility service fleets results in parity sooner. Possible barrier to electrifying AVs: charging speed and availability; EV driving range; battery degradation; computing load on batteries.

Session 4: Modelling energy and emissions impacts

- **Zia Wadud** (University of Leeds) presented his bounding analysis on the potential energy impacts of ACES. Together with other bookending studies conducted in the US, his work (Wadud et al. 2017) demonstrated the high probability that with the introduction of AVs, total road vehicle activity (vehicle-kilometres, or vkm) is likely to increase unless rides are shared (and even then it may still increase). His paper highlights the potential for more certain but minor early energy and emissions benefits of vehicle connectivity (V2V, V2I), but growing uncertainty on impacts as CAV technologies improve. Some of the mid- to long-term uncertainty could be reduced, and energy impacts steered to more energy efficient and reduce congestion, by for instance incentivizing 'rightsizing' or through congestion pricing.
- **Jeff Gonder** (NREL) presented an overview of the US DOE SMART Mobility laboratory consortium, which has collaborated on a wide range of ACES-relevant research and demonstration projection. He then highlighted studies and ongoing research projects at NREL. Early book-ending analyses (Brown et al. 2014; Stephens et al. 2016) showed large impacts under high levels of automation (-60% to +200%), but muted effects with partial automation (+/-10-15%). New bottom-analysis using FASTSim (e.g. Kaushik et al. 2018) aims to explore more nuanced scenarios (e.g. different driving scenarios, geographic variability) and their impact on fuel consumption rates. Such efforts have informed national-level analysis (e.g. Chen et al. 2017) and results are in the same ballpark as 2017 AEO. The ADOPT Model (a vehicle powertrain choice model developed at ORNL) incorporates fleet mix, non-linear consumer preferences, and sale and stock turnover from FASTSim to examine how preference characteristics change over time in a scenario where highly automated vehicles become technically and economically viable. NREL is also doing analysis on EV charging infrastructure (e.g. in the Columbus region using large dataset from INRIX GPS data), as well as on the energy impacts of TNCs (including commuting and deadhead miles).
- **Robert Spicer** (BP) shared results from the 2018 BP Energy Outlook (EO18), which shows moderate penetration (25-30% of vkm) of AVs by 2035-2040. EO18 uses a combination of modelling approaches – but relied in particular on the new custom built *Mobility 2050* model with vehicle-kilometres (vkm) as the key pivot point – meaning that projections are built upon demand for pkm, that modal split then determines the demand for mobility by car, which may then be designated (again according to vehicle choice functions) to be by AV, EV, and/or shared, on which basis the choices of vehicle powertrain and vkm (and ultimately energy and fuel use) are derived. *Mobility 2050* uses mobility activity data and projections with two consumer choice models (car ownership and mode choice) to estimate mode share and quantify the impact and dimensions of "new mobility". Next steps include model iteration and improvement, as well as integrating BP's legal transport energy model with the new *Mobility 2050* model. Key assumptions to test and explore include value of time and diffusion parameters.

Annex: Agenda

Expert Workshop (13 June)

8:30	Registration and coffee	
9:00	**Welcome and workshop objectives**	
	Laszlo Varro, Chief Economist	**IEA**
	Pierpaolo Cazzola, Lead Transport Analyst	**IEA**
9:15	**Session 1: The future of autonomous vehicles**	
	Real-world testing of vehicles with high levels of automation – "autonomous vehicles" (AVs) – is underway in cities around the world. Automakers and mobility service providers have announced plans to introduce highly automated vehicles and services as early as 2020, but there is still much debate around when and how they will be deployed and widely adopted. Challenges around technology and costs, regulation, liability, cybersecurity, and public acceptance of AVs remain. In this session, presentations will set the scene for a discussion where participants will debate plausible futures for automated driving technologies. • What is the status of automated driving technologies? What are the key remaining technical challenges? What policy and regulatory barriers need to be overcome? • What use cases in passenger and freight will be early adopters of AVs? In which geographic regions will we see earlier (or later) adoption? • When and how quickly will AVs be widely deployed? What will the transition look like? • How will deployment and impacts differ across passenger services and freight; in urban, suburban, and rural regions; in different cultural contexts and global regions; over the medium and longer-term?	
	Moderator: Tom Vöge, Policy Analyst	**International Transport Forum (ITF)**
	Zhang Xu, Director	**DiDi**
	Bryant Walker Smith, Assistant Professor – School of Law	**University of South Carolina**
	Hervé Clauss, Director of MAPS Global Sourcing	**TomTom**
	François Guichard, Focal Point for ITS and Automated Driving	**UNECE**
11:00	Coffee break	
11:30	**Session 2: Synergies between automation, sharing, and electrification**	
	Vehicle automation could have major implications for vehicle/ride sharing and electrification. AVs could provide major cost cuts to hailed or pooled rides, while also making mobility services more attractive. Higher utilisation rates of shared and/or highly automated vehicles are likely to favour EVs for their lower fuel and maintenance costs. However, whether EVs will be better placed than conventional ICEs to fulfil all the operational and technical requirements of shared and/or autonomous vehicles is less certain. Following introductory presentations, participants will discuss how to accelerate the sharing and electrification of AVs. • What are the key challenges in encouraging the sharing of vehicles and rides? What can be learned from TNCs and pooled rides today? How might the economics of mobility services change with autonomous vehicles? What are the appropriate roles of companies vs. governments? • What are the key challenges in electrifying autonomous vehicles of the future? What lessons can be learned from early EV adopting consumers and fleets? What near-term EV-related policies and infrastructure decisions can help accelerate the electrification of AVs? • How could EV charging infrastructure be better planned and built to support the operational needs	

	of shared vehicles today, as well as electric AVs of the future?	
	Moderator: Lew Fulton, Director, STEPS, Institute of Transport Studies	**University of California, Davis**
	Alan Clarke, Public Policy	**Uber**
	T. Donna Chen, Assistant Professor, Civil & Environmental Engineering	**University of Virginia**
	Mathieu Bernasconi, Business Development Manager	**car2go**
13:00	Lunch	
14:00	**Session 3: Implications for modal choice and urban form**	

Early evidence from several U.S. cities suggests that app-based ride hailing services provided by transportation network companies (TNCs) may be displacing mobility that would otherwise have taken place on public transport. Automation could drastically cut the costs of these services, making "robotaxis" an attractive option for urban mobility. Short presentations will introduce key questions around how consumers might use AVs in the future, and what this could mean for public transit and urban form.

- How will consumers use AVs? Will consumers prefer to own and use their own private AVs, or will they increasingly shift towards shared services?
- How will the adoption of AVs impact travel activity, commute times, and congestion? Over the longer-term, what impacts will AVs have on property values in cities and suburbs?
- How will automation and sharing impact public transport services? How will these impacts differ between urban, suburban and rural areas? In different global regions?
- What are the implications of automation for urban planning, equity, safety, and liveability?

Moderator: Zia Wadud, Associate Professor	**University of Leeds**
Mihai Chirca, Expert Digitalisation and Autonomous Transport Systems	**International Association of Public Transport (UITP)**
Clément Dupont-Roc, Manager Corporate Planning	**Renault Group**
Krista Huhtala-Jenks, Ecosystem Manager	**MaaS Global**
Emily C. Warren, Senior Director of Policy and Public Affairs	**Lime**

15:30	**Keynote: Focusing on AV use in the status quo tax, regulatory, and ownership frameworks**
	Robin Chase, Co-founder of Zipcar and Veniam
15:45	Coffee break
16:15	**Session 4: Policy priorities**

The impacts of ACES on future mobility patterns, energy use and emissions could be revolutionary. But they are also highly uncertain – in pace, direction, and magnitude. Government regulations and policy will play a critical role in i) facilitating the adoption and use of emerging technologies and business models, and ii) steering developments in technology and behaviour toward a more sustainable and equitable future. Case studies from Japan and Europe will lead to a moderated discussion around policy priorities.

- How can regulations enable trials and demonstrations in the near-term, while managing risks and public concerns? How might regulations need to evolve to manage the transition to broader adoption and widespread use of autonomous vehicles?
- What are the respective roles of government, industry, and other organisations (e.g. standard bodies) in managing risks and concerns around safety, liability, privacy, cybersecurity, and

employment?

- How can governments help to promote interoperability and integration across different modes and mobility service providers? How can EV policies and infrastructure facilitate the acceleration of electrification? What policies could dampen growth in vkm by promoting sharing, intermodality, and MaaS?
- How can energy and transport models help inform policy and planning decisions?

Moderator: Lucy Yu, Director of Public Policy	**FiveAI**
Naohisa Hashimoto, Senior Researcher – Smart Mobility Research	**National Institute of Advanced Industrial Science and Technology (AIST), Japan**
Zoi Sagia, Policy Officer – Smart Mobility and Living, DG Connect	**European Commission**
Suzanne Hoadley, Senior Manager	**Polis Network**
Robin Chase, Co-founder of Zipcar and Veniam	**Shared Mobility Principles**

17:45 Closing remarks

18:00 Reception

Expert Meeting on Modelling (14 June)

8:45 Registration and coffee

9:15 Welcome and workshop objectives

IEA – Brief introduction to the Mobility Model (MoMo)

Anticipated changes to incorporate the impacts of vehicle sharing and automation

- Activity demand-based projections (passenger-kilometres and tonne-kilometres)
- Uptake of ride-hailing, ride-sharing, and other mobility services (including MaaS)
- Uptake of highly automated vehicles (private and fleet owned)
- Modal shift impacts

10:00 Session 1: Surveys

Presentations – Clément Dupont-Roc (Nissan-Renault), Sebastian Hörl (ETH Zurich)

Discussion

- To what extent can we infer from patterns and behavioural responses of users of ride-hailing services future use patterns?
- How informative are surveys that have been conducted to date of behaviour and attitudes in other global regions? How is usage likely to adapt as technologies and offers evolve?
- To what extent will shared and/or autonomous vehicle usage patterns depend on urban form, including the availability of mass transit?

11:00 Coffee break

11:15 Session 2: Microsimulations

Presentations – Luis Martinez (ITF), Panagiotis Angeloudis (Imperial College London)

Discussion

- What insights on the impact of urban form and public transit availability can be gained by

comparing microsimulations in different cities?
- How can microsimulation results be generalised into global modelling?

12:15	Lunch
13:15	**Session 3: Cost comparisons**

Presentations – Zia Wadud (Leeds), Lew Fulton (UC Davis), Nikolas Soulopoulos (BNEF)

Discussion

- How do different combinations of business cases with technology powertrain platforms compare on a levelised cost basis (e.g. per kilometre driven)?
- What key sensitivity parameters (e.g. frequency of usage, density of customer demand, charging times and costs, hedonic value of not having to drive) might vary under reasonable assumptions or in different policy or geographic contexts? What are the impacts of these parameters?
- What considerations are not well captured by these cost comparisons, but are nevertheless likely to determine adoption of vehicle sharing, autonomous vehicles, and electrification?

14:15	Coffee break
14:30	**Session 4: Modelling energy and emissions impacts**

Presentations – Zia Wadud (Leeds), Jeff Gonder (NREL), Robert Spicer (BP)

Discussion – How can the modelling inputs, methods and results of surveys, cost comparisons, microsimulations, and other global modelling exercises be used to inform the IEA effort to incorporate uptake of automated, connected, shared, and electric mobility trends into its scenarios?

16:00	**Closing remarks**


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