



25<sup>TH</sup> ITS WORLD CONGRESS  
**COPENHAGEN**  
17 – 21 SEPTEMBER 2018

*Quality of life*

# Congress Report

## 25<sup>th</sup> ITS World Congress

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**10000**  
Participants



**2000**  
Opening Ceremony



**850**  
Speakers



**2400**  
Delegates



**92**  
Students



**525**  
Public Day



**95**  
Staff and Volunteers



**96**  
Countries



**250+**  
Sessions



**25**  
Associated Meetings



**17**  
Technical Visits



**900**  
Technical Visits booked



**12**  
Demonstrations



**1700**  
Demonstration slots  
booked via app



**200**  
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**36**  
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**200+**  
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**5555**  
Congress app downloads



**1115**  
Session ratings

**4500**  
MinRejseplan  
downloads

**10000**  
Travel requests



**400**  
Exhibitors

**2350**  
Exhibition Visitors

**3900**  
Exhibition Personnel

**20000 Sqm**  
Exhibition Area



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# Introduction



The Congress was organised around seven key Topics:

-  **Mobility services – from transport to mobility to liveability**
-  **ITS and the environment**
-  **Connected, cooperative and automated transport**
-  **Next generation goods delivery**
-  **Satellite technology applied to mobility**
-  **Transport networks evolution**
-  **Host Topic – Cross-border mobility solutions**

A team of rapporteurs was appointed for each topic tasked with capturing the key messages and outcomes from the Congress, the exhibition and the demonstrations. The tracks were addressed by a wide range of different types of sessions, over 250 in total – Plenary, Executive, Special Interest, Technical, and Scientific.

This Report summarises the Congress proceedings. The first part focuses mostly on the Technical & Scientific papers and the Special Interest Sessions; the second part paints a picture of proceedings at the Plenary and Executive Sessions; and the third summarises the proceedings at the High Level Round Table.

I give my profound thanks to the main team of rapporteurs who contributed so much to this document:

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**Professor Eric Sampson**  
Chief Rapporteur  
Brussels, October 2018

# Executive Summary

The Congress had as its main theme “ITS – Quality of Life” and was organised around seven key Topics:

- Mobility services – from transport to mobility to liveability
- ITS and the environment
- Connected, cooperative and automated transport
- Next generation goods delivery
- Satellite technology applied to mobility
- Transport networks operations

There was also a Host Topic of Cross-border mobility solutions. The main themes underpinning the seven topics were distilled into three plenary sessions supported by twelve Executive Sessions to reflect the hot issues of the moment, not just within ITS but across the transport discipline as a whole:

- Achieving higher quality of life in our cities
- Ensuring integrated mobility services
- What's next for automated mobility?

The High Level Round Table (HLRT) was a key element of the Congress with over 150 Ministers, Mayors, industry leaders and senior representatives of national and local governments coming together to review how intelligent and green mobility can contribute to sustainable growth and a better environment for all citizens. The participants enjoyed the opportunity to meet their global counterparts to talk about solutions to transport challenges.

Around 550 papers were presented in about 170 Congress sessions. In the three Plenary Sessions and twelve Executive Sessions high-level industry executives, public officials and international experts shared their perspectives and extensive experience of ITS topics encompassing policy, strategic, economic, technical, organisational and societal aspects.

**Mobility services – from transport to mobility to liveability** was one of the three busiest topics. It showed a steady evolution based on exploiting new technologies, adding new services using current technology, and integrating social media information. There was considerable interest in Mobility as a Service but with a rather limited number of schemes fully operating globally there was a relative lack of information, especially actual evaluations, so it was hard to measure success. MaaS business cases still had challenges to overcome. Moreover operational schemes usually focus on services for individual travellers but do little to optimise wider mobility operations through traffic and multi modal transport management.

Services for users continued to develop; we now know how to integrate traveller information and traffic management. Today's innovation is in using new digital platforms (cell phones, computers, social media) to bring greater connectivity between the two systems (*ie* draw data from road users to support road management decision-making; provide information to road users for travel options *etc*). Route planners now do more than give estimates of travel time based on traffic conditions at the time of departure; they can also predict traffic conditions as they change along the route during the trip and will

further improve when they become linked to interactive traffic management and connected systems generally.

**ITS and the Environment** was one of the smaller topics in terms of paper numbers but covered a lot of interest areas. It was clear from sessions that the available technology permits environmental issues to be looked at from different perspectives and suggests that many potentially useful solutions are being developed. The market was very active in updating systems and services in order to use less energy and reduce emissions but the regulators seemed not to be moving as quickly, for example regarding cleaner air in cities.

**Connected, cooperative and automated transport** was the busiest topic reflecting the worldwide interest in automated mobility. There was an interesting split – presentations and discussions on connected transport were very down-to-earth with a focus on getting the proven benefits from deployment as quickly as possible as a part of wider networks (for example interactive traffic management) and as data sources. The emphasis in sessions on highly or fully automated vehicles was very much on accident reduction and was urban-centric. Technology developments were often dominant although for both connected and autonomous cases there was emphasis on the benefits to the end users. The tone was quite optimistic with regard to automated driving although several speakers referred to the need to advance in very small steps to ensure successful deployment. In summary – connected is today; autonomous will be next month.

**Next generation goods delivery** was a story of incremental innovation to help increase productivity and minimise negative impacts rather than overnight revolution. This industry has tended to be rather conservative and dominated by direct supplier costs, rather than a wider perspective of social benefit. It was beginning to accept that open platforms holding shared data to open standards brought benefits to everyone. Platooning was seen as key to linking ITS innovation and breakthrough of automation in the future. Two visions were discussed: platooning as a driver support service; platooning as driver replacement.

**Satellite technology applied to mobility** was another small but lively topic. The well-established role of satellite as key enabling technology for positioning is developing steadily as constellations are expanded. Applications for communication were much discussed as the telecoms industry is bringing satellite and mobile communications together reinforcing the point that satellite communication is a reliable, accessible, affordable and proven technology. Sessions also addressed applications for earth observation and for the first time there were presentations on safety benefits such as monitoring infrastructure and the safety of vehicles.

**Transport networks evolution** was the second busiest topic covering the familiar areas of network and intersection management, simulation, modelling, security and safety but it also included many aspects related to data. There was emphasis on the value of 'Big Data' particularly as devices for collecting data can be

## Executive Summary



deployed cheaply and on a large scale. More and better data allowed more accurate simulations, which could be used to identify incident risk areas. Most of the papers presented evaluated the efficiencies of current traffic systems rather than introducing novel future techniques. Travel time estimation studies were still limited to individual traffic state estimation so were not moving forward as expected to cope with advances in big data analytics. It would be useful to see new methods for real-time travel time estimation for different origin-destination from medium to long distances.

And finally – looking back to the previous two Congresses we can see a mobility services thread running through them as well as Copenhagen. It was clear that we're going through a transport transformation driven by automation and AI, connectivity, electrification, digitalisation, and sharing that is disrupting beyond the transport sector *eg* land use planning, urban design. There was a common “feel” across all the Topics and

demonstrations with everyone giving broadly the same messages: share data (you don't need to own it to use it) held on open platforms in open standards formats; use vehicles rather than own them; move people not things; address the environmental issues before deploying not after; exploit Connected today and plan for Automated a little later on; expect business models to be dynamic; plan to evolve from transport, to mobility and then to liveability and recognise that there is no single definition of liveability – ultimately a city and its citizens need to agree on what they want and the ways to achieve it.



## TOPIC 1: MOBILITY SERVICES – FROM TRANSPORT TO MOBILITY TO LIVEABILITY

### The overall situation

The “Mobility Services” topic was organised around over 50 sessions and two workshops related to the following topics:

- Seamless travel, ticketing and payment
- Interoperability and cross-border solutions
- Policy, standards and integration of platforms
- From data to information
- Innovative multimodality *eg* Mobility as a Service [MaaS]) and the sharing economy
- Understanding users’ needs and behaviour

Five Executive Sessions and two Plenaries provided a broader perspective on the most relevant topics within the theme, including liveability, MaaS and smart cities. The Nordic Stream sessions also had presentations and discussions around cross border solutions for seamless mobility, MaaS, automation, “Corridor as a Service” (delivery alternatives for global traders), and improving mobility through public transport and 5G telecoms.

Technical and scientific sessions included papers on more specific topics, issues or opportunities, and illustrated applications or possible approaches to address the issues. The contributions were not uniformly distributed. There was a concentration in sub-topics relating to Data, Multimodality, and User needs and behaviour, while Seamless travel, ticketing & payment, Interoperability & cross-border solutions and Policy, standards and integration of platforms received much less attention.

Mobility as a Service (MaaS) was discussed extensively (there were 98 mentions of MaaS in the Congress Programme) However there are numerous definitions of MaaS, which led to several presentations about projects that perhaps did not belong. One presentation offered a definition of MaaS along with other terms that people are using interchangeably but are not MaaS. These definitions are shown in the figure on page 10.

MaaS implementations were few and far between. Many MaaS deployments were actually demonstrations rather than full implementations. There was a lack of evaluations of MaaS deployments since the UbiGo demonstration project in Gothenburg, Sweden. UbiGo produced detailed qualitative and quantitative evaluations.

Two aspects of overall mobility were mentioned in multiple presentations as well as papers and session discussions: (1) balancing customer mobility selections with city goals and objectives, and (2) dynamic assignment of pricing of city space (*eg* curb space). In the light of the first item some discussions suggested that regulation of mobility services could assist in better balancing customer selections with city goals and objectives since customer selections are typically selfish and do not necessarily reflect “the greater good.” It was suggested that there could be a third element – encouraging the private sector

to provide mobility services and platforms meaning that we are trying to balance a three-legged stool: customer mobility selections, cities’ goals and objectives, and the private sector’s opportunities to provide mobility services and/or platforms.

“Smart cities” featured less often in the 2018 Congress than in Montreal 2017 but there were still a significant number of discussions. There is still no agreement as to what constitutes a smart city. However in Copenhagen the dialogue focused more on citizens’/travellers’ needs and metrics to measure how “smart” a city is, or alternatively, how “ready” any given city may be to becoming a “smart” city. One weakness identified in covering the various smart cities sessions was that descriptions of how individual systems could work better together to create a smart city were lacking in the Congress.

One topic that was not covered in depth in Montreal 2017 was the subject of a specific workshop hosted by ERTICO and the European Commission – “Blockchain”. In the session on Distributed Ledger Technologies (DLTs) it was emphasised that blockchain is a part of the wider DLT scene and that different types of DLTs are predicted to support transport and transport service offerings in new and important ways. We are presently at a stage where DLTs are evolving at an explosive rate and no two blockchains are the same. The dominant application at present is identity management and protection of information use rights but it was stressed that DLTs are an “infrastructure technology” – a platform upon which use cases are built as just one component of a larger service.

Many “XXX as a Service” systems were mentioned throughout the Congress where in addition to Mobility XXX could be

- Blockchain
- Corridor
- E-Mobility
- Event Management
- Logistics
- Tolling

“XXX as a Service” was a general trend in discussing the digital transformation of systems particularly when there is a desire to move toward mobile and cloud-based platforms.

There were four key themes visible across nearly all of the Mobility Services presentations:

1. Mobility as a Service (MaaS) continued to be thought of as a key mobility solution. However, the number of actual deployments that had been evaluated was very limited. The complex balance within MaaS of customer focus, meeting city goals and encouraging private sector involvement was discussed throughout the Congress.

# Topic 1: Mobility services – from transport to mobility to liveability

2. Smart City solutions were being developed based on user needs. Further, the use of dynamic pricing of city space was mentioned as a way to facilitate mobility within a Smart City. Finally, the communication of real-time traveller information (RTTI) should become two-way, rather than one-way as it typically is deployed. For example, the user should be able to communicate back to the information service provider to verify or update the RTTI.
3. The future of mobility – shared, electric, automated and connected – was discussed throughout the Congress. But not discussed as often was ensuring that mobility must be accessible to all, including persons with disabilities, and equitable across all travellers, no matter their demographics.
4. We need a better understanding of changes in travel behaviour as a result of new technology-driven mobility choices.

## Discussions in Special Interest Sessions, Technical Sessions and Workshops

The Mobility Services topic was distributed among a variety of subtopics but there were some clear overall themes:

- The popularity of the “Living Lab” approach – a template for an innovation-enhancing hub of cooperation among a variety of public and private sector players to develop and test new ideas, technologies and systems. However there was limited discussion of how to develop and create the partnerships that are essential for success.
- The steady evolution of existing technology-based services by introducing and exploiting the potential of new technology developments or new applications for existing technologies – for example using existing

- sensors in speed enforcement systems to obtain weight distribution statistics for heavy vehicles
- Using AI and Data Science to achieve greater intermodality/ interoperability and connectivity
- Recognition of the need for well-planned roll-outs of technology and infrastructure to optimise potential gains/benefits and avoid problems of proprietary software & data formats or access to data
- The paramount importance of ensuring that technology or services were “user-driven”. Over 30 papers focused on techniques by which user needs could be identified. Several papers discussed the use of behavioural science and behavioural design to identify and propose different mobility services that could best fit the needs of different types of travellers.
- Recognition of the complexity of meeting users’ mobility needs while meeting city goals. Users’ needs do not necessarily lead to solutions that meet city goals in terms of environment, resources or transport. This was a delicate balance and was the subject of several papers.
- Acceptance, adoption of and attitudes toward new mobility services, including MaaS and automated vehicles were being studied and determined using techniques such as a Risk Integrated Technology Acceptance Model which measured the influences of Perceived Risk and Enjoyment, and Technology Acceptance Model factors on Behavioural Intention of users.

A regular discussion issue was the best way(s) to make progress with deployment: “Big Bang”, “Steady Evolution” or a little of both. A paper in a Technical session flagged the key decision questions (see diagram on page 11).

There was a vigorous session on “ITS for the Disabled” involving experts from government (policy-makers),

## DEFINITIONS

<b>MaaS</b>	Integration of various forms of transport services into a single mobility service accessible on demand
<b>New mobility services</b>	Ride hailing, ride sharing, car share, bike share, microtransit, etc. – <b>Not MaaS</b>
<b>Transportation Demand Management</b>	Service offerings and incentives to get commuters out of single-occupant vehicles. – <b>Not MaaS</b>
<b>Mobility Management</b>	Provide viable alternatives for non-drivers. – <b>Not MaaS</b>
<b>Mobility on Demand</b>	Multimodal, integrated, automated, accessible, and connected transportation system in which personalized mobility is a key feature. – <b>Not MaaS</b>

**Definitions of Mobility Terms (Carol Schweiger after Jeremy Dalton, “What is ‘New Mobility’ Anyway?” [Method City, July 2018])**

Conventional v Mobile ITS	
CONVENTIONAL ITS	MOBILE ITS
<ol style="list-style-type: none"> <li>1. <b>Passive</b> role of traveller</li> <li>2. Service is provided in <b>certain</b> locations</li> <li>3. <b>Accurate</b> data is gathered</li> <li>4. Based on <b>mature</b> technologies</li> <li>5. <b>Hardware</b> as main asset</li> <li>6. High <b>investment</b> required</li> <li>7. <b>Long time</b> to implement</li> <li>8. Based on <b>fix</b> communications</li> <li>9. <b>Conventional</b> solutions</li> </ol>	<ol style="list-style-type: none"> <li>1. <b>Active</b> traveller</li> <li>2. Service is provided <b>anywhere</b> and <b>anytime</b></li> <li>3. <b>Raw &amp; Statistical</b> data is gathered</li> <li>4. Based on <b>innovative</b> solutions</li> <li>5. <b>Software</b> as main asset</li> <li>6. <b>Cost effective</b></li> <li>7. <b>Short time</b> to implement</li> <li>8. Based on <b>mobile</b> communications</li> <li>9. <b>Smart</b> solutions</li> </ol>

## Mobile-based ITS. the disruptive solution to implementing ITS (Iñigo Larraondo, IDOM)

industry and transport service operators with many key messages. A good business case could be made for accessible transport tools because 40% of the population had a degree of reduced mobility (permanently, or temporarily – eg a broken limb) and doing something for this population means that all passengers benefit.

ITS tools for the disabled must be easy to use. The disabled community was diverse with an equally diverse range of needs so it was essential to engage this community in design, planning & implementation strategies. The immediate needs were availability of dynamic (real-time) and open data for better app design and development of systems to connect existing or non-standard information systems within and across countries

A session on “Defining Smart Cities: what is best for citizens” reinforced one of the Congress themes – determining user needs as they related to smart cities and overall mobility. Contra Costa Authority (California) had changed the way that citizen input was gathered to help to make smarter investment decisions to use technology rather than physical public meetings. They used their website as well as social media and conference calls to obtain citizen input. More input had been gathered in one telephone “town hall” than had been gathered in the previous 25 years.

The Hong Kong Polytechnic University discussed how focusing on the needs of the transport disadvantaged

and persons with special needs resulted in identifying smart infrastructure to facilitate mobility. Factors such as social bonding were being used including intelligent traffic signal systems, smart devices at signalised pedestrian crossings (particularly for the elderly), electronic audible traffic signals, barrier-free access facilities at footbridges, sheltered bus stops, and electronic bus time arrival panels.

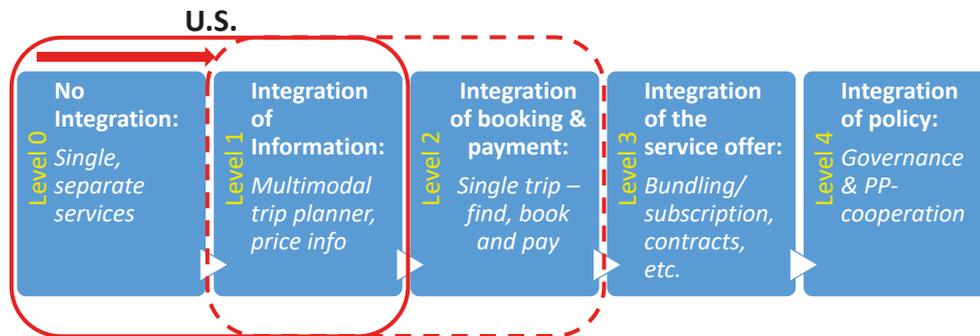
The Korea Transport Institute discussed how integrated smart mobility was based on connected and digitised travellers – a user-centric approach to MaaS; enabling real-time (on-demand), door-to-door, multi-modal transport services; and bringing convenience, and time and cost savings to mobility users.

There had been interesting developments with fare collection technologies such as facial recognition, overhead tracking, palm vein scanning, Bluetooth low energy and ultra-wideband. The benefits included speed, convenience and ease of use, security, revenue growth and protection, better data, and more personalisation. However there were limitations such as demonstrating privacy and security, the accuracy of biometric technologies in varied station conditions, speed of validation against large databases, and heavy back-end processing.

A very large number of papers and presentations addressed MaaS, the following is the essence of what was discussed. The session on new business & service approaches looked at four US projects in the process of developing MaaS.

# Topic 1: Mobility services – from transport to mobility to liveability

## MAAS TOPOLOGY: US MARKET



Source: Jana Sochor, Hans Arby and MariAnne Karlsson, "The topology of Mobility as a Service: A tool for understanding effects on business and society, user behavior, and technical requirements," Paper No. EU-SP1013, 2017 ITS World Congress, Montreal

### Where the US is in MaaS topology (Carol Schweiger)

The concept of MaaS having a standard platform was challenged on the grounds that every scheme was local; to make headway replacing car ownership schemes would have to include

- One bill, one contract, one app, 24/7 support
- A flexible subscription for a whole household
- No fixed fees, easy to change or drop out
- Keep what you don't use to the next month, and add if you need more
- Comprehensible and integrated price models
- A multimodal travel planner with booking, ticketing & account management

Ideally MaaS should extend the scope to include for example:

- Real estate developers as strategic partners
- Employers as co-creators
- Dynamic parking
- Incentives

Also in this session MaaS deployment was examined from cities' and regional authorities' points of view where a different set of constraints applied. It was agreed that both approaches had their advantages but that there were additional indicators of quality of life that must also be examined *eg* how people feel about: the safety of travel; equity of traffic signal changes serving various road users (*eg* pedestrians, cyclists, buses, emergency vehicles); wait-time at a stop-light; and reliability of travel time relative to a planned journey.

A session on "IoT advancing automated mobility and smart cities for improved Quality of Life" was very popular. Key messages included the use of standardisation to ensure technology solutions were simple, scalable and secure and the need for public

transit operators and agencies to become data-enabled businesses and have clear data strategies. It was stressed that almost the only way to bridge different sectors, markets, vendors was to keep things simple and aim for a minimal common technical ground. The session struggled to identify how best to ensure that the individual pieces contributed to a "smart city."

A session "Care-free paying for mobility in 2018" covered many aspects of fare payment approaches and systems, of particular relevance as integrated payment remained one of the most significant challenges of MaaS. There were many difficulties *eg* poor cooperation among operators because of concerns about losing profits or/ and losing control over data and pricing; the absence of a standard booking system; many different payment methods; and different regulatory regimes in different Member States of the EU and at times on regional levels. There was general agreement that further regulation was required to ensure information provision, access to data or participation in an integrated ticketing system

There were a very limited number of actual MaaS systems fully operating throughout the world and there was still a lack of information from these deployments (*eg* evaluations), so it was hard to determine success. There were multiple proof of concept MaaS projects being conducted in the EU. The MaaS Baseline project in Sweden was addressing the apparent lack of empirical knowledge on target groups for MaaS and not knowing how to generate value for customers.

The MaaS business case had some serious challenges to overcome:

- The willingness of incumbent mobility suppliers – public and private – to interface to and work with MaaS agents fronting the customers.

- Commercial agreements with third parties (MaaS Agents) on conditions to sell on behalf of a mobility supplier for a reasonable fee or commission, mark up on volume purchases or other forms for compensations.
- Customer conversion to and adoption of MaaS “one stop shopping” for mobility.
- Presenting a trustworthy offering to customers to maintain freedom of mobility by conversion from private car ownership to use of MaaS.

A potential MaaS charter contained eight elements shown below.

A Mobility as a Service Maturity Index was described to measure a city’s readiness for MaaS implementation based on the following characteristics/dimensions: 1. Transport operators’ data sharing and openness; 2. Citizen familiarity and willingness; 3. Policy, regulation and legislation; 4. ICT infrastructure; and 5. Transport services and infrastructure.

Mobility behaviour was strongly affected by routine behaviour and habits. To change mobility behaviour, existing research in the fields of sociology, psychology and behavioural economics should be considered in MaaS design since they describe a number of biases and heuristics which significantly influence decisions behaviour.

Synergies between connected and automated vehicles (CAVs) and MaaS showed that CAVs could be an important enabler of MaaS and contribute to its overall success. An interdependent relationship between the two could accelerate the achievement of the goals of MaaS, for example, seamless integration and on-demand mobility choices.

The session on “The Future of Mobility: the questions we are afraid to ask” was about the unintended consequences of deploying new technology and generated some vibrant discussions. Both utopian and dystopian scenarios were discussed, although more was revealed on the dystopian side and overall probably more questions were raised than were answered.

The key messages from this session are presented here as a series of statements and questions highlighting some of the possible unintended and negative consequences of ITS:

- How do we convince urban dwellers that shared transport is essential to maintain liveability & sustainability as our population increases?
- We are repeating the bad things we have done in the past. One example given was the “revival” of streetcar systems when other less expensive and more flexible transport services would serve people better (eg, the Q-Line in Detroit was a new streetcar system that goes nowhere and had merely become a tourist attraction rather than a useful public transport option for city residents/ workers).
- What if AVs don’t resolve transport issues, in fact, what if they result in the creation of an entirely new problem – the permanently moving personal car?
- How do we convince politicians to think long-term in transport & move to bipartisan views of the needs of the community?
- Why do we still operate transport based in silos?
- When will we see widespread road & transport user charging to produce a fairer & more equitable pricing system & better balance demand and supply?
- Why do we still operate transport based on ancient local authority boundaries?
- How do we convince city, regional & national authorities to deliver smart technology solutions to operate transport with every new project?
- Infrastructure Victoria in Australia attempted to answer these questions by describing 7 transport “futures:” Electric Avenue, Private Drive, Fleet Street, Hydrogen Highway, The Slow Lane, High Speed, and Dead End
- There were significant risks associated with AVs; for example: What if the marginal costs were very low – what would consumer do? They would travel more and there would be health impacts. Further, many cities were not ready for AVs. A wholesale regulatory review was required because using old legislation to manage brand new schemes like AVs or dockless bikes

- User focus and right to own travel data
- Open Market for public and private mobility services
- Unbiased A to B travel information
- Right to anonymous mobility
- Protection of user sensitive data
- Realtime mobility navigation and assistance
- SOME platform and service ratings
- Travel data available for suppliers, regulators and research



**Charter for MaaS ecosystem (Soeren Soerensen, SFMCON ApS)**

# Topic 1: Mobility services – from transport to mobility to liveability

would not work. How do we change those regulatory structures to cope?

- Another frequent theme also came up in this session – cities needed to dynamically manage spaces (eg for one part of the day curb space could be used for pickups and drops, and for another part of the day it could be the site of an outdoor café).
- From a city perspective, technology was not the important thing – the important thing was providing the right services for people.
- Public acceptance of new services was assumed – few people were thinking about what was needed for public acceptance
- One very extreme view was that public transport could come to an end if the cost of using an AV was very low – but judged by audience reaction this view was not widely shared.
- Open data was being called the 5<sup>th</sup> mode of transport and the new oil. The consequence of opening data was that private business was often based on selling data so giving away the new oil could be the wrong thing to do.
- From the audience: “AVs at Level 4 or 5 are a societal and technical dead end. We need to move away from binary transport system to a continuum of movement. Our industry has to move away from modes, and move to a completely integrated way of mobility.”
- There are things that we are not looking at in technology but should – for example, there will be an impact from quantum computing, but no one is really thinking about it

## Innovations

There were several new ideas in this topic area, as follows:

- Trials for linking stand-alone systems with a common open interface to cover larger geographical scope and across borders
- Several trials involving the identification of critical factors contributing to the success of new mobility on demand (MOD) and Demand Responsive Transport (DRT) systems – (a) marketing; (b) finding the geographic areas/corridors and pricing structures which maximise user satisfaction and income, and minimise costs/subsidies; (c) scaling services to optimise efficiency; and (d) integrating DRT with existing fixed lines.
- Emerging new tools from trials
  - Traffic measurement using vehicle-mounted cameras operating in the opposite lane
  - Driver navigation services providing routing directions based on low accident risk
  - Screening technologies to detect tyre anomalies in vehicles at highway speed
  - Crowdsourcing to show road quality and indicate where maintenance is required
  - 3D Mapping for automated mobility scooters for seniors
  - Algorithms developed through machine-learning to reduce time searching for parking
  - Use of regular vehicle sensors and CV-sensors to detect weather conditions and evaluate the state of the road

- Development of a cloud-based work zone traffic management system to recommend desirable speeds and lane changes before entering work zone areas
- Processing of sensor data collected from the smartphone such as GPS, acceleration, and gyroscope data to detect the transport modes of travellers
- Using data generated from a multimodal traveller information service as a data source for an indicator of the service quality of public transport.

## Trends and Key Messages – Constraints

Many private companies around the world were developing integrated mobility solutions for traffic management, traveller information, fare payment *etc* that claim connectivity or/and interoperability across cities, regions, and multinational boundaries. This appeared to replicate traveller information systems in the late 1990s and early 2000s where many solutions involved proprietary (and thus, non-interoperable) components. There appeared to be a risk that this situation could again occur with the roll-out of MaaS and explained why there were calls for a more structured, even regulated, environment within which MaaS solutions could be deployed.

In many cases MaaS schemes did not cover a smooth transition from private vehicle ownership to car sharing/usage – mobility sharing was just assumed. MaaS schemes often focused on services for travellers but did not address the optimisation of overall mobility operations through traffic and multi modal transport management.

More work was needed to model and understand the coordination of automated vehicle operations with “ordinary” vehicles that cannot be managed/controlled in the same way

## Trends and Key Messages – Opportunities

The EU’s Mobility Data Space (MobiDS) draws a variety of data from different sources to provide support to travellers and provide information on a wide range of mobility issues. It uses an open, decentral architecture that should enable widespread (and cross-border) integration. While of benefit within the EU a wider application of this approach required an authority like the EU to enact legislation requiring the integration of systems and services within and among member countries

Good work had been done on the definition of travel time reliability measures on urban and local roads. Travel time reliability measures for highways already existed (and were easier to determine).

Studies were beginning on how to re-theorise traffic flow characteristics using DSRC data and identify the transition process between the steady state and the congested state based on congestion boundary values.

## Where are we heading?

A number of strong trends were seen in Copenhagen that are very likely to continue to the next Congresses. We now know how to achieve symbiosis between traveller information and traffic management. Today's innovation is in using new digital platforms (cell phones, computers, social media) to bring greater connectivity/integration between the two systems (*i.e.* draw data from road users to support road management decision-making; provide information to road users for travel options etc). As an extension of this route planners of the past would give estimates of travel time based on traffic conditions at the time of departure. Today they predict traffic conditions as they change along the route and for the entire duration of the trip and they are likely to improve as the planners become linked to interactive traffic management and connected systems generally.

It was recognised that the explosion of new mobility services over recent years had added considerable complexity for the traveller, making it much more challenging to model travel behaviour and design systems that would meet users' needs. However there was a measure of simplification as a result of the regulation and encouragement of open data and open data sharing, and the development of consistent and reliable MaaS services would also reinforce the move to simplification.

There had been more discussion about the use of near-field communication (NFC) on mobile phones to facilitate integrated payment than had taken place in the past and this coupled with other developments in payment was likely to continue.

There had been a steady growth in the development of new smartphone apps for the mobility-impaired. Some had the potential to be quite beneficial – the major drawback, however, was that for many types of mobility impairment people were unable to operate smartphones. Developers of apps needed to be challenged to consult directly with their client base as they were likely to find the reality of using these applications completely different from their basic premises. This related to “user-centred” design of mobility services, which was mentioned earlier.

A number of commentators suggested that Quantum computing and Blockchain would be among the big topics for the next Congress – What would they enable? Would they be as transformative as the internet? Would blockchain be so quickly adopted that within a few years it would be part of background support rather like the ‘s’ in <https://?> And was there a “Technology X” just emerging from the research labs that might introduce new benefits and disruptions?

# Topic 1: Mobility services – from transport to mobility to liveability

## The Fourth Mobility as a Service Summit

The 4<sup>th</sup> MaaS Summit was held on 17 September and began with brief introductory remarks by Ann Berner (Finland Minister of Transport and Communications), Violeta Bulc (European Commissioner for Mobility and Transport) and Young Tae Kim (Secretary-General of the ITF). Four breakout groups then explored different multimodal aspects of MaaS: Data; Regulatory frameworks; Infrastructure and planning; Services. A number of key messages were recorded:

- The multimodal data group discussed what data was needed by MaaS, and what data should be exchanged. Data sharing must be two-way – the mobility service provider (MSP) should give data to government entities but must also receive data from those entities. Other discussions looked at what service level agreements should a city or government charge for? How do users trust their MaaS providers? How do the MaaS providers ensure the quality of data? Are Public Transport operators the backbone of MaaS? In conclusion, we urgently need standards for harmonised APIs.
- The regulatory framework group saw three critical factors. First, the need to develop the right regulatory toolbox based on better dialogue between local regulators and mobility service operators. Second, what was the role of legislation? We needed enabling frameworks, incentives, and clear objectives including multimodal and environmental. Third, we needed to look at the transport system as a whole and build bridges between the ivory towers.
- In the area of infrastructure and planning both public and private solutions were being delivered in silos. The key question was whether MaaS should be a single platform or multiple platforms. Not many countries were building authenticated identification or open access to information using a common syntax. We needed rules to integrate service operators and to provide access to parts of cities – city space might need to be reallocated. There were three dimensions that, in a perfect world, should be balanced: the MaaS customers, the city's goals/objectives, and private sector/commercial initiatives. It was hard enough to balance the user's decision making with the goals/objectives of the cities since each individual traveller makes a selfish travel decision that may not help the greater good.
- We needed to consider pricing to control access to city space and do it. Cities needed to provide information digitally about curb usage/access. MaaS procurement needed to be dynamic as well. Another thought was: should we have net neutrality in transport? One key quote: "We need a city to function for people (not vehicles)". And one of the most innovative thoughts was: Can we send code to mobility operators to get the information that is needed without the operators having to release sensitive data?
- In the area of multimodal services there were technological barriers, but trust was more critical. Without transparency and perceived fairness there could be no MaaS services. There should be scalability to agreements and alliances. We needed incentives and a value proposition to encourage the engagement of new players in the MaaS ecosystem (eg, housing). We needed to promote MaaS investments. More collaboration was needed. Legislation should not be rushed. There should be an experience-based approach to legislation.





## TOPIC 2: ITS AND THE ENVIRONMENT

### The overall situation

As has been the case for the last 4–5 Congresses the Environmental Topic was big in importance but small in size. The key topics of interest were Infrastructure and Smart Cities, Clean Urban Transport, Active Transport and Driver and Vehicle Optimisation. Mode shift towards public transport featured strongly as it features significantly in Copenhagen's carbon neutral city plans alongside active transport. Successes have been had in procuring electric public transport however the capacity of the supply chain will become an issue if the demand increases. As with active transport the public transport behaviour changes could have negative impacts on transport equity and were generally neither well identified nor well understood.

### Old vs New

While there was a marked shift in focus away from the electrification of vehicles that was prevalent in ITS Strasbourg there were still papers focusing on this issue. It is harder to make comparisons with Montreal as the environmental emphasis there was very much a secondary factor of CAV deployment with the primary goals being reduced accidents and infrastructure requirements rather than the more common EU goal of environmental and land use benefits.

One major change in Copenhagen was the processing of scientific papers where as a result of co-working with the Institution of Engineering and Technology the overall standard of presentations was significantly raised with 24 selected papers featuring in a Special Edition of the IET's Journal of ITS. The scientific papers were an opportunity to discuss methodologies and approaches that were less technologically ready. The papers presented focused less on directly implementable techniques but sought to introduce practitioners to ideas that might mature in a few years' time.

Topics of interest included fuel consumption optimisation and monitoring using novel statistical methods, and air quality monitoring and prediction. The dynamic prediction of vehicle energy consumption may help to reduce the negative consequences of electric vehicle use and provide additional peace of mind to the user by reducing range anxiety. Instantaneous emissions modelling was presented as a methodology for better identifying emissions hot spots in urban areas as well as developing some understanding of the real impact of policy interventions although challenges were identified in application of this method. These involve the validity of the driving data and post-process coupling with geospatial and GIS data.

Two papers included projects related to low-cost sensors, an emerging technology. The low-cost sensor market, if

nurtured correctly, presents an opportunity for significant development and real-world impact in the next few years. As European local authorities are facing fines for non-compliance with EU limit values, and other locations are dealing with their own air quality issues, any more information around the subject should be well received.

The scientific papers presented show that there is a clear and expected dependency on height for air pollution concentrations as concentrations at human height are significantly higher than the height at which typical measurement instruments are located. This result was very significant because it suggested that even if air pollution levels were observed to fall below the EU designated limit values using the current methodology, the concentrations at breathable height could be up to 5 times higher. As the strengths and weaknesses of low-cost sensors are better understood then local authorities can deploy them in more thoughtful ways so as to get better information about their local problems and propose local, targeted and relevant solutions to them.

### Infrastructure and smart cities

The challenges facing smart city infrastructure development were discussed in a couple of sessions and some key barriers identified. Local authority cooperation was important, as was developing an interest for new services in the local population and joined up thinking within the industry. Geofencing was proposed in both a scientific paper and a technical paper as a solution to air quality and ambient air pollution issues. This innovative infrastructure technology may be beneficial in the future and its scope may not be limited to air quality.

The necessity for local solutions to local problems was made clear in the Birmingham clean air study. Old technology – in this case ANPR cameras – used in a more joined up way and interfacing with new, or even older, emissions modelling and inventory generation processes provided insight that wasn't previously available. This reflected more the rate of change when applying new methods rather than the validity of the old approaches however. A concern about integrating these new approaches was whether they conformed to GDPR standards. Independent investigation suggested that GDPR ought not to derail a project such as this outright however GDPR was, is and will remain an impediment to getting the correct data into the hands of those that might help to influence air quality in urban spaces.

Geofencing as a method for targeting clean vehicle running in sensitive or high-risk areas was discussed in both scientific and technical papers. The technology was being taken seriously and the relative simplicity of the concept meant that a diverse range of solutions using this methodology could be tested. Initial geofencing solutions had been demonstrated and future roll-out of this

## Topic 2: ITS and the environment

technology seemed very likely in the near future. Initially this technology was best suited to controlled fleets such as buses, taxis and council vehicles. Deployment in the general fleet population was likely to be more challenging as people were often unaccepting of technology that forcibly changed their behaviour. In a commercial context the addition of this requirement might increase costs and have an overall negative benefit to society. In areas where the air quality was predicted to exceed the required healthy levels only marginally, and given that a large number of vehicles operating in urban spaces were of the types discussed above, it remained possible that the introduction of geofencing schemes would be an integral part of the solution.

### Active transport

Extending Active Transport is a key focus of the city of Copenhagen as it moves towards its carbon neutral aims. Many presentations were delivered on the active transport modes and a quick visit to the city centre reinforced the fact that Copenhagen was committed to this concept. The data requirements for active transport were investigated in a number of papers. Current methods for collecting cyclist data were acknowledged to be effective but a more optimised approach was possible and would yield greater insight. A platform for optimising cyclist routes had been developed and was presented. Optimising infrastructure and traffic management solutions for cyclists was also discussed and the benefits of green wave implementation presented.

There remained a largely undiscussed issue for active transport around accessibility and transport equity. If authorities are planning to reduce and remove non-active transport modes and replace them with active ones some care must be given to those who cannot fully take advantage of the policy change. This problem must include both a behavioural element and a technical one. Technical solutions can help to break down barriers however without the behavioural shift then it is difficult to make this technology as inclusive as it might need to be if its benefits are to be fully realised.

### Driver and vehicle optimisation

Analysis of the impact of traffic flow and speed was referred to in various projects. Reduced traffic flow leads to reduced emissions, as would be expected, however the data coverage was missing at a key point in the data time series. Green light optimisation was mentioned in some papers with quantitative analysis provided in one case. This analysis of the impact of green light optimisation appeared to be close to trivial and potentially within the margin of error of the methodology however the cases presented in the paper were not the most complex driving cases. More, and more extensive, data are needed here.

There were still significant challenges to accurately modelling the environmental impact of driver and vehicle optimisation. Some solutions from academia were demonstrated however they were rather complex and unwieldy, requiring very precise data sets and field

experts to both configure, implement and interpret the results. Traffic modelling software and vehicle emissions models had been designed in isolation and for different purposes so coupling these methods is full of pitfalls. The traditional methods had been shown as not fit for purpose for urban driving but they still represented the only robust and repeatable way of delivering any result at all. The state of the art was still at a low technology readiness level and targeting funding for improving these approaches would likely have a significant down-stream impact on policy and health outcomes if approached. Real-time monitoring of a fleet of vehicles would not be cost effective or desirable but tracking behaviour *via* designated smartphone applications, if designed for that purpose, could represent a way to avoid the pitfalls in coupling transport models with emissions models.

### Clean urban transport

Clean urban transport was typically expressed in one of two streams – public transport or electric vehicles. Public transport received a lot of focus at the Congress; electric vehicles were less well represented in the presentations but discussed in depth off-line especially regarding their unintended consequences such as reliability factors and negative economic externalities. Users of electric vehicles for long journeys might initially not be familiar with the power and recharging requirements of new electric vehicles. As hard shoulders are removed from motorways (eg in the UK) it will become increasingly difficult to access and charge these vehicles. A driver cannot simply walk to the next petrol station, fill up a reserve petrol tank, return to the car and top up the fuel. If electric vehicles remained stranded on live motorway sections for extended periods of time the risks of accident increase and the increase in congestion would be significant. Whilst it is encouraging that people were now raising these issues a solution had not yet been identified.

The obvious economic benefits of driving an electric vehicle are guilt-free miles and approaching zero marginal cost per mile. One congress delegate claimed a 50% increase in miles driven since shifting to an electric vehicle. The impact of increasing the demand on a network by shifting large fractions of people into electric vehicles would be significant assuming the observations here were broadly representative. No-one appeared to be seriously considering this issue at the moment. This factor would be further exacerbated by the introduction of autonomous vehicles in urban spaces. The additional capacity requirement that they would put on the network whilst looking for a parking space, or more likely just driving around the block for a few minutes, must not be underestimated.

### Forwards vs Constrained

It was clear from sessions that environmental issues were being looked at from different perspectives which suggested that many potentially useful solutions would be developed in the future. There was a role for both centralised and localised leadership, and market driven solutions. It was important that as many solutions as

possible were given the chance to be market-tested but this must be done in a well-considered way with policy makers supporting with flexible legislative ecosystems, allowing these solutions a chance to prove their worth and supporting the development of new innovations.

Policy makers must also avoid getting caught up in hype and potentially doing more long-term harm than good. There was a fine balance to be struck here – a strong testing and validation framework was essential to avoid unintended consequences, ensure good practice was recorded and acted as a counterbalance to hype. Good public and specialist engagement were also required to inform people about implemented projects and their outcomes, to avoid repeated work wherever possible and to ensure that knowledge was transferred between people who would put it to best use.

Citizens were at the heart of the issue and would remain there. They were both the people most exposed to environmental problems and in some cases the primary causes. They must be engaged throughout any process and their needs and concerns must be addressed. It was important that these potential citizen scientists were given the tools that could best help them engage with the problem themselves. This was where ITS potentially had the most opportunity to deliver real benefits. A citizen cannot necessarily, nor be encouraged to, develop and install a better catalyst for their car but they can use ITS solutions to ensure that their behaviour has minimal impact.

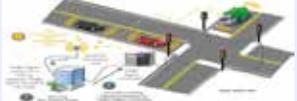
## Where are we heading?

There are many areas where ITS can have major impact on transport related environmental and sustainability issues. While there appears to be a shift towards these ITS solutions the full potential has yet to be realised. There is scope for engineering solutions to help however this engineering must be complemented by behavioural and technological solutions. There will not be one universal solution for transport related environmental issues because each transport and environmental context is remarkably different from even its closest neighbours. Local solutions are required for local problems.

National and local policy makers argue a need for more guidance on managing the complexity of environmental issues: for example how to improve inner city air quality while also sustaining traffic flows particularly for freight and public transport, and also minimising investment in infrastructure for electric vehicle recharging or for connected and highly automated vehicles. Future congresses are likely to see the results from trials and demonstrations with cautious development of innovative policies.

## ITS MEASURES CONSIDERED



Measure	Description and CO <sub>2</sub> savings
 <p>Green Navigation (GN)</p>	<ul style="list-style-type: none"> <li>✓ On-board, real-time routing recommendations taking into account traffic conditions.</li> <li>✓ Fuel consumption benefits.</li> </ul>
 <p>Adaptive Cruise Ctrl (ACC)</p>	<ul style="list-style-type: none"> <li>✓ Automatic velocity adjustment subject to distance of vehicle in front.</li> <li>✓ Avoidance of unnecessary speed variations.</li> </ul>
 <p>Variable Speed Limits (VSL)</p>	<ul style="list-style-type: none"> <li>✓ Speed limit management systems to avoid bottleneck effects.</li> <li>✓ Avoidance of stop-and-go conditions.</li> </ul>
 <p>Urban Traffic Ctrl (UTC)</p>	<ul style="list-style-type: none"> <li>✓ Adjustment of traffic lights green cycle according to queue lengths in intersections.</li> <li>✓ Improvement of traffic flow conditions in saturated sections.</li> </ul>

**Emission reduction methodologies (Leonidas Ntziachristos, Aristotle University, Thessaloniki)**

## Topic 3: Connected, cooperative and automated transport



### TOPIC 3: CONNECTED, COOPERATIVE AND AUTOMATED TRANSPORT

#### The overall situation

'Connected, cooperative and automated transport' was by far the largest of the seven Congress Topics based on the number of papers (170) and sessions (81). To put this into perspective, one Executive Session speaker pointed out that 120 years ago the biggest transport problem in big cities was removing horse manure and congresses at that time had to focus on that topic.

The overall theme in 2018 was primarily urban. It addressed transport, or rather mobility – the act of moving around, rather than the means – as a component in the city of the future. New models of mobility, and new technological innovation, can disrupt the existing transport eco-system. Connected, cooperative and automated mobility (CCAM) was one such disruptive element representing not only a disruption of transport systems, cities, and societies but also the source of a number of challenges to technology, system architecture, legal and institutional structures, validation, and certification.

While the topics were often discussed together as CCAM or connected and automated vehicles (CAV), there were numerous papers and sessions that primarily addressed one or the other, connected vehicles, or cooperative ITS, or automated vehicles.

Connectivity and automated driving are already having an impact on traffic management operations and systems. The related papers discussed vehicle integration, ramp metering, predictive signal control and traffic light assistance, automation of traffic management processes, and innovative weather and traffic sensing based on artificial vision, cameras and radars.

Papers also addressed diverse issues such as open smart city hubs, car-driving by disabled people, assessment of driver subjective tension, merging safety and cybersecurity analysis, security risk assessment and threat modelling, national access points, and road user charging. Prediction of mobility demand, future transport technologies and urban traffic management gave a more general view on future developments including connectivity and/or automation as one element.

The tone was quite optimistic with regard to automated driving: as one speaker put it "We drive cars now, tomorrow cars will drive us". However for many the optimism was wearing a little thin eg "It is not so easy to drive a vehicle like a human". Several speakers referred to the need to advance in very small steps to ensure the successful deployment of automated driving. We also heard that "around 11 billion miles would be needed to show with 95% confidence that AVs are 20% better than human drivers". Some speakers also pointed out that in the early stages of adoption, with mixed traffic, automated vehicles might have higher risks than human-operated

ones of becoming involved in collisions, although not often as the guilty party. Society might have to consider whether to accept certain risks inherent to automated vehicles because they were outweighed by the benefits.

We need to show to the users and the society as a whole that AVs are dependable and affordable, commercially viable and desirable. However dependability, desirability and adding an Operational Design Domain (ODD) complexity all come with a cost

#### Old vs New

There was a reasonable balance between bringing forward new ideas and reporting how the older ideas were performing. Simulation still played a major role in assessment of both technical performance and impacts, and the verification and virtual validation of connected and automated driving. The concepts of hardware in the loop and human/user in the loop of simulation were highlighted in the congress.

New ideas in the connected and cooperative transport included utilising CITS technologies for traffic density extraction, to create digital platforms for smart work zones, and for various road safety innovations such as safe logistics *via* real-time driver monitoring; identifying unsafe entities on the basis of sudden braking events; and utilising distributed intelligence in collision avoidance. The use of the Diffie-Hellman process to secure and authenticate vehicular communication networks was found promising, as also was the use of 60 GHz multi-gigabit wireless technology for connected vehicles. Papers also advocated optimising vehicle communications by reduced data amounts *via* principal component analysis or data relaying. An interesting idea was the integration of low-cost micro/nano-sensor networks embedded into road markings for I2X connected mobility.

CITS innovations for vulnerable road users included accurate positioning for motorcycles, and bicycles sensing. Crash prevention and efficiency improvement at signalised and unsignalised junctions with mixed traffic of connected and unconnected road users was proposed using advanced solutions for VRU detection and movement prediction, including LiDAR sensing, deep auto-encoders, artificial image noise application, neural networks as well as utilising Bluetooth and hybrid communications.

Automation of rail transport and related systems was discussed for the first time. The issues touched upon system engineering, ultra-wideband (UWB) communications, and automatic train operation.

In the exhibition, there were fewer transport network performance solutions to assist road managers and many more individual services to support end users. In addition

to demonstrations, the exhibition provided simulated and virtual experiences of connected and automated mobility.

It has become increasingly clear over the past three World Congresses that many technologies have moved rapidly from exploratory research to trial deployments and this has been reflected in the numbers and styles of demonstrations. For Copenhagen there was a generous space allocation immediately outside the Congress Centre where a number of products and services were available for delegate participation. The main group of demonstrations was based around connected or autonomous technologies – or both – and a smaller group illustrated aspects of vehicle connectivity where the ‘vehicle’ was a bicycle.

Bestmile, Ibeo Automotive Systems, PARAVAN and Hanseatische Fahrzeug Manufaktur (HFM) jointly presented driverless vehicles in the urban environment. An autonomous real time “hail-and-ride” shuttle carried participants through the ‘Urban Jungle’ to show how a vehicle can interact with its environment and provide a true on-demand service.

Keolis & Navya showed an autonomous taxi as an example of shared and electric mobility solutions. This type of autonomous shared vehicle is likely to be closely integrated with multimodal transport networks to enhance urban mass transit in the cities of tomorrow.

The Nordic Way consortium (Denmark, Finland, Norway and Sweden) demonstrated how public authorities can use Cooperative ITS (C-ITS) for traffic management while also allowing cross-border interoperability. The service showed how a car can react to traffic management decisions provided by “the sky” from any one of the Nordic road authorities without driver intervention. The car reacted automatically to traffic signal information by stopping the engine when appropriate and starting it again when there was a green light.

The ‘Living Lab Bus’ was designed to show how a conventional real-life bus could support innovation. A sustainable electric bus from Linkker with quick charging and a range of efficiency and driving optimisation solutions could also function as a mobile sensor platform delivering enhanced weather forecasts, driving condition reports and road surface condition reports. The bus could also serve as an autonomous driving trials laboratory.

The C-MobILE (Accelerating C-ITS Mobility Innovation and deployment in Europe) demonstration showcased interoperability between services deployed in eight European cities. The innovative architecture of C-MobILE allows service providers to receive data seamlessly via short-range radio (ITS-G5) and cellular (3G/4G) communication in a standardised way. Locally the City of Copenhagen will deploy a hybrid architecture on this model allowing the bundling of a set of C-ITS services within a suite of applications. As a further test of interoperability service providers from other cities will come to Copenhagen and use vehicles equipped with radio and cellular connectivity to show that their apps work seamlessly in another city.

Self-driving pods were predicted to change the way we transport people and cargo efficiently on the last stage of their journey from transport hubs to and from a wide range of destinations. Shopping centres, airports, campuses, sporting venues, aged care centres and eco towns are just some of the many sectors actively moving forward with self-driving trials. To bring home this point to Congress delegates Aurrigo’s 4 seater self-driving pods provided a service from the Metro station to the Congress exhibition hall.

The idea of Automated Valet Parking has been around for a while. On the demonstration site Swarco/Audi showed how a driver would arrive at a simulated car park and use an app to drop off or collect a vehicle by assigning responsibility for the movement of the vehicle to the parking infrastructure. The virtual navigation of the car inside the car park was illustrated using 3D visualisations of the infrastructure and the assignment of a bay, plus a simulated intervention because of other traffic.

Olli – a joint demonstration between LMI and, Autonomous Mobility – allowed delegates to experience autonomous technology first-hand while also exploring autonomous system safety and sustainability. The demonstration highlighted dynamic avoidance and seeing how Olli avoided obstacles and adjusted its path in real time. Delegates were challenged to move objects around to see how Olli easily rerouted around any obstruction.

Copenhagen has a reputation as one of the best cities in the world for cyclists. Q-Free took the local biking experience a step further and invited visitors to become urban cyclists in a Cooperative Intelligent Transport System. Using innovative technology the demonstration allowed participants to experience a range of practical urban ITS scenarios. Visitors using electric bikes were guided through a city environment with the help of audio and visual information from tablets and wireless earbuds that delivered interactive information on traffic situations to improve safety and efficiency.

SWARCO and partners showed a variety of novel safety use cases focusing on the interaction of vehicles, bicycles and pedestrians including a collision warning system between pedestrians and cyclists and “Bike Lane Assistant”. There was also an innovative way to cover the “last mile” mobility by means of the MoonStart e-scooters from Simob.

Avanti and Murata Manufacturing showcased a bicycle monitoring system that was originally designed for vehicles. It uses computer vision to provide information on count, speed, class, and type, and transmits it to the cloud via a self-healing wireless network. Employing such an architecture drastically reduces data output compared with traditional hard-wired camera-based systems. This minimises the amount of infrastructure needed, thereby reducing installation and maintenance costs.

There were a number of interesting new automation ideas – cloud-based large scale video annotations to improve mapping and mobility for connected, cooperative and automated transport; merging support for automated vehicles; mitigation of motion sickness; and automating

## Topic 3: Connected, cooperative and automated transport

a scooter by attaching an “automated driving set box” including LiDAR, omnidirectional camera, servo motor for steering wheel, and servo motor for accelerator pedal. Value chain innovation and business models in public private partnerships in vehicle communication, connectivity and automation were quite openly discussed in order to develop strategies for large-scale deployment.

Optimal routing for driverless vehicles based on “road clearance” or *via* staying within the Operational Design Domain (ODD) was highlighted for the first time. Many speakers reported on the development of operations centres and the associated processes/systems to deal with emergencies and the end of the ODD.

The C-ITS City Pool Workshop was held just before the opening of the Congress with over 60 participants from a wide range of backgrounds, including representatives from city and regional governments meeting for an exchange of experience on the benefits of Cooperative Intelligent Transport Systems (C-ITS) for urban mobility. Since 2015 the C-ITS City Pool has brought together transport authorities already engaged in C-ITS deployment and other cities interested in how C-ITS can improve urban and regional mobility with the aim of raising awareness and support deployment.

The workshop opened with a first look at the upcoming C-ITS Delegated Regulation, covering scope, application, mutual expectations, and potential impact for cities; followed by a session on the deployment of C-ITS as a tool to improve mobility through digitalisation. Other topics addressed were the resources and training required

by successful implementations of C-ITS and upscaling C-ITS deployment to the practical levels required by local authorities, and moving beyond pilot testing to large-scale deployment.

### Forwards vs Constrained

There seemed to be agreement in discussions that AVs form a component of a wider Smart Mobility concept which includes connected vehicles, electrification, active travel, conventional public transport, and fiscal measures; and that Public transport should still form the backbone of urban mobility; and that the main driving force behind AVs is safety.

For many cities and urban areas a smart mobility vision includes fixed route public transport and point-to-point (demand responsive) AVs. Low speed shared shuttles aimed at level 4 functionality were a major focus. Currently the favoured applications are on business parks and other campuses and for last/first mile transfer to public transport stations to reduce the parking burden (*eg* at public transport stops) and to improve mobility for disabled and older people (this is quite a well-covered area, especially in Asia Pacific Region). Point-to-point demand responsive transport and freight could be future applications. Some were concerned how CCAM would affect car use which looked to be a real problem in urban areas while there was concern that deployment of low speed inner-city shuttles would simply replace walking and cycling.



**Slow speed AV Integration (Randall Iwasaki, Contra Costa Transportation Authority)**

Much effort was going into establishing regulatory and user acceptance issues which was easier when done off road eg registration requirements, import/export regulations, safety accessories, etc. New laws might be required, or existing laws might need re-drafting or amending. The State of California, Transport for Victoria in Australia, the UK and Singapore were very active on this.

Security was also a major issue as connected vehicles and infrastructure provide new attack surfaces. Security was highlighted as issue for everyone and not just IT departments. There was a complex trade-off between privacy, anonymity and security so the issues must be approached with great care. It was also shown that current cryptography could be broken with quantum computing, and therefore we needed to provide quantum-safe schemes. An animated SIS on Cybersecurity highlighted the great benefit to system designers of discussing successful as well as prevented attempts to breach systems, countered by the widespread reluctance to discuss the topic especially with competitor organisations. As one observer put it – “When the knowledge reservoir goes down all the boats sink a bit”.

There was a growing interest in evaluation and impact assessment of CITS and by extension AV. Technical evaluations (“does it work or not”?) have often been carried out, but little more. There was a big role for development of common methodologies and assessing the impacts of C-ITS and AV and there seemed to be initiatives in this area in many countries. After all, as a speaker put it, “it’s great if it’s deployed and works, but what will it actually do for us and what will be the benefits?” Many speakers pointed out the risk of increase of vehicle miles due to automated driving, and that shared mobility should be achieved to get the benefits from automation.

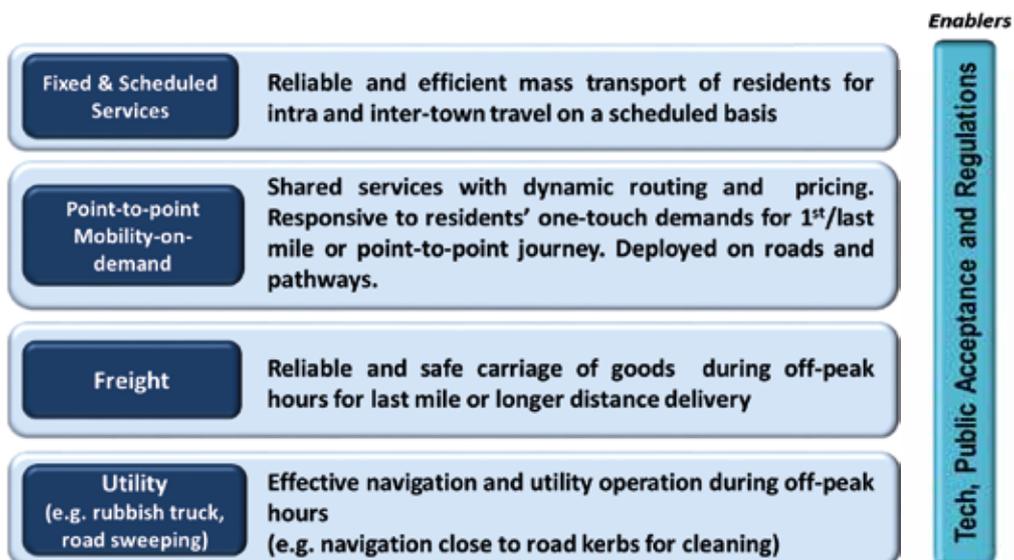
Also connected to deployment and evaluation was the fact that many trials and deployments are looking at a range of use cases. This was usually to do with what modes and operators might benefit from the technology. By extension this would feed into business cases in the near future.

There was a significant focus on deployment of connectivity and bringing the automated driving technologies closer to market through harmonisation and certification, by ensuring mutually compatible and interoperable technologies, and by establishing common frameworks and approaches which can be used across projects, systems and services. The aim was interoperability at all levels – national, regional and global. Interoperability should also allow for technology development. Interoperability, affordability and wide coverage were all required for V2X to be successful.

Digital infrastructure was much more prominent in this Congress than in previous ones, dealing with positioning, extended horizon, dynamic local maps, and back office systems. While High Definition Maps are sufficient for many ODDs, they might not suffice for all conditions. Full point clouds for LIDAR or camera could support precise localisation, viable for shuttles and robotaxis driving today in limited areas and using a central facility. These could also work for other use cases and environments but they needed to deal with millions of unique conditions for traffic environments. Such databases could probably be built in a cost-efficient manner by software alone without human intervention.

Other forward areas included object detection, enhanced LIDAR and radar sensing, trajectory forecasting, applications of artificial intelligence, cybersecurity for connected automated vehicles, validation and verification

## VISION FOR AV DEPLOYMENT IN SINGAPORE



(Alvin Chua Land Transport Authority, Singapore)

## Topic 3: Connected, cooperative and automated transport

processes, the collaboration of test areas facilities and pilot projects to share their experience, solutions for VRUs, and the utilisation of connected vehicle messaging for a number of different purposes. Concerning AI, companies appeared to be humanising computers and providing human representations in computers. This development rather appeared as attempts to give personalities to vehicles.

A popular area of debate was the necessary levels of connectivity *ie* to what extent should AVs be connected or should they be totally autonomous? They were likely to be safe without being connected but there was a balance to be struck with connecting to enhance network efficiency. Connectivity makes efficiency better without compromising safety. Established standards could help AVs communicate with infrastructure.

The technologies of connectivity and C-ITS were heavily debated in many sessions. Some stressed the importance of acting now with existing standardised DSRC/ITS-G5/802.11p solutions, some for existing cellular network technologies alone or together with DSRC (hybrid solution), and some for direct cellular communications C-V2X with 4G and upcoming 5G technologies.

User engagement was very important. We needed to understand what was required from a deployment, who would benefit, who would use it and when. We needed to know the right stakeholders to involve, and this would also include politicians through to customers. We needed to be clear and consistent on explaining the benefits and the constraints.

### Benefits of AVs

#### Convenience

- Time driving is not wasted
  - Working / Watching
  - Browsing / Reading
  - Gaming / Sleeping, etc.
- Vehicle will come to you
- Don't need to find parking
- More reliable travel time
- Don't need driver's licence?

#### Reduced Costs

- Driver is often highest cost
- Infrastructure savings (ultimately)
  - Speed/red light cameras
  - Warning signs
  - Traffic lights

#### Parking Stations

#### Enhanced Mobility

- Elderly / Disabled / Children

#### Efficiency

- More throughput on roads
- Vehicles drive closer to each other
- No crashes to hold up traffic
- Smarter dynamic routing

#### Environmental Benefits

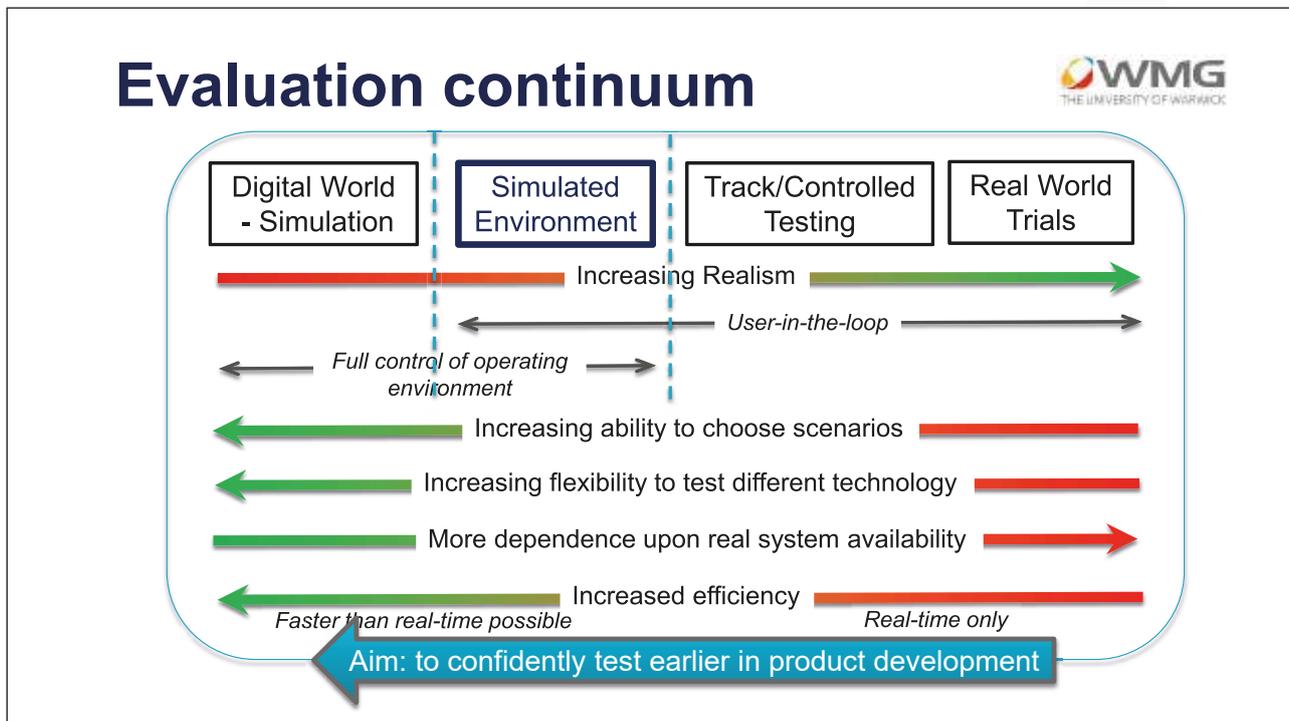
- Smoother traffic
- Platooning
- Lighter vehicle – less 'fuel' use
- Lower noise

#### Health benefits

- Lower stress – less road rage?

#### Reduced Vehicle Ownership

AV Benefits (Andrew Mehaffey, HMI Technologies)



Evaluation continuum (Siddartha Khastgir WMG, UK)

## Where are we heading?

There were many sessions presenting findings from early deployments of CCAM, especially FOTs. It is only relatively recently that we have seen real world deployments in CITS, let alone AVs, with previous findings and policy thinking often based on modelling and simulation. The concept of CITS was ready to move towards full deployment, the concept of AV was still in the FOT phase and that would be a key area for the next congresses. For wider deployment there were organisational issues. A complete and experienced project team would be needed, with infrastructure, vehicle and back office systems, performance measurement *etc.* Infrastructure needed to be deployed early, followed immediately by testing with infrastructure and with security. It was essential to look at the learnings from as many trials / pilots as possible.

There were technology issues not entirely resolved. Examples included aspects of communication that still required testing and optimising, and interoperability and architecture considerations to facilitate large scale deployments. This would also include issues like vendor lock in and procurement. However, "*Trying to standardise something that everyone does differently*" as a speaker put it remains a real problem at least for automated driving.

Perhaps reflecting the fact that there was still much to do on deployment and evaluation, business case issues were only moderately covered with this aspect and user acceptance accounting for barely 7% of sessions and about the same for papers. Local issues also needed to be considered and political engagement was imperative. However, in the long term the 'wow' factor (novelty) would wear off and the concept would need new selling points. After all, automation is just a tool in transport, not a goal in itself.

US schemes that were presented seemed to promote a small government / big business ethos, *eg* emphasising partnerships with agencies for their skillsets, but not on the payroll. In effect this was contracting out of services to the private sector, rather than purely central/local government. Also cities needed to move more quickly to remove regulations that were not safety-related to enable the market to flourish.

Regulations needed to catch up with the technologies. This concern ranged from the 'technical' aspects of vendor lock in and procurement to legal / liability and standardisation issues – points like uniformity of road markings, registration requirements, and safety-related features. For some parts of the world the gap between innovation and regulation seems to be closing with the regulatory bodies taking a more active role. There seemed to be an agreement that systems are not yet ready to be designated the legal driver.

There was much discussion of a proposal from the USA that every automated vehicle should have an Automated Driving Provider making a promise to the public about the safety of automated operation and being the legal driver. Some speakers pointed out that the current type approval legislation focuses on mechanical vehicle parts, not on software or the vehicle's behaviour in traffic – which it should also cover.

It was clear that user acceptance needs to catch up with the technologies. User acceptance and the wider social implications of CCAM remained an under-investigated feature at this point in time, but there is at least some acknowledgement of this in the presence of a small number of sessions. What if people don't really want autonomous? Do we actually know? Are we too technology/ policy-led? What are the wider social impacts (high/higher unemployment among fleet drivers?) Will there be any unintended consequences? (Increased congestion?) Can we predict impacts that we haven't yet identified? (Possible land use changes?)

### "If we could do it all again, we would"

- Solidified Standards Earlier
- Obtain a Better Understanding of "Available" Applications' Maturity
- Obtain a Better Understanding of "Available" RSU and OBU Hardware
- Obtain a Better Understanding of Vendors' Depth and Resources
- Like More Transparency in the Device Certification Process from Vendors
- Complete Integration Testing Before Private Vehicle Installs Begin
- Have Shifted the Focus Much Sooner to a Commercial Security Credential Management System
- Identify the Need to Use Traditional ITS Devices as Part of a Solution Earlier

**Learning from pilots (Bob Frey, Tampa-Hillsborough County Expressway Authority, USA)**

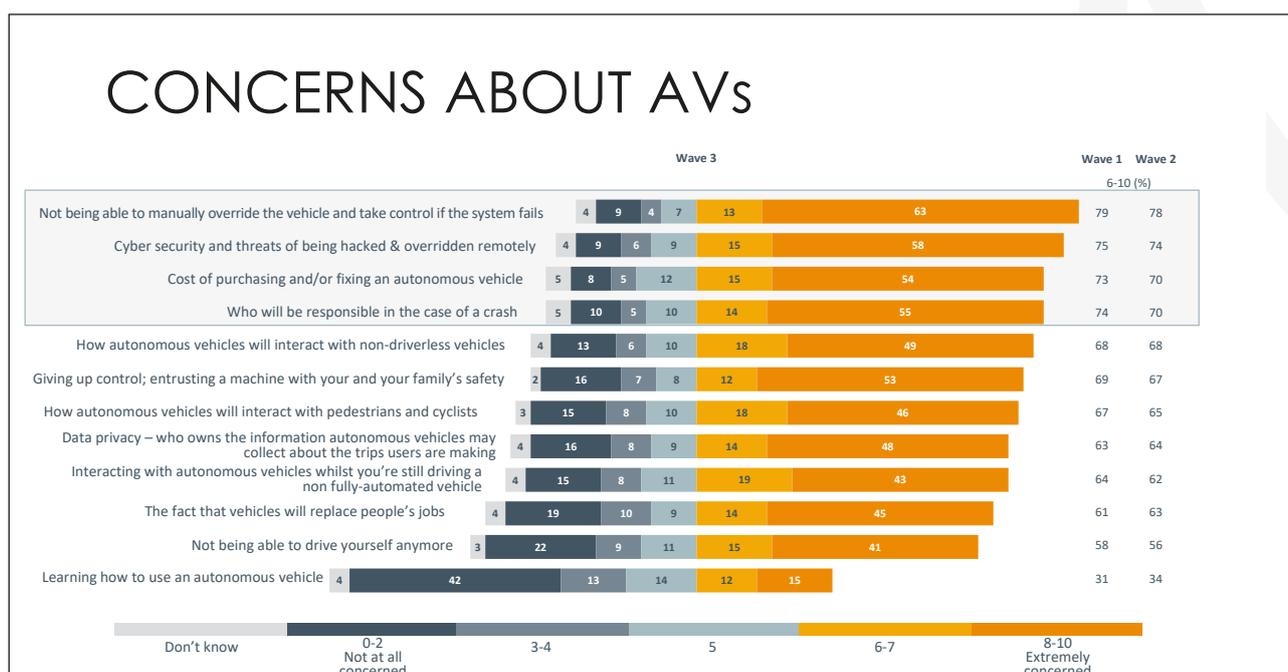
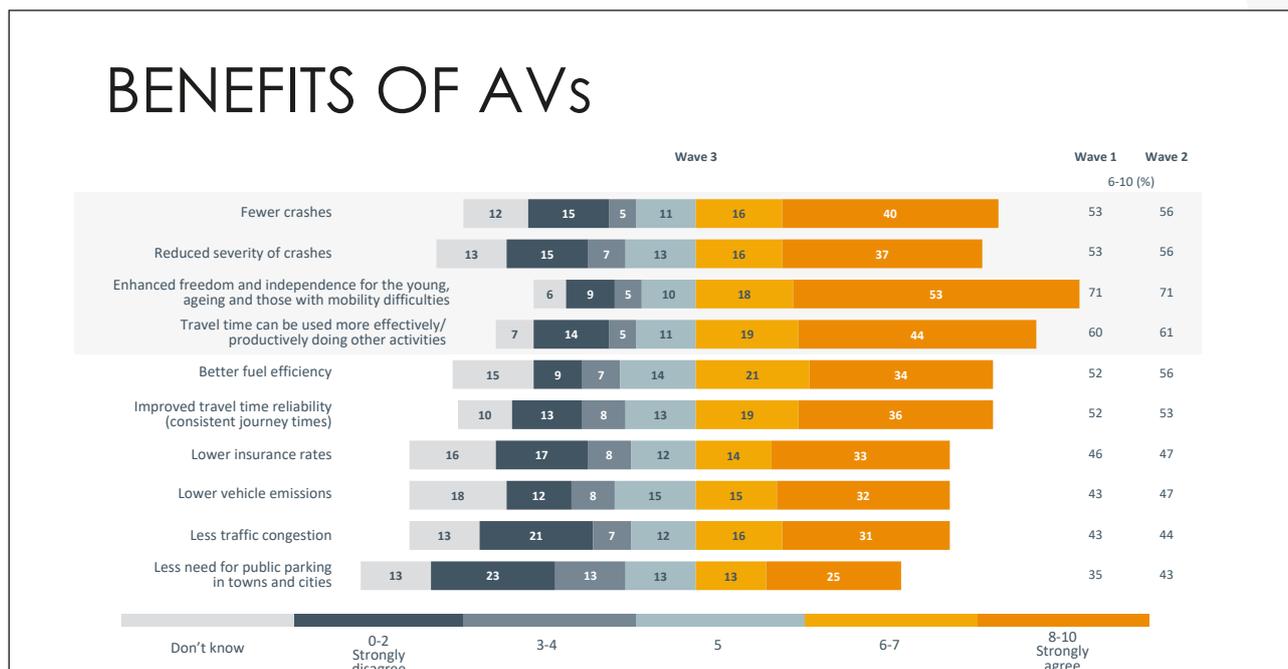
## Topic 3: Connected, cooperative and automated transport

As noted here and in the Topic 1 report there was a lack of understanding of user attitudes and changes to user behaviour once new technologies start to be deployed. In Australia the Royal Automobile Club had carried out a number of user surveys with the results below.

The study of CCAM was still very urban-centric. Even a session about rural CITS seemed to focus primarily on suburban and peri-urban locations. Rural areas have some common needs with urban areas, but also have some that are unique eg challenging infrastructure, ageing population, insufficient mobility resulting from the

elimination of public transport networks, poor technology connectivity. In most developed countries the accident rates in rural areas are markedly worse than those for higher quality roads and urban centres yet the emphasis of CCAM deployment does not reflect this in many cases.

Another rather neglected area was the potential benefit of C-ITS and AVs to the reduction in transport's gaseous emissions. A fuller description of this point is given in the Topic 2 report but there was a review of international progress with this important issue in SIS53. We can expect to see progress with this topic in future congresses.



### Automated Vehicle Programme (Anne Still RAC Western Australia)



## TOPIC 4: NEXT GENERATION GOODS DELIVERY

### The overall situation

It is fair to say that measured over a number of years dealing with the freight and logistics sector has been somewhat limiting. On the one hand ITS practitioners have many services available which if deployed in the industry ought to bring enhanced efficiency and effectiveness not least in the bottom line. But the industry is rather conservative – hardly surprising when delivery timing is critical – and visible supplier costs, rather than a wider perspective of social benefit, dominate.

The Congress was held in a city championing cycling so we might have expected to see swarms of cargo-bikes or other drones showing their potential for delivering goods.



**C-ITS based green flow for cargo bikes in the Exhibition**

The Congress did give a taste of these but in a realistic and pragmatic way. The topic of next generation goods delivery didn't attract the largest amount of papers and sessions. Discussions were therefore more about incremental innovation, ensuring positive business cases for technologies and services that can increase the productivity and minimise the negative impacts from goods transport on the roads.

Platooning was a key theme spanning C-ITS, automation, and corridor approaches. It was seen as key to linking ITS innovation and breakthrough of automation in the future. Two visions were discussed: platooning as a driver support service; platooning as driver replacement. Whilst road authorities have encouraged platooning for safety and road capacity benefits, the business opportunity of relaxation of driving time regulations for drivers was always present, hence a serious and important debate that did not come to an end in Copenhagen.

A confirmation of the trend initiated in previous congresses, the Port of the Future was an important topic that prompted wide-ranging discussions. The port

is a constrained environment where the widest possible scope of ITS solutions is needed, not least as a platform to connect them all. State-of-the-art container terminals showcased the most advanced automation technology, whilst lower-tech services demonstrated the scope for reaching the largest number of vehicles. The concept of logistics platforms was another element brought to the Congress through various projects and political initiatives. The wealth of data in logistics remains a fruitful area of research, for instance to achieve end to end visualisation. It was also debated whether the next step should be for platforms and clouds to be better connected. In the case of city logistics, it was argued that beyond the main platforms disruptive business models were increasingly putting responsibility for deliveries in the vehicles of private citizens as opposed to commercial businesses.

There was much (new) discussion about putting a value on kerb space, and new services and approaches were proposed to safeguard it as a public space. It was argued that the pavement was already a resource in short supply and one that would be much fought over by services companies, whether by existing traditional vehicles (delivery vans, taxis) or by newcomers (delivery robots, cargo bikes). It was claimed that over 70% of the congestion in Tokyo was caused by illegal on-street parking. Most cities seemed to realise that this battle was looming and some had proposed their own vision (eg Berlin in an invitation for testing light electric vehicles). Testing an autonomous pavement cleaning robot was described, undoubtedly a "first" for an ITS congress.

### Old vs New

The fragmentation of the logistics industry was reported from all regions of the world. In order to demonstrate affordable ways to increase efficiency Japan described the development of ETC2.0 – electronic toll collection combined with services to provide road users with road traffic information and to collect probe data from the vehicles. The resulting data can be used by the road operators to better manage their networks but they can also be used by logistics companies to improve their operations. Trial results were demonstrated, showing the potential gains for the logistics industry by simply using an upgrade to a widely adopted technology.

Platooning was discussed at previous congresses and it continued to trigger considerable interest in Copenhagen. Road operators described the outcomes of recent projects and trials, acknowledging that the benefits from platooning needed to be fully demonstrated before it could be deployed on a large scale. To reach this objective required more extensive sharing of data from all tests and pilots than hitherto. Road operators declared firm commitment to using platooning to increase safety and reduce the amount of primary or secondary accidents caused by, or involving, heavy goods vehicles.

## Topic 4: Next generation goods delivery

The second objective was increasing the capacity of the already very congested road network, knowing that the volumes of freight were growing strongly.

One approach to confirm this objective was described under the topic of infrastructure-based management of platoons. In particular, key use cases such as truck platoons entering a roadwork area were currently being researched and were intensely discussed. Similarly, road operators acknowledged a duty to evaluate which stretches of their networks could be allowed for platooning. Depending on the area and the presence of bridges and tunnels it appeared that continuous platooning over long distances could still be far away. The network owners/operators recommended starting tests on priority corridors, but not locations where safety is already a challenge. Besides, an additional requirement was that platooning should not increase damage to the infrastructure. The road operators made it clear that they could not subtract capacity from the network to allocate it exclusively to autonomous vehicle experiments or services.

This tended to confirm that more validation was still required before road operators were likely to agree to open their roads to platoons. There was a vast amount of research into truck platooning and development with large scale pilots in various regions. The underpinning technology and connectivity had been thoroughly tested and the focus was now on conformance aspects.

A number of presentations on container terminal automation prompted a realisation that for the “port of the future”, the future is around the corner with technologies such as in-operation electric vehicle charging already deployed. Although many container terminals were very advanced many city ports had to manage a legacy dating centuries back to when a city was built around its port. For these city-ports the battle was about developing,

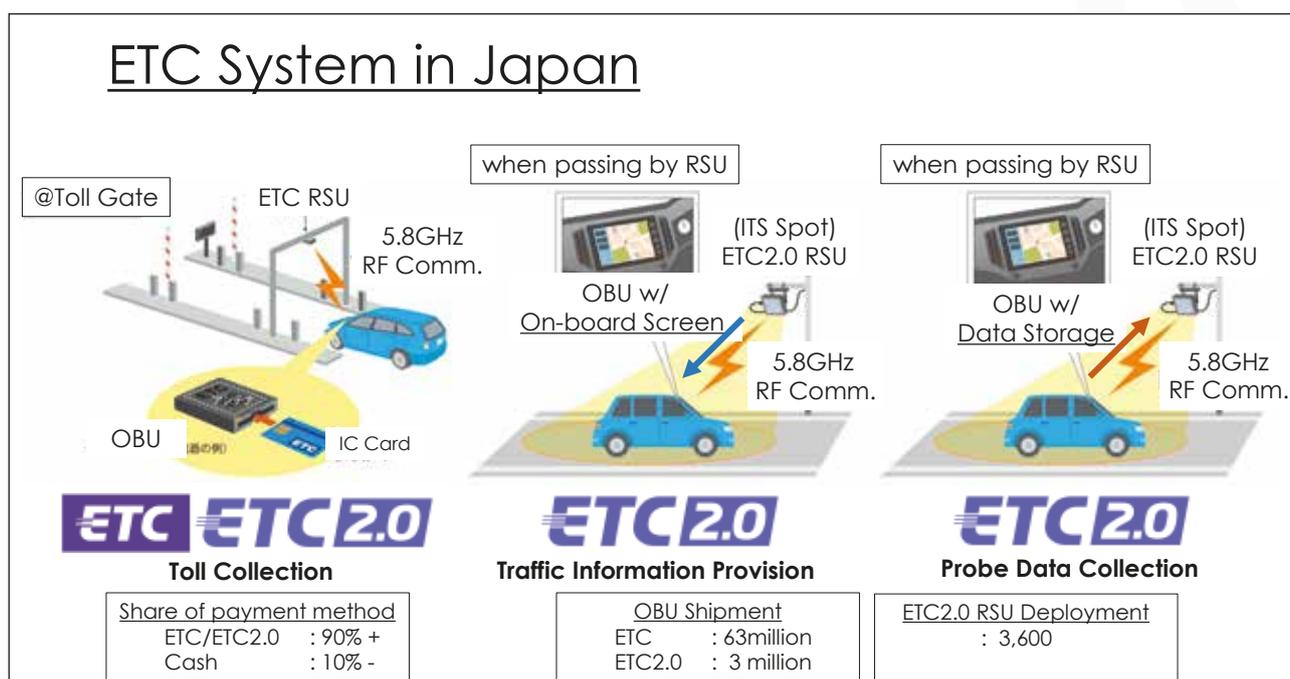
testing and implementing solutions faster than volume growth. Several port authorities and technology partners demonstrated the latest ITS at ports, such as ITS G5 or IoT platforms. New services deployed at ports such as truck appointment systems were not necessarily new per se but they increasingly add a layer of intelligence based on data analysis to support the port’s operational decision making.

The intelligent port concept was demonstrated by Hamburg, host of the next ITS World Congress in Europe, and described as an ecosystem for the transformation process. Discussions focused on improving the integration of the port as a node of the logistics network. This was of particular importance in the context of the development of end-to-end supply chain visibility, a topical issue for the logistics world as information gaps remained due to the disparate and passive nature of data. Discussions took place on this topic between shippers, freight forwarders and ports authorities. All parties recognised the need for harmonised, interoperable ICT systems on a global scale. Key elements for such platforms would include interoperability of data, compatibility of tools, integration of standards, and a shared dashboard.

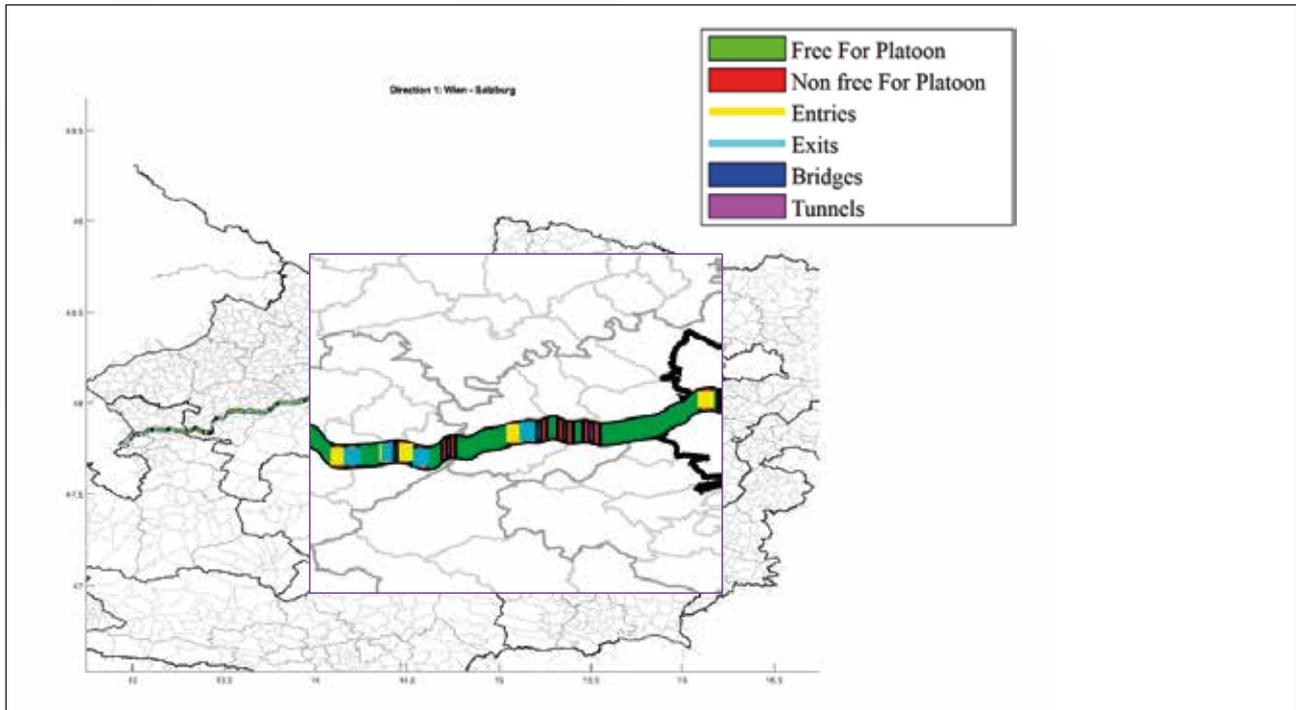
A number of large research projects involving global industries and associations have presented their current activities, and it was pleasing that this topic would remain prominent in future as the next ITS World Congresses will be hosted in world class port cities (Singapore, Los Angeles, Hamburg).

### Forwards vs Constrained

The discussions on platooning touched upon the opportunity of autonomy for freight transport so many discussions involved the present and future role of the freight drivers. Many countries had a shortage of manpower



ETC2.0 Technology in the commercial logistics business (Toru Owada, ITS Technology Enhancement Association)



## Interim results from Connecting Austria project (Wolfgang Schildorfer HiTec, Austria)

to drive trucks, a job that remained dangerous with a quality of life that failed to attract job seekers particularly for long haul transport. For many stakeholders it looked tempting to jump quickly to full driver replacement from full autonomy, a perspective that remains rather distant.

On the one hand several new technologies or services were presented to increase truck drivers' safety, and to support the driver in handling the new technologies that were increasingly present in truck cabins – particularly true for special work such as ploughing. These new services and technologies call for more advanced training for drivers, aiming at making the driving tasks more engaging and interesting. Freight transport experts recognised that too often truck drivers did not receive advanced training and education, and frequently objected to the use of new services or technology. Low levels of autonomy were presented as a way to take the most repetitive and simple tasks away allowing the driver to concentrate on more technical or advanced tasks. Emergency Braking System adjustment in the context of platooning was an example that would require advanced driver experience and awareness. In this context the drivers were an essential asset in the transformation of their industry and their work environment needed to be improved, particularly regarding safety, to increase the quality of their work.

The platooning business case perspective was also presented along with arguments in favour of higher-level automation that could leave the driver fully out of the loop for a significant amount of time, leading to the opportunity of more flexible implementation of driving and resting time regulations. Ultimately, the cost gain from removing the driver from the vehicles could indeed be appealing. There were a number of energetic debates on this question, and the role of the driver remained key in the question of automation of the freight industry. Should the driver be

a strong and active player in the field or is the driver an obstacle to be replaced as quickly as possible? Both visions come with various sets of benefits and disbenefits that were still being researched and evaluated.

Road operators and public authorities repeated their commitment to making safety the key objective for autonomy. The benefits of autonomy for freight were often presented as guaranteed but the position was not clear without realistic plans on how to capture the benefits rather than just wait for them to materialise. It was important to regulate, but also to manage expectations of benefits. The regulations for autonomy were clearly a key point to be taken with research and development efforts. There was also the aspect of control and interaction with law enforcement agencies – 50% of current regulations involved the driver. Transferring such rules to vehicle hardware and software had to be explicit and communities had to be included in order to ensure social acceptance of autonomous vehicles.

Whilst the discussion about “the last mile” was important this year we heard the topic of the last metre / last yard. Traditional industry players, such as the global freight delivery companies, had been struggling for years over the last yard question but suddenly new business models had emerged that were challenging the management of cities' public space. Following the same model as transport network companies or MaaS operators for passengers, parcels or groceries or meals were increasingly being delivered by third party individuals who were not logistics professionals and were only loosely connected to the logistics platform contracting them. This was a seriously disrupting model that was generating tough competition between goods and people movements in the city space, a serious challenge for city authorities.

## Topic 4: Next generation goods delivery



|15

- **ITS in shipping is happening now;**
- **Customer demands are a key driver;**
- **Benefits could be massive, but a change in mentality is needed;**
- **Clear positive impact on the climate and the environment;**
- **Regulatory environment is key: future-proofing.**



ITS For Shipping – data exchange (Simon Bergulf, A.P. Møller-Maersk Denmark)



### Platooning or autonomy? Or both?

- Passenger vehicles automation: strong focus on individual system, not on convoys
- Truck platooning: strong focus on creating convoys, less on automation
- Which comes first, and can they be combined?



Autonomous freight vehicles (Serge van Dam, Ministry of Infrastructure and Water Management, the Netherlands)

## Where are we heading?

The freight and logistics sector could well be the scene for a number of struggles for progress and commercial success. There is first the arrival of freight services for delivery “across the pavement” which have impact on traditional logistics models, inner city space management and the passenger / freight access balance and the value of parking and kerb space. The second key area is the relatively slow adoption by the sector’s smaller players of open platforms and the wealth of proven ITS services available ‘off the shelf’. The third factor is the increasing pressure for better air quality, not just in cities, that will force changes in the make-up of fleets of freight vehicles and when, how and where they are operated. And finally there is the sector’s continued move to reduce costs – will the safety cases for platooning deliver gains or barriers?

Overall the next Congresses are likely to see faster adoption of business cases for technologies and services that can increase the productivity and minimise the negative impacts from goods transport on the roads.



## Topic 5: Satellite technology applied to mobility



### TOPIC 5: SATELLITE TECHNOLOGY APPLIED TO MOBILITY

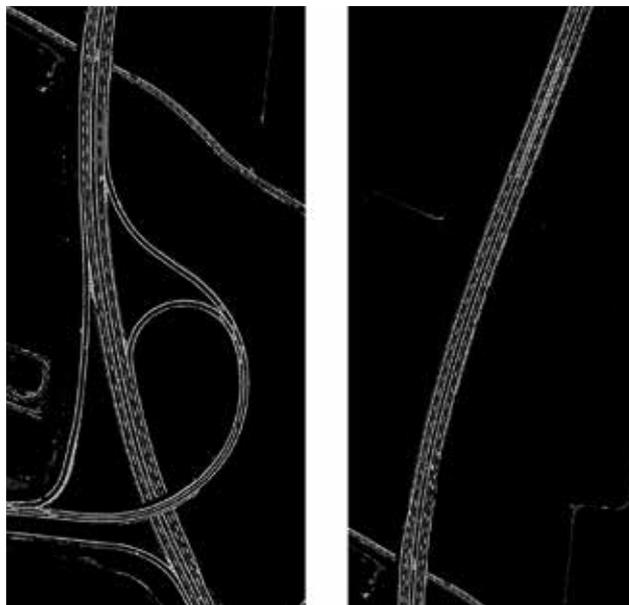
#### Overall situation

Having a visible satellite technology theme provided an identity and a strong link for space stakeholders to participate in the ITS congress. There was high level representation from the European Space Agency (ESA) and European GNSS Agency (GSA) along with several organisations working on projects funded by the two agencies. Compared to the papers and sessions numbers for Topics 1 and 3 this was a small Topic but it was a heavyweight one. Moreover a number of papers and sessions referring to or making use of satellite technologies were classified under a different congress Topic.

Papers and sessions were spread across the 3 key themes of the satellite technologies – communication, positioning and earth observation. While the overall focus for demos, the exhibition and the congress was on applications and services there was a renewed interest in the community regarding enabling technologies. In line with a more general trend communication technologies and the benefits from 5G was a notably hot topic.

#### Old vs New

In contrast to Bordeaux 2015 satellite technology had rather less visibility but had definitely gained much more support and understanding from the community. As an example, an OEM executive expressed the view that given a free choice satellite communication should be used for connected cars *“to take away all the issues related to geographical coverage and roaming as well as the hype regarding 5G and other technologies”*. For positioning technologies the Copenhagen discussions were more oriented towards GNSS mobility applications and services and using the overlap with complementary



**Precise road maps from space (Hartmut Runge DLR, Germany). Geo-referenced road features & precise coordinates from Worldview-3 satellite image (A96 at Lindau exit)**

technologies to deliver better value. This was in different to previous years where the focus was on accurate positioning for CCAV,

The discussion around trustable maps highlighted the immense challenge in terms of obtaining environmental information from multi-sources to create accurate maps for navigation applications as well autonomous driving. Companies were issuing billions of map updates every month – building accurate maps and detecting changes

#### GEOLOCATION IN THESSALONIKI (C-ITS)



**Galileo precise positioning for railway crossings (Josep Maria Salanova Grau, CERTH Greece)**

in the environment using FCD, IoT sensing as well as aerial and satellite imagery. With more satellite imagery made available (eg through the Copernicus programme) it was more cost effective to detect changes in maps from space.

Following the introduction of the earth observation topic last year, where delegates saw the concept of new satellites (cubesats) that could potentially enable real-time monitoring of traffic and transport infrastructure from space in the near future, this year more real mapping applications from space were presented.

Creating the digital twin from space has become possible as was demonstrated using satellite imagery to build accurate maps to the extent that lane markings can be extracted at various junctions of a motorway as shown in the figure on page 32.

GNSS remained a key enabling technology for existing ITS applications and services and we saw substantial interest in developments and enhancements from both the technical/scientific audience and from a business/strategic perspective. The benefits of the Galileo services were well understood with an increase in exploitation as a result of efforts by the community led by the GSA. Galileo routinely delivers high positioning accuracy (see figure on previous page).

Iridium presented a fifth global positioning and navigation service to add to the existing four global GNSS services. The new service, STL, uses 66 satellites in low earth orbit so can achieve greater signal strength, improving reach in buildings too. The service level offered is comparable to that of Galileo in terms of resilience and robustness against malicious attacks.

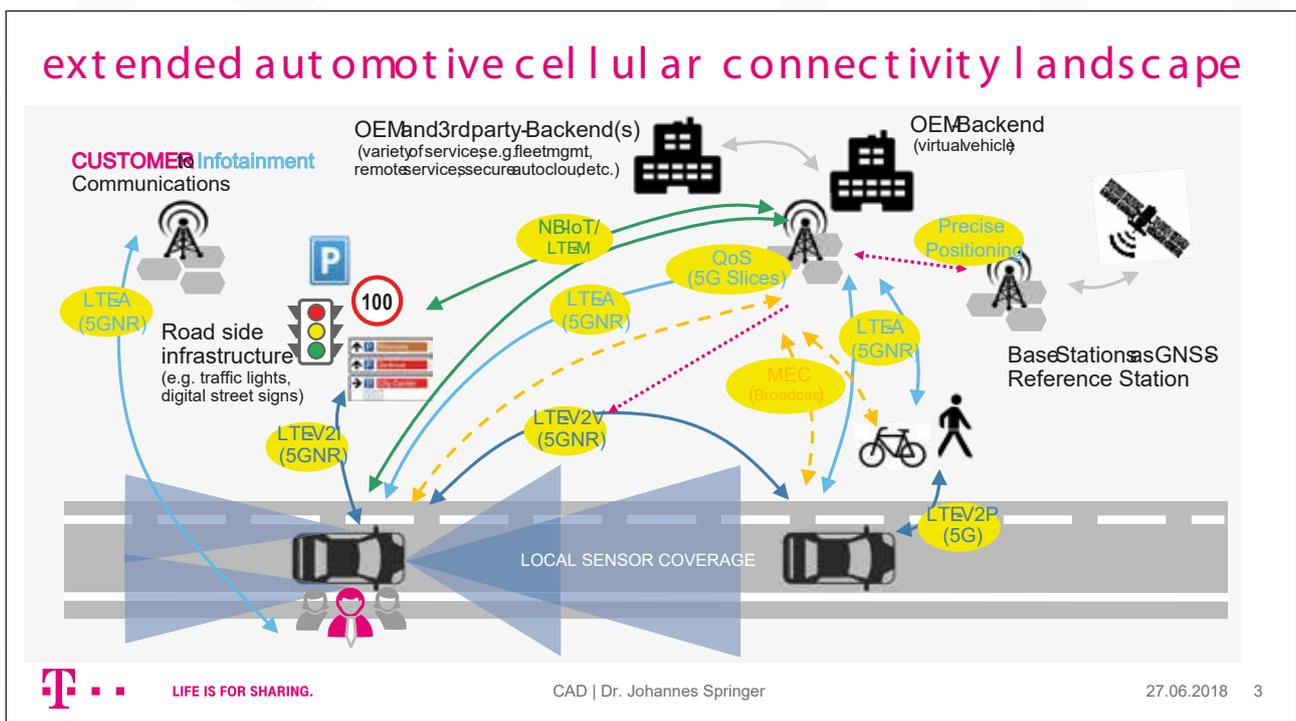
The fast acquisition time for Galileo chipsets was investigated in multi-modal travel applications and shown to provide significant improvement in terms of user experience. When using a non-Galileo chipset devices typically took a longer time to acquire the users position, resulting in frustration particularly during multi-modal journeys. For example when a user emerged from an underground metro system and wished to continue a journey on a motorbike taxi, the application would take a while before working out the location. With Galileo such acquisition was much quicker and such chipsets were integrated in commercially available smartphones so new applications and services could exploit them.

Applications ranged from simple navigation services and train crossing notifications to complex automated cranes at ports. In addition the security element of the technology would be scrutinised as more applications and services (such as autonomy) became critically dependant on it – with discussion around jamming, cyberattacks – covering threats and potential mitigation techniques.

The 5G buzz continued in Copenhagen. Developments in this domain have triggered innovation and drive in the telecoms industry to bring satellite and mobile communications together and these were an integral part of the 5G Phase 2 (3GPP Release 16).

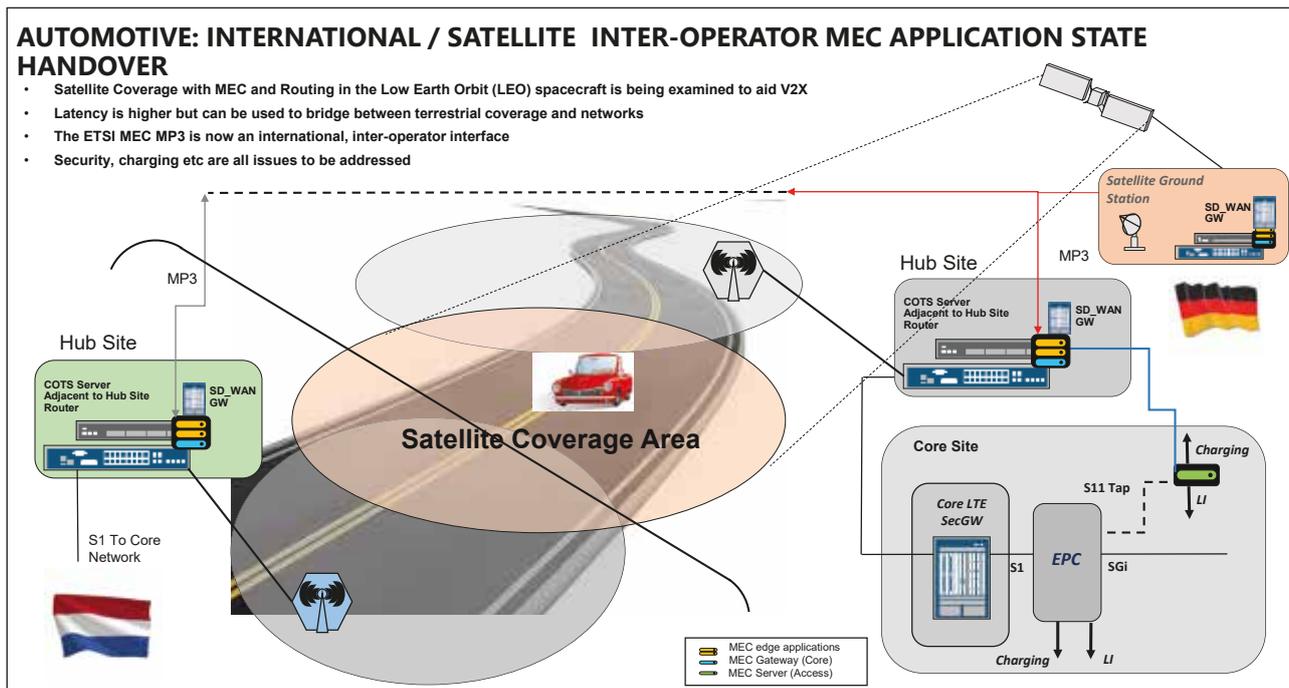
The satellite industry had reacted favourably to this trend. Speakers at the SIS31 presented the innovative work taking place across the entire supply chain – from operators, antenna manufactures, network equipment provider and 5G cutting edge research organisations.

Sessions discussed innovative solutions that used satellite communications technology to address foreseen



Satellite timing supporting 5G integration (Johannes Springer, Deutsche Telekom Germany)

## Topic 5: Satellite technology applied to mobility



### Satellite bridge between 5G network and border crossings (Ian Goetz, Juniper, UK)

deployment challenges of 5G that would impact the seamless connectivity required by CCAV and other mobility solutions. One such example was the use of satellites to bridge the connectivity gap at 5G network deployment at borders – which very often map on to geographical borders between countries.

A new topic was demonstrated at the Congress, the use of satellite imagery to undertake monitoring of road infrastructure from space. The combination of IoT sensors along with radar data from space was able to detect subsidence at bridges and other key road infrastructure. The demonstration also showed how satellite imagery could be used to build better situational awareness for emergency services when responding to eCall. Up-to-date maps allow services to take key decisions in terms of deploying resources – for instance, a hard to reach area could necessitate the use of helicopters to provide quick assistance.

The ERTICO ITS EU-China summit had a wide ranging discussion on using satellite technology to support large scale deployment of ITS applications. Satellite technologies were seen to play a vital role in transferring ITS applications and services from urban areas to large geographical footprints – a process of immense interest to countries such as Australia, Canada and China.

### Forwards vs Constrained

There was a consensus across the ITS community that connectivity challenges were here to stay so that diverse technologies could be integrated to work seamlessly together. The heated debate between DSRC and ITS G5 seemed to have some lost steam and had been replaced by concerns about what LTE-V and 5G-V2X would mean for vehicular communication. The lack of agreement, standards and industry lead in this area had



prompted a search for alternative solutions. Satellite communication seemed to be the unifying solution given its large geographical coverage and global reach by design. This technology does have limitations but there was a keen interest to address the integration and interworking challenges of heterogeneous networks within 5G – believed by many to be the “silver bullet” for many of the connectivity challenges that impact large scale and robust ITS services deployment.

As multi-modal navigation and travel services become more widespread, there was an increasing need to be able to realise real full end to end mobility – including space indoors. For vehicles, this meant accurate positioning in covered car parks (underground or multi-storey) while for individuals this meant the transition from positioning in a building to outdoor positioning. While a lot of work had been undertaken to improve and better utilise GNSS services outdoors, challenges remained for full integration with indoor positioning. New services such as Iridium’s STL could be the short term answer to this challenge – a satellite signal strong enough to be received reliably indoors to establish positioning.

## Where are we heading?

There was still some suspicion that satellite services are an expensive and distant promise but Copenhagen firmly reiterated the evidence that services were available, affordable and reliable. We should expect changes in other areas as this message hits home. The focus of many ITS applications and services continued to be around urban areas. Although many of the challenges seemed to be reaching conclusive solutions large gaps remained to achieve large scale successful deployment of ITS services at large. The target regions would include rural, semi-urban and urban areas.

Such a shift in focus would highly benefit the community and open up the space for innovative and robust solutions to issues on connectivity, positioning and mapping. In

most developed countries the accident rates in rural areas are markedly worse than those for higher quality roads and urban centres which ought to be a powerful driver for better attention to rural issues. This topic was addressed at the ITS EU-China summit organized by ERTICO.

Accuracy, resilience and security of positioning was rising up the agenda due to the 'over' dependency on positioning technology to deliver valuable and even critical ITS services. The potentially disruptive effect of cyberattacks on such systems could be far reaching in terms of disrupting not only transport networks but equally all individuals who rely on them for mobility.



# Topic 6: Transport networks evolution



## TOPIC 6: TRANSPORT NETWORKS EVOLUTION

### Overall situation

This was one of the three largest topics and sessions and papers covered areas such as:

- Traffic management particularly Interactive traffic management.
- Multi-modal traffic Information.
- Network resilience and traffic safety
- Intersection Management
- Data issues and Big data including data exchanging, probe data, open data, methods for collecting data, data integration *etc*
- Artificial Intelligence and Machine Learning
- Simulations and traffic modelling
- Cybersecurity, privacy and integrity

This topic also included traffic data analysis sessions *eg* open data and information, travel time estimation, traffic demand strategies, traffic flow control, data-driven traffic management *etc*. Key highlights of data-driven traffic management were the sessions on Deep Learning and the state-of-the-art approaches in machine learning and artificial intelligent which were starting to be widely applied in transport.

### Traffic and Network Management

Road users want fewer delays, safe, clean and comfortable trips and high quality traffic management is a fundamental tool to reach these goals. From the public point of view traffic centres needed more and higher quality monitoring information to be able to manage traffic to meet policy targets (*eg* safety, environment). Road authorities needed more guidance on their future roles and how to manage the transition from being the reactive traffic controller to being a strategic network manager. This approach was discussed in a number of sessions and especially the workshops on Traffic Management 2.0. It is obvious that traffic management will be more and more data driven in the future.

A session on sharing data for traffic information road authorities and service providers highlighted the current situation where a lot of information was lost in data exchanges and consequently drivers very often do not get the correct incident information, see the figure below. Six service providers were evaluated (A-F), none succeeded in always translating the DATEXII-message correct probably because the delay time was too long.

## MAIN CHALLENGES

- From incident to driver – the process is often slow and information is sometimes wrong or missing
- Difficult to find the right form of cooperation

Service providers	A	B	C	D	E	F
Time delay from DRD to SP	10-30 mins	5-15 mins	5 mins	5-10 mins	5-25 mins	
Accidents	✓	✓	✓	✓	✓	✗
Dropped goods	✗	✓	✓	✓	✗	✗
Translated DATEXII text is correct	✗	✗	✗	✗	✗	✗
Wind on bridges	✗	✗	✓	✓	✗	✗
Current road works	✗	✓	✓	✓	✓	✗
Future road works	✓	✓	✗	✗	✓	✗

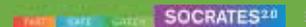
Challenges in relaying incident information to drivers (Stine Bendsen Danish Roads Directorate)



# LEVELS OF COOPERATION

	No joint approach – exchange info	Exchange info - common insights	Joint approach – common insights – coordinated services
<b>Situational – status sensors, actuators</b>	Monitoring with own instruments	Share data, jointly set up CSP and optional improve own monitoring	Joint development CSP and all agree to use it
<b>Operational – actions, measures</b>	Independent choice and deployment of measures	Share actions and measures and optional improve own measures and actions	Joint development, choose and deploy measures and actions
<b>Tactical – approach, TM services, motivation</b>	Independent development and choice of tactical approach	Share approach and motivation and possibly improve own approach and motivation	Joint development, choice and deployment of tactical approach
<b>Strategical – policy, priorities, objectives</b>	Independent development and deploy of policy framework	Share policies and priors and possibly improve own policy and priors	Joint development and deployment of policies

TM 2.0 and Public Authorities as Service Providers in Traffic Management



3

## Levels of cooperation between Road Authorities and Service Providers (Matthias Mann, HERE, the Netherlands)

The Socrates2-project was mentioned many times in presentations. It is based on TM2.0 work and is aiming to deliver better cooperation between road authorities and service providers. This is badly needed as was evidenced by the evaluation just described. This is exactly what Socrates2 is all about. There is probably no “one solution fits all” to describe how best to cooperate. The picture below was shown in the TM2.0 workshop and it illustrates a number of different models for cooperation between road authorities and service providers.

The Socrates2 concept also looked at managing people not cars and in-vehicle or in-pocket solutions. Traffic management supporting door-to-door transport with a multi modal approach linked to active corridor management principles was demonstrated and represented an important step forward.

Network management included a number of service-driven applications eg route guidance, traffic control, traffic flow, demand estimation and prediction, use of tolling in network operations. There was a special focus on turning movement analysis and traffic conflict in order to improve traffic flow and reduce travel time. Network management tools were important in monitoring and optimising traffic networks and they affect how traffic networks should be designed.

A study evaluated the effectiveness of a flashing speed limit sign in school zones located on arterial roads which contributed to the improvement of pedestrian safety by identifying the variation of vehicle speed trajectory and evaluating the effectiveness of the limit signs. Research into the changing patterns of the degree-of-saturation parameters in the Korean traffic-responsive signal control system guided the development of the degree-of-saturation estimation model for advanced use within the traffic responsive signal control system.

A different component of transport network management was operation and maintenance of ITS facilities using advanced technologies. This session included applications of data analysis techniques in Japan for tunnel lighting and old bridge inspection and for expressway maintenance. Infrared investigation was used for the non-destructive inspection of bridges. Various kinds of robots (eg suspended type and flying type) were utilised and the diagnoses was supported by AI algorithms.

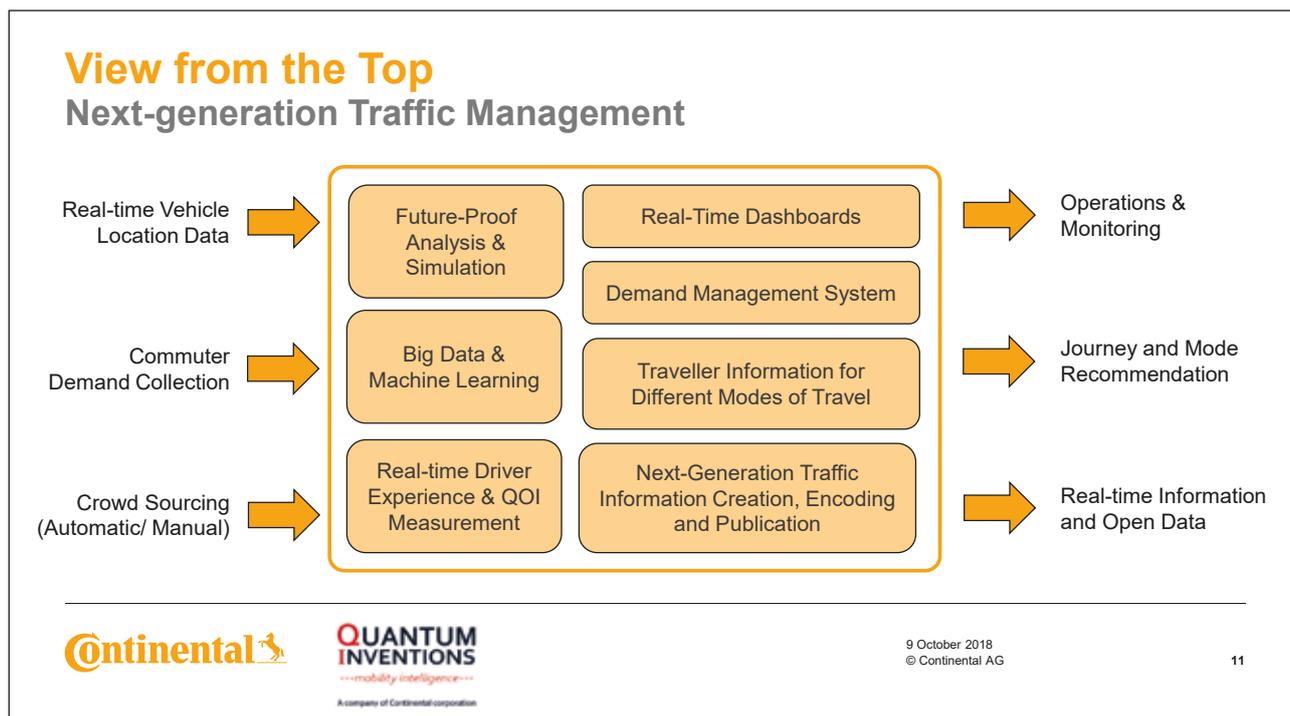
The impact of AVs on pavements was presented with an evaluation of road surface displacement and the conclusion that if autonomous heavy vehicles started to operate following exactly the same wheel path then the rate of rut development would increase rapidly even on high quality roads. This phenomenon was visible at the Bordeaux Congress in 2015 where driverless shuttles were being demonstrated on soft infrastructure.

A session on next generation traffic management argued that it would have to be more interactive – bringing data in from road users as well as infrastructure-based sensors and sending information back out to users. As an example, in Japan 2.8M connected cars routinely supply probe data for use in various applications such as safety, greening traffic and disaster mitigation; and a system was being developed that would detect road surface conditions. One assessment of the way forward is in the diagram opposite:

## Safety

Safety investigations were topical with many reported. As more information becomes available about incidents and traffic conditions more accurate analyses of incident risk become possible eg wildlife-vehicle and inter-vehicle incident studies or testing the use of infrastructure

## Topic 6: Transport networks evolution



(Mohit Sindhwani, Quantum Inventions, Singapore)

changes to minimise risk. Papers demonstrated that increasingly accurate road data can be obtained; one study focused on travel-time distribution estimation from floating car data, another focused on effective data aggregation for better risk assessment. A further study used historical incident data to evaluate simulations of 'conflict' between vehicles in a calibrated simulation environment. A study in Denmark analysed the scope for using video data to quantify the success of new infrastructure in increasing accessibility (for example an outlined left-turn 'box' for cyclists).

Intersection management helps human drivers and pedestrians go through cross traffic safely and is an important part of intelligent transportation systems. A study proposed an iterative and automatic method of revising control parameters so traffic signals can maintain control performance. A research paper evaluated the safety performance of signalised T-junctions and described a case study in Singapore focusing on three types of traffic conflicts. The analysis identified the most problematic type of cross conflict at this T-junction from both a descriptive and an inferential perspective.

Another research paper introduced the New York City transit signal priority (TSP) system, discussed a TSP Dashboard to facilitate system operation and introduced data visualization analysis and evaluation into the dashboard. It concluded that data visualisation would play an increasingly important role to improve traditional data analysis.

A paper described experiments with volunteers to investigate the time taken to read various types of graphic route information panels shown on a display monitor, and analysed the participants' accuracy in making right route choice decisions. A paper analysed pedestrians', cyclists'

and car drivers' behaviour and assessed the impact of waiting times on the rate of red light running. In general the papers presented in this sector suggested that new intersection management methods could significantly lower the number of traffic conflicts and improve management efficiency.

### Data

Many aspects of data were on the agenda – data exchange, the use of probe data, open data, methods for collecting data, data integration and Big Data, Artificial Intelligence and Machine Learning as new classes of data sources.

The eco-system of data exchange is a key enabler of future C-ITS services, Interactive and Cooperative Traffic Management, and efficient maintenance. Much of this data would be collected from in-vehicle services but other data sources would also be used. The most valuable information and knowledge would come from combining data from different sources and purposes, so standards for the exchanges and for data formats were essential and were reviewed in several papers.

It was agreed that open standards and clear specifications for data types and formats were essential for delivery of harmonised traffic information on a national level and the exchange of data for traffic information and network management. However the existence of standards in itself does not magically solve all problems: one paper explained that "a significant cause of inaccurate data lies in the scope for interpretation of the DATEX II standard". As one speaker stated: "standards are fake if you don't know how to implement them".

Data collection using all kind of techniques was presented in several sessions and papers. Fixed radar-detectors, cameras *etc* are still important sources. Probe data from vehicles and mobile phones has increased a great deal and we could also see that data can be extracted by using advanced sensing technology such as image processing and active sensing in On-Board-Units or Road-Side-Units. We also heard of tests using acoustic sensing. Telecom operators were looking at selling the data they collected from network traffic provided that they could ensure integrity and security. This could be a new way of getting a good understanding of a traveller's Origin-Destination, see picture below.

One paper noted that road authorities tended to maintain information in systems based on GIS standards, while the exchange formats and the receiving systems on the ITS side were based on standards from the ITS domain. The senders and receivers of data would need to resolve these different conceptual models and agree on exchange formats for the two domains.

An interesting approach to overcoming divergent standards was presented in a paper on the semantic web which aimed to isolate semantics from code and develop an ontology which would be more than a reference model. By using a semantic web you can integrate data from sources using very different standards and models for storing data.

## Big Data, AI, Machine Learning and Deep Learning

There was a growing awareness of the value of 'big data' – very large quantities of data of different types – in transport as in other fields. Devices for collecting data can be deployed cheaply and on a very large scale (such as IoT devices). With a rich volume of traffic data it was challenging to build reliable prediction models based on traditional shallow machine learning methods. Deep

learning was a new state-of-the-art machine learning approach which had been of great interest in both academic research and industrial applications.

At Copenhagen we heard how deep learning algorithms have been applied to popular transport topics (*eg* signal control, bus arrival time prediction), and had shown promising results for traffic data analytics. Data and information collection, analytics and utilisation were increasingly applied to current transport network operations to enhance performance efficiency and quality in various fields. However the data flow was frequently contributed by numerous sources, the data was presented in many different formats, and was often disconnected and unstructured.

A number of sessions covered the potential of data processing and big data analytics, machine learning and deep learning. Several sessions focused on the practical use of big data in applications and how big data and analytics could be used to deliver tangible results. Another session explained how insight and understanding gleaned from big data could drive better decision-making and improved service delivery. The edge computing concept was introduced as a way to enhance performance and bring more valuable information to the whole system.

Almost all of the studies presented on deep learning were heavily application-focused, without a particularly novel contribution to theory. However there were some papers aiming to integrate spatial-temporal dependencies of the traffic network into deep learning models but the numbers were limited and the scope quite specific *eg* signal control. It would be interesting for future Congresses to see other topics such as incident impact prediction, travel time/speed *etc* presented in deep learning sessions.

SIS68 included the provocative statement that if data is the fuel of the digital revolution then AI is the engine. Artificial Intelligence is more than the automation of

## Future goals for traffic data?

Collection from private sources



Probe vehicle data

**Probe Vehicle Data opportunities (Edoardo Felici, Netherlands National Data Warehouse)**

## Topic 6: Transport networks evolution

existing processes; it involved setting an outcome and letting a computer program find its own way there to a greater or lesser degree. AI had already been used to power ITS solutions so understanding the opportunities and challenges was crucial to making ITS installations and services smarter.

Examples of what papers in this domain described were:

- Big Data & Machine Learning Platform under deployment for toll highways.
- A pilot study to apply big data, image processing and AI techniques in traffic safety improvement.
- Deep learning for bus arrival time predictions.
- Deep learning for intersection signal control.
- Analysis of Traffic Incidents using Machine Learning.
- Traffic congestion forecasting with AI.
- The use of neural network for prediction of traffic.

There were many lessons to learn when establishing systems based on Machine Learning, eg ML is good at predicting what is normal but it is extremely difficult to work back and know why a trained system reached the “conclusion” that it did. The biggest issue regarding AI and ML was trust: “How do I trust a trained system to do what I want?” and the warning “We have never been able to test complex systems completely and we can’t inspect trained systems or construct them in a way that ensures that they will operate correctly.”

The global focus and investment in developing smart cities included the desire for cooperative ecosystems where services could be created, developed and deployed. In such an ecosystem the goal was for private companies and public operators to share information and policy goals, and to integrate operational procedures to facilitate innovative mobility solutions. The session on Public/Private Cooperation provided a snapshot of plans and success stories in creating such an ecosystem in cities around the world. The studies included a plan for a cooperative traffic control strategy in the Netherlands, integration of private sector traffic data with the existing public framework in Tokyo, and pilot testing open-access video data to monitor the traffic situation in Helsinki.

Applications were also explored, from evaluation and improvement of existing smart motorway algorithms in the UK, to the pilot-driven creation of various innovative ITS solutions in Oulu (Finland), to a rapidly deployed airport traffic management system in Auckland. Copenhagen city described the ambitions on green mobility and a carbon-neutral city. The city set service goals to be achieved by 2018 to support green mobility by KPIs on various modalities on selected corridors where they have the highest priority.

### Modelling and Simulation

This year simulation and modelling showed two main directions of research: connected and autonomous vehicles (CAVs) operating under various mixed traffic conditions and demand redistribution in networks affected by a fleet of autonomous cars, either shuttles or regular taxis. These reflected different problems of demand

estimation, controlling and optimisation but also the challenges of simulating this type of traffic network. When simulation was not practical traffic modelling was a key tool for ensuring an optimal flow in road traffic networks.

In one case a technique called “Autopilot” had been built to automatically present the scenarios potentially applicable to the current traffic conditions to assist network operators. Machine learning was used in some cases. A study applied machine learning techniques to complementing missing traffic flow data so that information services could be provided continuously. The use of different modelling techniques showed that advanced machine learning is becoming a useful tool in traffic modelling.

Various constraints on simulation and modelling were described including the challenges in passenger flow control strategies under special events scenarios as well as lack of data coverage. Furthermore, CAVs are hard to control and travel demand redistribution would need special attention. The session on improving intersection management included a number of studies proposing new management methods or analysis to improve intersection traffic flow fluency.

There was very little work presented on simulation and modelling to explore the impact of autonomous vehicles on intersection management. A number of studies had been presented that applied traffic modelling for effective traffic management including traffic parameter analysis, traffic signal controls, automatic traffic scenarios recommendation and machine learning based modelling techniques. However we did not see any modelling for transit demand analysis which would be important for transit management.

### Cybersecurity and integrity

As cybersecurity, privacy and integrity are horizontal issues and part of many areas, it was not surprising to find sessions and papers on these issues in several topics, not only in the topic “Transport Networks Evolution”. Enhancing cybersecurity and resilience of the transport infrastructure was also covered in an important Executive session. Also some papers were presented raising concerns on the risk of cyber threats against the entire road-operating eco-system and possible future cyber-attack scenarios against ITS. Blockchain was mentioned with one very intense session; we can expect more on this in coming congresses.

Data security is crucial in modern ITS networks. Vehicle-hacking techniques have been studied extensively and the attack vectors for modern connected vehicles and future autonomous vehicles are well documented. A network security session explored the growing scope for cyber threats against ITS services – for example in the Industrial Internet of Things world (IIoT) it was expected that Smart Roads would be fully integrated with today’s internet connected cars and tomorrow’s autonomous vehicles. The threats could be broadly categorised as: Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I) and Infrastructure-to-Infrastructure (I2I). ITS application

and systems (A&S) can be grouped into 6 categories: Vehicles, Roadway Reporting, Traffic Flow Controls, Payment, Management and Communications.

## Old vs New – topics discussed in Copenhagen

As described above on a general level many interesting topics were covered in the congress. Going in to more detail, new and innovative ways of using ITS could be found in some presentations. Examples were:

- Traffic Management as a Service (TMaaS) was a concept introduced by the city of Ghent in order to make it easier for small and medium-sized cities to establish Traffic Management in an efficient and cost-effective way. It sounded like an attractive concept build on a layered platform that combined commercial data with open data, giving multimodal and personalized insights. It would be possible for other cities and regions to subscribe at different levels to the platform in order to benefit from the developed functionality. We would see if the concept turned out to be a success.
- The use of the motion of cell phones of people as an additional source to traditional traffic information data. These combined data could give accurate and up-to-date indications of the overall travel activity. The data on motion of cell phones was provided by a major telecom provider and displayed the trips of approximately 50% of the people in the modelling area.
- A system called Driver's Dashboard that was developed collecting incident descriptions from Facebook and RSS feeds, filtering relevant messages, and fusing them with traffic data.
- The use of combined data, science and traffic modelling techniques, where an application was developed consisting of current and short term traffic prediction and a virtual patrol to detect congestion and incidents. Data fusion, real-time supply and demand calibration, fuzzy traffic state estimation and traffic flow theory, together provided a consistent and complete common picture which in turn offered the opportunity for several stakeholders to cooperate, negotiate and act faster thereby optimising their objectives.
- Cross-border ticketing for commuters on short distances was an interesting development. The areas of public/private collaboration and cross border transport collaboration have been making great strides forward. There was increasing collaboration between public and private sectors, as shown in the success stories of this session. Different levels of collaboration had led to different criteria for success and innovation. Public policies did not always allow for swift cooperative solutions. However, cheap pilots were demonstrated in this session to provide an effective proof of principle for larger-scale deployment of innovative ideas.
- Most cross border ITS solutions faced funding, legislation and non-uniform technical framework problems. In addition the processes for developing

and introducing standards were slow. Stakeholders did not want to risk loss of investments by being forced to reinvest before the original stake was fully depreciated. And the benefits of developing standards most often did not occur until significant investments had been made. This area was moving forward with a recent joint project of the Netherlands, Germany and Austria for a cooperative ITS corridor with the first harmonised applications addressing road works warning and improved traffic management of vehicle data.

## Where are we heading?

The ways of managing traffic networks had advanced considerably as a result of three developments – availability of new and better data sources, powerful AI and ML tools supporting predictive approaches, and the launch of some large-scale projects that had brought together specialist approaches previously developed separately.

New techniques based around data were even more on the agenda than at earlier congresses and all kinds of aspects were presented and discussed. There were very many presentations reporting experiences with implemented solutions and we heard much more about the implementation of systems using different kind of data as well as technical solutions for collecting and processing data.

Ways of collecting and using probe data from several sources, and the techniques and processes for using very large amounts of data, had taken some interesting steps since Montreal 2017. Big Data, Artificial Intelligence and Machine Learning in ITS, were part of how to use data – in all Topic areas, not just this one – and as pilot projects bedded in we were likely to hear more about practical results, real benefits and the scope for scaling-up. This is also true for Interactive, cooperative and data driven traffic management.

Copenhagen is one of a few cities trialling modern network management techniques for cyclists and there was much scope for extending this thinking to the “management” of vulnerable travellers more generally by using technology to improve safety for pedestrians and mobility-limited users. We had surprisingly few papers exploring the interactive management of electric vehicles using infrastructure equipped with charging facilities – and infrastructure for electric vehicles is likely to be more visible in future as a combination of topics 1, 2, 3, and 6.

Two other areas seemed under-represented: technical papers on cybersecurity and business models for next generation traffic management centres. Sessions incorporating cybersecurity identified a common aversion to public discussion of experience and thinking around the subject but the sessions were also notable for a wish by practitioners for a more open approach as a way to concentrate scarce resources.

# The Host viewpoint



## THE HOST VIEWPOINT, THE NORDIC STREAM AND CROSS-BORDER MOBILITY SOLUTIONS

The team of rapporteurs assessed proceedings 'vertically' – they looked at issues mainly from a Topic-related point of view. Representatives of the Host country worked alongside the main team to look at the Congress from a 'horizontal' and national perspective with especial reference to the key Danish topic of cross-border mobility solutions. Hereafter their thoughts and conclusions.

The Nordic Pavilion symbolised the Nordic touch – the Nordic way of cooperating across borders by approaching problems and finding solutions together. An example is the demonstration project “NordicWay 2” where the road authorities are working together to use C-ITS for Traffic Management.

The Nordic Stream was organised by the Nordic ITS organisations (Finland, Norway, Sweden and Denmark) with cross border focus, while the MaaS session on Friday morning focused on solutions to be applied in all Nordic countries.

The Nordic Stream had sessions featuring speakers not only from the Nordic countries but also experts from other countries. It was managed by the Nordic Region, in close cooperation with the Programme Committee and the host, which enabled a focus on important and common Nordic topics:

- Multimodal transport for passengers and freight
- The role of public transport in MaaS systems
- Cross border issues
- Access to data
- Organising test sites and demonstrations

An important lesson to keep in mind is the fact that every solution needs to be adjusted to the specific context – what may be a smart solution in Japan might not work in Denmark. It's important to consider different factors like cultural context, lifestyle, weather conditions, local infrastructure *etc.*

Many sessions touched upon public/private partnerships, and the City of Copenhagen aims at creating conditions for better cooperation between public and private sectors in order to develop greener and healthier cities. The maintenance of systems needed to be included in that cooperation otherwise the expected benefits would not happen. The shuttle service from Bella Center Metro to the Congress venue showed delegates how such services can meet demands for the first and last mile of a journey.

A number of solutions and services showed the potential to improve the convenience of cycling so contributing to a modal shift of increased cycling:

- The Avanti R&D booth and demonstration project on acquiring travel times from cycling had the potential for generating fundamental data upon which to build traffic management services; this would put cycling

on par with cars in regard to ITS solutions and traffic management. Real time data for cyclists can be used to improve green waves of traffic signals.

- The Hermes Traffic and Infrastructure solution for road surface monitoring could give road authorities a tool to improve monitoring and maintenance of bike lanes.
- Hövding – the Swedish bike-helmet/airbag for cyclists – expressed a willingness to supply data to help to improve city infrastructure, safety and traffic planning.

Volkswagen/MOIA had a great example of an electric vehicle that may persuade people out of their private car into public transport. Their idea is to place themselves in between the market of private vehicles and public transport by utilising the benefits from each transport mode.

The “MinRejseplan”, the Congress MaaS app, was an example of disruption in comparison to establishing the more classic route from A to B. It included travel planning for public transport, city bikes, car sharing and taxis. There is no doubt in the host city's view that it will spread rapidly and be further developed and deployed in many places. A lot of resource had been needed to develop “MinRejseplan” for delegates and it is expected that it would soon be rolled out to the public so giving value to citizens. The planning and deployment of “MinRejseplan” had brought the lessons that excellent collaboration between all parties, and the adoption of open interfaces, were essential for success

The Congress brought demonstration projects to Copenhagen which created awareness of the possibilities when technologies are applied to cycling traffic and other green modes of transportation.

Many of the delegates were very impressed with the mobility solutions in Copenhagen especially the many bicycles, and the City can expect a lot of people who will look at Copenhagen – both now and in the future – and get inspired.

Meeting with international partners face to face compared to the usual Skype calls was very beneficial and a great opportunity to get a good impression of what the partners are dealing with and to give them a better impression of the City's needs and being the largest municipality in Denmark. This will much improve future cooperation.

Particular achievements as seen by the City of Copenhagen:

1. Co-Creation – The City of Copenhagen's green agenda
  - Global challenges such as urbanisation, demography, the climate change and health issues demand joint efforts from very many parties including private / public partnerships, cooperation with universities and citizen involvement and engagement.

- Many participants referred to the 17 sustainability goals of the UN agenda 2030. The City of Copenhagen has adopted this agenda with the strapline “Co-creation Copenhagen”.
- The “Copenhagen Green Agenda” was included in the Congress App with a special focus on programme elements within the agenda – the CPH 2025 Climate plan, the ITS Programme and Cycling.

## 2. Improved traffic safety by ITS solutions

- The City appreciated the very strong congress focus on ITS and traffic safety, underlined also by a forceful keynote speech by Commissioner Violeta Bulc at the opening ceremony. In the debate that followed the UN Secretary-General's envoy for traffic safety, Jean Todt, emphasised the importance of the topic pointing to the 1.3M–1.4M global fatalities annually. At the High Level Round Table a number of mayors expressed support for the zero vision for fatalities and serious injuries in traffic.
- Many existing technologies could enable traffic to become much safer for vulnerable road users today if implemented on a large scale – a good example is Intelligent Speed Assistance (ISA). Better design of truck cabins to improve direct vision of pedestrians and cyclists from the driver's seat, sensor-based intersection design, and variable speed boards around schools, could all be easily deployed.
- Technological solutions based on pedestrians and cyclists actively emitting digital signals for motorised vehicles to detect will never offer a truly safe infrastructure – the technology should protect the vulnerable road users rather than subtly placing the responsibility on them.
- The risk of accidents for cyclists in Copenhagen has decreased by 53 % from 2008–2016, and 76 % of cyclists feel safe in traffic. On average Danes bike 4.9 million km between each serious accident by bike. We assess that the congress has inspired many cities to promote cycling as an essential part of green mobility and as part of the ITS tool box to improve safety for cyclists.

## 3. ITS and environmental issues as air and noise pollution

- The WHO estimates that poor air quality accounts for 7M premature deaths globally every year. The City appreciates the Congress's strong focus on the need for urgent legislative measures.
- On environmental issues such as air and noise pollution Copenhagen prioritises preventive initiatives such as reducing polluting car traffic rather than symptom treatment, eg photo catalysis technology or similar remedial initiatives. Prioritising cycling, walking and public transport not only improves environmental issues but also improves safety, reduces congestion and creates liveable cities.
- The City of Copenhagen has partnered with Google to improve the monitoring of air quality by using the Street View cars to measure the air quality at street level. Better monitoring can improve our knowledge about air quality.



## Plenary And Executive Sessions



### PL1 – ACHIEVING HIGHER QUALITY OF LIFE IN OUR CITIES

In a video message Mrs Mariya Gabriel, EU Commissioner for Digital Economy and Society, said that ITS must deliver clear benefits to citizens and society at large so services should be developed alongside dialogue with citizens. Similarly cross-sectorial and cross-border cooperation and collaboration were needed to ensure Europe's leading role in ITS and there had been considerable testing to facilitate this. The Commission was aiming to set a framework for connected and automated vehicles across Europe with three key EU-wide elements: connectivity using 5G; in-vehicle and city data for services to citizens; and cybersecurity for automated driving in any smart city and for public acceptance.

The Keynote speech “driving to the next generation” was delivered by Veni Shone (Huawei, China). A challenge was to bring mobility to the daily lives of everyone. There were around 5Bn connected people and 100M connected cars but although many of them were digitalised they were not fully connected, so C-V2X was key to linking people to infrastructure. The road to cooperative ITS and beyond went from cooperative digitalisation (eg V2X and C-ITS today) to system intelligence (advanced ITS and MaaS expected from 2025). C-V2X tests and pilots are underway in several countries. These goals could not be achieved working alone; joint efforts were needed.

Moderator Karsten Nielsen (City of Copenhagen, Denmark) talked about the different travel to work modes he had used while working in different cities worldwide, with the conclusion that most people chose their travel according to what was convenient according to their situation. In the same way cities' requirements for ITS would differ.

A public authority perspective was given by Mayor Ninna Olsen (City of Copenhagen). Technical developments in traffic management and transport had been amazing but we must not lose sight of the need to serve citizens. The Copenhagen metro was autonomous but that did not necessarily mean autonomous cars would solve congestion, make the city safer or increase the quality of life. ITS supporting walking and cycling was important as any solutions should make cities better, healthier and greener.

Kian Keong Chin (Land Transport Authority, Singapore) said that Singapore transport had to focus on efficient, high capacity public transport so a lot of resources had been spent on the metro. But metro systems also bring a first and last mile issue so for this walking and cycling were key components and suitable facilities to encourage them were being introduced. New services like automated vehicles were being looked at in order to bring people to high capacity public transport systems. Demand management such as congestion pricing was used for the road network to ensure there was space for everyone.

Carlos Bracerias (Utah Department of Transport, USA) said we needed to understand the “why?” such as to grow the economy or increase the quality of life. When you understand the purpose you put solutions in a much broader context. We were not moving cars and trucks, but people and goods. Utah asked the public what was important; the responses (by priority) were first agriculture, then air quality, disaster resilience, access to education, energy (availability and affordability), housing and cost of living, jobs and economy, public (federally-owned) open land, recreation, then transport choices and finally clean water. On the face of it, transport

seemed to come a long way down citizens' priorities, however all these other aspects are either helped or hurt by a good transport system. It was vital to engage in a process to find out what citizens valued, because these were the things that transport professionals could facilitate and be successful on.

“Technical developments in traffic management and transport had been amazing but we must not lose sight of the need to serve citizens.”

**Ninna Olsen**  
Mayor, City of Copenhagen

Jan-Bert Dijkstra (Ministry of Infrastructure and Environment, The Netherlands) agreed that ITS can contribute to a liveable city and people must be central. Spatial planning was important. At national level there was a new procurement procedure for nationwide MaaS in association with seven Dutch cities. Intelligent traffic lights were a tool but it was up to the city to determine the levels of priority. He also looked forward to welcoming the ITS community to the Brainport region of Eindhoven next year for the European ITS Congress.

In the discussion that followed the question was asked whether public authorities shaped the possibilities for citizens or the other way round. NO argued “both”; for example the authorities provided the first cycle lanes but their use was so great that they became congested creating a public demand for more space for cyclists.

KKC reminded that there were increasing numbers of private operators in the field of mobility and purpose was more important than ownership. The key question was how to make mobility sustainable. Regarding public vs private the jury was still out.

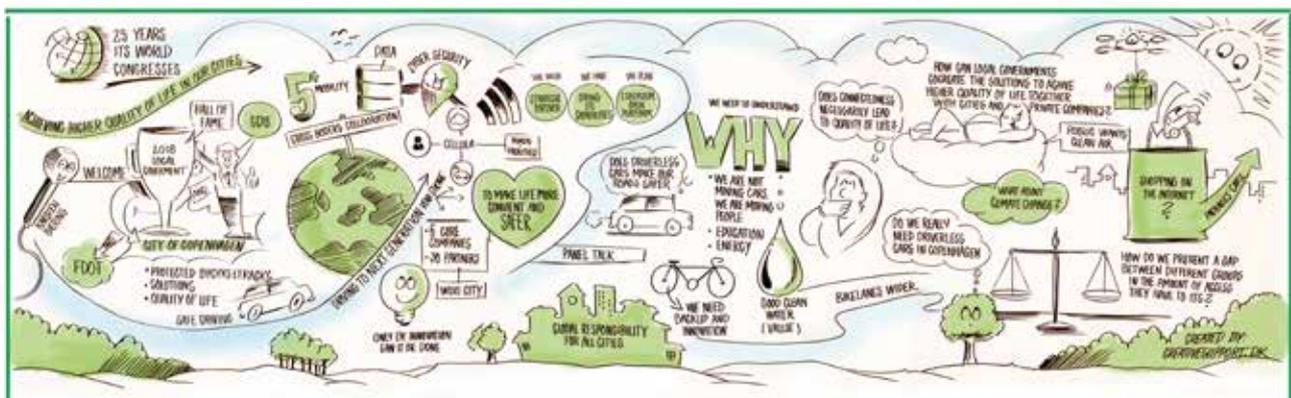
On self-driving cars CB said that younger people were less in love with cars than previous generations and this transition was being felt in cities but it presented difficulties as US city infrastructure had been largely built around the car. Reducing the number of poor driver decisions through driver assistance and autonomy would be a major success and the biggest motivation for an

infrastructure owner like Utah DoT. NO said that we needed to understand what problems driverless cars might solve. It was not clear whether in Copenhagen they would solve anything and might well attract people from cycling and add to traffic congestion. KKC reminded that we should also look at other autonomous transport eg buses, freight vehicles. Automated shuttles for the first and last mile could solve manpower issues and make public transport more attractive. Autonomy could also extend the first and last mile and make the whole system more efficient.

Audience question: Should we put climate change as one of the top priorities that ITS can mitigate? KKC said that the politically correct answer had to be “Yes” but the importance depended on where you lived. It was very important in Singapore because it is a flat city close to sea level so is at risk from the effects of climate change. CB said that Utah had been using air quality as justification for funding and management eg traffic light sequencing to reduce stops and therefore reduce emissions. NO said that political boldness was needed to take unpopular decisions to achieve climate change goals. J-BD said that if the goal was zero casualties, zero emissions and zero traffic jams then ITS had to contribute as there was no other way. The key questions were in which ways ITS could contribute, in which amount and at what speed, especially since developments were moving at a very fast pace.

There was inevitably a gap between big issues like climate change and personal choices and convenience. Who should take the lead? The Netherlands had succeeded in getting 80,000 people out of traffic jams and onto other modes, but you had to start at a local level and it was a tough job. In Utah there was bad air quality in winter so they informed drivers when it occurred to encourage car-pooling and use of public transport. The key was making people understand so helping them break out of a routine. People choose the easiest transport option, so we should make the greenest option also the easiest one.

A final audience poll asked “how can technology support higher quality of life in cities?” The most popular response (49%) was Mobility as a Service to make it easier for citizens to choose the optimal mode for their trip. Second (27%) was smart priority: allocating priority to all means of transport in an intelligent way. 24% selected “safe and clean” – connected driverless vehicles that are clean, safe, secure and accessible for all.



## Plenary And Executive Sessions



### Four Executive Sessions were grouped under the PL1 theme:

#### ES01 – Healthy and liveable cities

Moderator Tina Saaby (City of Copenhagen, Denmark) welcomed delegates and speakers. The session aimed to explore what needed to be done to get maximum benefit from ITS – How could cities embrace the future deployment of smart and intelligent transport systems and set the agenda for a better future world?

The first speaker was John A. Barton (HnTB Corporation, USA) who argued that we were going through a transport transformation driven by automation technology, connectivity, electrification, digitalisation, and sharing that was disrupting beyond the transport sector to land use planning, urban design and real estate values. Emphasis was being put more on moving people and goods, rather than 'vehicles', in safe, healthy and efficient ways to add to the quality of life. One emerging solution for cities was the concept of the Mobility Hub – the place where longer transit services linked to first and last mile connections and also active modes such as walking and cycling.

Wai-leung Tang (Government of Hong Kong) spoke about delivering mobility in a densely populated city. Hong Kong had roughly the same population as Denmark but in one fortieth of the space and the population was ageing. Despite 90% of travel being by public transport the roads were congested with over 350 cars/ Km. There were established policies to deter the use of personal cars and encourage public and non-mechanised transport, and at the highest level transport policy was linked to social

policies for example the ways in which care was provided for older citizens.

Gary Liddle (Melbourne University, Australia) thought that both cities and transport were changing as there was a global shift from rural to urban living. It was increasingly being appreciated that transport was not an end goal – it is a means to an end. The focus was now on the movement of people and goods rather than the carrying vehicle so we needed to change our metrics to match. Similarly we had to think of an overall transport system of different modal corridors rather than elements such as traffic management. It was vital to think through policies carefully to explore possible consequences; for example modelling the impact of autonomous shared vehicles in Melbourne suggested a considerable reduction in the total number. However those vehicles were then likely to spend much more time in use or moving between jobs so overall there was likely to be an increase in congestion.

Wolfgang Hoefs (DG CONNECT, European Commission) reported on the European Commission's work which covered 28 Member States rather than any one city. Urbanisation was a global trend with 70% of populations in cities and 80% of GDP produced in cities. The EC saw liveability as a major benefit from a wider Digital Society which used technology innovations to make cities safer, cleaner, healthier, more prosperous and more enjoyable. Objectives included multiple mobility options, decreased numbers of accidents and improved sustainability. Achieving this ambitious agenda would require citizens,

travellers, industries and other stakeholders working together to design and implement solutions. The next Multi-annual Financial Framework was expected to offer additional co-financing options to encourage deployments. A holistic approach was needed so success would rest on cross-sector, cross-border and cross-culture cooperation

The moderator initiated a wide-ranging discussion from which the following points arose:

- Accessibility was easier to deliver in dense inner-city areas where collective transport could be given higher priority than individual modes and parking could be restricted. Providing affordable and equitable transport for suburban and rural areas was much more difficult and also more expensive.
- Accessibility for all had to work for people with reduced incomes as well.
- Transport policy had to include space allocation as density, city planning, the cost of land all have impact on transport systems. In most locations car driving received a subsidy in the sense that the true cost economic of using the road were not recovered.
- The need for inclusion was underlined: “mobility for all” meant for the elderly, for children, for mobility-impaired people. An ageing population translated into challenges for mobility. New application could help people with impaired mobility, but a few extra seconds at a pedestrian crossing was also a quick and cheap benefit for elderly citizens.
- The move to Automated, Connected, Electric and Shared transport could not be left to chance. National and city

authorities both needed to ensure that they supported an overall vision for healthy and liveable cities.

- Good policies were just the start – they also needed good implementations. This was true too for the respective roles of private and public transport: for example, private transport could be used for first / last mile and support public transport. Yet it had to work for all and be affordable too.
- The role of cities was to offer choices to citizens which also took socio-economic aspects into consideration so societies should encourage citizens to understand that their actions would have consequences.
- There was a general consensus to evolve from transport, to mobility and further to liveability. It was all about moving people, not vehicles.
- We should recognise that there was no single definition of liveability – ultimately a city and its citizens needed to agree on what they want and the ways to achieve it.

Last thoughts from the panel on how to move towards better liveability:

**(WH)** Keep open minded on options

**(GL)** Focus on connected and leave autonomous alone for a few years

**(W-LT)** One multi-app on my phone

**(JB)** Open platforms open standards to ensure you are future-proof.



# Plenary And Executive Sessions

## ES03 – Essentials for developing a smart city

Kirk Steudle (Michigan Department of Transportation, USA) moderating opened the session with the promise of wise advice from many perspectives on establishing a smart city and introduced the speakers.

Russ Shields (Ygomi LLC, USA) wanted to focus on what was thought by many to be the key element of a smart city – an autonomous vehicle. He argued that achieving this was a lot harder than many people and the press were saying and in his view Level 5 autonomy was 15 years off at least. He was not challenging the eventual deployment of highly automated driving as a part of the suite of mobility services in a smart city; rather he believed that the software capability needed for handling every road and driving situation in the complex infrastructure of any large city in every weather condition was not yet ready. Moreover current autonomous vehicles testing was often disturbing communities and did not reach desired safety levels.

One key innovation would be to have AVs as part of the public transport network to improve it and this would happen relatively quickly. Shuttles were well-suited to moving people the last mile or two from mass transit hubs to their ultimate destination or from out-of-town car parks to the railhead. There had been strong advocacy for robotaxis but overall they both added to traffic problems and increased the vehicle miles travelled. One essential for a smart city was public transport that worked well.

Gaku Nakazato (Ministry of Internal Affairs and Communications, Japan) began with the background position for cities in Japan – population and economic growth rate both declining slowly but a steady increase in the age distribution. Regional areas were shrinking fastest leading to decreasing living standards and many were struggling to cope with road maintenance and other devolved duties. New technologies should not create disadvantages for people who can't use them. He outlined the concept of "compact and networked" as a model for smart city strategy. Smart cities should be seen as part of a system with a service layer, a platform layer and a network layer, based increasingly on wireless connectivity. Open standards were essential for this model to work efficiently.

Sharelynn Moore (Networked Solutions, Itron, USA) explored what a smart city delivered – we should think of it as a platform for connecting entities, solving problems in new ways and creating new business opportunities. It should offer citizens a more efficient, healthier and safer environment in which to live. The key enabler was a network that linked the "hard" infrastructure elements but could also support other services for citizens or the city's managers.

Leen Balcaen (HERE Technologies, Germany) noted that when she started to look into the requirements for a smart city an obvious problem was silos – different departments in the same city compiling duplicated data but based on different standards and quality. The second odd issue was different services each maintaining data

on the same issue – city maps for example – but in very different ways because of different final requirements. The scope for collaboration and efficiency savings would be considerably limited until some measure of common specifications and standardisation could be introduced.

The moderator steered a wide-ranging discussion which included the following points:

- The initial investment (eg a wireless network) was the hardest to justify; it must be open and scalable so that further services could be added at marginal cost
- Many transport advances had been driven by hardware costs reducing while performance improved which provided the platform for software to deliver new or better services. This had driven dramatic changes to telecommunication networks and made wireless connectivity cost-effective but we were decades away from being able to remove wired connections for electricity supply. Smart cities needed to think about jointly managing many linked networks – wireless, energy, water, waste *etc.*
- Becoming a smart city was a combination of smarter components and using them in smarter ways; the latter was harder to achieve as it meant changing working practices.
- In some ways larger cities were the hardest place to try to 'go smart' as in many cases the political leadership was over-cautious and changed too frequently to support consistent policies and decisions.
- Audience Qn – *what do you do first?* – (SM) be clear on your problems and the solutions available so that you can build a business case; (GN) make sure the political decision takers have alternative choices; (LB) start with one small robust example then scale up.
- Audience Qn – *how do you remove silos?* (KS) they frequently reflect local kingdoms so high-level leadership and ownership are very useful.
- Audience Qn – *where are there good examples?* – Everywhere but an interesting pattern is port cities that have held or will hold the World Congress: Sydney, Singapore, Melbourne, Copenhagen, Bordeaux, Hamburg plus Austin, Michigan, Texas.

Closing the session the moderator noted that the methods to use to deliver smart cities included removing silos, carrying out project works with strong leadership focusing on peoples' needs, and sometimes challenging the role of the government. For both government and industry it was important to ensure that equipment investment was driven by strong business cases and very clear understanding of the top-level objectives such as safety, congestion reduction *etc.*

Whilst cities were encouraged to move as quickly as possible with smart city ideas, all panellists agreed on the considerable importance of first getting the vision right. The vision had to be sustained in the longer term as successful collaboration needed time. It was also agreed that to be a smart city size did not matter, but cities needed to be open to engaging with industry to deploy smart technologies.

## ES08 – Efficiency in Freight transport

Zeljko Jetic (IRU, Geneva), the moderator, opened the session with comments on the breadth of the topic: long distance freight transport using different modes (rail, road, maritime, from continent to continent) or short distance within a city perhaps using cargo bikes. There were differences too regarding the cargo – parcels, dangerous goods, even live animals so talking about freight efficiency meant taking several subsets into consideration. e-commerce was an increasing business bringing new challenges and opportunities. Achieving sustainable transport for either passengers or freight required efficient collaboration between the different modes together with what would come from digitalisation *eg* self-driving vehicles, truck platooning, drones, autonomous vessels etc. ITS was able to help with making the transport more efficient, making the movements of all different modes more sustainable.

Gzim Ocakoglu (DG MOVE, European Commission) talked about different approaches to measuring efficiency. For some it might mean all your goods arriving at the right place at the right time; for others filling the trucks might be an indicator. But efficiency needed a policy context. The freight supply chain was multimodal; the average split in Europe for inland freight was roughly 50% road, 35% rail, 15% inland motorways. By 2050 we were expecting 60% more freight on all modes. For a supply chain manager the priority was freight arriving on time and at the right place but for a policy maker the focus was the impact on society, for instance the weight of freight in the carbon footprint. Transport accounted for 20% of green-house emissions in Europe and was the only sector growing compared to other sectors. Could the transport activities be reduced? The impact could be reduced by looking at trade patterns, the layout of cities, reducing the energy needed for transport and shifting from road to other modes. Better traffic management and better use of (electric) vehicles for the last mile of freight delivery could help. A mix of technology, policy instruments, incentives and fiscal instruments would be needed to help evolution.

Bill Panos (Wyoming Department of Transportation, USA) saw many similarities between Europe and the US on freight. Around 71% of the freight tonnage moved in the US travelled by trucks so the road system was important for the economy. The gross was 10.5 Bn tons in 3.5M vehicles. Competition was driving businesses to be as efficient as possible and the most successful knew how to manage the supply chain drawing on information about the roads network. Wyoming was a large farming state hosting 400 miles of Interstate road that regularly had very bad weather so ITS was extensively used for connectivity and changing driving behaviour. The building blocks of deployment were real-time trip information; road-side information; in-vehicle information and centre to centre information.

Mike Kopczynski (Cisco IoT, New Zealand) looked at technology. Improving freight efficiency would involve connected trucks and commercial vehicles and that in turn required smart connectivity including communication networks not just physical infrastructure. For freight in the connected space there was a need for a platform for data exchange between public and private identities, to

get information to people that could make use of it and through this exchange of ideas address the challenges in the transport world. Sharing data and turning it into intelligent and actionable information was key, particularly as there were more and more sensors deployed so data volumes were increasing. There were several IT systems thus bringing all data together from various systems to add more contexts and able to provide data to multiple parties was crucial.

Young Kyun Lee (Executive Director, ITS Korea) reported on a truck platooning project in Korea that had started relatively recently. Four processes for assembling the platoons were being looked at: *ad hoc* formation, guided formation, formation at a static site and a fixed time, and dynamic formation for vehicles cleared in advance for compatibility. There were many research objectives for the trials: reducing congestion, emissions and fuel consumption; and improved safety, driver productivity and asset utilisation.

Common points among all speakers were: aim to have good efficient transport where all transport modes were used and become cleaner in the future.

The moderator opened a Q & A session by asking *how can intermodality be made more efficient and what are the biggest challenges for truck platooning to be accepted on public roads?* The following points were made:

- Instead of starting with a specific mode and considering whether to try to develop it or reduce it you could look at the impact of that mode – for example its contribution to emissions, to congestion *etc* – and then work on reducing that impact. Financial incentives were usually effective for example shifting freight from the road to the rail for instance or the inland motorways and maritime.
- A revolutionary view was aiming to avoid intermodal operations by making it more advantageous to use the available resources in the territory instead of moving them. As an example: building meat processing and packaging plants connected by rail to reduce the road movements of cattle. “Removing the need for transport” was a valuable idea.
- The movements across the mode interfaces could be optimised when all stakeholders have digitalised and were using a data exchange and data sharing platform.
- If an incident happened people would demand to know who was going to be held responsible. This would be easier to address at levels 2 or 3 but if something were to go wrong at levels 4 or 5 who would handle the incident and who would be held liable? Understanding liability was one of the key factors for both passenger and freight automated vehicles.

Closing question: *What will have most impact on logistics in future: blockchain, automation, drones or what?*

(GO) AI

(BP) Blockchain

(MK) Blockchain

(YKL) AI

# Plenary And Executive Sessions

## ES12 – Upping the game in safety

The moderator Brian Negus (Immediate Past President, ITS Australia) welcomed delegates and explained that the session aimed to discuss how, why, and to what extent automated driving systems could deliver enhanced road traffic safety. He welcomed Claire Depré (DG MOVE, European Commission) and thanked her for substituting at short notice.

She reviewed the overall situation in Europe. Recently a Third Mobility Package had been adopted with a wide set of measures related to road safety elements of which were

- A systems approach – if driver behaviour and infrastructure were below standard there would be as much impact as the vehicle so these three dimensions would be addressed
- A long term goal of Vision Zero by 2050. Intermediate targets were needed
- Emphasising safety in the many EC funding sources and trying to engage with all stakeholders beyond EU borders to learn from them and share our best practices
- A strategy for CCAM based on more ADAS to make vehicles safer now and enable higher levels of automation in the future; C-ITS using V2I and V2V communication for improved performance and vision of the vehicle

Cat	SAE	Detailed use case	Benefit score
Public	5	Fully automated urban vehicle	0,87
Public	4	Automated shuttles (dedicated roads)	0,84
Public	4	Automated buses in mixed traffic	0,82
Public	4	Automated shuttles (public roads)	0,82
Private	4	Suburban Pilot	0,76
Public	?	Ride / vehicle sharing for persons	0,74
Private	4	Urban Pilot	0,74
Private	5	Autonomous private vehicles on public roads	0,71
Freight	4	Highly Automated Trucks	0,69
Freight	5	Fully automated freight vehicles	0,66
Freight	4	Other than platooning, e.g. logistics operations	0,65
Public	3	Automated bus chauffeur	0,65
Private	4	Highway Autopilot	0,64
Freight	4	Highway pilot platooning	0,62
Public	2	Urban bus assist	0,62
Private	4	Highway Convoy	0,60
Private	3	Highway Chauffeur	0,59
Private	3	Traffic Jam Chauffeur	0,59
Freight	3	Traffic Jam Chauffeur	0,57
Freight	3	Highway Jam Chauffeur	0,55
Freight	2	Automated truck platooning	0,52
Private		Automated Valet Parking	0,15
Private	4	Parking Garage Pilot	0,06

The vision for the future was based around connecting autonomous vehicles in order to be able to handle complex road traffic situations. The EC had worked on the expected benefits of CAD, rating use cases based on benefits yielded, to identify where the most public support was needed and to prioritise deployment. The top of the list was “fully automated urban vehicle”: challenges in mixed traffic and a mixed population, where CAD could also help a lot with collective transport. The prioritisation

exercise had helped to realise the benefit from a focus on use case (“learning by doing”) and seeing the technical and non-technical barriers in terms of uses cases. The EC wanted a holistic approach by trying to solve not progressively but within the same timeline a number of issues that needed to be addressed quickly. The EC also wanted greater cooperation between the different actors in the same way as for the success story C-Roads (platform for cooperative mobility). The EC felt that they needed to increase this type of cooperation and expand the scope of actions to be tackled. Concrete work done through PPPs, with which EC would have a working relationship, would help to move ahead.

CAD had been discussed a lot through technological perspectives and as well as road safety there was the challenge of mixed traffic. It needed the systems approach to incorporate driver licensing, roadworthiness testing, training of professional drivers, requirements from the physical and digital infrastructure perspective, next generation traffic rules, vehicle and infrastructure connectivity etc. We should not avoid the relatively easy demonstration projects but we should also try to understand how things would work in a complex traffic situation.

Randell Iwasaki (Contra Costa Transportation Authority, USA) quoted the NHSTA figure that 94% of US accidents were due to human error. We had made major advances in safety but a key issue was driver distraction and automation was the only technology that could help reduce fatalities by taking the driver out of the equation. He explained that he was managing the largest of 10 federal AV test beds, GoMentum Station. Other technologies were being studied. Users wanted first and last mile solutions to avoid driving cars where possible so four EasyMile vehicles had been secured. They had been tested at a business parking lot and it was announced in March 2018 that they were ready for public streets. For this Contra Costa had been granted the first licence in California to operate a L4 vehicle on public roads.

Takahiro Hirasawa (Ministry of Land, Infrastructure, Transport and Tourism, Japan) explained his work on automated driving issues at the Road Transport Bureau of MLIT. Overall road fatalities in Japan were decreasing but there were targets to further reduce those numbers and to achieve them AD was one of the measures being studied. There were other priorities where AD was expected to help such as an ageing society and transport for elderly people. In order to promote the development of Level 3 automated vehicles, MLIT had recently published guidelines for safety requirements. They included a safety target to reduce to zero the accidents caused by AD systems (which is a world first).

There was much interest in travelling the last mile by an automated driving transport service. Demonstration experiments had started in three areas with a small car and in one area with a small bus to evaluate public acceptance. It was hoped that there would be a mandatory transportation automated service by 2020.

Mike Lenne (Seeing Machines, Australia) focused on the driver. Automated driving promised reduced human error but until that was realised we needed to think about how

drivers' safety behaviour might change. From a safety viewpoint we were moving from current driver behaviour issues *eg* distraction and drowsiness which we understood pretty well and were still trying to solve. Academic and industry circles agreed that driver disengagement was going to be paramount. We would go from no technology support to exceptional technology (*eg* no steering wheel) with vehicle capability and drivers' expectations well matched. However in the interim phase they were no longer aligned as the driver tended to believe that the vehicle's capability was much higher than it actually was.

A key point was how attentive would the driver need to be; and how would we know? Discussions in regulatory and crash testing circles were taking place about driver monitoring, which could mean different things. There was a growing recognition of the benefits gained by learning more about what was happening inside the car. Vehicle technology had had a huge impact in reducing road fatalities but many of these technologies relied on action by the driver to some degree. The next big breakthrough would be inclusion of interior sensing to complement exterior sensing, as knowing more about the state of the driver and the vehicle would improve the decision making of the driver-vehicle collective. The automotive industry was striving for the integration of these two as the next major step.

Questions [moderator] *The speakers have talked about CAD as the way to deal with human errors or violations. Are we being too optimistic?*

(CD) We'll know more once we have the technologies we have been discussing. We need to monitor accidents avoided by humans and not just the ones they cause and be sure that the machines perform as well. And how do we handle complexed and mixed traffic situations?

(RI)] Today you are much safer in a new car than older models due to the safety technology they have and these technologies are the results of previous testing programmes. It's the same process for the technologies – components being tested today will be embedded in time. It's important to move in the right direction to bridge the gap between zero fatalities and now.

[Moderator] *Full automation on expressways by 2025, which is not far away from now, so how to achieve that target?*

(TH) Japanese authorities have to consider how to change their registration scheme in order to reach the 2025 target. We also needed to promote development of such kinds of cars. AD systems would help decrease the 96% of accidents caused by human violations but new types of accidents or risks would occur because of the lack of conventional communication between the drivers, the car and other traffic participants. That was why HMI was very important. In Japan drivers were sometimes too confident in their advanced emergency braking system, for example, so we have had to notify the function limits to the users.

(CD) In Europe many test beds had been funded by EC or national funds but we don't have enough access to the data collected by these pilots. We would learn more if we could share more the project learnings. The EC was

trying to put some obligations in relation to sharing the data from the research community; but we also need more commitment from industry.

[Moderator] *There seems to be more willingness to share than in the previous years, perhaps because we have similar goals in terms of reducing crashes, air pollution and congestion.*

(RI) We had to compete to become one of the 10 USDOT designated test beds and there were specific rules *eg* appoint a safety officer and share data. The problem is that some of the testing data is proprietary as it is giving companies a business advantage. We are trying to develop a framework specifying the kinds of data that are needed *eg* near-misses.

(ML) In some use cases we were being too optimistic (in terms of rate of change of vehicle fleet, regulations, *etc.*) while in others we were being conservative. For example driverless pods were probably quite close in defined use cases *eg* short routes and, designated paths. There were some Level 2-ish vehicles on the market *eg* Tesla, Volvo, and the approach was very different from one OEM to another: some wanted to know quite a lot about what the driver was doing, others did not care. However this first step was more about user convenience than safety. To get to safety we had to get to Level 3 at least. There were discussions in the industry on whether to by-pass L3 and go straight to L4 but safety was not the primary driver at the moment. To realise safety gains in mainstream traffic a lot was needed to be done to at least support Level 3.

[Danish Road Directorate] *Speakers mentioned increases in certain kinds of incidents in the next 15 years eg rear-end collisions when AD vehicles stop and non-automated vehicles do not pay attention and hit them. What are the opinions of the panellists?*

(RI) We have a pilot project to send signal phase information to the vehicle which slows if it knows it cannot clear the intersection on green; non-equipped vehicles don't know so either stop on yellow, with the hope that the following car also stops, or potentially run a red light. These situations can be eliminated through better connectivity between the car and the infrastructure. We will also be able to fit older vehicles with aftermarket sensors or receptors in the on-board diagnostic port to make them connected.

The moderator invited final thoughts:

**(ML)** We will only realise the safety benefits when the vehicle's capabilities match the driver's expectations

**(TH)** Harmonisation is very important for HMI design

**(RI)** We had made major progress so far and the regulatory environment had developed in parallel in a way that had not slowed innovation and the development of these technologies.

**(CD)** We needed to increase cooperation on the various safety topics. In Europe we would work on this with the PPPs that we planned to build; and we needed to learn from the other experiences across the world.

## Plenary And Executive Sessions



### PL2 – ENSURING INTEGRATED MOBILITY SERVICES

In her keynote address Leen Balcaen, HERE Technologies, identified some changes in the transport sector – an explosion of transport modes; a shift from vehicle ownership to leasing; and public transport no longer solely in government hands. Such fast change tended to lead to friction which could be avoided by a novel approach to transport needs. Consider the question, “*What if instead of our trying to find ways of getting from A to B, A and B could find us?*” We naturally seek solutions that are easy to use and convenient so service providers must offer flexibility (versatility) to give users options to choose from; visibility so users can easily find the best option, and incentives to reward users for using their services. She stressed that no single entity could provide integrated mobility services – many stakeholders held different pieces of the puzzle that must be assembled so collaboration was key.

Cees de Wijs, moderating, then invited the panel to explore ways of shaping new integrated mobility by addressing how companies and cities can succeed in this changing climate. The focus was on leadership, the potential of (new) public/private partnerships, investment in digital and physical infrastructure and legal and regulatory framework requirements.

Ole Harms (MOIA, Germany) argued that intermodal platforms eg integrated ticketing were a consideration for the future. While the end objective was integration the immediate need was for incentives to use shared services and leave one’s car at home. The later step

would be to focus on integration in the public and private sectors.

Matthew Baldwin (DG MOVE European Commission) agreed with the keynote speaker. He noted that people wanted clean, efficient, socially inclusive, cheap, seamless, connected and safe transport, for both passengers and freight. The European Commission was trying to speed up collaboration with public and city authorities to find such solutions. Digitalisation was transforming the transport sector but data was not the only factor; political will must combine with commercial will and be expressed in team efforts. The Commission’s Vision 2050 goal of zero fatalities was only achievable with collaborative contributions from others.

Jarrett Wendt (Panasonic North America) said we must not let technology ‘just happen’. Two important factors called for swift action: there was unprecedented disparity between the public and private sectors. Cities and smaller governments had been more successful when cooperating with the private sector to provide good services. The second issue involved the use of data. For OEMs owning safety critical information was of lesser importance but it remained very desirable for other stakeholders, especially users.

Xidi Liu (DiDi Chuxing, China) echoed the message in the keynote speech that convenience is one of the main requisites when thinking about mobility. The other two are safety and economy. The key element to delivering

these in the developing new mobility ecosystem would be collaborative systems. This holds both from the passenger point of view – provision of information, navigation/ mapping, payment options – and from the point of view of multimodal providers: safety, allocation of modes in cities and costs.

The Q & A session started with the moderator asking how the needs of individuals could be combined with the needs of the cities. LB argued that citizens defined the city so understanding their behaviours and needs was an essential first step in defining the needs of the cities. Governments must protect citizens and must find ways to do this even with regard to the complicated issues of data privacy.

OH emphasised the need to for all parties to work closely together for integration. Regulators must define a strategy and objectives first. There are problems for automation that will need careful study *eg* how to regulate what goes on in inside an autonomous car if an assault or similar crime should occur – how far does liability extend?

XL explained how China was facing challenges similar to those in other countries. Two key factors were adopting a positive picture of the future and having good large scale pilot programmes so that problems could be identified and fixed swiftly.

An audience question asked where panellists thought integrated mobility services would first be achieved – and would China be first as the problems were more acute? Some thought that China and the US were leading in their efforts. JW thought that whereas China had a good position on standards the EU's challenges were amplified because of interoperability and cross-border implementation. MB felt that this gave the EU an

advantage; it also had a clear strategy and was not afraid to regulate especially for safety. LB suggested that the winner would be whoever acted fastest, had a long-term vision, and leadership prepared to carry out testing and be critical.

A second question addressed making mobility inclusive and affordable. JW said equity was key and could be achieved by scaling up services to be ubiquitous. MB suggested that equity came from affordability and accessibility (for the poor, disabled, elderly, the rural population, *etc*). We must avoid 'gadget rich and mobility poor' world. OH agreed that mobility must be democratised and made accessible to those currently excluded but the price of services should not go below that of public transport.

The moderator closed the session by thanking the guests and audience and repeating the main messages. Integration of mobility services required a long-term vision, good leadership and risk taking. Data sharing brought associated challenges regarding privacy protection and effective regulation. Quick action was important but achieving integrated mobility was not a race, rather it was a shared objective that required collaboration on many levels.

“No single entity could provide integrated mobility services – many stakeholders held different pieces of the puzzle that must be assembled, so collaboration was key.”

**Leen Balcaen**  
**HERE Technologies**



# Plenary And Executive Sessions

## Four Executive Sessions were grouped under the PL2 theme:

### ES02 – Putting citizens first in mobility design

Mike Rudge (Stantec, New Zealand) moderating briefly introduced the speakers and explained that the session would focus on the evolving role of public authorities and the acceptability of different transport policy measures from the end-users' point-of-view.

Carlos Braceras (Utah Department of Transport USA) emphasised that transport users needed to be aware "why?" – why certain decision had been made and the various measures affecting their lives implemented. In the USA the majority of those working for transport authorities focused on "How" – building or maintaining railways, bridges, roads to move cars efficiently. It was essential to think in terms of moving people or goods. He stressed the important role of transport in the economy to help to generate growth and improve the quality of life. The rather ungrateful nature of transport was that when it worked well nobody cared; it only became interesting in the case of unexpected disruptions or incidents. The key action was to consult the users to establish their service priorities.

Michael Fischer (MOIA, Germany) focused on cities which were both growing and ageing. He argued that the mobility problems of the cities – air quality, noise, lack of space – were mainly caused by vehicles with "empty seats". Shared mobility could solve most of the traffic related problems as introduction of ride-sharing could reduce empty seats by 90% and bring cities back to the citizens. However in many places the enabling legal framework was unclear and new services like car- and ride-sharing were often seen more as a part of the problem than as an option or solution. Co-creation was needed between city administrations, service providers and people to realise the full benefit of new services.

Muhan Wang (Ministry of Transport & Communications, Chinese Taipei) focused on behaviour when taking mobility-related decisions. People made a complex assessment of time, cost, accessibility, convenience *etc* but tended to be slow to change habits. Users needed to be persuaded to make more socially responsible decisions and a key tool for that was making public transport use as easy as possible. Taiwan's new MaaS services would provide a mix of safe, reliable, affordable options open to all as part of a general move to incentivise use of the preferred options rather than penalise those that were unwelcome.

Roger Millar (Washington State Department of Transport) linked transport to the wider societal context of happier living and the key question for providers was how to make the users more satisfied with services. Today businesses could prosper anywhere if given access to quality physical networks and high speed communications which doesn't inform why they then choose to locate in certain communities. Investments in transport would pay back only if the community was attractive. He also emphasised the importance of "third places" knowing how people wanted to spend their time when they were not

working or not at home. Transport systems needed to be seamless. Users didn't see the infrastructure providers in the background or cared who owned the road or who was responsible for maintenance. The transport system either delivered together or failed together.

In a vigorous panel discussion the following points were made:

- Users needed to be involved in all processes. New services were enabled by state-of-the-art technology but for their successful adoption we needed consultative design to be clear on users' priorities and for users to understand any delivery constraints.
- Infrastructure was an important enabler but it also determined priorities: to encourage use of electric vehicles build infrastructure for EVs, if you want more cycling you need to build cycling lanes.
- The concept of public transport needed to be updated to be more personalised. People tended to associate cars with freedom and considered that when using public transit, they were giving away part of their freedom or control to be dependent on someone else. One attractive factor of MaaS was partly giving this control back to the user.
- Any discussion related to mobility design needed to involve funding and full cost transparency. "PPP" should not mean public money and private decision-making *eg* big retailers in the USA closing warehouses and using the national interstate network as their mobile storage. At present the US has no adequate pricing elements to discourage this kind of situation. In future dynamic congestion pricing should be seriously considered and the revenues used to design more balanced subsidy schemes. Even a cost-neutral tolling system would be satisfactory as long as it had an impact to the behaviour.
- Panellists reminded that it's not just about road pricing but also more generally about infrastructure pricing including parking. Some sort of push was needed to help people to consider new options, as people were creatures of habits.
- When moving towards a quality of life approach where people had a more central role the transport focus had to shift from vehicles to people and the related decisions made based on the things people valued. The great tunnels and bridges were seen as engineering masterpieces. A new mind-set was needed where data, connectivity and interoperability were appreciated as the key elements.
- Public officials needed to become interpreters explaining the complex time dimensions of transport planning to politicians and helping to match the political terms of around 2 years with infrastructure designed for 70 years.

### ES04 – Managing the ebbs and flows of travel

The moderator, John Sun (THI Consultants, Chinese-Taipei), welcomed the speakers and introduced Leslie Richards (Pennsylvania Department of Transport, USA).

She explained that Pennsylvania was a very busy State requiring large-scale transport interventions. A key policy was surcharging users during peak demand periods to reduce congestion as adding infrastructure was rarely possible and was not a long term solution. Strategies with and without tolling were used. The former deployed HOT lanes, express tolled lanes, variable price tolling for a whole road and zone-based pricing in cities. The latter was predominantly based on parking. Pay-as-you-drive was being examined to see if it was a better solution for both drivers and road operators and to what extent it would change travel patterns and volumes.

Kian Keong Chin (Land Transport Authority, Singapore) said that Singapore was a small State in a small place – roughly the same population as Denmark in one sixtieth of the area. There was also a shortage of skilled labour and the population was ageing. Getting the best out of infrastructure was essential as there was no room to extend. Consequently high capacity public transport was a priority; the key demand management policies were to reduce the use of private low-occupancy vehicles, encourage walking and cycling and also a shift to public transport. The policies were delivered by a mix of road user charging, vehicle ownership taxes and parking strategies.

A key development was improving the first and last mile access to the Metro through facilities for walking and cycling. Trials were underway to see if driverless shuttles could be used for this task and there were also new initiatives on provision of real-time information to travellers to support mode choices. A key message was cooperation: government could not achieve the necessary changes alone so consultation of users and the private sector was essential as well as collaborative delivery.

Dennis Pozzobon, (Transurban, Australia) described the different road charging services his company supported. There were two key points: explain clearly to users in advance what options they had to enable choice; and make the payment part as easy as possible. A recent interactive survey of established users had simulated their normal travel with a number of different charging approaches applied; the clear favourite was charging by distance travelled. It had been clear for a long time that the technology was not an issue: once objectives and policies were set the market would supply competitive options.

Jeremy Cowling, (SWARCO, UK) felt that compared to the situations of his colleagues on the panel the UK was lagging on charging. The national motorway network was free; there was charging for a number of estuarial crossings and a limited congestion charge scheme in London. The London charge zone had been sponsored by a committed Mayor; attempts to introduce charging at two other cities had failed. Two key questions were whether the declared national air quality targets could be met without a massive shift to electromobility and whether the only way to counter the associated drop in fuel duty was some form of national charging scheme.

In the UK there were a number of governance issues – roads were managed at national, regional and city level with variable integration and different objectives. Public

transport was managed by authorities separate from the road managers and parking tended to be a private sector commercial activity. Integration was badly needed so that users could have one access point to plan a trip, assess the modes and options available, see the associated service quality and price, make the necessary reservations and then pay.

The moderator launched a discussion by asking if satellite-based systems were the future solution for road pricing and demand management. The following points were made:

- Many users were uncomfortable with systems based around satellite movement monitoring so it was essential to explain the mechanisms and get the public on-side.
- There was a trust difference: users seem not unhappy with mobile phones doing the same type of tracking that they were opposed to for charging schemes.
- In Europe the GDPR made it a little harder to implement a distance-based charging scheme because of the additional cost and complexity of maintaining anonymity and privacy
- Real-time traffic data could be very useful as a source of information for demand management. Network managers should be willing to give information to third party service providers and the media in order to get the widest possible awareness of the overall condition of the system.
- Connected cars were bringing a powerful new data supply for network condition assessment as well as origin–destination recording. We still had a lot to learn about user behaviour and especially behaviour in response to real-time information messages.
- It was important to test for unintended consequences: ride sharing in a number of US cities had increased congestion as the service was more attractive than public transport. This also posed questions regarding regulatory regimes.
- Audience question – *do road pricing schemes increase social inequity?* There's nothing new about different levels of charging for different levels of service; the essential issue was providing a free option. One of the difficult policy issues was avoiding rural/urban inequity and finding ways to supply affordable public transport for lower income groups.

The moderator invited one final message from the panellists:

**(JC)** Improve the integration of the service providers

**(DP)** Share as much data as possible on an open platform

**(KKC)** Be clear on your objectives and publicise them

**(LR)** Get all the key players in all modes to the table for collaboration on goals

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### ES05 – MaaS: Seamless and effortless mobility

Opening the session the moderator, Henriette van Eijl, (DG MOVE European Commission) said that Mobility as a Service was seen by many as the next transport evolution delivering seamless travel on all modes through a single personalised application. The challenge, and the subject of the session, was bridging the gap between the lessons learned from pilot projects and delivering seamless services at an international level. She posed three key questions to the panel: Can we integrate public and private services? What business models were affordable? Were adjustments required from local governments? She invited preliminary thoughts on the topic.

Paul Campion (Transport Systems Catapult, UK) said that liveability was the ultimate objective and we must not lose sight of what passengers and citizens wanted. Choices were based on knowledge and would be driven by cost and convenience not what the local city wanted you to do. The 'S' in MaaS was Service so integrating the supply side and setting regulations had to keep this in mind.

Randell Iwasaki (Contra Costa Transport Authority, USA) described his region's vision of MaaS – it was seen as the means to change a 20:80 shared:personal transport split to 30:70. The goal was helped as millennials did not want a car but still needed transportation. The MaaS vision was a combination of public and private services to provide personalised mobility options based on travellers' needs, to enable end-to-end journeys made with a single payment, and designed to optimise the transport system.

Eddie Lim (NCS Pte Ltd, Singapore) set out a vision which inevitably focused on the 2019 Congress. A new app had just been launched, a personal-based travel companion that brought together all mode suppliers, all classes of users, regulators and non-transport data suppliers. The goal was a single access point for any transport demand by residents, visitors and commercial organisations. A key problem had been coordination and getting people to share data.

Blair Monk (Aurecon, New Zealand) focused on his government's role which was to create a MaaS support platform that companies could use to create their own apps. The majority of mobility service or data providers had operated under a closed data model. The Transport Agency ran a pilot based on open data principles so any

third party developer using the platform can access the information provided and present it *via* their application to customers. The benefits of the investment were improved utilisation of assets and services; improved system reliability and response to incidents; economic opportunities for suppliers and potential new entrants

The moderator asked *how best to integrate public and private services?* Points made in discussion included:

- You help companies by providing conditions for solutions rather than imposing solutions
- Consider if the market is doing what you want as Regulation can create markets
- Getting public sector agencies to have the same vision was not easy but was necessary
- Start with something easy then develop and promote
- Dynamic information had to be accurate to get trust.
- Promote multimodality through the app.
- Encourage competition because services have to be good to be used.

The moderator asked the panel for *3 bullets for the minimum requirement of a common determination of MaaS.* Points made in discussion included:

- Data and getting shared data for APIs is difficult
- A common payment mode
- Addressing how to share benefits
- If you cross countries' borders dealing with different modes of payment is difficult as it is not standardised
- Anticipating likely technology development is difficult; you must be able to be flexible.
- Ensuring privacy
- Deciding whether the main intelligence is in the platform or in the phone

The moderator asked *whether MaaS would help accessibility issues;* points made in discussion included:

- Where sectors were under-served by public transport it could help to get small companies and local transport working together to deliver service
- MaaS can reduce the use of ambulances as health taxi transport and open the supply of small specially adapted means of transport
- It can help optimise health budgets by identifying other sectors able to deliver services.

In closing the session the moderator asked *whether the transition from pilot projects to delivering seamless services at an international level was likely to be tough?* Points made in discussion included:

- It would all depend on finding the money
- People look for adequate solutions now; something better in 2 years is not very popular
- The public sector asks people what they need and then aims to come up with matching services; we just have to live with a tough future
- The market may decide to build the substantive products differently from those of trials and demos which may mean some people will be hurt but users will get something.

## ES07 – The role of Open Data in the digital infrastructure

The moderator, Jarrett Wendt (Panasonic Corporation USA), opened with the comment that this was both a difficult and exciting time to look at data issues as we were starting the transition from ownership to sharing and using in an open economy with open standards.

Ralf-Peter Schäfer (TomTom Traffic, Germany) was first speaker and put the company in a context of 500M+ connected devices and 400Tb+ of historic data. This enabled the production of congestion indices by city and real-time traffic data but also fed many second tier commercial services. Both data collection and analysis rested on standards and it was vital to recognise that open standards and platforms supported competition rather than inhibiting it. The current Big Challenge was the data requirements (especially mapping) for connected and highly automated vehicles leading to more questions about the nature of future traffic management and the design and functionality of infrastructure. Data volumes would grow rapidly but processing times would have to reduce so road authorities and service providers would have to reinforce their collaboration. The company was moving as quickly as possible to open data platforms.

Keith Delle Donne (Microsoft, New Zealand) reported on experiences with data in the mining industry. Years back researching the application of AI to mining had been expensive as the data lived in a closed environment – the logistics industry was similar and to an extent still was. Today the key data were mostly open so there was competition to innovate; the problems – in this and many other areas – were too many “standards” inhibiting joint working and integration. Trust was essential; if partners accepted the quality and reliability of the data you shared with them then they in turn would start to be more open and share with you.

Katsuya Abe (Ministry of Land, Infrastructure, Transport and Tourism, Japan) explained the functions of the Japanese ETC 2.0 system which was electronic tolling and payment, combined with data collection, analysis and distribution using both in-vehicle and roadside units. The data were shared and used for reducing congestion, supporting public transport and freight operations, and generally improving safety. Considerable care had been

taken to demonstrate users’ privacy in order to encourage take-up of the new devices and services.

Cordell Schachter (New York City Department of Transport, USA) aimed to review the foundation requirements to support a widespread move to secure, shared and open platforms. He noted that in New York City a Freedom of Information law required that any non-personal data created in the course of city business was ‘open’ and should be shared with whomever wanted to use it. It was pointless to try to guess what the new customers might want – governments should share data using non-proprietary standards and support robust marketplaces of open data.

During discussion the following points emerged:

- It was possible to have a limited access platform with open data – ETC 2.0 was such an example as the government managed the platform and controlled direct links to it in order to be certain of privacy but the data held were open.
- Governments would need to be funded to provide services in future that they had not supported in the past which might mean applying charges to the availability of data.
- Europe and N America seemed to be leading on opening up data and cooperative working as the gains were recognised as substantially larger than the downsides.
- The huge numbers of road deaths represented a powerful argument for international sharing of safety-critical data. The EU’s C-ITS Platform was leading on this.
- Opening up data had associated “risks” in the sense that in most cases there was no requirement for a third party to explain the purpose for which the data were wanted and inevitably there would be unwelcome incidents.
- Organisations providing open data had to ensure that any privacy framework was in place before sharing not after; they also had to be clear on intrinsic quality and reliability as well as any constraints applied by the data source.

Closing summaries by the panellists:

**(CS)** NY City had recognised that the world had changed and we lived in a digital knowledge-based world so it had elected to set a good example by supporting a competitive market place open to anyone without any restriction on using the data it had created.

**(KA)** Public-private cooperation was essential. Sharing data was sensible as governments do not have a monopoly on thinking of clever solutions.

**(R-PS)** TomTom had made a significant shift in its market position to recognise on the one hand that business benefits came from using data not owning it and on the other hand the future was going to be dominated by thinking about moving people not moving vehicles.

**(KDD)** The key issue in cities was making sure that barriers between changing modes did not exist and a data economy was key to that.

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### PL3 – What's next for automated mobility?

Louise Wolff, moderating, introduced the session with a brief overview of the scope. Vehicle and ICT developments had brought automated vehicles, driver assistance systems and connected services that together could lead to driverless mobility for goods and people across all modes. Each of these advances had potential benefits for safety, traffic efficiency, environmental impact and society as a whole but they also raised questions about investments, infrastructure, markets, regulations and acceptance. The session would pose the question "Where do we want to be by 2030 and how do we want to get there?".

Zoi Sagia (DG CONNECT, EC) gave the keynote presentation. Significant deployment of connected mobility and high levels of automation could be expected by 2030. Connected and automated mobility were interdisciplinary topics and deployment required cooperative efforts from all involved parties. Regulations should be flexible but also provide the clarity and guidance to enable businesses to develop. The radical transformation facing transport required a smooth transition towards the higher levels of automation bearing in mind that the ultimate target was improving people's life and guaranteeing prosperity.

The Commission favoured a progressive approach based on experience gained during testing that validated the safety of the new technologies. An approach integrating automation and connectivity was needed with Member States and Regions co-financing associated Research,

Innovation and deployment. The Commission would work with Member States to compile a priority list of use cases for large scale testing and would put in place a European wide platform, grouping public and private stakeholders, to coordinate open road testing and making the link with pre-deployment activities. Commitments had been made for telecommunications with the agreement on a roadmap to equip the main European transport paths with 5G services by 2025.

The moderator then convened the panellists and invited views on *where we aim to be by 2030 with the deployment of Connected and Automated Vehicles*.

Sylvain Haon (UITP, Belgium) believed that cities would not be fully automated but would have shared mobility services offered by autonomous vehicles in dedicated areas on specific routes, integrated with public transport and part of a collective mobility supply. A significant change of behaviour towards shared mobility would be needed to achieve a sustainable urban transport system. Deployment of AVs for collective transport was possible in the mid term needing less technology development than would be required for the private car.

Wassim Chourbaji (Qualcomm Europe), agreed with Sylvain arguing that that we have many challenges. To reach a vision of smarter cars more safety was needed as globally there were more than 1.2M deaths on the roads



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Liability and who was responsible if something went wrong were other important questions. Automation would not only disrupt the automotive industry but also the insurance industry and the way we work and live.

We needed to address awareness and acceptance as there was fear and misunderstanding about what the technology would do and what the new services would provide. Governments needed to spend more time talking about new products or services and set up safety assurance systems that were robust and explained to the public. Cybersecurity must also be addressed in a robust way.

Regulation was most effective when it was neutral, technology agnostic and allowed innovation to happen.

The key need was more accessibility – access to jobs, services, leisure for all so the question was about AV technology improving access and inclusiveness with more on demand services and collective transport.

To conclude the moderator asked panellists *for a recommendation looking towards 2030*:

**(TMT)** Start now and don't wait until everything is automated. In the short term improve intermodality and cooperation between the different transport service providers. Then start improving the infrastructure and make it intelligent to create more flow, avoid congestion and improve life of people. In addition, the legal framework and liability needed to be addressed.

**(WC)** The EC's Digital Single Market was key as no one country could do it all. Transport and ICT needed to be a single market so that users had the same services across borders.

**(SH)** Make people aware and accelerate authorisation to enable test demonstrations and services to run. It currently took too long to get authorisations.

**(PB)** Governments and industry needed to collaborate as we work to bring this technology to market. We must be smart about the roadmap or the next steps and use it as an opportunity to build trust with communities as community benefit or interest might override the individual.

## Four Executive Sessions were grouped under the PL3 theme:

### ES06 – Institutional and legal challenges of Cooperative, Connected And Automated Mobility (CCAM)

The moderator, Atsushi Yano, (Sumitomo Electric Industries, Japan) welcomed participants and commented that the development of connected and automated vehicles (CAV) had been helped by various events in the last five years: eg the onset of open data / automated driving (2013), the launch of the UN Sustainable Development Goals (2014), the designation of the SAE levels 0–5 (2016). This progress could develop to real commercialisation if the societal issues could be resolved and this was what the session aimed to explore. He welcomed the keynote speaker,

Marten Kaevats (Estonian Government Office, Estonia) noted that Estonia had been leading the move to digitisation for over 20 years. The testing of self-driving cars had been legalised in March 2017 but the country was still struggling to establish who was guilty when something went wrong. He felt that the answer was not ‘sector-based regulation’ as existing traffic laws could be applied to self-driving cars. Governments needed a radical shift in their approach to legislation to fully embrace artificial intelligence-related technology changes. Sector-based approaches to legislation regarding self-driving cars at national or EU level would be slow whereas technology evolution was generally quick. If each technology was regulated separately laws would not be able to keep up with the changes.

The legal system must be kept understandable with a simpler approach to self-driving cars and a focus on the rights and roles of all those involved. Estonia was holding a public debate on taking three different approaches to this aspect. Mr Kaevats stressed that public involvement was essential for “legalising” artificial intelligence [rather than “regulating” as that term implied boundaries rather than bridges].

Claire Depré (DG MOVE, European Commission) took the audience on a journey from technology to sustainable mobility with a focus on infrastructure. She argued for evaluation of the elements of the various challenges and their specific issues considered for regulation. The EC was putting forward an agenda to help advance automation through Connected Cooperative and Automated Mobility (CCAM) and this required looking at transport legislation. Connectivity was an important element of automation and involved road traffic and related regulation. Consultation with many actors (industry, research, NGOs etc) about accelerating the introduction of automation on roads had shown that the key element for deployment was safety followed by traffic efficiency. Delivery priorities had been set with a distinction between ‘must-have’ and ‘nice-to-have’.

Security and data protection legislation were key and the EU took very seriously its commitment to protect privacy. The EU has also looked at liability related to infrastructure eg within a vehicle when there is data transfer or use. The EU framework would be both regulatory and enabling so

included measures to ensure consistency of physical and digital infrastructure and harmonisation of data formats. Private sector actors would be able to use it for both services available today and in preparation for tomorrow's services.

John Schroer (Tennessee Department of Transportation, USA) described what was happening in Tennessee as an example of what different regions were doing in their journey towards CCAM. Tennessee is a large producer automobiles and auto parts so automation had implications for employment. They had taken actions for economic development in the state: on legislation they had passed the State Automated Driving System bill (auto driving with someone in the driver seat) to put responsibility on the vehicle owner as they wanted to enable OEMs (Nissan, GM & Audi-VW) to test and drive the cars produced in Tennessee. The Platooning bill assisted Fed-Ex, a frontrunner in automation based in Tennessee. The State had supported the formation of TennSmart Intelligent Mobility – a consortium to advance automation and save lives with a focus on connected and automated vehicles, electric vehicles, cybersecurity, freight efficiency and multimodal commuting

Neil Pedersen (Transportation Research Board, USA) offered a ‘non-lawyer’s’ perspective of some basic legal issues of CCAM referring to a TRB report: *A look at the legal environment of driverless vehicles*. The lessons learned from the last 100 years of legal environment changes in response to changes in technology showed regulatory delays often resulted in legal decisions based on current law because of expediency. Civil liability for personal injury with mid-levels of automation raised questions of whether the driver should have taken over control and so would probably lead to much more legal complexity than higher levels. The concept of negligence would play a big role. Currently product liability law related to three types of defect: manufacturing; design; warning. With higher levels of automation civil liability cases would shift from negligence cases to product liability legal issues – ie from occupants to manufactures of vehicles

Criminal law and procedure at higher levels of automation would see complexity added to apportioning liability because more actors would be involved in the scenario (connectivity provider, manufacturer etc). In the case of connected vehicles, information also coming from infrastructure would make legal responsibility more complicated; similarly for insurance laws eg how to set insurance rates without a case history. Other issues were issues (4<sup>th</sup> amendments search limitations); cybersecurity; legislative & regulatory points. Mr Pedersen accepted that he had probably raised more questions than answered

Toshihiro Sugi (National Police Agency, Japan) reviewed NPA initiatives on automated driving with respect to road traffic; the promotion of automated driving by Japanese police; and the current AD testing situation. Regarding road traffic situation generally road fatalities were on a downward trend in Japan with rates higher among the 65+ population in comparison to some European and US

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countries. Fatalities among pedestrians and pedal cyclists were also relatively high. Japan had launched the '10<sup>th</sup> Fundamental Traffic Safety Programme' (2016–2020) to help adopt advanced technologies including automated driving. The goal was the safest roads in the world by reducing the number of fatalities within 24 hours of the accident to less than 2,500 and cutting the number of casualties to less than 500,000 a year.

On the promotion of automated driving the Japanese police were implementing policies to support development as it was seen as key to reducing fatalities as well as congestion. They had taken four key measures: a regulatory review; issuing guidelines for an experimental environment; developing international discussions; R&D and enhancement of infrastructure. The NPA was storing data related to AD vehicles to monitor their relationship with other road users and issue penalties as required. For AD testing two sets of documents had been issued: guidelines for testing on public roads (testing all levels of AD is allowed but a driver must be ready to take over control) and the criteria regarding permissions required when a driver operated more than one vehicle by remote control. These allow flexibility for various stakeholders to test the technology.

In a panel discussion some key points were:

(CD) clarified that the EU's regulatory framework for normal driving also applied to CCAM but new regulations must be based on experience. She stressed the importance of use case studies from a legal perspective as they would help to crystallise issues and solutions.

(JS) maintaining the functionality and safety of the highways was most important, followed by looking into

connectivity as soon as possible and putting DSRC units into vehicles;

(TS) we needed to understand the liability of drivers at level 3 and look at the penalties for traffic infringement and decide how an AD should comply with traffic rules.

### ES09 – Delivering effective cooperative, connected and automated mobility (CCAM)

Beth Kigel (State of Florida, USA) moderating set the scene by reviewing some of the technical, administrative and societal issues that needed to be resolved before CCAM became routinely deployed.

Eddy Hartog (DG CONNECT, European Commission) described EC actions in this area. There were three main strands: investments in infrastructure and associated technology; the regulatory environment; and the societal dimension such as the impact on jobs, on ageing travellers etc. Not all issues were linked to physical transport for example cybersecurity and data ownership and privacy were being looked at and there was a separate activity to get the regulators for energy, telecoms, and vehicle engineering to act jointly not separately.

Kenneth Leonard (US DOT, USA) looked back at the changes across the ITS sector since the early days 25+ years ago. Today we had the basic tools to deliver connectivity that held the promise of an 80% reduction in the 6M collisions annually in the US and the associated 40,000 loss of life. The key points were deciding how we wanted to move forward.

Koji Hachiyama, (Cabinet Secretariat, Japan) reviewed the high level objectives for ITS in Japan – improved transport in rural areas, accessible transport for an ageing society, and measures to counter the difficulty of finding drivers. Possible solutions were automated driving on expressways, autonomous systems in designated locations, and truck platooning on expressways. This in turn required much work on vehicle engineering standards, traffic rules and the overall legal framework especially for liability.

Klaus Schierhackl (ASFINAG, Austria) said that as a road operator he was keen to supply as much usable information to customers as possible. This might be on traffic levels, weather conditions, incidents and that information supply would be improved if the vehicles using the roads acted as probes and sent data to the operator. ASFINAG was therefore very active in a range of European connectivity trials and research projects

The moderator put a number of questions to the panel [Greg Winfree (Texas A&M Transport Institute, USA) was obliged to join midway through] and the following points emerged from some vigorous discussions:

- The panel was in broad agreement that CCAM affected the quality of life of individuals and it was an important discussion to have. The motivators behind CCAM varied between regions but general agreements were around safety (reducing accidents/road fatalities), addressing the mobility needs of an ageing population as well as people with disabilities, and countering driver shortages. The challenges were even more acute in rural areas where there was a higher percentage of elderly population.
- Connectivity came as the top enabler that had to be leveraged in order to realise CCAM. This dependency required close collaboration between the ITS and the telecommunication industries – in particular on spectrum allocation and the technology to be adopted. Other enablers from other industries that were equally important were artificial intelligence and energy. It was highlighted that while vehicle were regulated and their type approval legislated, there was currently an absence of regulation when it came to the enabling technologies for CCAM. This was by choice to allow for an organic and industry-driven standardisation.
- The panel was split over the need for education about CCAM. On one hand the automation technology currently available in modern cars was not used or opted for, for fear of what the technology would do and how it would behave. In addition, the 'interference' from the technology in the driving experience was negatively perceived by some users (eg proximity and lane departure warnings). On the other hand people were comfortable with smartphones that did not require education; adoption was driven by the perceived usefulness. In trials in Japan the most sceptical elderly users in rural areas, saw the technology benefits immediately once they had tried them.
- There was also a recognition that CAVs were not for everyone and that regional factors would play a significant role in its use and adoption. In some compact and dense cities public transport was viewed favourably, in large cities and rural areas CAVs

would bring significant benefits. While the majority of individuals might embrace CAV evolution, future CCAM solutions needed to cater as well for those who were not enthusiastic.

- The safety gains from CCAM were considerable but they had an associated cost for both the road owner/operator and the vehicle owner. It was vital to keep these costs as low as practical and also the costs of exchanging data to enable full open connectivity to work.
- It would be necessary to resolve liability questions before extensive deployment of CCAM given the complex assembly of road operator, telecoms provider, vehicle manufacturer, sensor provider(s) and vehicle user(s). This looked far simpler for a connected vehicle as that retained a recognised driver.
- The model used for deployment of CAVs could have an impact on the nature of car ownership. Once again the panel agreed that regional variations would be significant. In remote areas car ownership would probably stay, whereas shared ownership schemes could be more workable in cities. CAV and car ownership could also be complementary – with private cars being owned and CAVs being used for taxi services.
- The societal impact of CCAM was seen as significant. On the positive side there would be an increase in productivity with individuals freed from driving able to undertake other tasks. However this would also mean that professional drivers would be at risk which could pose an adoption barrier. The point was also made that the freedoms of individuals on the road might have to be limited in the interest of traffic optimisation for society as a whole. Practically, restrictions existed only in the case of platooning and there was currently no known initiative to orchestrate and limit the freedom of CAVs in the future.

## ES10 – The real impacts of cooperative, connected and automated mobility

The Moderator Joost Vantomme (European Automobile Manufacturers' Association, Belgium) invited Marc Vrecko (Valeo, France) to open the session. He reviewed developments with in-vehicle sensors which were now very effective but nevertheless a car fully embedded with sensors would not be enough for autonomy: extensive connectivity such as car-to-car, car-to-infrastructure, would be needed to expand the horizon. But sensors and connectivity would not enable success without strong confidence and buy-in by the public. Awareness and sense of comfort within the car were extremely important and would drive redefinition of the vehicle's HMI. Engagement with administrations, cities and all public bodies was essential as we will still need to regulate what happens on the roads.

Martin Knopp (FHWA, USDOT, USA) said that we believed CCAM had the potential to save lives by reducing human error and to benefit rural, urban and ageing populations but we didn't know all the impacts that AV might have. Might they extend vehicle distances travelled adding to congestion? Would people chose to live further out because of the comfort and convenience of letting the car travel itself but adding mileage? And what were the implications for freight eg potential for improvements

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to the first and the last mile delivery? The complexity of impacts emphasised the need for collaboration so that different sectors could understand each other's goals, needs and hurdles. There would be greater benefits if vehicles, infrastructure and other parties cooperated rather than act in isolation.

Rajeev Roy (Regional Municipality of York, Canada) described some Canadian challenges:

- Low population density complicated deployment especially in rural areas as the need to travel large distances prompted a culture of car ownership that was slow to change.
- Lack of a centralised decision-making body created challenges for funding initiatives and funding can vary after changes of political power at the federal or provincial level.
- Seasonal conditions deterred walking the first/ last mile or taking a transit
- Navigation on snow-covered roads challenged the pavement markings needed by AVs.
- Public sector agencies tended to be risk averse when assessing innovative solutions but calculated risks and new approaches were needed for even testing innovative solutions.
- Insurance issues and liabilities associated with AVs were being investigated as well as consequences *eg* would changing Traffic Acts impact the Criminal Code?

Solutions to overcome these known problems would arrive but were likely to be adopted more quickly in other countries. There were also challenges that we were not yet aware of and we needed to be ready to address them.

Naohiko Kakimi (Ministry of Economy, Trade and Industry, Japan) explained how Japan's FOTs of AVs tested technical and legal system development as well as social acceptance. Previous tests focused on technical evaluation of AV systems; demonstrations had now started to assess AV commercialisation possibilities looking at profitability models, reducing the cost of vehicles and roadside equipment, income from beneficiaries, and possible public subsidies. Trials of truck platoons using V2V communication had started revealing legal issues – is a truck platoon just one unit or is the first truck a tractor in control of forming the platoon? The Tokyo Olympic Games 2020 would be an opportunity to showcase automated driving technology with demonstrations of various personal mobility services in three areas: the Tokyo waterfront area, expressways, and around Haneda airport.

Chien-Pang Liu (Ministry of Transportation and Communications, Chinese-Taipei) looked at the challenge of applying CCAM on two-wheelers to save lives as many accidents and fatalities involved motorcycles, and designing affordable systems for mid-price vehicles. A trial project started last year in three university campuses: vehicle-to-roadside unit using WiFi (cheaper than DSRC) has been deployed on all motorcycles. RSUs can detect on-board devices to monitor location and approaching speed at intersections to warn motorcyclists of potential danger. Around 50 intersections had been equipped; the next step would be equipping two-wheelers with devices in a motorcycle-sharing scheme to overcome the penetration and thus reliability issue.

Joost Vantomme highlighted the need for trials – the concept of a “living lab” was important, as we needed to

be able to experiment and collect data and experiences in order to understand what worked in the context of safety and regulations. AD deployment was likely to start by use cases before we reached high levels of autonomy eg ADAS services helped promote public acceptance of autonomy and bringing solutions to the market step by step.

Audience questions – *Most trips are short-distance, shouldn't our first aim be to get them done by walking, cycling, etc instead of private autonomous cars?* (MV) autonomy brings benefits to many use cases; choosing a priority is subjective. Start with affordable, sound basic technology and a draft business model. Last mile mobility is as important as multimodality ie using autonomous shuttles means people avoiding the car for the equivalent trip. (RR) human nature will look for the most comfortable, safe and economical ride. One solution would not fit all: we needed to customise solutions for particular categories of riders. A lot of training and coaching would be required for the elderly to use unconventional transit vehicles for the last mile. (NK) Last mile automated mobility services were not easy to deploy. They were more likely to start near tourism sites as travellers, but also hotels and shopping malls in tourist areas, can afford to pay more expensive costs than local residents.

*The challenges in Japan are regulatory eg UBER and similar are not allowed. The government is testing autonomous shuttles for the Olympics but will not allow such unconventional vehicles to run freely and pick up or drop off. How do you see this contradiction?* (NK) In Japan the government is responsible for passengers but with UBER it is the driver. So concern for safety required drivers to have a special permit. For automated cars safety would be supported by a company or another special permit. Automated driving systems would be expensive and probably not owned by individuals but companies would offer these AD systems for mobility services in a similar way to taxis.

*Are you capitalising on university research to overcome some of the challenges?*

(RR) In Canada a dedicated organisation looks into research opportunities addressing all new mobility solutions, including autonomous cars, working with the private and public sector agencies and telecommunications companies who will be an integral part of any future solution. (MK) US universities were very much involved; they were key stakeholders. We had many institutes operating test beds as well and they had been involved from the beginning as well as are participating in our national dialogue. (MV) This was similar to the EU where the Road Transport Research Advisory Council coordinated many research areas for multimodal transport and was very involved in automation and connectivity.

Moderator's closing question: *What is your biggest frustration slowing progress and what is needed to resolve this:*

**(C-PT):** Finding ways to improve accessibility for rural areas

**(RR):** Leadership – administrative structures that supported the mobility of the future

**(NK):** Getting public subsidies for automated driving development was too complicated

**(MK):** Lack of people resources to engage with everyone and also work on projects while the research funds were available

**(MV):** Establishing the path from here onwards and how we could get there. Mandating some interim solutions such as ADAS pulled us forward but it would be decades before we were fully autonomous so every single step we could make would drive us towards saving more lives.

## ES11 – Enhancing Cybersecurity and resilience of transport infrastructure

The moderator Douglass Couto (Aquila Group USA) began the session describing a 2017 attack targeting the Ukrainian Government which affected the Maersk shipping company because it had a copy of the attacked software. Maersk was eventually able to recover but the cost was about \$300M plus 10 days' lost work across the company. This showed a new dimension to cybersecurity – not being directly targeted did not mean not being affected.

Jim Beveridge (ERTICO – ITS Europe, UK) presented thoughts on “Attack Surfaces”. The first class of attack was from the regulators against users not looking after data. There were several regulations in Europe (eg GDPR, ePrivacy) which applied data protection to IoT devices. Fines for contraventions were increasing so industry was starting to take care of data. The trend was clearest in Europe but was starting in the US and Asia Pacific.

The second attack surface was the chip with attacks such as Meltdown and Spectre which changed sequences and instructions in the chips. This type could be expected to get worse in the new world of IoT. The chips were low power so there was not much space for hardware to look after security and so they tended to be easier to hack.

The last attack surface was Networks. A connected car had so many risks it might become the unconnected car. Connected car systems were complex so a hacker's dream as the greater the complexity the more opportunities to be compromised. The car included more than 50 sensors but they were from different manufacturers and it was not clear who was responsible for the overall security of the vehicle. Technology did not have to be complex and difficult to understand to be vulnerable – a Polish school boy reprogrammed an infrared remote control to change the signals of the Warsaw Tram to cause a crash.

## Plenary And Executive Sessions

Joe Waggoner (Tampa Hillsborough Expressway Authority, Florida, USA) spoke about security in an electronic tolling system. It did not offer a cash option and billing was either through transponders on gantries or by identifying number plates on a database. Exposure to cybersecurity increased dramatically with the latter operation and the business model was at risk based on how well the data systems security was maintained.

Abbas Mohaddes (Econolite, USA) addressed security and traffic management. When mechanical controllers were the norm systems were isolated and the only risk was from people having physical access to the cabinets. Security today was left to the IT but we all had to be mindful and responsibilities could not be delegated. In Traffic Management work still needed to be done as there was connection to many subsystems involving different modes and different connectivity technologies. Significant amounts of data were being processed and sent to the cloud which exposed the systems to a variety of levels of vulnerability. The key issues were the physical networks, the endpoint, and data security. Privacy and active monitoring were important as well as a security mind-set. It would be wise to follow the National Institute of Standards and Technology Framework and its 5 major components: Identify, Protect, Detect, Respond and Recover.

Jaeson Yoo (Penta Security Systems, Korea) presented an overview of C-ITS Projects in Korea and the steps taken to maintain security. There would be a pre deployment project in Seoul testing different conditions including safe driving support, traffic management and road management. A larger project on urban roads would focus on Cooperative Automated Driving and Bus related C-ITS. Another pre-deployment project on the island of Jeju would address Tourist-oriented services that can be offered through V2V and V2I.

Korea was looking at 5 areas – local dynamic maps; hybrid (Wave+LTE) V2X communication systems; cooperative automated vehicle control modules; demonstration vehicles and validation procedures for CAV; and construction and operation of test beds. With these systems they were exploring communications lines which would be secured, encrypted and anonymised to build the trust necessary for C-ITS infrastructure

The moderator launched a discussion session noting that a key conclusion from the presentations was that security was everyone's business. The following points were made:

- Challenges existed at different levels. In the past design was done internally; now there was a need to look at the partners you worked with. Co-working had to be planned collectively and security frameworks and common standards followed rigorously.
- People were the biggest risk as simple things like clicking on an infected e-mail could be critical. It was important to get people more aware of risk; the GDPR helped as it took awareness to Board level. The security mind-set must go throughout the organisation.
- Public Key Infrastructure could help to create trust in the back offices for C-ITS systems by authenticating

end points with data transmission encrypted. However all parts of a system were points of failure as they had to connect to enable the service. Components could be isolated but as soon as one was connected it became a point of failure.

- Audience question – *devices have life cycles of about 18m, vehicles 5–10 years and infrastructure 15 – 150 years; how can integrity and security be maintained over these longer times?* Using Blockchain could be an approach to maintain timestamps when there was an upgrade to record what was running. Cars would become more like mobile phones and not be declared “secure” at a single point in time.
- It was likely that danger would not come from hackers that altered a website or stole some information but from those hanging around for months in the network and looking at causing damage. The costs of future attacks would be much higher than those in the past on the internet. This needed to be taken into consideration before setting up new services. Security should be the first thought starting with defining a clean architecture.
- Cybersecurity was becoming an organised crime with people dedicated to it. It tended to be addressed in silos for each sector of which ITS was one. However the silos come together in the digital city and community where all departments are integrated and connected.
- A person from the audience commented that security standards needed to be harmonised. ITS systems are very complex and overlapped different domains with different standards and that affected the costs of development. The US and the EU have been collaborating on harmonisation for a long time in particular for Traffic Management. However there are still differences between regions; technology moves fast but cooperation between people moves slowly.

To conclude the session the moderator *asked each panellist for a last thought.*

**(JB)** It was all down to the people. A cultural change had to take place and the organisations had to incentivise people to look into cybersecurity and consider security by design. Technology was available eg Blockchain can solve some security issues; but the hard thing to change was getting people to work together.

**(JW)** It was important to let people know that interest in cybersecurity started at the top and went right down. Security audits had to be part of the business process at the same level as finance audits.

**(AM)** Cultivating and developing a culture of security and investing in education was essential. If an organisation had not done so it should immediately assess security aggressively to identify the gaps.

**(JY)** Many new connections would emerge in the future and the momentum was unstoppable so rather than operate from fear the next important steps should be to find trust models other than PKI, for example Blockchain, to keep the integrity and accuracy of messages.

# The High-Level Round Table

The High-Level Round Table on Wednesday 18 September was a much anticipated part of the Congress. Around 160 Ministers, Mayors, Industry leaders and senior representatives of national and local governments came together to review how intelligent and green mobility can contribute to sustainable growth and a better environment for all citizens.

After a short **orientating Plenary** including welcomes by Ms Ninna Hedeager Olsen (Mayor of Technical and Environmental Affairs, Copenhagen) and Mr Jacob Bangsgaard (CEO, ERTICO) the participants divided into five parallel streams to explore solutions for issues facing most cities globally. These included space management, pollution control, safety and security, regulatory issues for new technologies and the general challenge of maintaining seamless mobility for all citizens when expanding and ageing populations were putting increased pressure on transport systems and urban spaces.

The Round Table streams were based around three broad themes:

- Making cities more liveable by reducing congestion and improving air quality
- Helping cities to plan for the deployment of new mobility services
- The changing roles of Governments, especially regulating and legislating

These themes were translated into five key questions to prompt discussions

- How can we reduce emissions and improve air quality?
- How can we achieve modal shift in cities?
- How can cities plan for the deployment of new mobility services?
- How can we manage urban space use for public transport, active modes and private vehicles, to deliver enhanced green mobility and accommodate highly automated vehicles?
- How might legislation facilitate the deployment of automated transport for both people and goods?

The **Ministers** talked about many points relating to deployment of highly automated vehicles ranging from the possibility of drastically reducing fatalities to benefits for older or restricted drivers; and from the likely impact on congestion and vehicle ownership to enabling a variety of innovative mobility services. Many countries were hosting trials of some form of automated vehicle and it was not yet clear whether their large-scale deployment would require changes to how cities managed urban space use.

Mobility was not yet a stand-alone aspect of everyday life and Governments were faced with the challenge of working on various policy and legislative aspects relating to the new services that automated transport would support. For many Governments there was not yet a clear picture of the amendments to legislation and regulation likely needed to facilitate the deployment of automated transport for both people and goods. The need to refresh legislation to keep up with the development of transport technology was emphasised.



The Ministers noted a number of areas in which regulation needed to be introduced or updated to support transport and mobility. These related to safety, privacy and cybersecurity issues stemming from data use, and the new emerging partnerships of industry, government and private actors in providing new mobility services.

Further discussions focused on the use of data, strategies for reducing emissions and improving air quality, the changes needed in regulation for deployment of new mobility services, and the push towards the goal of zero-based fatalities. Using data for mobility presented challenges and opportunities. There were still a number of trust issues and a lack of adequate (digital) infrastructure for data. This pointed to the need for a clear definition of the objectives for data use and for standards and open APIs for data exchange.

The Ministers agreed strongly that a zero emissions strategy with goals for all stakeholder sectors must be worked out. Transport should be an enabler for lower emissions. In Europe the EC was already seen as a big part of the solution in initiating measures to encourage

# The High-Level Round Table

cleaner mobility. In some countries tax changes had advanced the penetration of electric vehicles (EVs), setting an example perhaps for others to follow.

The Ministers agreed that a goal of zero-based could not be achieved in a hurry. The most optimistic scenario showed 2060 and beyond for realising the goal, underlining the view that much work remained to be done in this regard.

The **Mayors** met around two tables to discuss pressing issues facing cities today in terms of deployment of new mobility services, modal shift, the use of urban space, and reduction of emissions and improving air quality.

To manage urban space efficiently for public transport, private vehicles and active modes as well as aiming to deliver enhanced green mobility and additionally accommodate highly automated vehicles, cities would have to set priorities by making difficult choices. One group of mayors ranked different modes in order of preference for space management: walking, cycling, public transport, mobility-as-a-service (MaaS), cars. Autonomous vehicles carrying multiple passengers should be given more priority than vehicles carrying single drivers/passengers. The Mayors stressed the importance of exploring the scope for deploying highly automated vehicles for freight as well as passenger services.

Every city needed to look for the causes of its congestion problem and choose the most suitable solution from the multiple options available. It was important to think long-term for mobility planning but also to be flexible at the same time. Some transport policies and plans operated for longer than the term of the elected officials who instituted them and should perhaps be reviewed regularly to ensure that they still served the best interests of citizens.

New mobility services must be deployed to increase the possibilities of modal shift. “Top down” and “bottom up” approaches to deployment could both be effective provided cities acted as enablers. The users must be made to feel that public transport was good and something worth valuing. Very often they did not consider it a good enough option.

It was clear that cities around the world had a lot in common while facing unique sets of local issues. City authorities had the vision to come up with solutions and with decision making powers on transport issues, and with bold mayors, they could realise their goals. The Mayors felt that the public sector should have more oversight and regulatory powers to give the right to experiment and run pilot deployments for prioritisation of modes.

Working together with other cities to share knowledge and experience had brought many benefits – not least the sharing of open source data to improve safety and efficiency of transport. As a complement to that the Mayors pressed the case for more “State of the Art” documents: simple reports on what cities and countries were doing, why they were doing it and links to any more detailed information available.

A mix of **Industry Leaders and Government Officials** also had two tables for their discussions on the use of urban space for private and public transport, including autonomous driving and solutions for greener mobility.

The answers for handling future mobility challenges in cities were not building more infrastructure for cars. The boundaries between transport modes needed to be removed to create integrated and efficient solutions – across borders and also across fleet and personal transport. We needed to rethink mobility and work with users to understand their needs and “nudge” them towards new habits and a culture change. There was not always a good understanding of user behaviour and in some areas this would be essential for change to take place – for example we could not support future population growth in cities if the demand for individual cars continued. It was very important to focus on the human factor and to understand different users’ needs.

Financial mechanisms had been proven to influence behaviour but options such as road pricing were not always popular for political reasons. If policies were recast into incentive-based frameworks they could be very effective – for example a traffic guidance system to ensure a more efficient use of infrastructure (driving at off-peak hours, guiding to less congested/polluted roads, changing to mass-transit or bikes *etc*) could deliver excellent results.

Good solutions required access to good data *eg* about traffic and air-pollution, which in turn required good sensors, etc. To support the technological development and innovation needed to create future modern mobility solutions policy-makers must introduce test zones for new technology such as autonomous vehicles. There must be more emphasis on benchmarking and scaling projects when launching tests and pilot projects. Autonomous vehicles that were tested in different environments and climactic conditions would help improve mobility in rural areas too where public transport is not feasible in many areas.

There was a need for rethinking approaches to infrastructure as ITS could ensure a more efficient and flexible use of the limited space in cities. For example better maintenance and optimisation of traffic lights could reduce emissions by over 20% but politicians often preferred funding for capital projects where they could “cut the red tape” to an increased budget for maintenance.

There was much discussion on data and how legislation could both help but also hinder data’s crucial role in enabling automation. GDPR was given as an example of how legislation was seen by the industry to be potentially hindering automation and connectivity. However there was no consensus between the stakeholders regarding who should own the data and who should have access to it.

A poll of participants revealed the paradox that although legislation in general was seen as a hindrance there was almost unanimous agreement that it would be necessary to make automation happen. The issues of liability, standardisation and harmonisation (across industries but also across borders or even beyond the EU) would

need some legislation to enable widespread uptake. All participants agreed that it was critical to make this a global process even though that would be extremely hard and slow.

The discussion on modal shift prompted the key questions “Why do we, or more specifically cities, actually want automation? What are the outcomes we want to secure?” This should be the basis of discussions on automation and modal shift, and the regulation and policies behind it. It was also noted that we needed different regulatory and policy approaches on urban and rural areas for both automation and modal shift.

In the **concluding plenary session** the participants recorded their appreciation of a stimulating opportunity to meet their global counterparts to talk about solutions to transport challenges. They also looked at emerging opportunities as in many cases problems previously considered too difficult were beginning to be addressed because transport technology was developing so rapidly.

The participants at the High Level Round Table:

- Noted the proven benefits of ITS for reducing congestion, emissions and energy consumption while enhancing safety and mobility for people and freight
- Invited the Regional Congress organisations to continue to work with public and private sector stakeholders to encourage the publication of evaluations of completed ITS implementations
- Stressed the need for more
  - large-scale trials of highly automated or driverless vehicles to assess the combined impact on safety, air quality and congestion
  - research on the behavioural aspects of transport
  - guides to the potential of emerging ITS technologies for policy development
  - research on ways to manage city space including parking and automated vehicles
  - guides to the different processes for procurement
  - research on the needs of travellers with reduced mobility
- Confirmed their wish to continue to work together to address the mobility challenges facing cities today through the deployment of efficient and sustainable ITS solutions
- Welcomed plans for the organisation of a similar high-level policy discussion at the ITS World Congress in Singapore 2019
- Thanked ERTICO and Copenhagen City Council for organising the event.



