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26th ITS World Congress
21–25 October

Smart Mobility, Empowering Cities

Organised by

Land Transport Authority — We Keep Your World Moving

ITS Singapore

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Asia-Pacific ITS

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CONGRESS REPORT

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INTRODUCTION

The Congress's principal theme "Smart mobility, empowering cities" was chosen to highlight how Intelligent Transport Systems can enrich people's daily life through smart solutions that put the user and the user's personal needs at the centre of mobility systems of many cities. All these come from ITS delivering improvements to network capacity, air quality, energy use and safety. The Congress was organised around eight key Topics:

- **Intelligent, Connected & Automated Vehicles**
- **Crowdsourcing & Big Data Analytics**
- **Sustainable Smart Cities**
- **Multimodal Transport of People & Goods**
- **Safety for Drivers & Vulnerable Users**
- **Policies, Standards & Harmonisation**
- **Innovative Pricing & Travel Demand Management**
- **Cybersecurity & Data Privacy**

The Congress Board of Directors, co-chaired by Andrew Chow (ITS Singapore) and Kian Keong Chin (Land Transport Authority), appointed rapporteurs 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 200 in total – Plenary, Executive, Special Interest, Technical, and Scientific.

This Report summarises the Congress proceedings. Part One paints a picture of all Congress sessions and the associated events. Part Two reviews discussions at the Plenary and Executive Sessions. Part Three focuses on the Technical & Scientific papers and the Special Interest Sessions. I give my profound thanks to the marvellous team of rapporteurs who contributed so much to this document:

- Darren Capes
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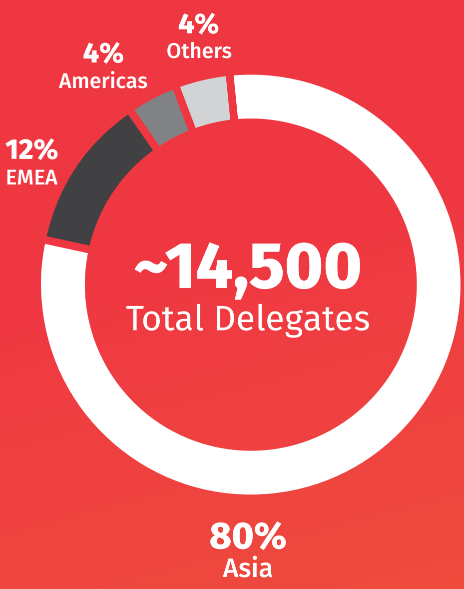
PROFESSOR ERIC SAMPSON
CHIEF RAPPORTEUR
BRUSSELS December 2019

26th ITS WORLD CONGRESS IN NUMBERS

• Participation



2,214
Public Day

3,500
Opening Ceremony

229
Media

148
Staff & Volunteers

• Tours & Demos

25
Technical Tours

788
Technical Tours Booked

8
Demos

1,270
Demo Rides Booked

• Programme

214
Sessions

11
Associated Events

21
Sponsored Sessions

SUMMARY

The Congress Theme was "Smart mobility, empowering cities" and the Sessions, the Exhibition and the Demonstrations illustrated this in many different ways. There were exciting contributions from large global organisations and from tiny start-ups that did not exist last year. Delegates heard how it was all coming together. How traffic of all types – some of it vehicles with conventional drivers, some of it driverless; some on two wheels, some of it on legs – could be better managed in small towns and large cities and also whole Regions thereby helping both freight and passenger users.

The **Intelligent, Connected & Automated Vehicles** topic was again the largest of the Congress based on the numbers of papers and sessions. About a fifth of the papers were Connectivity; use cases for connected and automated vehicles were a third, and vehicle automation almost half. Discussions addressed the technical challenges of automated vehicles including perception sensors and also, much more than previous years, the artificial intelligence approaches and solutions. It was clear that highly automated driving was moving closer to actual deployment. This was particularly so for public transport and mobility services in dedicated or partly separated areas where there was movement from "proof of service" to "proof of business".

When might we have driverless or self-driving cars on open roads? Some argued within a few years, whereas others were much more hesitant, especially because of largely unsolved road safety issues. What was desirable for human drivers was essential for machines. But there was a growing confidence that in specific areas of vehicle control and in specific closed environments elements of autonomy would soon be available commercially. And there was confidence that the more complex uses of this technology, leading to true level 3 and 4 vehicles, were now viable.

Crowdsourcing & Big Data Analytics had a strong focus on using large data sets to improve operations in control centres. More use was being made of artificial intelligence, machine learning, deep learning and data fusion to monitor how people travel and why, discover congestion hot-spots early on; and predict how congestion would impact the network. Using data from road management and public transport systems was taking traffic demand and congestion management to a new level. Big data was being used to quantify demand, travel speeds, and recovery time. New traffic policies were being deployed that coordinated motorway and arterial roads and so reduced congestion by managing them jointly not independently. Transport centres around the world had adapted machine learning techniques to analyse data and were using data-fusion and real-time simulation modelling for traffic congestion management. We were moving quickly to data-driven decision-taking – a complement to evidence-based policy making.

Topic 3 was **Sustainable Smart Cities**. Smart cities had always featured prominently in Congresses but 2019 emphasised the "Sustainable" aspect. Sustainability was of particular interest now as deployment of the supporting technologies had only been accomplished in the last few years. The focus was much less on travellers' needs and how close a city might be to becoming "smart"; rather it was the need for collaboration between different city departments.

Around the world transport operators were under pressure to meet the changing needs of society such as commuter demand for real-time travel information, faster incident management, and multimodal solutions. Consequently, a common interest in papers was traffic management tools, traffic control and operations, and integrating electric vehicles into the systems. And the integration of traffic management and mobility schemes such as Mobility as a Service (MaaS) was discussed for the first time at a World Congress.

Smaller deployment projects were happening everywhere with exciting new ideas being developed and implemented rapidly. However, the bigger, more ambitious projects with potentially larger impacts were slower moving. They were often constrained by excessive concerns on regulation, integration, competition, and collaboration – none of these was a technology barrier.

Putting people and freight in the same stream of **Multimodal Transport of People & Goods** might seem odd as there were fundamental differences in their strategies. Multimodal freight represented a contractual arrangement where usually one agency was responsible for the end to end journey of the goods by land, sea or air. Nobody was responsible for the multimodal end to end passenger journey. However, papers discussed Quality of Service, Contracted Responsibility, and universal services such as those that were emerging in MaaS initiatives – a similar model to freight operations. And while we were awaiting the results of many MaaS trials a discussion of MaaS sustainability had started.

The two sectors were converging. Multimodal transport of people used to reflect interchanges between modes of public transport. With the explosion of first and last mile solutions for people and goods, and improved data and technology for routeing systems, public transport was becoming just one part of a wider transport system. For both sectors the relationships between traffic flow, real-time information and kerb-space management needed to be developed quickly given the increase in small and nimble vehicles carrying passengers and completing urban deliveries.

There had been an intriguing shift in the **Safety for Drivers & Vulnerable Users** topic. The Copenhagen emphasis was on getting the expected safety gains from highly automated vehicles. In Singapore that seemed to be taken as a 'given' and the key issues were how to test the technologies safely, including testing in live environments, and what else was required beyond technology to move to vision zero.

The sessions and papers stressed the importance of studying the whole transport safety system – sensors, data and data analytics, AI networks, service operations, incident management (especially weather response) and the provision of information to enable appropriate and timely interventions. And connected systems of sensors, cars, cycles, traffic signals, intersections, pedestrians, even footpaths would allow us to protect all road users, not just those in vehicles.

Policies, Standards & Harmonisation saw some new thinking especially on the design of policies. Policy innovations included the use of social credits to nudge transport behaviour and processes for co-funding innovation. But new policy thinking was needed for human monitoring of vehicles; safety testing; legal liability frameworks and insurance needs.

Smarter enforcement using technology was enabling a shift from manual inspection methods to targeted enforcement. There was agreement on the need for wider thinking on city regulation. In a scenario of seamless mobility cities could look radically different, with robo-taxis, autonomous shuttles, advanced rail signalling and predictive maintenance. Through effective regulation and incentives cities could for example encourage the use of shared automated vehicles to achieve goals of sustainability, convenience, affordability, accessibility and efficiency.

Topic 7 was **Innovative Pricing & Travel Demand Management**. The link between road user charging and demand had been well-established. The emphasis in sessions was on how to enhance infrastructure to enable free-flow charging and faster transactions, and the effectiveness of various forms of use-based congestion pricing. Besides the usual point-based or distance-based approaches other scenarios presented included a form of time-based (to address illegal parking or circulation issues).

Two other prominent topics were parking as a demand management measure, where authorities and industries were increasingly recognising the importance of user response in the design of systems and using incentives to nudge travel behaviour and manage demand.

With the rapid development and increasing dependency on real-time connectivity the threats to transport **Cybersecurity & Data Privacy** were acknowledged as real and requiring constant vigilance and mitigation. The most common issue discussed was identifying then overcoming hacking and malicious attacks with examples from road, rail and maritime. Current work was centred on anticipating attacks by human actors. However as artificial intelligence and deep learning techniques become more advanced digital intelligence might develop so that hacking using deep learning becomes a reality and so we may need to set computers against computers.

The Congress included an innovative 8-day development experience for Young Professionals. There were around 30 showcases, demonstrations and technical tours that ranged from large vehicles such as an electric autonomous bus to individual 'pods'. The focus was not just transport by road – there were examples from air, rail and marine such as automated port crane operations.

It was clear from many different sessions that the traditional policy of providing information to enable a driver to take decisions based on it would not be enough in future. There were huge potential gains from exploiting connectivity, and we needed to think in terms of an active urban traffic management system optimising traffic and making decisions on behalf of the individual drivers. This Congress gave the strongest indication, yet that public authorities and road and street operators should now be thinking seriously about how to embrace and maximise the public benefits of this coming revolution.

The Congress host provided an interesting perspective on a possible urban transport future. 12% of land in Singapore is dedicated to roads and transport, only slightly less than the 14% dedicated to housing, and this means that getting the best out of the network is essential. Technology and automation were key to this and the Singapore government had already legislated to allow automated vehicle operation, testing and use and was producing technical specifications to prepare for AV use and address the key issue of how best to incorporate AV operation into open roads.

PLENARY & EXECUTIVE SESSIONS

PL 01:
ADVANCING CONNECTED & AUTOMATED MOBILITY DEPLOYMENT

Moderator	**Saurav Bhattacharyya** (Quantum Inventions, Singapore)	
Panelists	Swan Gin Beh (Keynote address)	Singapore Economic Development Board (EDB)
	Young-Jun Moon	Korea Transport Institute, Republic of Korea
	Seleta Reynolds	Los Angeles Department of Transportation
	Carlo des Dorides	European GNSS Agency (GSA)

Mr Beh explained that Singapore required the deployment of ITS solutions as soon as they became available to counter the prevailing problems. These included an ageing but increasing population, a shortage of physical space for installation of additional infrastructure and difficulty filling transport-linked jobs such as bus drivers. The objectives were the provision of mobility that was efficient, safe, reliable and affordable with the associated preference for solutions based on public transport rather than single-occupancy private cars. It was hoped that deployment of automated vehicles would improve efficiency, help to address labour shortages and support the creation of new business opportunities. There had been a lot of work on studying how best to integrate AVs into mixed traffic complemented by development of new regulatory legislation and opening special vehicle test tracks.

Young-Jun Moon described the programmes being managed by the Korea Transport Institute that were researching automation, electrification, modal integration and the collection and use of data – the key drivers of the mobility revolution. The revolution was expected to lead to reduced traffic congestion, increased personal mobility, reduced traffic accidents and fatalities, and the creation of new services. However there would also be reductions in the employment of drivers and both positive and negative changes to land values as a consequence of city space changes. The infrastructure needed for future mobility was not yet completely clear but was likely to be a combination of digital, logical and physical bound together by telecoms technologies. It was still not clear what mix of telecoms would deliver the most efficient and effective solutions and there was more work to be done on ownership and availability of data. In short, there were still many questions needing research results for resolution.

Seleta Reynolds looked at the session topic from the point of view of a manager / service provider for Greater Los Angeles. This sprawling area had developed from an intensive horse-dependent region through motorisation and extensive roads construction to a point where the car was seen by most travellers as the only available mode despite chronic congestion and the associated delays. The transportation department had focused on a massive shift from analogue to digital data handling and changing the business model for (shared) public transport by encouraging the availability of open data and APIs based around sets of mobility data specifications. There was still much to do but the data policies were proving popular.

Carlo des Dorides reviewed the need for accurate position determination as a key element of both connected and automated mobility solutions and the benefits from the deployment of the GALILEO constellation. Adding to the numbers of GNSS in operation brought improvements for users from reduced reflections and greater visibility, which in turn supported the deployment of value-added services. But an important advantage from the more up-to-date system designs of GALILEO were the availability of very high precision positioning and authentication services which gave considerable gains for cybersecurity processes.

The Panel discussion centres on the difficulty of changing physical infrastructure to match changes with digital systems, for example developments in battery technology had encouraged the deployment of personal mobility devices such as eScooters and eBikes which used city space in different ways to traditional cars. The steady increase in 'first mile' and 'last mile' services based on PMDs was prompting pressure for redesign of physical parking and the associated parking services.

Another key issue for cities was the availability and ownership of data. Cities were keen to share the data they owned at zero or low cost but it was unacceptable for the private sector to make significant profits from this data so in many cases the availability came with a requirement to accept 'no exploitation' clauses. This type of problem needed to be solved quickly as both connected and automated vehicles generated potentially useful data for the public sector that was the property of the vehicle owner/operator.

PL 02:
PROMOTING INNOVATIVE MOBILITY SERVICES

Moderator	Lina Lim (Singapore Land Transport Authority)	
Panelists	Ping Soon Kok (Keynote address)	Government Technology Agency, Singapore
	Roger Millar	Washington Department of Transportation, USA
	Henrik Hololei	European Commission, DG MOVE
	Mu-Han Wang	Ministry of Transportation & Communications, Chinese-Taipei

Mr Kok's keynote address focused on innovations by the Government Technology Agency to improve mobility in the lives of citizens. Services needed to comply with the three "I"s – to be Integrated so moving from A to B in one trip, regardless of the number or forms of transport, should feel like a single, seamless trip. It should also be Intelligent using data analytics, machine learning and AI to build predictive and autonomous systems. And it should be Inclusive offering benefits to everyone including the growing and ageing population, and people with disabilities. Services also needed to address the 3 "C"s – be Convenient meaning easily accessible; Comfortable with high standards regardless of mode; and "Chop-chop" in the sense of fast. The goals for speed were no more than 45 minutes to get to a city wherever you live even during peak hours using public transport or/and active mobility and at most 20 minutes to get to the neighbourhood centre.

Roger Millar described innovation projects in Washington State. Washington was one of the most trade-centric states in the USA with very high business income from freight-dependent industry, A third of employment was linked to international trade but the state's geography restricted the scope for developing transport corridors and the cost of adding to physical infrastructure was prohibitive. There were concerns about social equity and accessibility as transport was taking too high a percentage of household incomes. These points had driven moves to use ITS technologies to get more output from existing assets with a particular focus on cooperative automated transport. The medium- and longer-term goals were deployment of automated, connected, electrified, and shared mobility to support safe and efficient transport emphasising public transit and active modes and promoting liveable and economically vibrant communities with affordable housing and convenient access to jobs and other activity centres.

Practical solutions aimed to address congestion within available resources, planning the next generation of infrastructure investment, working as stewards of the transport system rather than "delivering projects", development of Mobility on Demand, enabling open access to transport data, and modernising the regulatory frameworks.

Mu-Han Wang commented that his country had similar problems to many others – increasing urbanisation of the population coupled with faster growth of travel demand in urban areas; an ageing population; concerns about the effects of climate change and global warning on transport infrastructure and air quality; and pressures to improve road safety. To help deal with these issues there were a number of powerful technology developments: Artificial Intelligence, the Internet of Things, tools for managing Big Data, Cloud and Edge computing, highly automated and autonomous vehicles and deployment of 5G networks.

In Chinese-Taipei, the emphasis for the deployment of technology was currently Mobility as a Service, encouraging access to active transport modes, installation of comprehensive electric vehicle charging networks, production of better journey planners, designing easier payment options, and deploying better network management based around predictive- and demand-linked tools. A key to all of these activities was digitisation of transport.

Henrik Hololei noted that he represented the transport problems and opportunities of nearly 30 countries rather than just one. The Commission had launched a series of initiatives designed to remove barriers to cross-border operation of services and inappropriate regulatory frameworks and accelerate the opening up of data and the trial deployment of promising new technologies and products based on them. Support had been given to a number of experimental schemes for Mobility as a Service and for extensive field operational tests of connected and highly automated vehicles.

The Commission had sponsored a major package of work on the development and delivery of Sustainable Urban Mobility Plans with policy and technology links to the goal of making Europe carbon neutral by 2050. He reminded that there had been dramatic social changes over the last 20 years leading in turn to change in the demands placed on transport services. It was vital that all classes of stakeholders were involved in not just the design of mobility services but also the ways in which they were delivered and regulated. In that context, he applauded the ITS Congresses as a vital forum for the exchange of ideas and experience across the world.

There were a number of questions from the moderator and from the floor – "How can innovative mobility solutions help a densely populated city?" Roger Millar responded that it was dependent on the available services but the key points are public-private partnerships for the planning phases complemented by open access to data. Mu-Han Wang argued that technology was hardly ever the problem provided there were clear descriptions of what ITS was required to do and recognition that in many cases the hardest processes to change were people's behaviour. HH stressed the benefit from having an open society and an open-minded government that encouraged innovation and experimentation. Smart mobility needed smart regulation, which should be evidence-based with the evidence drawn from unconstrained tests and trials.

With regards to the question on "What brief advice for non-motorised societies to implement resilient MaaS schemes?", Mu-Han Wang's views is to start small and proceed in defined easy stages. Also, it is important not to focus exclusively on cities but to remember the need for rural solutions. Roger Millar highlighted to involve all sections of society in the planning as mobility needs differ widely and are liable to change. Henrik Hololei shared on the importance to pay careful attention to the intended uses and not the methods for delivery.

PL 03:

INTELLIGENT MOBILITY SOLUTIONS FOR A SUSTAINABLE SMART CITY

Moderator	**Men Leong Chew** (ST Engineering, Singapore)	
Panelists	**Chong Kheng Chua (Keynote address)**	Land Transport Authority, Singapore
	Claire Thurston	Roads and Maritime Services, NSW Australia
	Steve Morriss	AECOM, USA
	Leen Balcaen	HERE Technologies, Belgium

Mr Chua reminded the audience of the difficult combination of constraints in Singapore – increasing urbanisation, an ageing population, increasing demand for mobility, limited land space with almost zero room for infrastructure expansion and a shortage of skilled labour. Offsetting these points were a highly educated workforce and some early steps towards digitisation. There was now a third generation Land Transport Master Plan that described a series of long-term, holistic and integrated transport policies and strategies. It aimed to make effective use of technologies and data to support regulations and policies, embrace innovative mobility solutions and encourage business models, support inclusivity and enhancing safety.

Key elements of the Plan included: enhancing transport accessibility and connectivity; offering multiple transport modes; applying Artificial Intelligence, providing timely, reliable & relevant information, deploying intelligent traffic light control and generally encouraging 'real world' trials of possible new services.

Claire Thurston said that she would focus on the practitioners' perspective with Sydney as case study. Currently around 75% of weekly commuter traffic was road-based (70% car, 5% bus) and the infrastructure was struggling to cope. In order to support the city's aim to become smarter, many support services were rethinking their operation and their flexibility for responding to new types of demand from the city client. In the case of traffic control, a key factor in evolution was getting better data on customer needs and preferences on the one hand, and current demand, predicted demand and historic actual demand on the other. Data was also needed on the physical assets and about irregular events such as traffic incidents or adverse weather.

Getting and using data was the key basis for being both an informed customer and an informed supplier / manager, coupled to a modern control system in which AI, machine learning and real-time modelling were used to react swiftly to changing conditions without the need for operator intervention. In the case of Sydney, ways were being trialled to improve the productivity of the networks including development of the control systems to use Big Data derived from new types of sensors (cameras, radar, lidar etc) which in turn meant changing software to be sensor agnostic.

Steve Morriss began with a reflection on the difficult position modern cities were in. Increasing urbanisation and the associated movements of people and goods was driving transport demand leading to congestion; there was growing pressure to adapt all traffic modes to reduce environmental impact and in most cities a wish to reduce transport spending. Transport safety was always expected to show improvement and an ageing population was calling for changes to the accessibility of transport. Against these points, there was an increasing array of new solutions but that in turn generated pressure for integration with existing assets especially staffing.

Cities were looking to electric vehicles as a major contribution to increasing sustainability and reducing greenhouse gases and steady improvements in dynamic induction charging were helping to secure support from previously unconvinced users. Technology was able to make powerful contributions to safety through speed management, red light violation detection and traffic management. It was regularly claimed that over 90% of road fatalities were a consequence of driver errors so the successful development and deployment of automated vehicles could be expected to make a major contribution here.

Leen Balcaen explored the implications for a city of being designated 'smart'. The accepted consultancy definition of a smart city was one that added digital intelligence to existing urban systems, making it possible to do more with less. A better explanation was possible by starting with the history of a city as an assembly of citizens' common needs to which we could now add the gains from digitising, using artificial intelligence, data analytics and automation. We could therefore do more because we have better insight as a result of collecting, analysing and using data.

Cities have emerged as assemblies of groups of solutions to our requirements – healthcare, education, housing, mobility, retail centres. Smart cities could be seen as a nervous system within which the services in their specific domains are joined up. By making cities more connected, more data can be collected – an IBM estimate is 2.4 M Tb being collected every day and growing exponentially. With this collected data all aspects of daily city life can get more connected and automated over time and thereby making the smart city the coordination centre. We need to recognise that while the disparate services of today will become smarter they will increasingly overlap with one another, sometimes leading to conflicts resulting in an increase of complexity and confusion. Hence, cooperation is required to create clarity and for the smart city to function effectively.

As an example of the benefits of partnership working, Ms Balcaen cited plans to reduce vehicle emissions in Hamburg in which connected vehicles would count down to traffic signals turning red and reduce speed to avoid coming to a full standstill. However, city traffic operators had a separate role adjusting traffic lights to avoid congestion within a city. Both actions aimed to do good separately but in isolation, they could lead to conflicting decisions. By ensuring system interoperability and joining the functions, the most efficient and effective cooperative solution emerges.

EXECUTIVE SESSIONS

ES 01:

TECHNOLOGY AND SAFETY ISSUES FOR CONNECTED AND AUTOMATED DRIVING

Moderator	**Angelos Amditis** ICCS, Greece	
Panelists	Toshihiro Sugi	National Police Agency, Japan
	Ed Bradley	Toyota North America, USA
	Collin Castle	Michigan Department of Transportation USA
	Andree Hohm	Continental, Germany

The Moderator welcomed all to the session dealing with an extremely important and timely topic. The panellists started with their individual presentations.

Toshihiro Sugi gave an overview of the regulatory governance situation in Japan, where NPA reviews traffic rules, prepares for testing, participates in international discussions and promotes R&D in the domain. The Road Act was being amended to consider automatic operation devices. The new regulations required, for instance, that operational state recording devices need to record vehicle actions. Two sets of guidelines were important for the stakeholders as supporting the regulatory framework. In May 2016 guidelines on public road demonstration experiments were released. In September 2019, further guidelines followed on the criteria for permission for public road testing including remote supervision and special controlling devices. He also reported on truck platooning of unmanned vehicles connected by electronic traction – the first truck is manned. Because of accidents caused by too much reliance on technology NPA was working on raising awareness of risks in connection with L2 driver support systems and reminding that the driver was responsible for safe driving even when these systems were in use.

Ed Bradley pointed out that his company president had recently stated that driving enjoyment was and would remain an inherent part of the automobile and technology was used in order to support the human driver. Toyota applied both cellular and DSRC connectivity to improve road safety in the different phases of the accident chain of events for risk mitigation, collision avoidance, and finally crash mitigation. The on board sensors were deployed to enhance safety when utilised in pre-collision system, pedestrian detection, automatic high beam headlights, lane departure alert and adaptive cruise control.

Regulatory certainty was very important for an automotive manufacturer, especially in order to ensure interoperability and backwards compatibility. For customers public acceptance was crucial and was built on maintaining customers' privacy, sheltering them from hacking, and increasing their awareness of the systems in the vehicles and their rationale and operation.

Collin Castle argued that safety was still the main driver for connected and automated vehicle technologies which had other benefits as well. The DOT vision for smart mobility was currently being implemented with four areas of action: testing edge cases in a safe and controlled environment such as living labs and test centres; supporting physical infrastructure; supporting digital or cyber infrastructure; and establishing consistent enabling regulatory frameworks.

The roadways were being enhanced by connected vehicle technologies and deployment so that all new and upgraded signals were connected vehicle enabled. The quality and consistency of lane markings was being ensured. In all, the deployment program connected the entire state's mobility and had an action plan for connected vehicle technologies' network coverage for the period 2018 to 2023. The deployment of connected vehicles was also expected to have several consequences on the existing infrastructures such as reduced signalisation, narrower lane widths, and no need for wide shoulders. The regulatory framework was in place in the state of Michigan. The Council of Future Mobility played a major role as a catalyst and activities included an $8M Michigan mobility challenge

Andree Hohm from Continental predicted that the future mobility would look considerable different from that of today although stakeholders rarely agreed on exactly how. The spectrum of transport modes would be much wider, and the level of autonomy would increase. The building blocks for the evolution were in addition to the key technologies, also the key tools and competencies such as system architecture, system integration, system validation, system safety, artificial intelligence, fleet test data, and data management.

He raised the issue of socially acceptable risks and compared the status of human driver safety in terms of crashes per distance driven, and automated system safety in terms of disengagements. The latter had decreased with a very promising trend. We needed comprehensive environment perception for challenges of city traffic, and the integration of system components to implement a driverless vehicle development platform. The users would benefit from a holistic interface, while the interaction of the automated vehicles with the other vehicles and road users could deliver societal gains. Smooth interaction could be achieved through comprehensive situation awareness. Systems like infrastructure sensors are needed at intersections to serve interaction. Last mile delivery robots would be important for deliveries.

Points arising in questions and discussion:

- With regard to the big technological challenges to achieve safety, international cooperation was considered very important. Standards needed to be international as developers wanted to have their system in the global markets so UNECE regulations were important although China and the USA were not in officially. It was good that safety systems are close to harmonisation; the US states were also discussing how to reach harmonisation across the USA.
- The mix of automated and non-automated vehicles would soon be large enough to show any effects and the possible discrepancies in behaviour needed to be investigated to test whether this is a real problem. Learning by doing was important – for example the predictions of young pedestrians jumping in front of automatically braking buses to see what would happen did not actually occur emphasising that changes to regulations should wait until something had actually changed or gone wrong. For a vehicle manufacturer safety was a major concern when putting a vehicle to the customer's hands. We certainly needed safety regulation and the traffic rules of the future needed to be looked at in detail.
- **Qn:** What were the benefits from intelligent infrastructure? First, effective maintenance of vehicles and the infrastructure was essential. Provision of event and incident information to vehicles was very useful, but the benefits were hard to measure. The same applied to the potential of improved signals – it was very hard to measure the value of infrastructure. Technology in vehicles working well could bring infrastructure costs down. Safety was not the only benefit but also efficiency, and public transport competitiveness. It was crucial to have data available on the benefits. The ongoing connected vehicle pilots could demonstrate the benefits, and the past Ann Arbor pilots had already provided benefit data. The ongoing European L3Pilot and the L4 projects soon starting would provide such data as well.
- A performance-based regulatory framework could work also in road vehicle automation just as in aviation. The present system must change; much more dialogue was needed between industry and regulators in the form of an active dialogue on the expectations of the regulators and how the industry wants to go forward.

- The disengagements are not a good road safety metric, are there any that are better? While not perfect, the disengagements can be used. Risk acceptance of travellers is valid in all modes, also the accepted safety levels. Eventually, we should have a metric that can be put into regulations. An audience member pointed out that the degree of personal control was connected to the level of safety accepted.
- **Qn:** Why did we need automated delivery robots? In urban areas the demand for people mobility would double in 10 years, but for goods mobility it would triple.
- The closing statements dealt with data. Personal data should be owned by that person, while an anonymised data layer was needed belonging to the public. Raw data was still needed in eg research, but should not be shared in public. The industry was prepared for sharing of safety-related data but needed to protect customers' data. The authorities pointed out that in Japan, a recording device was already mandated, and that social acceptance was also related to liability. Discussions between industry and regulators were essential to reach data sharing.

ES 02:

AUTONOMOUS VEHICLES TESTING - HOW DO WE ADDRESS LEGISLATION DISCREPANCIES?

Moderator	Shailen Bhatt, ITS America	
Panelists	Kirsten McKillop	National Transport Commission, Australia
	Jennifer Cohan	Delaware Department of Transportation, USA
	Ken Leonard	ITS Joint Program Office, USA
	Phil Blythe	Department for Transport, UK
	Claire Depré	European Commission, DG MOVE

Opening the session the moderator remarked that 3 years previously, when at the Colorado DOT, he had been asked whether a proposed autonomous truck test trip was legal and had replied that it was "not illegal". He noted that operating in a grey area when testing was not a good place to be especially as the test was ultimately linked to reducing fatalities.

Kirsten McKillop took the audience through the current regulatory framework for vehicles and drivers in Australia where there were different regulators for vehicles and drivers. The Commonwealth was responsible for vehicles, and the States and Territories regulated in-service (regulation of human drivers) and vehicle registration, licensing and civil liability. The testing of Automated Vehicles on public roads conflicted with laws so some form of exemptions or permits was required and Ministers had agreed that a level of national consistency was needed. In May 2017 the NTC issued testing guidelines to reflect a need for a national level of prescription and common levels of predictability. The States could implement the NTC guidelines through their own legislation using exemptions or permits but must follow the same criteria. Ministers had made it very clear that they wanted end-to-end regulation and to go beyond enabling trials with by enabling safe and commercial deployment for all levels of automation ie SAE L3 - L5..

A key challenge for Australia was the Commonwealth/States split and also how regulation of the vehicle/driver split when it came to regulation of AVs because the AV was acting as both vehicle and driver. The NTC was working on a national framework for both testing and deployment and has initially identified 700+ barriers to deployment. There were 5 key issues:

- Who was in control of an AV?
- How to ensure AVs were safe when they first entered the market?
- How to ensure AVs operated safely throughout their life on the road?
- How to manage injury insurance for AVs?
- How to manage access to data?

Ministers had decided that the Commonwealth body as vehicle regulator would continue to regulate the first supply. They had approved the creation of a new entity the Automated Driving System Entity and manufacturing companies would self-certify their ADSEs against 11 safety criteria (similar to the NHTSA criteria). There would be a purpose-built national law to regulate the on-road operation of AVs. Other decisions include the ADSE being deemed to be in control of a vehicle when the ADS was engaged; fallback-ready user obligations requiring sufficient vigilance to be able to respond to ADS requests and failures, and regain control when required; and motor accident injury insurance to cover crashes caused by AVs. Driver testing, licensing and in-service activities with a human driver would remain at State and Territory level.

Jennifer Cohan began by asking the audience how many thought AV regulation should be at federal level rather than State and did not get a clear response. She commented that this reflected the practical problem in the USA of a lack of cross-border consistency making it difficult to drive across the States. This situation was perhaps addressed by the slogan of "fail-forward fast" (ie learn from temporary setbacks). Looking at testing legislation from a State perspective Nevada was first to regulate and since then 21 States had passed legislation. Those that were in front were having to go back and revise. This perhaps reflected their being broadly three types of legislators –

- Progressive – they like new and shiny so support a quick reaction
- Stick foot in – I'm interested but not sure so we're not first or last
- Ain't going nowhere near that

Federal government regulated the vehicles and the states the driver (like Australia) but as noted earlier AVs were both vehicle and driver. The technology in this area was moving quickly and if public policy did not move fast enough then the US would be left behind. We also needed to think about drivers – what would driver education look like in the future? Would established, more senior, drivers trained traditionally have to be re-trained?

Ms Cohan felt that legislators' time was being wasted trying to decide if AVs would be a threat or a benefit for public transport and this was pointless given that in nearly all States public transport needed all the help it could get. The key issue was quality of life and it was a mistake to get legislators involved so soon and so deeply regarding AVs. In some ways Shailen Bhatt's grey area in legislation 'not illegal' was to be preferred as it gave scope for experiment.

Ken Leonard also conducted a quick survey asking the audience who thought Society was ready for AVs – again no clear answer. He noted that AVs held many attractions such as benefits to safety, fatigue, impairment, distraction, mobility for rural areas or/and impaired drivers, system efficiency, convenience when travelling long distances etc. There was a great deal of work under way but a strong regulatory approach was highly unlikely in the USA at this point. Typically, an administration in its third year issued 50 sets of regulation a year but the figure for this administration was just 15. However, this should not be read as silence on the key transition issues.

The DOT had issued AV 3.0, a flexible framework for working collaboratively with state and industry partners to advance technology and the emerging AV environment. Include how to work with US DOT, clarify policy and roles and provide multi-modal safety guidance. Key policies and actions included:

- Safety first
- Technology neutral but not agnostic as there is concern about AVs performance
- Modernise regulation which also involves de-regulating eg AVs will not need wing mirrors
- Encourage consistency of both regulations and operation at a State level including privacy
- Have introduced voluntary safety assessments, industry assessing safety, started with 2, now over a dozen
- Support for the power of demonstrations to help understand more about AVs with $60M recently awarded for 8 projects on safe integration of ADSs

There were some internal housekeeping issues needing resolution: NHTSA regulates vehicles, FMCSA regulates drivers of commercial vehicles but as before an AV is its own driver so who was best placed to regulate the driverless vehicle?

DOT were working with the National Institute for Standards and had produced a technical report on safety assessment methodologies. Mr Leonard closed by commenting that while there was a great deal of work under way there was still much to do!

Phil Blythe began by describing the UK Industrial strategy which addressed four main topics – the "Grand Challenges"

- AI and data
- Ageing population
- Green and clean
- Future mobility

Automated and electric vehicles were therefore very much at the heart of the strategy. The UK was the first country in the world to produce a Code of Practice for testing AVs. This was an essential start but the bigger challenge was how to get them on the roads – safety needed both the right regulatory environment and opportunities for inward investment. Trials and demonstrations were seen as key steps on a path to future mobility. To support this the Government had invested £300M with industry matching that sum. The Centre for Connected and Autonomous Vehicles was coordinating this work and was also looking at regulation where a three-year project was underway jointly with the Law Commission to review legislation for automated driving. The first phase of studies aimed to articulate what future regulation should look like and in the week before the Congress a public consultation had been launched.

The first major legislation, the Automated and Electric Vehicle Act, had passed into law at the end of 2018. It aimed to look at the key processes beyond trials so for example was also addressing insurance. There was a lively longer-term research programme covering autonomous taxi services (Greenwich), autonomous buses (Edinburgh) to address traveller reactions to autonomous public transport, freight and logistics trials including platooning on the M6 motorway. This programme included studies by the Department's Agencies responsible for vehicle and driver licensing.

Prof Blythe closed with a message from UK Ministers that AVs and their testing must be designed for the user and "market pull" rather than a "technology push". The automated and autonomous world was exciting but it was essential to get users at the heart of studies and think about doing things differently – for example how to manage the handover for a Level 3 vehicle ? What would a future driving test look like? Were we at risk of deskilling driving? As was often the case the 'soft' issues were harder than the technology ones.

Claire Depré stressed the European philosophy of seeing a bigger picture: Connected and Automated Mobility. Policy development started with the connected / cooperative aspect and connectivity was the first enabler. AVs can work without it but it is seen in Europe as a major help in moving AVs into real life. Managing AVs was supported by a different approach in Europe as there was an EU-wide type approval. If devices or vehicles were not approved it was possible to apply for a derogation and so get a vehicle on the road. Member States assessed, validated and submitted for their own country and then consulted for a neighbour's agreement to let the vehicle go from one country to another.

The system described worked well but it was felt that something more was needed to get more consistency across the Member States so guidelines had been issued to encourage the testing of more advanced types of vehicle across borders. Complementing this there had been production of enabling legislation such as the General Safety Regulation which set out the safety technologies and design features that must become standard for all new vehicles. This included event data recorders, standard approaches to pedestrian recognition and a potential link to UNECE work on cybersecurity.

In 2016 there was a big effort on testing with Ministers giving a mandate of enabling automation on the road by 2019. Europe was not in a position to deliver to this timetable with more work needed as "learning by doing". Despite there being many demonstration and test facilities we still did not know enough about AV deployment especially understanding how the technology worked and its impact on the wider mobility environment so the Commission have set up a platform for a common research agenda to acquire the knowledge to be able to regulate reliably with strong emphasis on evaluation and data sharing.

The platform would be as open as possible with wide involvement across Europe but also by road safety colleagues who do not yet see AVs featuring in their proceedings. The platform was looking at AV impacts in 3 areas: reducing emissions, reducing congestion and reducing fatalities.

Ms Depré reflected on whether AVs were a game changer? Automation could be but would just making vehicles smarter change their occupancy and usage? We needed to use technology differently and as Prof Blythe said focus on people not vehicle technology.

Points arising in questions and discussion

- It's essential to plan how to manage mixed fleets. Over reliance on automation could be a significant problem with large gaps in the types of vehicles in service but gaps too in driver skill sets. If accidents occurred because of inadequate forward planning it would set back the whole automation and connectivity programmes
- Perhaps we need to think differently about risk? In many countries road safety is driving AV developments and the rationale is removing human error. However public surveys show high level of distrust coloured significantly by a single reported AV accident, yet we accept very many accidents on our roads now. Politicians don't like risk; and giving a safety assurance doesn't mean people will not die – "vision zero" will never happen. We need to be able to say what is an acceptable level of operation and risk and that needs more trials and more evidence.
- Will automation de-skill drivers and pose a safety risk?
- Where is the "sweet spot" for regulation – too soon means revisiting; too late may mean missing out
- Having a grey area in legislation is a barrier as acceptance of AV accidents is much lower than for conventional vehicles. We accept many more so need to change the narrative

ES 03:

AUTONOMOUS VEHICLES TESTING - HOW DO WE ADDRESS LEGISLATION DISCREPANCIES?

Moderator	Mara Bullock, WSP Canada	
Panelists	Mahmood Hikmet	Ohmio New Zealand
	Katsuya Abe	Ministry of Land, Infrastructure, Transport & Tourism, Japan
	Malcolm Dougherty	Michael Baker International, USA
	Rossella Panero	5t/TTS Italia, Italy

Opening the session the moderator commented that the Gartner Hype Cycle placed Level 5 autonomous vehicles at peak over-hype which suggested that there was fertile ground for the session's discussions!

Mahmood Hikmet began by asking what we wanted from connected and automated vehicles – not a technology specification but use cases, If we assumed that all travellers wanted to reach their destination as quickly as possible then subsequent decisions would be taken to benefit individuals rather than benefit the system, but if all travellers behaved in this way it would be unsustainable and congestion would result. He described a spectrum of decisions – greedy at one end where it is about you and non-greedy at other where it is about the system and making decisions that are better for everyone overall. To economists and similar this was the Tragedy of the Commons – if everyone acted in their own self-interest in a shared-resource system they would be motivated to take actions that would be bad for everyone. The key was to have knowledge of what was happening elsewhere.
Ramp metering gave a good example of the need to get the wider picture. A local installation could simply look at the waiting queue and the scope to allow vehicles to join the main road but the better process was to look at ramps downstream and only let vehicles through when there was some benefit for all. Non-connected AVs could take decisions only on the basis of what they could see around them. To get optimal benefits for the maximum number they needed "vision" from sensors or/and connectivity. AVs used as a part of public transport needed to have the goal of delivering maximum benefits for the many not the few so they needed to have access to system-wide vision to enable the globally optimal decisions to be taken.

Rosella Panero argued that the mobility sector was changing very quickly for many reasons: new policies, behaviours, technologies, business models and competition. Consequently the role of public authorities was being changed – on mobility issues authorities traditionally satisfied their citizens' mobility demands by providing transport services and infrastructures; guarantee sustainability of their cities and regions, especially now at a time of increased urbanisation, with

sustainable urban mobility plans (SUMPs); and support industry development with incentives and policies. A good public governance system ought to be able to get a good balance of intelligent planning, meaningful vision and regulatory action to manage the introduction of AVs and other new solutions into the provision of public transport.

Moving from city levels to national, Italy officially started its "Smart Road Experimentation" programme under a Ministerial decree in 2018 which authorised the testing of technology solutions and the adaptation of the Italian infrastructure network. Regulatory work was continuing and an updated Regulation was expected fairly soon. The purpose of the decree was two-fold: transform the existing national road network into a digital and intelligent one, able to connect with the new generation of connected vehicles and so provide real-time traffic safety information to drivers; and launch the testing of autonomous cars on urban and national roads in specific studies authorised by the Ministry and led by local authorities, car makers, universities or research centres. The Italian Government had also established a "Smart Road Observatory" to support national and local smart roads initiatives with a focus on safety and security.

Malcolm Dougherty opened with the warning that from observing the CAV field it was clear that many things in technology would happen faster than expected – but the opposite was also true. It was particularly relevant for the transit sector to give guidance on how to deploy to obtain all possible benefits and no unintended consequences eg for space utilisation an increase in zero occupancy vehicles would be no better than single occupancy; and AVs shifting people off public transport would be a distraction. Public acceptance was also key. The public seemed comfortable using passenger rail where no operator is present but seemed to be much less accepting of an autonomous bus on a road – perhaps because they are less exposed to them. There were undoubted benefits for transit from using L2 or L3 technology with connectivity eg allowing equipped vehicles to use hard shoulders on congested roads or running buses more closely together in urban areas to increase carrying capacity.

We were in the middle of a wave of technologies arriving at different times and in different situations and we needed to keep reminding ourselves of the problems we are trying to solve and the goals – moving people and goods more efficiently and effectively. Testing and trialling remained important for understanding technology and its social acceptance but need to move past testing and into pilots involving the public and then deployment. Above all we should: build the technology into the system and be careful not to build system around the technology.
A good example of working with what you had was a project by the Jacksonville Transportation Authority in Florida to use autonomous vehicle technology to modernise then expand the Downtown People Mover – an elevated monorail. The rails would be replaced by a smooth running surface designed for increased numbers of, smaller vehicles running at high frequency with platooning capability for higher capacity service. The concept offered operational flexibility, the possibility of at-grade extensions to nearby neighbourhoods and other expansions. Trialling using an elevated system was ideal for initial AV transit deployments.

Katsuya Abe said that he would focus on a reality issue – the challenges of introducing AVs into public transport operating in hilly and mountainous areas. A number of Field Operational Tests had been implemented in rural areas; the underpinning reasons included: exploring how to deal with a rapid ageing society (55% of the rural population is 65 or older); testing ways to provide adequate commuting services for senior citizens who had surrendered their driver licences, researching how to provide public transport in rural areas, and finding ways to deal with the ageing of professional drivers (around 40% of truck drivers were over 50).

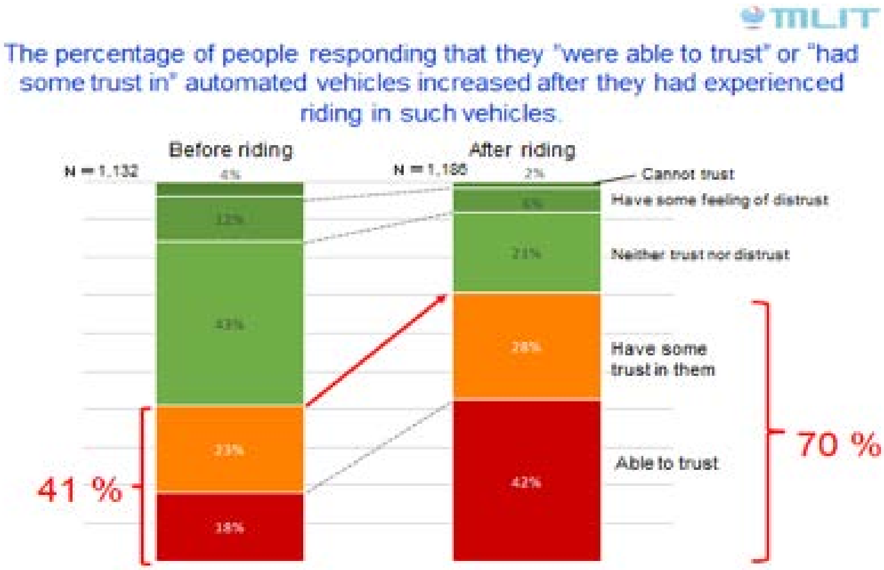
The tests included technical verification of the possibility of designating dedicated driving routes and also implementing adequate V2I technology. Alternative business models were evaluated by transporting agricultural products in the mixed passenger-cargo transport and by trialling different methods of card payment. A major study was assessing users' reactions to the new technologies using questionnaire surveys and observers who participated in trials as passengers. Over 70% of respondents said that they felt able to trust AVs, a significantly increased change in attitudes toward the reliability of ADS before and after actually riding in vehicles. – Participants were asked for their concerns with respect to automated driving; these were a fault in the vehicle (in particular the vehicle running out of control or suffering a cyber-attack) or the occurrence of a traffic accident.

Mr Abe reported some very favourable results from the FOTs regarding their contribution to reliable public transport in rural areas. Passenger acceptance was high and increased after direct experience; there were cost savings for bus operations as semi-paid volunteers could replace professional drivers without a loss of efficiency; even slow speed AVs could be integrated into regular bus services to connect local homes with the regular bus stops.

Points arising in questions and discussion

- AVs are unlikely to yield labour cost savings in the short term but for the longer term savings in many situations were probable.
- We need to communicate our science and engineering in non-technical ways to prevent hype and help users get acclimatised to developments and make realistic assessments.

- We need to look at whole systems to get benefits rather than individual technology elements
- Introducing AVs is more than adding vehicles to the park – the AVs represented around 40% of the whole service, infrastructure was also 40% but management systems were needed and were a further 20% of the overall system.
- If we are not willing to take some element of risk we will never get close to vision zero.
- We are currently "accepting" high levels of fatalities which relate to human error. If deploying AVs halved the overall fatality rate would we tolerate this lower rate when the accidents and fatalities were related to computer errors?
- We are still in the "early adopters" phase and it doesn't help to have some decisions always under public scrutiny as the tendency then is to do nothing to try to be safe; failing is an important part of the journey.



(Katsuya Abe Ministry of Land, Infrastructure, Transport and Tourism, Japan)

ES 04:
FREIGHT PORTS AND CROSSINGS

Moderator	Richard Easley, E-Squared Engineering, USA	
Panelists	David Foo	Maritime Port Authority of Singapore
	Lance H. Kaneshiro	Port of Los Angeles, USA
	Xinming Wang	Suzhou City Transport Bureau, China
	Phanthian Zuesongdham	Hamburg Port Authority, Germany

The moderator explained that there were two linked ports sessions in Singapore: ES 11 would address primarily inland issues; ES 04 was focused more on the maritime side. These sessions were also the first of a series on ports and freight with the second in Los Angeles 2020 and the third in Hamburg 2021. They were organised to demonstrate the importance of ITS technology in freight and would explore the processes from when you order something online and the key roles of ports in what follows.

David Foo noted that the maritime industry was very complex with 90% of world trade moved by sea. There were many different networks and processes; the industry was also one of the later movers into digitisation but efforts had accelerated over the last couple of years and it was in disruption. Currently there were six key trends:

Key trends in maritime transport (David Foo, Port of Singapore, ES 04)

Digitalisation of supply chains had led to an increased platform economy. Ports were used to harnessing data – Singapore collected 12M different data points every day to help gain better insights. System interoperability was essential or the supply chain would break. It was recognised that to get the full benefits from digitisation it was also necessary to invest in different technologies. In many cases the benefits were obvious – a ship could arrive at a port with a berth and support services ready, so did not have to wait at anchorage, This coordination also has a positive impact for the environment.

A major goal for the industry was streamlining of documentation to avoid the need to deal with separate companies for processing and paperwork, a one-stop-shop. This meant that Governments and port authorities also needed to digitise systems to ensure the necessary permissions were granted for port arrival but for operators the results were full end-to-end visibility of the vessel and its cargo. Singapore was aiming at a maritime single window for all documentation enabling better scheduling for vessels, for water, fuelling, garbage, repairs. Today it was necessary to fill out 16 forms and deal with 3 different agencies.

Achieving "just in time" services for ships in future would mean less time in port, greater efficiencies in port and business conducted faster and more efficiently. There was also a need for global standards. Ships needed to be digitised as well as the cargo aspects which meant not just data standards but also interoperable global connectivity to deliver communications with ships in real time. The maritime single window project was progressing well for Singapore and was about to trial interoperability with other authorities to avoid a need to recreate information for another port. In the background were three key challenges: cybersecurity; collaboration between all parties; and building an ecosystem with alignment of people, processes and technology.

Xinming Wang explained that he would share some views on the logistics solutions to improve the quality and efficiency of Suzhou Port. Suzhou was a 4,000-year-old city in Jiangsu Province in eastern China, 80 Km west of Shanghai along the Yangtze River. In 2018 Suzhou Port ranked 7th in the world for cargo throughput. It handled three main types of shipping: Yangtze River lines, domestic lines covering most of the ports in China's coastal areas, and short-sea lines covering 20+ countries and regions in East and South East Asia. The port had an extensive network of highways connecting across the region and also within the port and a waterway network with the Yangtze River plus a deep-water channel from Shanghai to Nanjing passing through Suzhou.

The port had developed an intelligent control system for bulk cargo with conveyor belts, coal blending, metering management and on-site video monitoring remotely controlled. There was automated inspection technology in the container terminal for loading and unloading operations. Container information was collected automatically by Image recognition. The system improved the accuracy of container terminal movement and raised the efficiency of dock loading and unloading operations. Suzhou could handle chemical raw materials and hazardous products using 851 storage tanks with throughput of ≈32M tons in 2018. It used video surveillance by various port operators and an information platform

Port and City of Hamburg (Phanthian Zuesongdham ES 04)

that integrated the declaration and approval of dangerous goods, security risk management and emergency response. This enabled real-time, visualisation, early warning and safety supervision.

For the future Mr Wang explained that optimisation of transport infrastructure had become a strategic planning aim in China. The target was reducing the volume of road transport by transfer to rail and waterway. The smart port would be developed to be more cost efficient, more effective and safer by using autonomous trucks and unmanned automatic loading and unloading of port terminals. These deployments would also help to address labour shortages and driving while fatigued, and reduce labour costs, safety risks, energy use and emissions.

Lance Kaneshiro spoke about the port of Los Angeles, the largest cargo gateway in the USA delivering to around 15,000 trucks and 50 trains a day. Given the volumes involved there was a constant search for efficiency gains which tended to focus on 3 primary points – better use of the land space; improvements in the supply chain process; and introducing technology to get more efficient operation within the port. Digitisation was already occurring in different parts of port operations to some degree but applied to localised and specific functions with individual operations for individual operators. Taking efficiency to the next level would require working along the whole supply chain which was now possible with the data becoming available and the associated technology to transmit and aggregate it.

The Port Optimiser project was developed with the stakeholders who would benefit from it. It brought together large data sets for analysis and aggregation in the cloud to prepare for provision to stakeholder, this has raised the visibility of cargoes from 2-3 days in advance to 10-14 days enabling more productive, reliable and efficient movements. Various upgrades to the system were under way including a universal appointment system to allow truckers to schedule pickups at any terminal as opposed to having to go to each terminal. This would then be extended to cover rail.

The port had a cleaner action plan focused on emissions reduction and had achieved the 2023 targets through improved port efficiency, incentivising the use of cleaner ships, using shore power (connect to electricity and turn off diesels) and the use of cleaner equipment on the dockside. Over the last 2 or so years there had been extensive investment to improve physical and cybersecurity reflecting the enhanced exposure as digitisation increased.

Phanthian Zuesongdham painted a picture of Hamburg, the third largest seaport in Europe handling 9000 freight vessels annually plus 3 cruise ship terminals and feeding 200 freight trains a day and thousands of trucks. The port was more than 800 years old, In the middle of the city and 120 Km inland from the sea. The driver of innovation and ITS deployment was the need to balance the growing cargo traffic and the growth of the city and citizens. There was a major constraint in that it was not possible to expand the port to cope with increases in global trade so instead the port must process its business, and use its land, more efficiently.

These problems triggered the smart port campaign with three strategic areas of actions: infrastructure, traffic and cargo flows, and sustainability.

Projects to improve the installed physical and digital infrastructure were handled internally. Work on how to improve the management of traffic and cargo flows was done in close cooperation with some of the 1000+ stakeholder companies based in the port itself, to further streamline operations the port has implanted the Single Maritime Window for EU Member States. Regarding sustainability on-shore power supplies will be enhanced to help reduce gaseous emissions. The port has pioneered the use of drones for catastrophe management, such as flooding, and fitting sensors to monitor the build-up of tidal silt in order to create geofences for the ships' navigation. Work has started to build a digital twin of the city and port to support modelling of different ways to manage the movement of the 1M or so passengers from the cruise ship terminal.

Points arising in questions and discussion

- **Qn:** There had been many references to interoperability in the presentations but it still looked as if individual ports were developing systems to integrate locally rather than regionally of globally. How likely was it that shippers would be able to benefit from one single interface? PZ: we need to move on from document exchange to data set exchanges and a standard data model to enable wider interoperability. It would be hard to persuade ports to give up legacy systems but much more workable to look for the data route. DW: Ports need to be platform agnostic and open to document / data exchange in many ways. LK: I don't expect to see one global standard but a convergence of current initiatives to simplify interoperability.
- **Qn:** We have heard different approaches to digitalisation but it will not stand still – do we need to work closer together? DF: As we become smarter we open the way potentially to more threats so we need to work closer together on designing to be safe

Key points:

- Although Maritime might have been late to the party deploying ITS solutions and technology was already making a significant impact. Could they catch up and realise the benefits of technology for the maritime sector before land transport?
- Technology was bringing benefits to the whole end-to-end supply chain, not just for one port. But interoperability of platforms would enable data sharing globally and bring the potential for different optimisation platforms to work together
- Technology was enabling a reduction in paperwork, "berthing just in time" etc enabling greater utilisation of a space that is invariably limited.

ES 05:
TRANSFORMING MAAS FROM IMAGINATION TO REALITY

Moderator	Jacob Bangsgaard, ERTICO - ITS Europe, Belgium	
Panelists	Shu-Chuan Chang	Kaohsiung City Government, Chinese-Taipei
	Roger Millar	Washington Department of Transportation, USA
	Maximilian Eichhorn	Siemens Mobility, Germany
	Chris Bennetts	Transport for New South Wales, Australia

In opening the session the moderator noted that MaaS had featured with an increasing profile over the last few Congresses because the concept, the imagination, was moving steadily towards actual deployment of MaaS and other smart solutions to city problems. The Panel was a mix of service providers and integrators, and city, state and national regulators.

Shu-Chuan Chang from the Kaohsiung City Government in Chinese Taipei explained that Kaohsiung was a harbour city and one of at least 80 worldwide thought to be deploying or planning for MaaS. The city had around 2.8M residents with about 2M scooters which were the main transport mode however this high usage brought some serious societal problems and costs, including air pollution. Over 60% of accidents were linked to scooters and they also caused traffic jams during rush hours. The city was promoting public transport and usage was growing slowly. The city's MaaS project started in December 2017 with the aim of encouraging scooter drivers to use public

Goals of the MaaS project in Kaohsiung City, Chinese Taipei (Shu-Chuan Chang ES 05)

transport services by providing an on-demand, single mobility service for integrated multi-modal transport branded MeN-Go. There were three specific objectives: decrease the use of scooters, reduce the numbers of traffic accidents and reduce air pollution.

A number of workshops were held to establish the daily transport needs and pain points of the target user groups (commuters and students) and the corresponding public transport services. Big data analysis on electronic ticket and cellular phone data was used to understand the potential target users' transport behaviour in terms of spatial and temporal distribution, and transport modes used. Users had clear requirements – real-time time saving with a 24-hour service; flexibility meaning available anywhere; high reliability; and cost saving from an affordable price for the future service. The MeNGo service launched has 5 conventional transport modes plus taxi, scooter-sharing and parking. After 12m operation there were 20,000 users and 60,000 passes issued at different prices for suburban and urban usage. Initial user satisfaction was very high.

Roger Millar explained that Washington was one of the most trade-centric states in the USA with around 1 in 3 jobs related to international trade. Transport was important for ensuring a high quality of life but also for social equity and equal access to opportunity. More than 85% of people using public transport walked or rode a bike at the beginning or end of their trip. Active transport (biking, walking, skateboarding etc) served as fundamental, low-cost transportation for people who could not use a vehicle. Those able to afford housing in the cities had access to good multimodal transport but in rural areas a car was the only choice.

Congestion in the State was getting worse and adding new roads capacity was not a practical or affordable solution. MaaS, together with a more managed use of assets, was seen as a potentially workable solution for helping to reducing congestion. The secret to raising productivity was deploying MaaS to boost the use of multiple occupancy vehicles which were a more efficient use of road space, Washington's policy goal was Cooperative Automated Transport where Cooperative meant deploying technology to encourage all modes of transportation to work together; Automated meant automating functions (traffic management systems, fare collection, trip planning and scheduling, etc) or access to various vehicle types (car, van, plane, truck, bus, rail, ferry, bicycle, scooter, etc.) and Transport was the whole system of vehicles, infrastructure, modes, services, etc working together.

The approach to MaaS / Mobility on Demand was bringing together the various services (public transport, ride sharing, bike sharing, payment options, taxis, parking services etc) with a simple front-end app. A number of trials were under way with promising early results. There were two key messages to share – private transport and public transport needed to cooperate not compete; and all stakeholders needed to be involved in and committed to the ways forward.

Max Eichhorn put forward the case for cities to simplify access to mobility for the user. At present just about every service / solution used its own app which was highly inefficient and unfriendly. A far better solution was a city app – a way for cities to manage point-to-point seamless connectivity across all modes covering central traffic control to match the city's strategy and

KPIs; provision of demand responsive transport with flexible routes and schedules; fully autonomous vehicles differentiated by user groups and capacity; shared fleets; and Mobility as a Service linked to various fleet operators.

Cities needed to be able to see the "Big Picture" and make fast adjustments to rules and regulations depending on circumstances. For example, during the Munich Oktoberfest city managers wanted to constrain the use of e-scooters but the first generation technology on the units did not allow this to happen by geofencing and instead the blunt approach of temporary paper legislation and police enforcement had to be used. Similarly, if a taxi service was carrying passengers parallel to established metro or bus routes then the wider interests of the city justified applying a road use charge to the taxi journey to encourage a mode shift.

Chris Bennets talked about developments in New South Wales and Sydney. In 2016 a Future Transport Technology event was organised with a very wide range of stakeholders to take stock of what was being done, where technology was changing, and initiatives that should be taken to try to future-proof deployments. The workshop generated a Roadmap on probable developments and proposed management strategies for short- and longer-term. Five key action objectives emerged:

- Personalise customer interactions. Develop and connect real-time digital information, navigation, payment and engagement platforms so they are simpler to understand, easier to use and can give personalised service.
- Increase the attractiveness of mass transit. Increase automation and apply new technologies to improve efficiency and service frequency and reduce transit times,
- Foster shared demand-responsive services. Stimulate the development of new offerings to offer a greater variety of options and flexibility of choice.
- Enable connected and automated vehicle platforms. Pursue national standards for the road infrastructure, systems, safety and regulatory frameworks needed to adopt greater levels of vehicle automation earlier and identify how best to deliver community benefits.
- Create intelligent transport networks managed with data. Invest in smart infrastructure and collect and use the data generated to enable increasingly efficient, flexible and dynamic service delivery with improved safety, availability, reliability and responsiveness

Regarding MaaS the feeling was that it was still in a pilot phase with no standardised models. Customers indicated that they wanted door-to-door mobility with choices on first and last mile plus choices on the main trip element with clear cost information. A platform approach was chosen for trialling to minimise entry barriers for new service providers and a MaaS data sharing specification was published. An Open Data community was launched to emphasise an open data approach and encourage the development of an open data user community. A number of pilots and trials were running with particular attention to integrating a range of options for users to choose from.

Overall Transport for New South Wales had changed the way it engaged externally and interacted with delivery partners and was moving quite quickly from being the single supplier to being a facilitator and building strong partnerships with the private sector for delivery.

Points arising in questions and discussion

- **Qn:** was it difficult to adopt open payment rather than a plastic card linked to a credit balance? CP: It was complicated but the right way to go as removing the need to belong to a card scheme removed a barrier to using services
- **Qn:** Although the speakers had described geographically large schemes most MaaS services tended to cover smaller local areas. What were the challenges to having MaaS scheme roaming between cities or even countries? RM: We're looking at that in the USA with the Mobility on Demand Alliance. The key links were between transit system operators and state governments who wanted data, and improved users' experiences from service providers. We know that providers like the idea of some form of standards template for a scheme that is adopted by multiple states. The problems so far have been around data – what is proprietary or personal and what isn't; data security; who owns what; who can use what. We have learned a little from customer pressure to have roaming for tolling payment schemes which took a very long time to resolve. ME: industry prefers bidding once for the 'big fish' contracts rather than many competitions for small units. But the standardisation ought to be wider than national; there's no good reason not to be global and here Europe has an advantage as there are 20+ countries working together on this issue. S-CC: the two Taiwan schemes do not integrate at present; this is not an issue as one scheme is primarily for tourists but we intend to move to enabling roaming.
- **Qn:** a lot of transport was being disrupted as a result of technology change and in many cases there were implications for employment – any advice from the panel? RM: change and disruption don't just impact employment; they potentially impact everyone and everything involved. The absolutely key factor was that if change wasn't done with people they tended to think it was being done to them. All shades of stakeholder engagement need to be brought into the planning at the earliest possible stages and any prior "no go" areas that participants' have must be dropped. The new mobility involves everyone working together. ME: the hardest thing for a commercial

body to accept will be recognising that although you have the request for a service a different company is better placed to fulfil it because of reduced energy consumption and reduced environmental impact. Organisations are going to have to adapt to being team players not solo stars. CP

- **Qn:** MaaS is a solution to meet different parties' interests – which should be considered the most important? S-CC at different stages of a project different parties needed to be given priority but overall it was the traveller. RM: it has to be the customer. Policy goals are pointless if nobody is prepared to get involved. ME we are supplying transport services to meet a range of societal demands so it is the 'customer' in the widest sense ie not just the traveller.
- **Qn:** Are there any key factors for achieving behaviour change and accelerating the move away from the personal car? CP we found that addressing payment options early removed a barrier to using public transport but we also realised later that the payment 'cap' was popular as it removed an uncertainty as people knew what would be the maximum charge.
- The moderator invited one last thought from each panel member – CP: open everything to encourage industry to participate ME: technology can solve the problem you just need to think through how you deploy it; RM: stop thinking of data as an asset instead think of it as a common good to help everyone meet goals SC-C: ensure that city services are truly multi-modal.

ES 06:
MANAGING URBAN SPACE

Moderator	**Johanna Tzanidaki, ERTICO – ITS Europe, Belgium**	
Panelists	**Chien-Pang Liu**	Ministry of Transportation & Communications, Chinese-Taipei
	Wai-leung Tang	Transport Department, Hong Kong
	Andy Taylor	Cubic Transportation Systems, USA
	Tassilo Wanner	Lilium, Germany
	Augusto González	European Commission, DG GROW

The moderator launched the session by discussing how planning the use of urban space should not be limited to curb management (the 2D aspect) but should also be about urban space management (3D), given the advent of urban air vehicles for delivery and passenger transport.

Tassilo Wanner began by introducing Lilium, which was unique, being the first electric transition aircraft, that was ideal to operate in urban space. He described its characteristics:

- a 300 km range and able to fly at 300 kph
- zero gaseous emissions and virtually no noise in cruise flight
- can be used for point-to-point and on-demand services
- one pilot and up to four passengers
- a simple aircraft with tilting electric engines

Lilium and the associated operations were designed to fit existing regulations. The airframe was Type Certified as a fixed-wing aircraft requiring pilots with a commercial pilot licence and was built to design and production organisation approval. Flying operations were possible in both controlled and uncontrolled airspace with traffic coordination under existing separation minima and commercial operations permissible With an air operator certificate Lillium could fly from / to certified aerodromes, larger airports (high maneuverability and precision), inner-city locations (low noise profile and high safety level) so was fit for different environments. Lilium would establish fast and affordable on-demand air mobility by offering:

- A completely new approach to public transport in metropolitan areas
- Very competitive pricing, comparable to a taxi ride
- Four times faster than a conventional car connection

These last two points were illustrated by the argument that travelling from Los Angeles International Airport to West Hollywood would take 50 minutes in a taxi to move just 12 miles as opposed to 6 minutes in a Lilium to travel 10 miles.

Andy Taylor likened urban space management in cities to the same management that was required in airspace when aircraft started providing passenger and delivery services so the familiar demand and capacity problems in airspace were what we were now approaching in cities. Sharing data was one of key solutions to managing urban space together with automation analogous to the air traffic control systems that managed conventional airspace. He proposed that Mobility as a Service (MaaS) schemes should be considered as public and private solutions for urban space management since the urban landscape is rigid – we cannot build new roads – and to increase capacity it is better to use the assets that we already have. The key was to answer the questions:

- How can we shift people's travel patterns?
- How can we manage freight traffic in and out of the cities?
- How do we manage construction vehicles?

He argued that MaaS could provide better information to make journeys seamless, particularly about information and about different modal choices. People would need to have confidence in the information so accurate vehicle arrival information would be critical. If the trust in the information was not there MaaS would not work. As a final thought he suggested that MaaS would force data sharing. In Sydney an integrated congestion management programme was being developed that had data from all modes and was co-located on a single platform. This example showed how data sharing could force silos to be broken down.

Wai-leung Tang said he would discuss managing urban transport space in a vertical city –Hong Kong. He argued that his city was the most vertical because of a population of 7.49M, a 275 km2 built-up area and 355 buildings over 150 metres high. This compared with Singapore (5.64 M, 518 km2 built-up area and 89 buildings over 150 metres). He went on to discuss mobility in Hong Kong from underground to airspace:

- 90% of daily passenger trips used public transport
- 70% of the population was within 500m of a rail station
- 14% of traffic lanes were elevated or underground
- It has the world's longest bridge-tunnel sea crossing at 55 km

This created many challenges:

- 362 licensed vehicles for every km of road – a very high vehicle density
- Land scarcity – 72% of fleet size (570,000), 4% per annum car growth, an increase of 0.5% per annum road length, and an increase of 0.9% parking spaces
- Need to have resilience for a highly compact city
- An ageing population with 16.5% of the population over 65 in 2016 and an expected 31.1% of the population over 65 in 2036

The overall approach to managing urban space was called SIGMA: Safe, Informative, Green, Mobile and Accessible and was built around three components: the use of technology; traffic management; and promoting walkability. The goal was managing urban space by moving from mobility to liveability and changing travellers' mindsets.

Technology in use included

- "HKeMobility" on smartphones to disseminate real-time traffic information
- Free flow tolling system to eliminate toll plazas
- An automated parking system to maximise the spatial efficiency
- Intelligent traffic signals to maximise junction capacity and reduce delays
- Real-time vehicle and pedestrian detection
- Dynamic green times for different road users
- Privacy protection

Traffic management used advanced control and incident management system with automatic incident detection based around 1200 traffic detectors at strategic routes and major roads. There was a congestion charging scheme in the core business area

Hong Kong's approach to promoting walkability is shown below

Promoting walkability (Wai-leung Tang, Hong Kong Government ES 06)

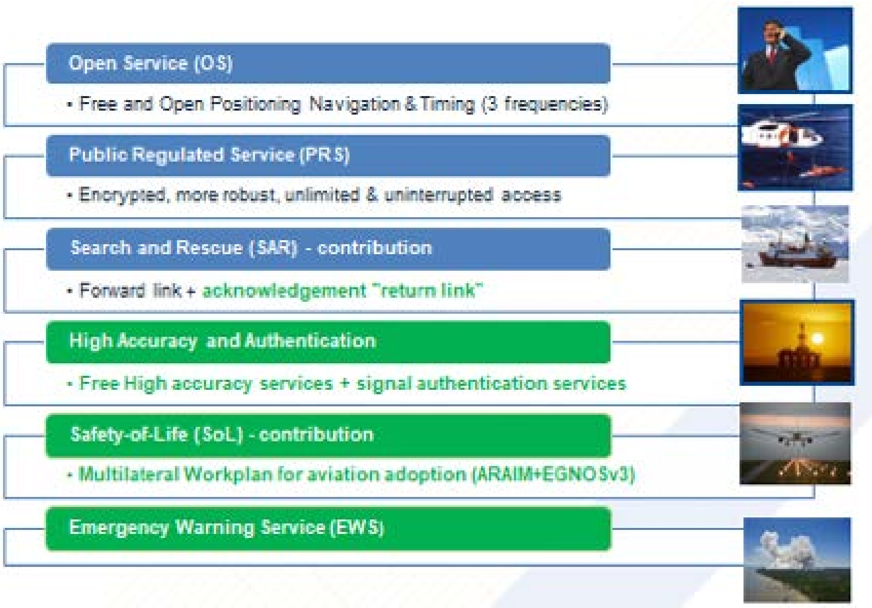
Chien-Pong Liu discussed how trends in Taiwan had created urban space management issues, including a population of 23 million, 8 million private cars, 14 million motorbikes, and an average vehicle ownership of 1.1 vehicles for people over 15 years. This situation had created a market for unmanned vehicle rental services for electric motorcycles. Currently there were two companies and a surging sharing mobility market supported by:

- Regulations encouraging managed shared motorcycle services in Taipei and Kaohsiung
- Parking allowed at roadside parking spaces with management in place
- The companies paid a premium and deposit to the local authority
- Company business plans needed to be approved by the local authority

The turnover rate often reached 10 times per day and scheme memberships was over 300,000. The cities did not have a good understanding of traveller behaviour and were wondering if sharing mobility would trigger a decrease in motorcycle ownership and freeing of urban space. An increase in food delivery services had resulted in unexpected crashes and loss of life prompting the government to consider fines for not reporting crashes and granting better protection for food delivery workers. More work was needed to be accomplished to identify the relationship between delivery companies and the government.

One step forward was the establishment of the MACES strategy (Mobility as a Service, Autonomous, Connectivity, Electrification, Sharing) for future smart mobility. MACES would be traveller-centered, integrated and service-oriented. Another step was the development of a regulation for unmanned vehicles (the Unmanned Vehicles Technology Innovative Experimentation Act), a framework to allow small scale, live testing of innovations by private firms in a controlled environment (operating under a special exemption, allowance, or other limited, time-bound exception) under the regulator's supervision. It includes self-driving vehicles, drones and autonomous ships, and excludes restrictions in existing regulations.

Augusto González reviewed the development of the European Global Navigation Satellite System (GALILEO); the available services are shown in the diagram:



GALILEO and the linked European Geostationary Navigation Overlay Service (EGNOS) that had been adopted extensively throughout Europe covering:

- Local-based services (LBS): 600+ M smartphones used Galileo
- Timing and synchronisation: there was increasing interest towards Galileo by owners of critical infrastructures
- Agriculture: 50% of GNSS receivers are Galileo capable; 80% of farmers use GNSS
- Surveying and mapping: over >50% of real-time kinematic network service providers had upgraded or were upgrading to Galileo
- Railway: GNSS technology had been included in the European Railway Traffic Management System roadmap in view of its operational and safety benefits
- Maritime: Galileo was IMO recognised as a "World Wide Radio Navigation System"
- Aviation:
  - Over 800 EGNOS based approach procedures in 360 airports in 19 EU countries
  - 60 drone receiver models with EGNOS/Galileo were available on the market
- Road:
  - In-vehicle-systems were car embedded platforms that delivered entertainment, infotainment & personal navigation applications

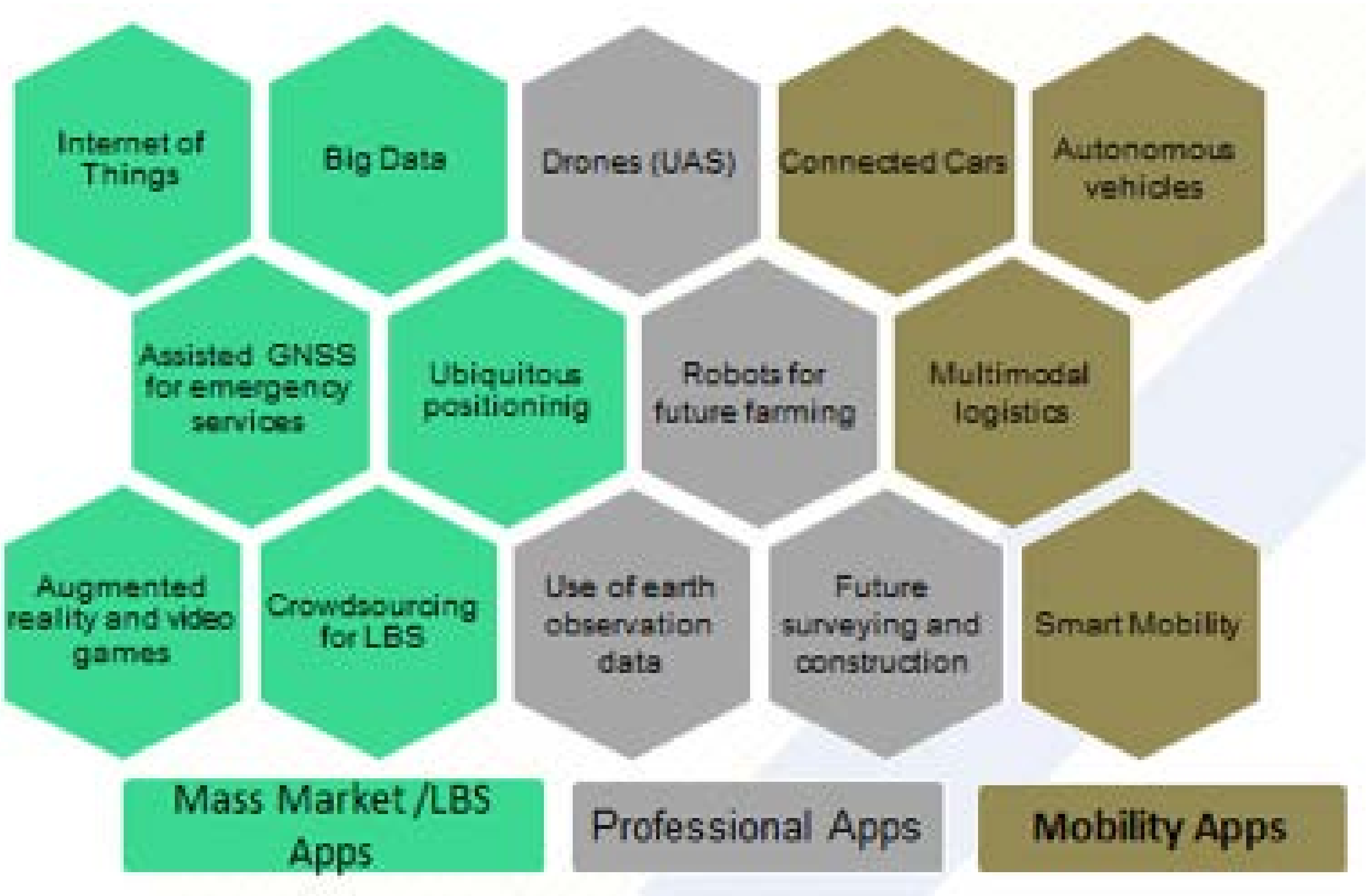
- Personal navigation devices are portable standalone devices specifically designed to run road navigation applications
- Insurance telematics are solutions enabling a new category of car insurance with costs depending upon the time, location, distance etc.
- eCall sent an automatic emergency call to 112 in case of an accident, to accelerate emergency assistance to drivers (mandatory in the EU from 2018)
- Road user charging (RUC) applications supported the toll collection based on the actual use of the roads and the management of congestion
- Smart tachograph leverages on GNSS to support road enforcers to control the driving and resting periods in commercial vehicles (in EU from 2019)
- Hazardous goods tracking devices were aimed at providing the robust location of a cargo transporting dangerous products, waste or livestock
- Advanced driver assistance systems are aimed at automating driving tasks mainly to improve road safety

He noted the advantages of using multi-constellation (GALILEO+ global positioning system [GPS] + GLONASS + BeiDou) when obstacles blocked the signal and reduced the number of visible satellites. The availability of more constellations ensured a furthermore accurate/robust position and increases robustness of the position against jamming because even if a satellite was not available or providing incorrect data, a reasonable accuracy would be achieved.

GALILEO alone had excellent observed precision, dual frequency in open service, authentication for the open service, encrypted authentication, and high precision. With EGNOS there was enhanced precision and integrity, features that are crucial for autonomous driving.

Points arising in questions and discussion

Discussions were limited due to the amount of time the five presenters needed. An audience question asked about the role of drones in urban space management. Panellists mentioned their role as potential delivery or survey devices, but none discussed using drones to monitor urban space or drones as potential passenger vehicles.



Technologies and market trends for GNSS in a Smart City (Augusto González ES 06)

ES 07:
MOMENTS OF TRUTH IN MaaS IMPLEMENTATION

Moderator	Brian Negus, ITS Australia	
Panelists	Colin Lim	MobilityX, Singapore
	Neil Pedersen	Transportation Research Board, USA
	Devrim Kara	PTV, UK
	Christof Schminke	Trafi, Germany

The moderator launched the session commenting that many factors made MaaS solutions attractive but a common issue was the extent to which they were transferable without major changes. Colin Lim opened the presentations with a description of Zipster, a MaaS product providing access to all public transport services within Singapore, with a focus on the implementation challenges. The initial product was journey planning, booking and payment across all modes with a carbon calculator and subscription services in the pipeline. It was piloted at a university then steadily rolled out nationally.

He responded to the moderator's question suggesting that one size of MaaS would not fit all cities as the local geography, regulatory framework, population density and stakeholders would require different local-specific solutions, business models and routes to the market. The key entities were the mobility service providers, government regulators and local commuters / travellers. For Zipster it was necessary to get the existing service providers to see the MaaS operator not as competitor but as a way to expand their market by bringing in more business.

Regulators needed to recognise that when designing (new) MaaS schemes they should not see it as an opportunity to over-react to the disruption caused by ride share or micromobility schemes and that creating a public monopoly was just as bad a creating a private one. It was essential to involve all stakeholders in planning and scheme design from the beginning. Public transport had to be a fundamental part of the new product and both payment and ticketing needed to be open source to lower the barrier for new participants. Ultimately the MaaS app had to appeal to the intended end-users so needed to be well-designed, flexible and adequately marketed with incentives to use it.

Neil Pedersen talked about activities in the USA to accelerate planning for MaaS schemes (usually known as Mobility on Demand MoD) particularly by studying what had been done in other countries. There was also a federal mobility management study looking into which regulations and policies needed to be implemented, removed, or changed to make mobility as a service possible within the United States.

It was necessary to note a background US trend of most public transit losing ridership to transit network (ridesharing) companies. The reasons for this were complex but undoubtedly reflected a modern generation used to having apps delivering multiple choices for anything. A key driver for all the work was the concept of putting users at the core of transport services, offering them tailor-made mobility solutions based on individual needs. This implied easy and intuitive access to the most appropriate transport mode or service which would be included in a bundle of flexible travel service options.

The studies of projects overseas had supplied some key lessons for US thinking. Perhaps the most significant was that MaaS needed to be seen as a part of a broader long term regional vision with a range of goals including improving the quality of life, reducing GHG emissions and reducing single occupancy vehicle use. A robust transit network was the backbone of a MaaS system which in turn was a part of a larger, integrated multi-modal network incorporating transit priority lanes, bike lanes, bike sharing, car sharing and micromobility and a single payment system. Key success factors were:

- User-centric approach/customer focus
- Transit stations as mobility hubs
- Partnerships among providers
- Clearly defined roles for public v private sector
- Agreement on Governance systems
- Interoperability/data integration
- Accepting that the app is a means, not the end

Two final thoughts – transit agencies need to rethink their mission to be mobility managers rather than just modal operators. Second, enlightened, educated elected leadership was necessary that accepted a willingness to experiment, fail, and then adapt.

- Service is available when needed
- Convincing modal providers to be part of a larger system
- Private providers trying to develop their own MaaS
- Partnering with Transportation Network Companies
- Seamless connections
- Fare integration
- Multiple operators all agreeing to a single fare payment system
- Making MaaS trips less expensive than a la carte trips
- Privacy issues
- Equity issues
- Public acceptance
- Density of trips to make MaaS workable

Challenges & obstacles to MaaS development (Neil Pedersen, TRB, ES07)

Christof Schminke argued that most cities were uncomfortably placed between yesterday's conditions and tomorrow's challenges. They were expanding while their infrastructure remained stagnant which translated into traffic jams. They tended to rely on legacy procedures to collect data which constrained them from implementing new mobility policies. And residents expected public transport to have the same flexibility, comfort and freedom as they received when they used the new shared mobility or micromobility services which were also disrupting planning and add to congestion.

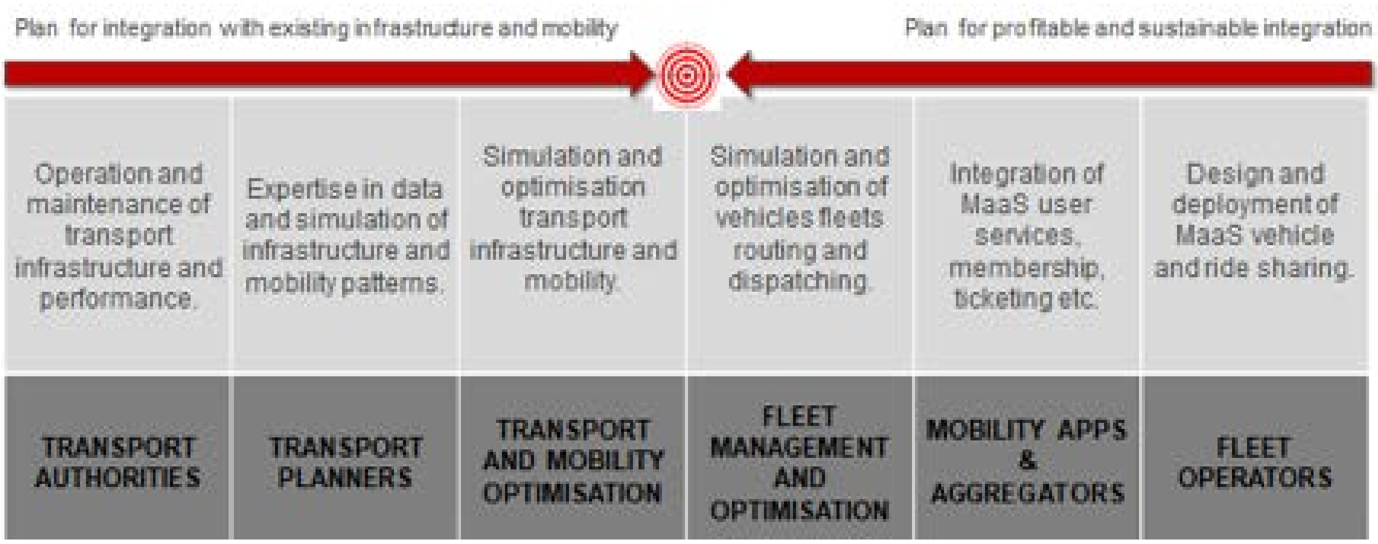
Cities were driven by what was beneficial for the whole population, not just profitable market segments. Therefore, cities needed to take back control and start by focusing on the causes of overloaded transport systems not just on the symptoms, that would then open up new opportunities. It would be short-sighted to rely only on technology; the better path forward was to combine correct mindsets, modern processes, and cutting-edge technology, and to put people's interests first. This prescription implied changes in how we acted and how we thought. Only cities could encourage a change in people's travel habits but if get flexibility, freedom, and comfort from their travel they will leave cars at home.

Achieving such a change could be done by using a centralised city mobility app which allowed residents to find best routes and pay for their trips easily with a master account. Such an app – in other words a MaaS solution – would be based on public transport and connectivity allowing residents of cities to find, book, and pay for all their trips with public transport, micromobility, bicycles, E-scooters, metros, car or ride sharing options etc.

Devrim Kara outlined the need for digital evidence to enable planning transport provision and land use by generating various forms of transport model. He illustrated this with a planning case study in Frankfurt exploring car users switching to MaaS shared mobility and looking to identify the optimal operator model that would provide high levels of service to the customer whilst also demonstrating city wide benefits. The study aimed to examine varying fleet sizes, occupancy rates, operator costs, impact on journey time if there were multiple rider drops, initial wait time and the overall 'fit' with city strategies and objectives. It used a modified transport model to simulate all combinations of input parameters to enable the identification of optimal operational service levels and vehicle fleet configuration. The complexity of the interactions sent the strong message that cooperation of the various stakeholders was essential and also showed that as cities increased in size and demographics changed sharing of all resources would become unavoidable.

Points arising in questions and discussion

- **Qn:** It was argued that one size does not fit all; does this mean every city around the world would build its own unique app? **CL:** cities differ, particularly with regard to the transport managers' powers, so a direct adoption of another city's product is unlikely but I would expect to see elements of the total solutions that were very similar. **BG:** In Australia that some cities are leaning towards a very laissez faire approach whereas others are following a very similar more managed approach. DK: We have noticed in tenders a strong move to look for national solutions that permit city variations.
- **Qn:** What are developments with national roaming solutions and taking the MaaS system beyond transport to, for example, real estate? **CL:** A single solution is unlikely as use cases differ for example a rural MaaS would be different from an urban one and there might be a version for those with reduced mobility. It's still early to give clear views on



Collaboration is key (Devrim Kara PTV Group, ES 07)

roaming solutions where we are looking at the Telco histories and experiences and linking to real estate. **NP:** the USA includes cities that are very different and States that are very different so the use cases will vary considerably and we should expect many different solutions within the same country. DK: the evolution is likely to be suppliers having semi-standard products that are adjusted to suit a particular tender requirement.

- **BN:** A couple of key points so far – cities need to lead with planning using their public transport as the base then form partnerships with the private sector. Second a single MaaS service is highly unlikely but providers need to think in terms of integration of the back end systems, like mobile telephony.
- **Qn:** In planning developments in a city we discovered a digital divide in that some operators were not yet up to speed. There seemed to be a wish for some standardisation for example on data exchange and sharing, privacy, payment systems etc. Why were there no standards? Were we helping monopolies to develop? **NP:** In the US the SAE has decided to take a lead here because the automotive companies are starting to move into MaaS and they require standards. **CL:** The APIs are not clearly defined so moving to standardisation is difficult but a bigger issue is that cities want data to be opened and many private sector organisations are resisting this. **CS:** Cities need to be involved and aware as the development of MaaS will include activities such as road user charging and that is a subject to be managed by the city not by a private sector operator within a monopoly.
- **Qn:** There's the extremes of everything controlled by the city or by a few private sector organisations – how do we find the acceptable central zone described as a "regulated free market"? NP: in the US the American Public Transportation Association was trying to move forward from a city by city individual approach

Moderator – what's the biggest single challenge? **NP:** lack of enlightened political leadership; **CL:** not learning from what others have done; **CS:** cities not being able to state their objectives; **DK:** deciding if MaaS is a public service or a commercial initiative or what?

Moderator – one last priority thought each? **NP:** we need to educate the legislators; **CL:** start thinking about how we pay for it all. **CS:** cities need to act now and experiment. **DK:** look 20-30 years ahead and think how MaaS will fit with the population growth.

ES 08:
TODAY'S MOBILITY: ACCESSIBILITY, INCLUSIVITY AND SAFETY

Moderator	Carol Schweiger, Schweiger Consulting LLC, USA	
Panelists	Susan Harris	ITS Australia
	Amy Ford	ITS America
	Helen Wylde	Connected Places Catapult, UK
	Leslie Richards	Pennsylvania Department of Transportation, USA

The moderator welcomed everyone to a milestones session – the first at a World Congress dealing with personal safety, diversity and accessibility and also the first with an all-women panel. She mentioned a recent study (Sochor & Nikitas) that had established that on many occasions women were more open to changes in the transport paradigm than men, even if they didn't necessarily see a personal benefit but when changes could be perceived as having a strong social character. Safer mobility for women was a major focus for the session; presenters would cover a range of issues that impacted on that including infrastructure design, the lack of women-friendly public transport options and the lack of women involved in the planning of transport mobility options.

It was generally recognised that many women did not feel safe travelling by public transport. In the USA street harassment was a real issue and it was noted that women are concerned about lighting, alleyways, waiting times in public spaces. The lack of safe transport for women and the impact that this had on women's access to employment, healthcare and other critical services would also be examined. Critically, the lack of women in key senior positions in transport meant that safety and inclusivity were often not addressed by either public or private providers.

Susan Harris argued that different types of people used transport differently and were unlikely to be looking for the shame thing from future transport. A study in 2018 on how likely people would be to embrace Mobility as a Service showed that those most likely to adopt MaaS were also likely to be college educated, employed and male. The next bloc most likely to be positive towards sustainable transport options (and negative towards cars) were women.

ITS Australia had recognised the need for a clear leadership role to support the industry's becoming more diverse so had devised a diversity vision to guide internal practices and give encouragement and support nationally – ."As the peak body in Australia for advanced transport technology, strengthen the intelligent transport systems industry and our impact and influence through inclusion, respect and valuing diversity" The underpinning context was that only 21% of contacts with members were with women, and only 15% of delegates at events were women suggesting that the Society was not fully representative of the community it was aiming to serve."

As part of the diversity vision there were three objectives: focus on gender diversity as a first step; leverage gender diversity initiatives to strive for greater diversity overall; and have a clear objective to improve board diversity. There were also specific actions to give direct support to women in mobility activities –

- Providing forums for Women in Transport and Technology Leadership
- Inclusion of formal event program elements on diversity
- Most recently agreed to provide complimentary registration to members who are on parental leave

Helen Wylde described the three primary factors that had driven market failures and which impacted the future of inclusive mobility, and so in turn would impact social, financial and environmental success if not addressed:

- Design. The physical implications, usability and comfort provided through both vehicle design and the infrastructure layout
- Safety & Security. The physical safety and mental security through information and applications, and the devices on which they are displayed
- Accessibility. Consideration of wider society when connecting to people and places, and the unintended consequences of poor design and exclusion.

Helen gave an example of not designing for inclusion and accessibility for all – the 1950s standards for test-crash dummies and similar scenarios based on "Reference Man" who was Male, Caucasian, between 25 and 30 years old, weighing 70 – 75kg, and a minimum of 5 inches taller than the average woman. This thinking had led to a market failure in terms of the inclusion of women in vehicle safety but also in the use of public transport. Consequently if a woman were to be in the same crash situation as a man, the woman would be:

- 47% more likely to be severely injured
- 71% more likely to be moderately injured
- 17% more likely to die

Similarly the majority of women had to sit in a more upright position in a car in order to see the dashboard and to reach the pedals, all of which made injury or death more likely. It also meant that on public transport females had to stretch to put their feet on the floor or to reach for the straps to hold as the vehicle moved. Women had on average significantly lower bone density than men and often found seating in both personal vehicles and public transport too hard. It was also sobering that car crashes were the primary cause of foetal deaths arising from maternal trauma. Recent evidence also suggested that 62% of women could not drive as a result of design issues in their third trimester.

Mobility as a Service schemes were predicted to provide better levels of transport immediacy and personalisation, enable public transport to be more widely adopted, and lead to higher levels of active travel. However core to this optimism was an assumption that devices and applications supporting MaaS would be designed and built to suit the widest cross section of society. However there were already examples of issues associated with data, devices and software not meeting this objective. For example there was often a gap in data collection, such as not asking both genders about design preferences. In terms of devices, a smart phone design was typically for men to be able to use with one-hand whereas women may need to use two. With software, voice recognition apps were 70% more likely to recognise a male voice. This had safety implications in terms of distracting drivers or walkers.

In summary, inclusion in mobility could be addressed by focusing on three key areas on an individual basis for all sections of the population:

- Improving individual mobility experiences by removing pain points
- Improving mobility choices to enhance end-to-end journeys
- Improving the mobility fit by enabling lifestyles

It was not difficult to ensure that the designs of transport innovations were human-centred for all people types and focused on personalisation and recognition of individual needs. Doing so would lead to better and more inclusive transport solutions that drove better work opportunities, greater socialising, reduced environmental impacts and were safer and more secure for all.

Leslie Richards described how commute times impacted women more than men:

- Every additional minute of commuting led to a 0.3% drop in the rate of working married women
- The effect was largest for women with young children (under age 5), where a 1-minute commute decreased the probability of working by half a percent, followed by women with older children
- Men's likelihood of labour force participation declined less than women's with the same commute length increase

Some countries (eg Egypt, Mexico, Brazil, India, Japan) had created women-only spaces within their transport networks. These spaces and metro cars did not operate all the time, sometimes only during peak travel times, so there were still long periods when women could be at risk in public spaces. We should also think about the impacts on women, especially, from infrastructure –

- Stroller rules and storage spaces on transit systems are challenging for parents everywhere
- Women literally hurt themselves on infrastructure because they wear high heels to conform to their profession's expectations and standards

There were other diversity-related considerations impacting mobility:

- Bike Lanes improved women ridership rates and a number of studies had shown that separated bike lanes increased the numbers of women, as well as overall numbers of people, choosing cycling as a transport
- A 2015 study found more women were riding for recreation than commuting, but that 55% of women respondents still felt concerned about safety compared to 49% of male respondents
- Shift workers needed special attention as they needed to get home safely without driving while tired or exhausted. A number of cities were beginning to harness technology to protect shift workers.
- Combatting street harassment of women was essential. 67% had experienced harassment before age 14; 77% under age 40 reported being followed by a man or group of men in the past year in a way that made them feel unsafe. Over half of the survey respondents noted that they changed their clothing, refused a social event, and/or chose different transport as a result of street harassment

Some solutions were quick and easy to deploy for example designing gender neutral driver licences & IDs and bathrooms (Pennsylvania DOT facilities) and using gender neutral language in documents and signs.

Amy Ford gave a comprehensive look at women and mobility by stating the women walked more and relied more on public transport; their trips were shorter and slower and were often at off-peak hours. Women's travel was often dictated by the care economy in which they travel with children, elders, bags, and conduct errands. Moreover most women were afraid of being harassed in public spaces (80%), and for 16.5% a lack of access and safe transport reduced their participation in the economy.

Amy turned to women's use of mobility services and ridesourcing with the results of a survey on women's experience with ridesourcing There were too many cases of women experiencing sexual assault and harassment when using mobility services and/or working, or/and having safety concerns about male drivers or passengers.

Women trusted ridesourcing more than taxis and public transit but women also wanted women drivers (45%).

Another way to improve facilities for all users was adoption of gender-informed infrastructure such as recent efforts in Vienna where stations and waiting areas were redesigned to provide ample visibility of the surrounding area, systems were simplified to become more user-friendly, and route pavements became wider, and footpaths were added.

A recent study in Portland about micromobility showed

Ridesourcing companies are launching different programs including Lyft's community safety program and Uber's "women preferred" feature. Survey results "What women experience during rides" (Amy Ford, ITS America ES 08)

that women liked scooters as much as men (64%) but more men rode (64% v 34%), women tended to ride for fun and recreation (35% v 25%), whereas men tended to ride for work (22% v 15%). Infrastructure and its design also had an impact particularly on microtransit and ride-sourcing. The percentages of women who had had a negative experience "on the street" was 64% in Lima, 67% in Madrid, 79% in Kampala, 59% in Delhi and 60% in Sydney. A recent Portland study had asked what would get women to use e-scooters. More women indicated having a safe place to ride (54% v 46%) (also consistent with bicycles), being consistent with where riding, more women choosing paths or trails than men (23% v 18%); fewer women chose a shared street with vehicles (37% v 25%).

The so-called "pink tax" or additional cost pf women's travel had been determined in specific areas for example in New York City, where women spent an average $26 to $50 extra on transportation per month for safety reasons, and up to $100 each month if caregivers ($1,200 more than men).

Bringing more women into planning and design of mobility services was critical. Women made up 20% of engineering graduates and nearly 40% of women engineers are not working in the profession. We needed to make a greater effort to understand women's mobility barriers outside transport structures. Another angle on this came from a study in Mexico City which showed that a lack of affordable and nearby childcare, and fear of the unknown made women unwilling to travel, despite the existence of accessible transport service.

There was a vigorous discussion forced to end by running out of time:

- There was a question from the audience asking how to ensure that young girls were made aware of careers in mobility, ITS or transport in general. For the most part, panellists mentioned Science, Technology, Engineering and Mathematics (STEM) programs as a way to make these career areas visible to young people, particularly when girls are not often encouraged to pursue them. Also, programmes like Women in Transport (WiT) which was established by the European Commission and European Economic and Social Committee were helpful. WiT was an EU 'platform for change' designed to strengthen women's employment and promote equal opportunities for women and men in the transport sector.

- The moderator commented that the "Connected, Automated, Shared and Electric" (CASE) future that everyone speaks about should also include Accessible, Equitable and Inclusive as part of the vision. We could not afford to retrofit our future vehicles and modes to be accessible and inclusive of everyone.

- To sum up the presentations and discussion afterwards, the panellists' shared answer to "Why is diversity important in the mobility and ITS fields?" was that enhanced diversity leads to better decisions.

Leslie Richards, Amy Ford, Susan Harris, Helen Wilde, Carol Schweiger

ES 09:

IS PROLIFERATION OF NEW TECHNOLOGIES CREATING A LEVEL PLAYING FIELD?

Moderator	**Dean Zabrieszach, HMI Technologies Ltd, Australia**	
Panelists	**Deog-Cheon Jang**	Bucheon City, Republic of Korea
	T. Russell Shields	Ygomi LLC, USA
	Ramin Massoumi	Iteris, USA
	Jeffrey Davis	BlackBerry, USA

The moderator opened the session explaining that he had asked speakers to keep to succinct presentations to leave time for two-way dialogue and audience questions.

Deog-cheon Jang described Bucheon as a smart city built on five pillars which he would present; his vision as Mayor was for Bucheon to lead the way for smart cities. The city worked closely with central government to develop the concept of a smart and sustainable city and he would explain what road and infrastructure projects had been started to make the city truly smarter and connected.

Dynamic Bucheon – the thousands of ITS field devices providing traffic and transit information, smart parking, signal operation, traffic safety and regulation and accident management, based on big data & AI.

Advanced Bucheon – there was a high speed, wide-area network to support a range of ITS services throughout the city. All systems were shared between the public and private sector.

Sharing Bucheon – reflected Bucheon's being the first city in Korea to introduce a bus information system based on collaborative cloud computing which utilised the hardware, technology and human resources of multiple nearby cities, resulting in a great reduction of construction and operating costs.

Innovative Bucheon – Dynamic Bus Stop Allocation was a world first, using deep learning and image recognition to allocate buses to multiple stops in real-time.

Smart Bucheon – Bucheon operated an effective smart-parking system, utilising electronic mobile pre-payment, automated fee discount for the disabled and eco-friendly vehicles, and sharing of parking lot information between public and private buildings.

Russell Shields said that he wanted to try to answer the question "what are the things that will enable smart mobility"? with a specific example. He focused on the road databases that were required for highly automated driving, and the differences faced by geofenced 'auto-taxis' and series production vehicles. Highly automated driving (HAD) could not function safely without knowing where the vehicle was (localisation), what it could expect in its immediate environment, and what was ahead of the vehicle beyond the range of its sensors. Road databases provided this information and he suggested that anyone who said that they were going to use only high definition maps for highly automated driving did not know what they were talking about.

He explained that there were two distinct scenarios for using road databases for HAD – vehicles operating in a limited (geofenced) area such as shuttles and automated delivery vehicles, and the mainstream or Series Production Vehicles (SPVs) operating over wide areas. These had different requirements and utilised different technologies.

Geofenced vehicles would store data for limited, predefined areas and use detailed databases, while SPVs needed to store data for a much larger area and therefore their "maps" needed to be simpler. Geofenced vehicles would routinely return to a central facility, allowing for direct updates to the in-vehicle databases, while buyers of SPVs would not accept being restricted so they would have to receive updates over low-cost data communications which would limit the size of updates. Lastly, to remain commercially viable SPVs would have to be cost-limited in terms of the sensors and equipment used.

We were dealing with different scenarios, different technologies, different players, but the same goal. Widespread adoption of highly autonomous driving depended on the success of both geofenced vehicles and SPVs. Geofenced vehicles would typically use more expensive image processing equipment and data storage than would be cost feasible in SPVs. The SPVs would use the image processing equipment and data storage that was affordable to most consumers and have software that could produce a road database from the data generated by such equipment. These differences in technical solutions opened room for new industry players.

Ramin Massoumi said that he wanted to stand back and talk about a few of the key trends which were driving changes in the ITS industry. Examples were in the area of technology cloud computing, communication

Differences of in-vehicle equipment and software (Russell Shields, Ygomi, ES 09) systems including 5G, increases in computing power and processing speeds were all trends developed outside our industry. They trickled into the ITS industry and had a major impact from both increased capability and reduced costs. Other key trends were not related to technology but derived from buyers and the customers' increased demand for real-time information, new procurement and ownership strategies such as public/private partnerships, and on-demand mobility as a service.

Agencies also asked for solutions in high level terms for example the comment by the Mayor about Bucheon wanting to be a smart and sustainable city. There were other trends best described as social, for example the steady move to urbanisation, as the populations of cities and city regions continued to grow, and the shared economy especially ride sharing. These trends together shaped what we were asked to deliver as an industry; the technology available to us determined how we delivered it.

As industry professionals, we should always keep in mind the 'why'. What were the problems we were trying to solve? At a high level it was about increasing safety and mobility. However at a lower level there were always needs that must be considered. We needed at all times to ensure we were not producing new technology without a clear goal.

Jeffrey Davis opened by sketching the business activities of Blackberry which had moved a long way from just supplying hand-held devices. The development had rested on integrating many different technologies and he argued that there were four conditions that needed to be met to realise the advances that new technology such as Artificial Intelligence had to offer. You needed the availability of 'clean' (structured) data; a problem that needed to be solved; time to verify that products were successfully tested as safe to use; and most importantly, funding. This became more important as technology continued to advance and availability of funding became increasingly significant.

Looking back to the theme of the session he argued that availability of technology alone did not create a level playing field. There would always be winners and losers, and money would play a big part in determining that. Successful solutions and technical proliferation required a mix of funding and bringing academics, private industry and public entities together in situations such as the ITS World Congress was an important enabler for the discussions and sitting down to work through the challenges.

A new attitude was also needed towards processes and modelling of what users actually needed. The automotive industry had always been very customer-facing and able to respond to demand changes but it traditionally had been highly regulated. By contrast public transport had always been developed with a top-down approach partly because of the cost of its infrastructure and the time taken to build or modify it. These models needed to be challenged as the public now had a greater say in adoption. The roll-out of new technology in the transport sector, especially infrastructure, needed to be flexible to be able to fit with users' needs as they changed.

Points arising in questions and discussion

- **Qn:** One of the big future issues is managing a mixed vehicle fleet. How do we cope with automated / non-automated and different types of vehicles occupying the same space? RS: I don't know of any planning for dedicated 'automated' lanes – the assumption is that the different types will co-exist. JD: Personal mobility vehicles were not predicted and did not fit into most plans. There seemed not to be any 'clean' way to manage this integration, not least as it looked to be more of a cultural issue to solve. New technologies were always going to hit the roads and we would not always have control over how that happened. We had to be ready and flexible and we needed to take care not to kill innovation. RM: We need to register that the model has changed. The government used to set the standards, develop the concepts, fund the projects, and others would develop infrastructure based on these standards. Now funding can come from many sources, with private industry driving solutions without formal approval or regulation, creating large amounts of disruption. It has become more important for agencies to be able to adapt rapidly.

- **Qn:** It seems unavoidable that we will have mixed fleets; how does that lead to benefits? Is there a threshold penetration for getting the benefits? RS: There seemed little doubt that 'robotaxis' would increase congestion not reduce it. When the cost of vehicles able to drive autonomously on expressways dropped the take-up would increase and probably cause more urban sprawl but the driving experience would be seen as a benefit.

- **Qn:** Is it likely that for automated driving there would be a mandatory minimum headway? RS: If we are describing genuine 'eyes off' driving then regulators are likely to demand a quite large headway but with a mixed fleet that would lead to cutting in. Nobody knew what would happen or really understood the options. A safer way forward was looking at the use of slower speed shuttles as feeders to established services.

- **Qn:** Apart from opening up data what do you think are the biggest barriers to the entry of new players.

JD noted that opening data did not level the playing field as much as was sometimes thought.It was having a capability to process the raw data that was important, and that depended on workforce. Skills shortages were one of the biggest limiting factors in this sector so one of the biggest things we could do to level the playing field was get more talent into the workforce. RS: It's money – if you had enough money you could deal with the other issues. RM: The other great leveller is having standards.

- **Qn:** In the space of rapid technological advancement there is frequently a debate in government about whether to define a need and look for a solution, or to develop a solution based on the new technology and try to find the best way to use it. What's the opinion of the panel? JD identifying the problem needed to come first but governments needed to recognise when to exploit an existing solution. RM: The key was to be agile and realise while following a procedure that there was a better way forward and be prepared to change direction. There's an old saying "if your only tool is a hammer then all problems look like a nail" and that describes the risk with adopting an established solution and devising applications for it. RM: It all comes back to the end point – will the solution solve an actual problem?

- **Qn:** Does Bucheon try to measure citizens' satisfaction with the developments? DC-J: We consulted on users' top demands then tried to benchmark solutions from other cities to guide what we did.

Moderator's final question: Where are we going with AI and Machine Learning? RM: They represent new ways to acquire data and combine different sources giving us new tools. JD: Machine Learning has changed the ways we can use data but it's often difficult to work out what was done. RD: Everything follows from shifting the edge of what's possible and the big driver of almost everything is improved processing power at reduced cost.

ES 10:
DRIVING ITS THROUGH THE POWER OF DATA

Moderator	Young-Jun Moon, Korea Transport Institute, S Korea	
Panelists	Syahrunizam Samsudin	Touch 'n Go, Malaysia
	Jarrett Wendt	Panasonic Corporation, USA
	Klaas Rozema	Dynniq, The Netherlands
	Carlos Braceras	Utah Department of Transportation, USA

The Moderator welcomed everyone and commented that the value and power of using data in ITS and mobility generally was steadily increasing. The session would look at the changing roles of the various stakeholders with a particular focus on privacy, security and accountability.

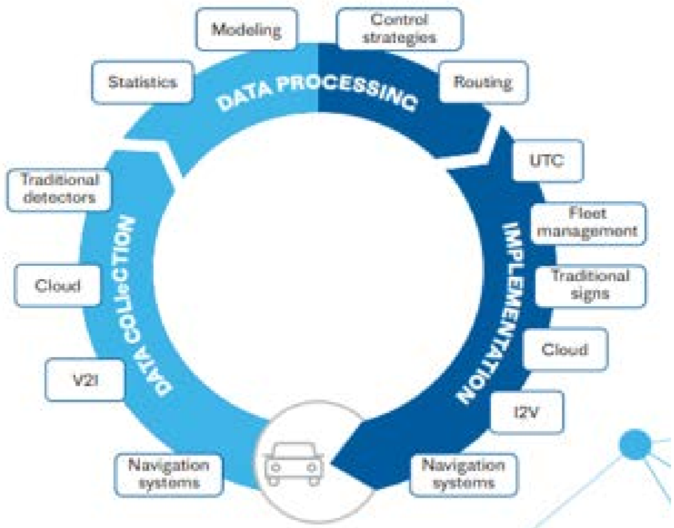
Jarrett Wendt talked about his company's involvement in hardware for connectivity, electromobility and autonomous driving. It was sobering to look at some numbers. In 2000 early connected cars averaged 1M lines of code; an average car today was nearer 100M. Connected cars transmitted data ten times/second so the 100M estimated to be on US roads by 2022 would generate ≈ 20Tb / hour. However, arrangements for using the data were lagging – most OEMs had no plans to share with any other organisation and governments were unclear what they might do and what they should do.

It was now possible to monitor a wide range of vehicle parameters – driving-related data such as engine speed, gear, wheel angle, road speed etc but also the status of the majority of vehicle components eg tyre pressure, tyre temperatures, fog lights off/on, wiper operating at basic / fast / intermittent speed, left / right turn signalled. In addition, the outputs from the vehicle's sensors could be tracked and downloaded. The result was a powerful tool suitable for real-time analysis, fleet management, driver advice and fault diagnosis. In future years it was likely that selected data outputs would be fed to systems for traffic management, vehicle routeing, road use charging with instructions, warning and advice returned to the vehicle.

Klaas Rozema reflected that in early Congresses sessions on data analytics had focused on the poor quality, unreliability, incompleteness and slow delivery of data from sources linked to traditional infrastructure. This congress and those of the previous 2-3 years had demonstrated the orders of magnitude improvement from data derived from digital networks and connected vehicles. As a result, cities could now link together the management of mobility and parking in the city space, and energy use.

Models of a vehicle's situational awareness ("digital twins") were immensely useful for testing the impact of changing a management strategy. Capacity gains of up to 30% had been identified from such studies – a much faster and cheaper alternative to adding new built infrastructure. Provided data were held in an open platform to agreed standards a variety of third-party businesses would be able to work on designing apps to deliver solutions.

In Europe this cooperation had been taken a stage further with the TM 2.0 traffic management platform that joined road operators, infrastructure providers, and other service operators in a coordinating framework that allowed an open market for mobility solutions while retaining a mechanism for the city managers to assume control in the case of accidents or similar incidents.



Planned developments in this area were extending access to data – the enormous collections described by Jarrett Wendt were not routinely available as agreements on ownership and shared use were incomplete – and developing more powerful analytic tools.

Syahrunizam Samsudin argued "data never sleeps" and we should prepare for continued massive growth as a consequence of urbanisation bringing with it higher sharing and collection of data from connected and always on mobile devices. Malaysia had the problem of recognising the need to address mobility growth using mass transit but the population was very attached to owning and using cars. People wanted reduced congestion and clean air but they also wanted cheap travel. All types of mobility app were getting busier but their data was held in silos by operators, merchants, government, agencies etc. A project was therefore under way to bring the data from these apps into a unified framework that enabled a new engagement platform combining mobility data and social interactions and linked commercial data. This in turn gave users a range of new services but it also gave operators and city managers new insights into traveller behaviour to support the use of modelling and simulation software.

Carlos Braceras talked about change. During the session and the congress generally we had heard much about future technologies, the need for new policies, data volumes etc and it was tempting to think of waiting for the changes to finish and the situation to revert to normal – but it would not do that.; 'Change' was the new normal. We needed to use all the options available to improve transport and better use of data, and the collection of better data, featured in the Utah State planning.

Utah DOT had seen the benefits of data-driven decision making in the past, initially for asset management and performance measurements. Subsequently many data applications had been introduced, for example a situational awareness model that enabled holistic and seamless integration of information for maintenance, operations, safety, and mobility planning. For road users and taxpayers this led to a better user experience connecting people to what mattered for them (family, economic opportunities, recreation). Nearly all DOT data was available from the website as real-time information.

Points arising in questions and discussion

- **Qn:** What's the key characteristic of data – data volume, real-time element of variety? CB: for us the key is accuracy and then speed for example we need to know about incidents immediately. KR: Accuracy then volume; speed matters less for asset management. JW: Accuracy then volume combined with IT power to handle it. SS: Speed first then accuracy; our systems have to be first with reliable information however unwelcome to recipients.

- **Qn:** One version of a data value chain is Collection, Adoption, Information, Integration, Analysis do any panellists use this model? SS: Something similar but the problem for industry is gaps in collection when some key data either does not exist or for whatever reason we can't use it. JW: the problem with the chain is getting access to some data: the OEMs are not clear on what they hold and on what terms if any they will share it. KR: the National Access Points in Europe are in a sense a self-contained chain and although they do not yet handle large volume they are growing. CB: we're doing real-time traffic signal analysis and the collection side is fine; the volume rather overwhelms the analysis capability.

- **Qn:** Once data has become information for customers what are the benefits? CB: The most important benefit is moving toward zero fatalities and adoption of automated vehicles can do that. KR: I agree; using connectivity and automation to separate getting the benefits from driver behaviour. JW: Safety also. SS: using data to calm drivers which is socially acceptable and brings safety gains.

Closing the session the moderator noted two clear messages – the potential benefits from using data for safety and the overriding need for accuracy.

ES 11:
FREIGHT MOVEMENT FOR SMART CITIES

Moderator	Zeljko Jeftic, ERTICO - ITS Europe, Belgium	
Panelists	Kevin Thibault	Florida Department of Transportation, USA
	Gary Dolman	Department of Infrastructure, Regional Development & Cities, Australia
	Lars Anke	Hamburger Hafen und Logistik Aktiengesellschaft, Germany
	Daniela Rosca	European Commission, DG MOVE
	Fotis Karamitsos	Senior Advisor, Europe

The moderator reflected on his previous experience with the difficulty of digitising and tidying up the mass of paper documents used for international road freight so it would be interesting to look for similarities in problems or solutions in the maritime sector.

Fotis Karamitsos began by referring to the discussions in ES 04 which had looked at the sea-facing procedures of ports with emphasis on technology enablers such as digitalisation, data analytics, interoperability standards and automation including automated vehicles. He gave some background facts on maritime freight – over 80% of European international freight traffic moved by sea; and in the 1990s the largest container ship held 5000 units whereas the figure was now 25,000. The larger shipping companies were expanding to become door-to-door service providers. Freight was moved to / from ports, between ports, and then to the hinterland for road, rail and inland waterways transfer. The nature of the flows demanded both international standards and collaborative working by all the stakeholder bodies.

Digitalisation enabled cooperative working of the supply chain actors, real-time management of cargo flows, reduced administrative overheads, and more intensive use of infrastructure and other assets. However there were a number of challenges: a lack of connected systems and interoperability standards; arguments over data ownership, sharing and access; concerns about data protection, and security and privacy more generally; uneven recognition of electronic documents; and disagreements on governance.

Kevin Thibault painted a picture of the State of Florida the 22nd largest state but the 8th largest GDP. It had a population of 21M but was visited each year by around 120M half of whom arrived by air. Supplying goods and services for this total was a demanding requirement. There were 20 airports and 15 sea ports, 12 of which were deep water. He referred to the common global issues – improving safety, reducing environmental impact, increasing mobility, reducing congestion and achieving sustainability – while noting that different States adopted different paths to addressing them. Easy movement of freight was often seen as a key factor in developing a local or the regional economy.

Technology was being used or trialled for improving the efficiency and effectiveness of transport so for example both connected freight vehicles and truck platooning were being studied and a truck parking location information service was in use to help separate stationary vehicles from the main roads and to support enforcement of driving hours legislation. There had been a demonstration of an 18-wheel truck with both autonomous driving and remote control capabilities. A test track was available to help assess the impacts of the extreme weather often encountered in Florida.

Australia government role on freight strategy, data, and integration (Gary Dolman ES 11)

Lars Anke presented some of the innovations being tested in Hamburg. HHLA was a terminal operator and logistics services provider so not directly involved in setting policy. Hamburg was a river port (110 Km from the N Sea) but was also a city port as it was collocated so efficient physical movement of freight after unloading was critical and explained the extensive rail links as well as road connections. Because of the location on the R Elbe the company had a vessel traffic management platform that supported movements along the river as well as traffic into and out of the docks.

Innovation was key to increasing port throughput and decreasing waiting times but a perennial problem was introducing the new equipment or service as the port could not be closed to allow uninterrupted change – it was bit like open heart surgery. There was also a people dimension: shipping was a rather traditional industry and initiatives such as digitalisation had to be handled with thorough consultation of the workforce.

As examples of innovation HHLA and truck manufacturer MAN were jointly working on a project for autonomous transports of goods by road to and on the port terminals.

Drones were being used through a cooperation with a start-up company. The technology was seen as having potential in a variety of capabilities including monitoring and directly as a delivery mode. There was also a research partnership to look at developing a transfer station for a hyperloop system in the Port; it was hoped to have this as a demonstration for the 2021 World Congress in Hamburg.

Gary Dolman talked about Australia government initiatives rather than work by specific ports. The three high-level aims were strategy and long-term planning, bringing systems together, and better operations and data use I order to address key challenges listed by Fotis. There was an Office of Future Transport Technology responsible for leading and coordinating government work to prepare Australia for emerging transport technology which generated a series of Action Plans. The first plan (2016-2019) delivered on regulatory reform, trials, ITS, geo-positioning and security. The second (2020-2023) had five themes:

- Safety, security and privacy
- Digital and physical infrastructure
- Data
- Standards and interoperability
- Disruption and change

A project on city freight in Brisbane had collected GPS fixes from working trucks to establish the more intensely used roads as evidence for decisions on traffic control, road infrastructure investment and the optimal location for distribution centres as well as considering whether to aim to replace some truck trips by short-haul rail. A parallel study on port freight traffic in Melbourne analysed the competition between freight and passenger traffic in the morning and evening peak periods as part of a study into changing the permitted travel times or routes for trucks or amending traffic signal timing.

A trial was under way on sharing data across the supply chain. The industry wanted to know the position of a freight consignment and when it might arrive and its condition.

The Infrastructure operators and planners wanted to know how much freight and in how many vehicles was moving between A and B as well as the average freight travel time and variability. This information was essentially different analyses of the same basic data but the data needed to be a combination of what was held separately by the two stakeholders so a collaborative pilot was running.

The clear learnings so far were that collaboration enabled data sharing which in turn produced improvements to port performance, freight flows and supply chain efficiency. And these improvements in turn led to improved infrastructure planning and investments, better regulation and more efficient freight operations.

Daniela Rosca spoke about earlier work by the European Commission to try to reduce the impact of ports traffic on cities located very close to a port. The 2017 Ports Services Regulation applying to all EU Member States focused on financial processes, market access, openness, and transparency of operation. But it also mentioned the need for connectivity, close working links with the port's hinterland, high levels of training and the need to monitor the development of new techniques.

The Commission had a number of ports and marine initiatives under way plus a great deal of work on connected and automated road vehicles that had immense potential for the freight and logistics world as had been discussed by earlier speakers in the two Freight sessions and other ESs. This included many studies on loosening the regulatory frameworks. The European Maritime Single Window was now in legislation significantly cutting the administration overheads for operators and shippers. The Commission's overriding objectives were the development more liveable cities, reducing greenhouse gas emissions, reducing transport congestion and preserving biodiversity in conjunction with a stable regulatory framework with open market access.

Points arising in questions and discussion

- **Qn:** There's been a lot of emphasis on automation in ports but as a US resident I saw increased numbers of strikes by port workers over job losses – how are Europe and Australia handling this? LA: port unions are traditionally strong and in Germany this is reflected in extensive consultation arrangements but in ports and logistics generally we have labour shortages so automation isn't seen as cutting jobs. KT: it's about training and the key message is training for a change to a new job. FK: In Europe ports workers tend to be older rather than younger so it's not easy to work with them on training and job changes that they do not react well to. Traditional practices cannot keep up with the global changes to shipping and containerisation; there have been cases where faced with a reluctant workforce the operator has dismissed all of them and then re-employed those with the potential and attitude needed. GD: two Australian ports have had some union dissatisfaction but now that it's over there seems to be acceptance. But it was challenging at the time. ZJ: Automation is technology enabled as opposed to technology driven to open up new business and in the freight sector there's many other changes for example automotive manufacturers moving into service provision directly to customers so focusing on employment in ports is missing the bigger picture.
- **Qn:** The use of drones in Hamburg – was this theory or actual experiment? LA: the slide image of an empty container being carried by a drone was theory but we regularly use drones for maintenance inspections, security monitoring.
- **Qn:** Actual container weight is a big issue is anyone looking at this? GD: Container weight declaration ought to be straightforward similarly the actual loading of the container. FK: there's no problem avoiding weight issues as cheap RFID tags can label a container with contents and weight. This is being adopted by ship operators to avoid stacking the ship with the heavier containers not at the bottom but at the top which affects handling.
- **Qn:** Shifting trucks from peak passenger movement times can be done but dealing with a city port with local government in the management chain introduces decision problems – has anyone any experience in this area? LA: We are trying to get freight in the bigger trucks off the roads and on to rail but the steady growth in vessel capacity keeps the pressure. It's difficult to move a lot of freight movements away from peak times as making deliveries depends on someone being in attendance. Ultimately this means tighter control on when vessels can berth and unload.
- **Qn:** GD: Isn't the problem that regulators don't enforce? The requirement to know a container's weight is quite clear and the IMO rules on loading are also clear. Why does nobody enforce poor loading leading to over-weight trucks on roads?

FK summary – nearly all the technology solutions existed; the problem was uneven adoption. For that we needed interoperability of systems and that required standards and most of them did not yet exist. We had to have more cooperation and sharing – and that meant ports moving away from their own proprietary solutions and becoming a part of a larger system.

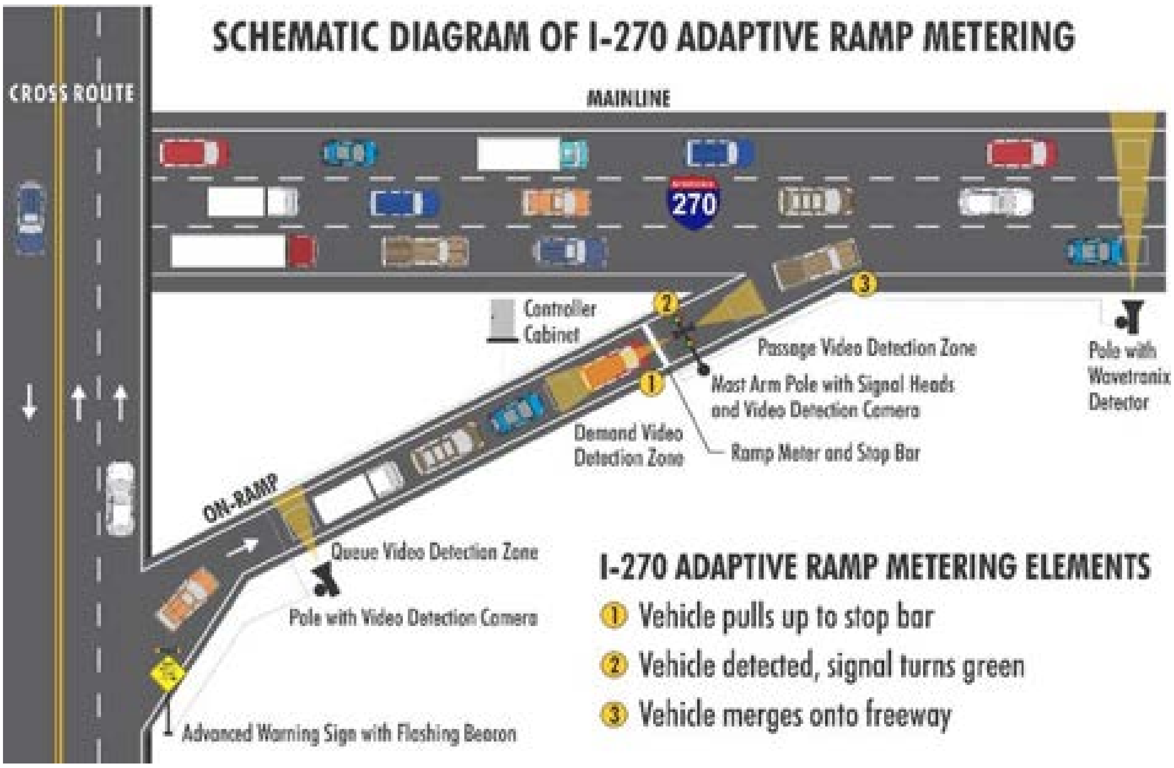
ES 12:
DEMAND MANAGEMENT STRATEGIES AND PRACTICAL CONSIDERATIONS

Moderator	Stephen Hewett, Beca Ltd, New Zealand	
Panelists	Kian Keong Chin	Land Transport Authority of Singapore
	Pete K. Rahn	Maryland Department of Transportation
	Soren Tellegen	Kapsch TrafficCom APAC
	Xiaojing Wang	China ITS Industry Alliance

The moderator welcomed everyone to the demand management discussion. It was universally recognised that increases in supply could not match growth in demand so some form of management was necessary and the session would present various options.

Pete Rahn noted that regular congestion and long commute times remained a persistent and growing issue on Interstate 270, the critical roadway for Maryland, Virginia and Washington and the most congested route in Maryland. To address this Maryland was in the process of implementing two priced managed lanes through a public private partnership. Maryland had launched an Innovative Congestion Management Programme. Six teams were invited to make proposals for a fixed fee to design a solution fulfilling the KPIs of optimising traffic flow in the fastest and safest way a fixed $100 M budget with the best proposal receiving funding to develop the proposed scheme by August 2020. Anticipated challenges were from the environmental, data availability and scheduling perspectives.

The outcome of the selection exercise was an effective toolkit comprising 14 total improvements covering both roadway and technology-based improvements. The former were solutions rooted in performance-based practical design like auxiliary lanes and extending acceleration/deceleration lanes; the latter included adaptive ramp metering (being considered for the first time in Maryland) and active traffic management using ITS such as dynamic speed advisory signs and queue warning information. The collective solutions were expected to bring about corridor wide benefits in peak-period travel times and speeds, as well as vehicle throughputs. The intent was to apply the



Adaptive ramp metering (Pete Rahn, Maryland DOT, ES 12) same methods to Interstate 695. Maryland's vision was to create a cohesive and connected network, a "Systems of Systems" for transport related activities. This was particularly relevant seeing that it oversees all transport modes within the state (state highways, public transit, port, airport, motor vehicle admin and even Maryland transportation, the tolling arm). The lessons learned from I-270 were being deployed on other congested routes. No single technique could be described as 'leading edge'; a key success factor was undoubtedly the synergy from combining solutions proven elsewhere.

Soren Tellegen shared his supplier perspective from a holistic, system-wide angle, on how innovative solutions could make mobility more efficient and sustainable by incentivising and stimulating long-term behaviour change. Most people recognised the big problems:

- excessive CO_2 emissions of which 28% had transport as its source
- traffic accidents causing 1.3M fatalities every year
- 30% of urban area congestion caused by vehicles in search of parking.

With the projected 34% increase in world population by 2050, and the proliferation of mega cities worldwide as they grow by a predicted 70%, we could expect significant increases in congestion and its related costs. We needed to establish an overarching view of the situation and think how best to address the increasing demand for travel time reliability, transport safety and information accessibility via apps. While most citizens had fair and equitable access to transport modes, they now expected multiple alternatives to driving.

The practical reality was that whilst we had access to tremendous amounts of raw unstructured data ("people are using data like it's going out of fashion!"), extensive infrastructure and intelligent transport systems, many cities did not possess a clear situational awareness of their current traffic conditions and were attempting to make tactical decisions with only limited data. Some systems and control centres still operated as silos without crucial interfaces to a bigger world, or with operators attempting to use their own skills to coordinate between systems. Not every system owner or user understood how their actions within their own system could trigger repercussions in other parts of the network.

In order to manage demand effectively control centres needed an open platform to enable coordination across all modes of transport. The key was to increase the peripheral inputs to which the system had access so that it could coordinate the highways, data, fleets, public transport and traffic management functions in a cohesive manner. This global situational awareness would greatly enhance knowledge across the network of the availability of alternatives to priced roads, whether in terms of metro routes, bus service availability, a less congested route for drivers to their destination, or even a feasible temporal shift. He felt that demand management was a major piece of this puzzle,and could be more easily achieved through such level of coordination.

Xiaojing Wang said he aimed to discuss ETC technologies and applications on expressways throughout China, the influence of technology improvements, the standards adjustment to road user behaviour, and travel behaviour changes to toll pricing. The China government had a policy of using ETC technology for demand management. By the end of the previous year, there were already more than 140,000 km of expressways and more than 4.84M kilometres of highways in China. To meet the needs of communications, monitoring and toll collection systems across expressways a cable system has been built with different communications systems between the provincial and national trunk networks.

Expressways in China were either manual toll roads or ETC systems. Whilst both were distance-based, the manual system computed charges based on point of pass-card pick up and return, while the ETC technology is based on DSRC at 5.8 GHz frequency, using a 2-piece configuration of active On-Board Unit (free to user, funded by the banks). The National ETC System was undergoing an upgrade, the main objective of which was to replace main toll stations between provincial expressway networks. The ETC gantries would therefore act as the entry-exit points of charged expressway segments, and charges could be automatically computed. Implementation would be carried out in 2 phases, the first of which involve building regular ETCs with accompanying communications and power supply infrastructure.

The Ministry of Transport had carried out trials and demonstrations of demand management schemes across four provinces. Toll policies trialled included toll price reduction along expressways during periods of low traffic volume, on segments with parallel ordinary highways (to attract highway traffic to the expressways) or toll reduction for trucks and container vehicles in specific areas to attract them to low traffic sections.

The trials yielded three key learning outcomes. Firstly, the high truck volume increase (from 24% to 60%) indicated that trucks were sensitive to toll prices. This was interesting as earlier studies indicated freight was less elastic than private vehicles due to business efficiency demands or the assimilation of road usage charges into business costs. Secondly, toll price effected an obvious spatial distribution of traffic demand within the highway network. Whilst the evidence of spatial, temporal and modal distribution from road usage charging had already been learned from several cities with road pricing (eg Singapore, London, Stockholm), the key information from these trials was that in a network where every single expressway was already tolled a discount could achieve the same spatial distributive effects.

Price reduction did not necessarily result in lower revenue because the induced traffic demand resulted in higher total payments. As an indication of the government's resolution towards ETC adoption and success, China had incorporated discredit behaviour on the expressways into the national credit management system, where any discredits could affect citizen's access to key services like financial loans, air tickets or high-speed train tickets.

Kian Keong Chin explained that travel demand changed over time in Singapore and road pricing was among various options the Land Transport Authority adopted as a part of a holistic package of measures to manage demand and supply. The response to increased travel demand had conventionally been providing more supply by building new roads or expanding public transport. In recent years however many cities were giving more serious consideration to demand management tools like petrol duties, parking charges, tolls and in some places even congestion charging and car ownership restraints.

The need for road pricing was best justified from transport economics. With increasing flow, the actual costs incurred by motorists deviated from the real marginal social cost the additional vehicles were imposing on the congested traffic stream. Only by pricing at the margins could these social costs or externalities be minimised.

The externalities could include costs to the community in terms of travel delays or environmental degradation. In theory a toll was needed to reduce traffic volume from equilibrium flow to optimal flow. However, in practice the value of the toll was not easily ascertained. Singapore had therefore adopted a pragmatic approach by introducing a starting charge to influence some demand elasticity, then allowing subsequent adjustment of toll rates in response to traffic conditions. The pioneering 1964 Smeed Report outlined some operational requirements for the practical introduction of road pricing schemes to which the Singapore system subscribed:

- Charges closely related to amount of road use
- Charges should be variable
- Prices should be stable and ascertainable before start of journey
- Incidence of system for individual road user should be accepted as fair.
- Methods should be simple for road users to understand and use
- Systems should be reasonably free from fraud and evasion
- Payment in advance should be possible
- Any equipment used should be highly reliable
- Systems should be capable of being applied country-wide

The paper-based Area Licensing Scheme (ALS) deployed between 1975-1998 progressed to include variable charges for vehicle types like cars, motorbikes, lorries, as well as lower charges between peak periods. Colours were used to distinguish between the time-periods for which the paper permit was valid. In later years, with charging coverage expanded beyond the Restricted Zone, charges also varied by location. Aside from technology availability it was the desire to enhance the equitability of road usage charges, as advised by Smeed, that prompted the transition to Electronic Road Pricing (ERP) in 1998. Today, ERP charges had variability by time (potential to vary between 30-min periods), location and also congestion. Distance based pricing was not yet possible without placing multiple gantries on each road segment which would have resulted in hefty costs.

The Smeed report offered a useful starting point for cities embarking on road pricing, individual cities' requirements and needs varied according to local behaviour and drivers' culture. Cities needed to adapt their system to meet local needs; one size did not fit all. Regarding the management of motorists' behaviour the Singapore systems had room for adjustment to manage user behaviour changes. The time variability of road pricing charges meant that during rate transitions to lower rates, or at the tail end of operational hours, motorists could be tempted to stop their vehicles on shoulders to wait for a charging period to end or to pay a lower charge. As this behaviour would have serious impacts on road safety and traffic efficiency the LTA placed warning signs informing that the area was under surveillance. The Road Traffic Act allowed the LTA to impose penalties on vehicle owners who stopped illegally at the roadside. Graduated pricing was also introduced wherever adjacent 30-minute charge periods had a price differential of at least $1.00 the first or last 5mins period within the more expensive 30-mins period would be priced at the average of the rates to produce a gentler transition that helped to curtail the propensity to "beat the rates".

A key success factor behind ERP was Singapore's good and affordable public transport system. Almost all commuting destinations in Singapore could be reached entirely by public transport. This was essential if the intent of road pricing was to achieve significant mode shift. The importance of good communications could not be overly emphasised, especially during the introduction of any new pricing system. Just like London and Stockholm (the latter through its pricing trial and referendum in 2006), LTA invested extensive efforts in communications when ERP was first introduced in 1998.

When the LTA first explored using GNSS as the positioning tool for the Next Generation Road Pricing system, there were suggestions of using smartphones instead of building a new On-Board Unit. However positioning accuracy is the critical KPI to ensure accurate computation of charges based on road usage, and the positioning function in smart phones was considered inadequate for this functional need. Devices meant for road pricing need to be bespoke and custom-built for the core pricing functions.

Points arising in questions and discussion

- **Qn:** If you had a burning request for the automotive industry, what would it be? (without telling them to make fewer vehicles)? PR: For the automakers to work collaboratively with the US Federal Communications Commission to maintain the 5.9GHz spectrum for future V2X communications. Also I'd like the automakers to install an ability to detect intoxicated and drunk drivers in the vehicle. KKC: I'd like all vehicles to be interconnected through cooperative ITS, not to minimise individual travel time but to optimise traffic flow across the entire network at the system level. Putting trip destinations into the connected system could then recommend routes and departure times based on network-optimised flow distributions taking into account alternative routes, congestion level and other trip destinations.
- **Qn:** How much of congestion pricing is a generational issue? Is it simply more acceptable to Singaporeans as they grew up with it? KKC: generational elements have a part to play in perceptions towards any schemes. Older generations grew up during the era where car ownership was seen as a luxury symbol of life success, whereas there were indication that today's youths perceived smart phones as sexier than cars. However, access to a comfortable transport mode for their journeys remained an intrinsic need of all road users. Today's air-conditioned and reliable transit vehicles offered far more comfortable journeys than the hot and crowded buses of yesteryears during which time a personal car was clearly the superior option if you had access to it. PR: Judging by the complaints and grumbles we get I think there's not much of a generational factor but rather there's a figure to go beyond which people regard as unreasonable.
- **Qn:** Was ERP fair for freight given that they had a lack of alternatives? KKC: The pricing management of vehicle types needed to be rooted in the underlying objective of the road pricing scheme. If the essential intent was congestion pricing then any vehicle that contributed to that congestion should pay, even buses and freight. Alternatives need not be a route alternative but could be a timing alternative. There is an unpriced window in the Central Business District on weekdays between 10:00 and 12:00 because of better traffic conditions so logistics vehicles had the option to use that period to minimise business costs.

TECHNICAL & SPECIAL INTEREST SESSIONS BY TOPIC

TOPIC 1:
INTELLIGENT, CONNECTED AND AUTOMATED VEHICLES

The overall situation

The connected and automated vehicles topic was once again the largest of the Congress based on the number of papers and sessions. Within the papers presented for the topic, connectivity represented about one fifth, use cases of connected and automated vehicles one third, and the issues related to automation of vehicles almost half.

The topic in detail

Connectivity

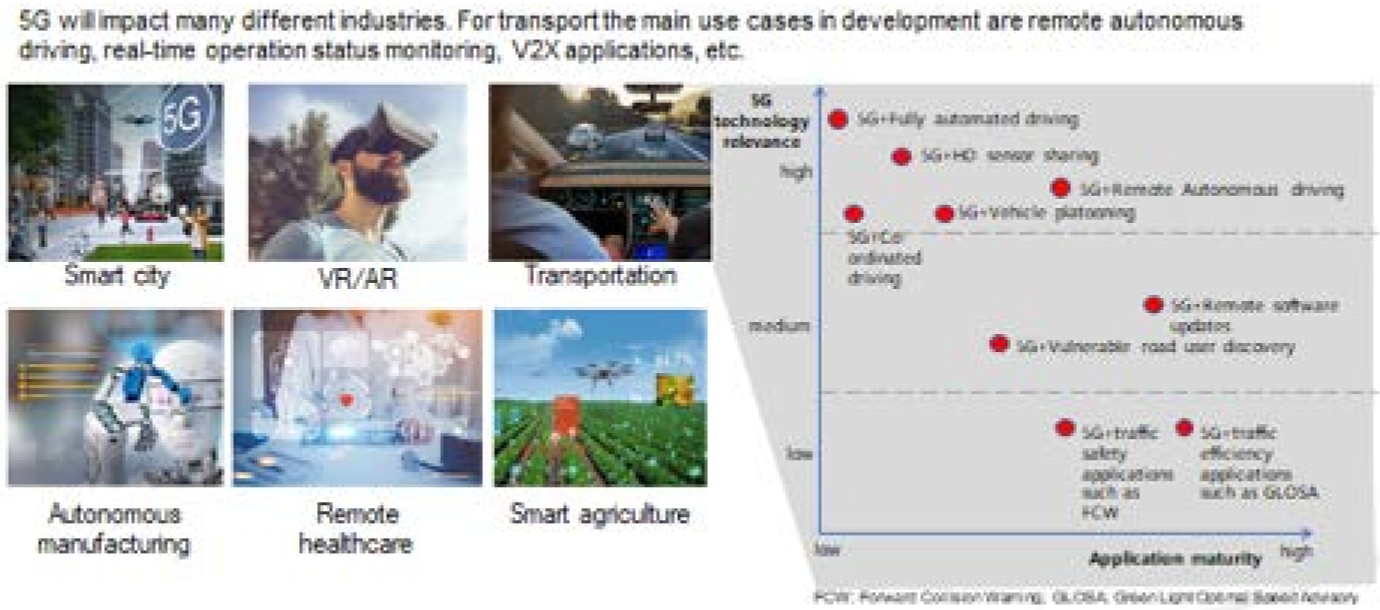
The emphasis here was clearly moving to deployment with issues such as roadside unit placement schemes, priority C-ITS services with regard to transport problems, operational aspects in deployment, solving privacy issues, regulatory needs due to distracted driving, evaluation of deployments, and comparison of trust and security mechanisms. The need to connect the whole system of sensors and all users, and to identify the communication technologies in doing so, were stressed. Data sharing and access to data were once again pointed out as major challenges. Some speakers noted that data sharing may prove unrealistic, and advised the public sector stakeholders to collect and create their own data not relying on others to do it for them.

The communication solutions included Dedicated Short Range Communications (DSRC, 802.11p), Cellular Vehicle communications (C-V2X), cloud-based cellular network communications and also mmWave technologies. The security, privacy, quality, latency and other performance aspects were discussed. The provision of seamless connectivity utilising various communication technologies in hybrid combination remains a major challenge. 5G was emphasised in the congress, in the sessions, papers and the exhibition. 5G was seen as very beneficial for the scaling up of communications, especially in cooperation with the road infrastructure operators.

The use cases dealt with hazard warning, signal control, eco-driving, traffic management, speed control, navigation as well as intersection and vulnerable road user safety. Connectivity was regarded in the short term much more important than automation with regard to benefits, and especially safety and efficiency benefits.

Connected automation use cases

While many papers dealt with the testing, living labs, proving grounds and test sites for connected and automated vehicles, some looked further into the future by discussing the related opportunities, challenges and perceptions, or even to the epistemological shift ignited by the connected and automated vehicles. The shift towards deployment also applied for connected and automated vehicles, with an aim to ensure that such vehicles could be integrated in a safe and efficient manner in the existing transport system at the global level and that it would be



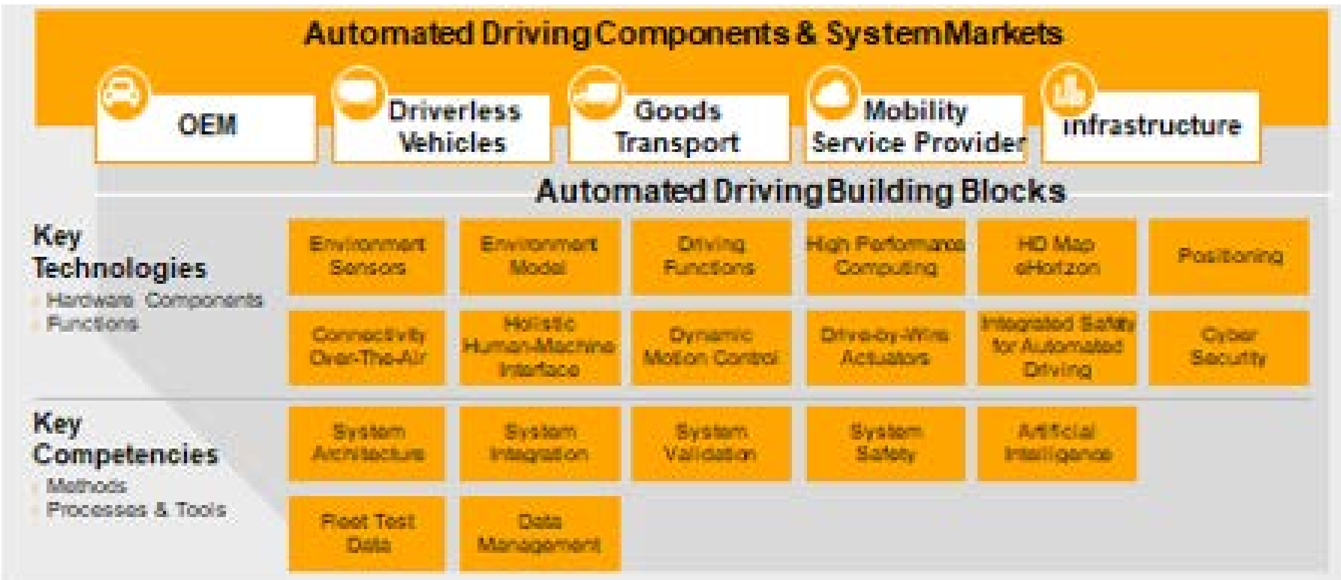
5G Use Cases (Ning He, China. SIS55)

acceptable for the users. Papers and sessions made it clear that in order to achieve that it was essential that knowledge and lessons learned were exchanged between stakeholders and regions on activities and approaches related to testing and safety validation, living labs, data sharing and user awareness. An important aspect was the Integration of automated vehicles with existing public transport systems and car sharing solutions. Regional particularities like differences in traffic environment, market expectations, communication technology deployments which could pose difficulties for developers in creating solutions that should work globally were also addressed.

Automation of vehicles

Presentations and discussions addressed the technical challenges of AVs including perception sensors and their performance in adverse weather conditions, specific challenges in laser scanner based sensing, and accurate positioning. Artificial intelligence is one of the key challenges if automated driving is to reach better performance levels than human drivers. Many presentations dealt with AI and machine learning utilising, for instance, neural networks. The primary prerequisite for machine learning was data on what was happening in the environment of the vehicle, what were the key aspects and especially the correct choices to make in different traffic situations, and what kind of situations the vehicle might meet in the transport system. Such data was vital for the development of highly automated driving.

The trust and acceptance of the users, in addition to the optimal human machine interaction, were identified as key to the adoption of AVs. Safety remained an essential



Building blocks for highly automated driving ecoSystems (Andree Hohm, Continental: ES01) prerequisite for automated vehicles. Presentations dealt with crash risks and their estimation, collision warning systems but also with the regulatory framework for certification and authorisation of automated vehicles as well as the safety assurance processes for allowing automated driving systems to enter public roads. Testing was very much in focus. Many speakers presented testing and evaluation approaches, methodologies, tools, and also some results as well as lessons learned. All in all highly automated driving was moving closer to actual deployment. This seemed to be especially evident in public transport and mobility services provided in dedicated or partly separated areas. In those areas there was a marked movement from "proof of service" to "proof of business".

Old v 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. Simulation was also used together with software development and mechanical design in the design and development of a self-driving car for a smart city use case. New ideas in the connectivity area included connected navigation (navigation on demand or Navigation as a Service NaaS), optimisation of traffic signal synchronisation with real-time public transport priority and driver speed advisory, queue length estimation at signalised intersections, and cyber-physical identification of connected vehicles.

Some ideas related to improving communication performance were also brought forward. One proposed utilising location-oriented pseudo noise code allocation with short-range communications, and another combining UWB Radar and V2V communication by time synchronisation via two-way ranging and repetitive detection scheme using a successive interference cancellation technique to reduce interference from other vehicles.

With regard to connected and automated vehicles the new ideas included introducing cognition to vehicles for predicting and correcting the fading of V2V transmissions due to obstacles in urban environments, dynamic mapping, passenger sickness detection utilising radar, the development of a network space reservation algorithm, generating a reference trajectory for vehicle by projecting the curb/lane points about a Frenet frame, use of moving sensor detectable code by colour markers for vehicle position estimation, identification of crash risk of lane changing for automated vehicles in mixed traffic applying spectral analysis of relative speeds in car following, probabilistic collision risk estimation for automated driving, and a novel model for vehicle outlines conflict for collision warnings.

A new idea was a surrounding-view visual mapping and localisation system for automated cars and buses by fusing data from multiple surrounding-view cameras, LIDAR and GPS/INS (Global Position System/Inertial Navigation System). Sensing related image recognition was proposed to be enhanced by mimicking the stochastic resonance by inserting artificial noise into test images for the neural networks used. A novel on-board intelligent management functionality was presented which automatically and dynamically proposed the optimum automation level to the driver when he/she wanted to make a certain journey with his/her automated vehicle. The proposed system utilised (i) a driver's personal preferences, (ii) information based on sensor data fusion systems, and (iii) previous knowledge and experience on driving automation parameters.

Micromobility was also introduced into the automation development with a proposal of a modular controller box for autonomous personal micromobility. An interesting idea was the novel symmetric intersection design to accommodate safe and efficient automated driving and cross-street pedestrians at four-arm signalized intersections.

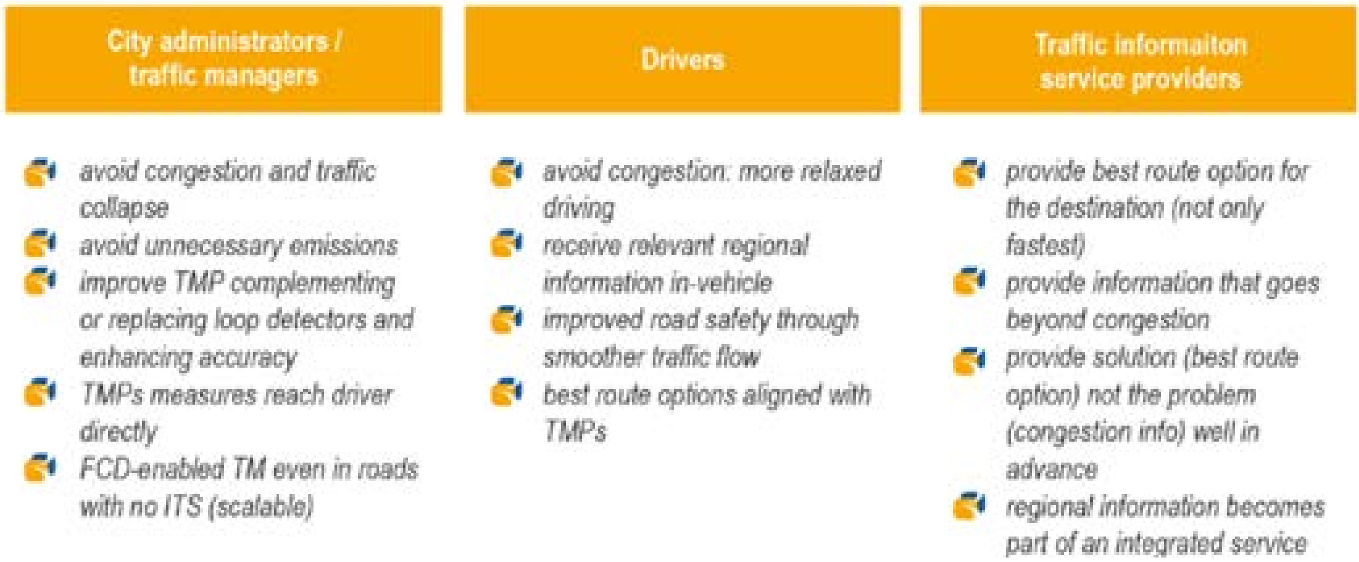
The TM2.0 standard being developed in the EU promised a 'win-win-win' for transport users, public authorities and vehicle manufacturers. It focuses on vehicle centred data and how the automated vehicle operates on the road. TM2.0 aims to use this and be the platform for the optimisation of the transport system using newly available data opportunities.

Forwards v Constrained

Forwards

While testing was still very much in the foreground, deployment issues and challenges had clearly moved more into the light. Regulatory and organisational aspects, roles of different stakeholders, deployment outlooks, and national strategies were presented. The safety assessment and assurance processes were much more in focus in this congress.

Artificial intelligence (AI) was an area clearly advancing,and was much more prominent in this congress that Copenhagen or Montreal. The AI approaches in different regions, use of Deep or Convolutional Neural Networks (DNN and CNN), embedded context-aware machine learning, ranking of danger in different traffic situations, and safety analysis were among the AI-related issues discussed. There was a view that AI should not be used if at all possible. It's complexity and 'black box' nature meant that it would not help operators understand underlying problems. It could only enable them to combine complex data sets to see results and therefore was not a substitute for fully understanding a system or problem. AI was only ever likely to be 90% useful to solve



Added value for stakeholders under TM 2.0 (Johanna Tzanidiaki ERTICO SIS09)

problems and there were diminishing returns to get to the final 10%. Also, because AI tuned its conclusions, it was impossible to ever fully know what the system would do in a given situation, or quality control or audit its performance.

There was a growing interest in evaluation and impact assessment of connected and automated vehicles. We saw major evolutions in the management of the large data sets collected in field operational tests, and also in ensuring that sufficient amounts of key evaluation data in order to estimate eg safety impacts would be accumulated. The results on impact assessments predominantly still came from simulation or other modelling studies. The issue of the transition period from 100% human-operated traffic to 100% highly automated traffic had risen in importance, especially in the evaluation dimension. The need for novel tools and mobility simulation models for analysis of mixed traffic was highlighted, and the issues with coexistence of automated and conventional vehicles in cities and on roads were discussed.

In goods transport, both the sessions and the exhibition witnessed the emergence of different small delivery vehicles and robots. Their importance was stressed on the basis of the predictions that in urban areas, mobility for people will double during the next ten years, but mobility for goods will triple in the same period.

Digital infrastructure was more prominent in this congress than in previous ones, dealing with positioning, mapping, data sharing, extended horizon, dynamic local maps, and back office systems including remote fleet management and supervision centres. Concerning the infrastructure needed by the automated vehicles, a speaker pointed out that "What was desirable for human drivers is essential for machines". Concerning the quality of the physical infrastructure, a speaker stated that if it was good enough for a human, it would be good enough for a machine vision system. The discussions indicated that with regard to road operator and vehicle industry cooperation road work zones were the priority application area for the public and private stakeholders to work together. Interestingly, the concept of digital infrastructure for connected and automated vehicles varied between regions – in Asia it would also also cover processing, simulation and traffic management activities.

Digital services in connection with intelligent, connected and automated vehicles were announced, discussed, and demonstrated at the congress. It was also predicted that for the automotive industry business that while vehicle-related services would decline, digital services would more than compensate.

<u>Constrained:</u>
Provisioning of seamless connectivity on the move in all environments was becoming a reality and would enable richer ITS services, although the implementation carried many challenges. The hot topic of previous congresses had been the technology debate on the dominating communication technology: Dedicated Short Range Communications (DSRC) or cellular. This debate had now calmed down, and most seemed to have accepted that no one technology would dominate the connectivity of vehicles, conventional or automated. Connectivity would build on a number of communication technologies used to complement one another leaving ample room for technology evolution. However, the switching between different communication technologies and the related interferences in hybrid communications remained issues to be thoroughly explored.

Experience thus needed to be shared in deploying different communication technologies, in particular regarding data volumes, security and integration with providers. With commercial deployments of 5G networks having started in some regions, it would be interesting to look at how the ITS community foresees benefiting from 5G technology and where risks and opportunities couldn't be identified. The discussion highlighted that the needs and benefits of connectivity for safety and traffic efficiency should be further explored together with requirements for policies, standards and international harmonisation. Providing comprehensive technology coverage transport research is essential as many communication and computing technologies are mixed.

Concerning automation, the congress was more road and motor vehicle oriented than the previous one. With regard to use cases, robot taxis were not covered in the papers or sessions to any considerable extent. This was probably due to the fact that the major global stakeholders running the robot taxi deployment were not visible at the congress. While different aspects of platooning were discussed some aspects still needed more attention such as the role of infrastructure, business models, impacts, guidelines for implementation, business models and standardisation, regulation and certification.

Some important issues were not addressed as much as they probably should have been. What would happen to mobility and kilometres travelled by different modes when highly automated vehicles enter the markets in earnest? It was essential to understand the impact of automation on greenhouse gases and thereby on climate change. There were frequent words of warning that unrestricted automated mobility on demand would cannibalise public transport and increase vehicle kilometres travelled, and congestion even more.

In digital Infrastructure access to vehicle data and data sharing remained a key challenge. The need for data types, quality, security and traffic management had to be further defined. The role of the road operator for collecting, maintaining and ensuring safe and efficient operation of the automated driving systems, as well regarding communication infrastructure, also needed to be clarified. What elements of digital and physical infrastructure and to what extent and quality would actually be required by highly automated vehicles entering the marketplace? How much were the local and national governments willing to invest to facilitate connected and automated driving?

To enable a deeper penetration of AVs outside urban areas challenges would need to be solved on how to handle unpaved roads. Currently utilised sensors and mapping techniques may struggle for example in an off-road environment which changes significantly with the seasons. For artificial intelligence the challenges included the lack of awareness and ethical aspects which were closely linked to liability issues and regulations. Many road operators still lacked experience of using AI technologies and needed to be prepared for the integration of AI in future deployments.

Where might we be heading

The sessions and papers in this Topic showed the continuing maturing of autonomous vehicle development. While it had been clear for some time that the technologies associated with connected vehicles were become mainstream and the business cases around connected vehicles were being better understood, it was clear that the thrust of research and development in automated driving was also starting to more closely examine widespread market adoption and use. Common themes included real-world sensing and situational awareness, security and data handling and strategies for practical vehicle to infrastructure cooperation and interoperability, . The detailed problems around the use of highly automated vehicles on the public road network included investigation of merge-point support for automated vehicles at highway on/off ramps; modelling of cooperation between adaptive cruise-control systems; and detailed consideration of driver 'take back' from autonomous operation in SAE level 3 or 4 vehicles. This pointed to a growing interest in the research community in solving the practicalities of connected and automated operation, rather than the basic science and engineering. Many of the papers began with the assumption that highly automated vehicle adoption was coming closer and from this we appeared to have the strongest indication yet of an industry eager to move from the capital intensive development stages to monetisation and commercial exploitation.

The subject of vehicle to infrastructure was covered widely in the papers. Again, this showed a transition from basic engineering to consideration of practicalities of operation. Papers reported progress of on-street trials and living labs in locations including the UK (Ipswich), Taiwan and Spain (Catalonia). Each of these reported on activities around taking automated driving technologies out of the laboratory and placing them in real world settings and dealing with the challenges that this raised. From this work we could also see the increasing belief that with many of the underpinning technologies now well understood and proven, it was commercialisation and marketing of connected and automated driving technologies that is driving research and development interest.

There was clearly a belief that the coming of highly automated vehicles to the public streets and highways was nearly upon us. The sessions and papers showed a growing body of research focussing on the practicalities of delivering autonomy and starting to monetise technologies that have long been considered developmental. There was growing confidence that in specific areas of vehicle control and in specific closed environments elements of autonomy would soon be available commercially and there was confidence that the more complex uses of this technology, leading to true level 3 and 4 vehicles, were now viable and not too far away. The primary question was: when exactly would we have driverless or self-driving cars on open roads? Some indicated that this would occur in a few years, whereas some are much more hesitant, especially due to road safety issues still largely unsolved.

The importance of the distinction between Level 5 fully automated and Level 4 highly automated vehicles (automated in certain circumstances only) was raised in a number of sessions. Both these forms of automated driving built upon and were different from Connected Vehicles, that were a basic requirement for all shared mobility services. Ten factors were seen as important for public bodies to recognise and prepare for as we move from connected vehicles, through to highly automated vehicles and then possibly to fully automated vehicles, (although at this stage, this is by no means see as a certainty);

- Infrastructure issues including EV provision, V2I, smart parking, kerb management, maintenance / asset suitability,
- Safety during the transition to automated vehicles, particularly moving through level SAE 3, implication of long-term mixed vehicle fleet; automated / manual hand over,
- Policies to ensure safety prior to full automated vehicle deployment. Clarifying regulatory responsibilities between Nation, State and Local levels, risk management during on-street testing / piloting,
- Data Issues. Sharing crash & near-miss data, standardising comms protocols,
- Traveller behaviour issues. Encouraging more productive use of time spent in vehicles (if not driving) could lead to increased vehicle miles; what impact would empty automated vehicles have; and should these possibly unwelcome aspects of autonomous driving be taxed,
- Could automated vehicles kill public transport? How do public bodies respond to this threat while supporting the likely positive possibilities for automated vehicles to deal with first / last mile,
- Planning and Planning Models. Effect of automated vehicles on planning, modelling, forecasting, and mitigating land use issues and impacts on urban sprawl,
- Addressing Social Impacts, particularly of the unintended consequences of autonomy, such as effects on labour, (truck, bus and taxi drivers for example),
- Social Inclusion and equity and equality. There was a potential for automated vehicles to provide services for those who cannot drive themselves but current MaaS providers threaten to put traditional taxis, which often help meet social responsibilities out of business.

Public acceptance and trust were highlighted as critical to the success of highly and eventually fully automated vehicles. Many of the early discussions around AVs and future technology were carried out behind closed doors and between experts. The automated vehicle industry should pay more attention to keeping the public well aware of their plans for rolling out automated vehicles as well as understanding the requirements of the travellers potentially using them. Public studies had revealed some interesting results; opinions were 'yes' for autonomous mobility, but 'no' if it would be expensive. Inclusiveness, sharing and no drastic increase in cost were critical aspects.

TOPIC 2:
CROWDSOURCING AND BIG DATA ANALYTICS

The overall situation

The majority of the crowdsourcing and big-data analytics sessions in Singapore focused on the benefits from using large data sets to improve operations in transport control centres or to improve overall economic activity. There was a major trend of applying more, and more advanced, techniques such as artificial intelligence, machine learning, deep learning and data fusion technique to early discovery of congestion hot-spots, monitoring how and why people travel, and most importantly predicting how congestion would appear in the network. The power of data analytics and crowdsourced monitoring techniques had been extended to the management of demand for public transport, traffic control, and traffic operations. Data integration from different sources and real-time data processing were also very popular topics

The topic in detail

Five main themes dominated the session papers and discussions:

Cloud technologies were being used more frequently for building an on-demand navigation service, front-line highway management, and data storage and real-time operations in traffic management centres.

Deep learning algorithms had become more common since Copenhagen and Montreal. There were case studies using convolutional neural networks and long short-term memory techniques, feature boost, decision trees, etc.) with applications covering:

- tolling systems and detection of abnormal behaviour
- traffic congestion prediction, performance evaluation; and speeding detection
- incident duration prediction in cities
- incident modelling using Bayesian networks for freight transport operations,
- delay estimation for urban delivery fleets,
- people movement using mobile data
- route choice modelling linked to travel time reliability,

Computer vision including operational use for road defect detection

IoT implementation in a variety of ways including:

- testing as an object tracking technology for un-gated rail stations
- a network of smart lamp posts forming an Internet of Things infrastructure with integrated cameras, meteorological monitor, Wi-Fi and other sensors

Operational implementations and real-world applications including

- Modelling of mobile data sources to capture people's travel, as this type of data is believed to be more accurate.
- An experimental smart transit hub built on the base of IBM Watson, which was a question answering system and real-time sign-language system. The platform was designed to support the shift towards autonomous and connected vehicles and make sure smooth transitions were made for bookings.
- AI-based machine vision for ITS applications using different types of deep learning framework. This was used for dynamic events detection, object detection, traffic flow applications, anomaly detection, traffic monitoring and video analytics.
- Using mobile network data for road asset management. An experimental application looked at capturing origin-destination patterns, travel mode, and trip purpose. The driver is the problem that the greater the volume on a road the greater the maintenance attention needed as there was a higher chance of road damage. However concerns remain about privacy aspects.
- Using deep learning to detect vehicles using mobile apps. By analysing the probe vehicles using the app the AI model in the cloud could generate real-time congestion and speed maps. This enabled a complete loop of collecting data from mobile devices, processing the data in the cloud, and pushing the data back to mobile devices with an overview of traffic condition.
- Development of the Singapore traffic operations control centre to include data collection; data processing; and data analytics for traffic operation. The core services were using data fusion techniques for providing insights from mapping, situational awareness (for example sudden drops in traffic speed), incident management, and for generating information sent to charts for analytical investigation of the performance of the network.
- An in-depth analysis of data independency in traffic forecasting which characterised the data into: statistical properties, long-timescale influences, and short-timescale influences.
- A successful hierarchical traffic control policy for managing heavy vehicle accession and merging flows. The green wave and common cycle time methods were used together with diverging, metering and departure strategies to minimise the impact of merging flows. The best case strategies saved around 49% of average travel time.
- Traffic information systems had been used to provide road users with routing information and safety information. Mapping and location technology companies had been working on ways to develop smart cities and autonomous driving ecosystems. An experimental platform of traffic data analysis used three major components – Origin-Destination analysis, route monitoring and traffic stats and using probe vehicle data for traffic flow analysis,
- As most cities were collecting more data from their transport systems researchers and practitioners were able to get more information from the sensors and therefore move to a deeper understanding of traffic conditions. Large city-scale traffic modelling had been applied to big cities in India, the Czech Republic and the UK. The ViaRODOS system in the Czech Republic was an advanced intelligent transport system utilising big data with multiple interfaces containing different analyses of the big data content. The next stage of ViaRODOS was integration of public transport.
- Use of both accident data and traffic data to predict post-accident road network recovery time in UK. Multiple machine learning models were tested and the best achieved t4% accuracy; it was also noted that typically the flow and speed dropped about 30 minute later than the time of an accident.

Use of data analytics in Singapore's traffic operations control centre (Tay Chi Wen Germaine and Poh Sok Ee, LTA; TP 2184)

Old v New

There was a pronounced trend visible in many sessions of experimenting with the application of new techniques to relatively old problems. For example new approaches to building models for improving traffic management in various centres around the world had generated results that aligned with the work presented in previous congresses but offered higher precision and reduced processing time. Some recent developments on this theme included adapting the latest machine learning techniques to analyse data thereby demonstrating the power of AI. This methodology fitted well with the practices of the many transport centres around the world which had adopted data-fusion and real-time simulation modelling for traffic congestion management. This type of traffic modelling offered greater focus on the dynamics of traffic instead of just its static status, and also enabled coordination of traffic signals between motorways and arterial roads rather than just optimising them independently.

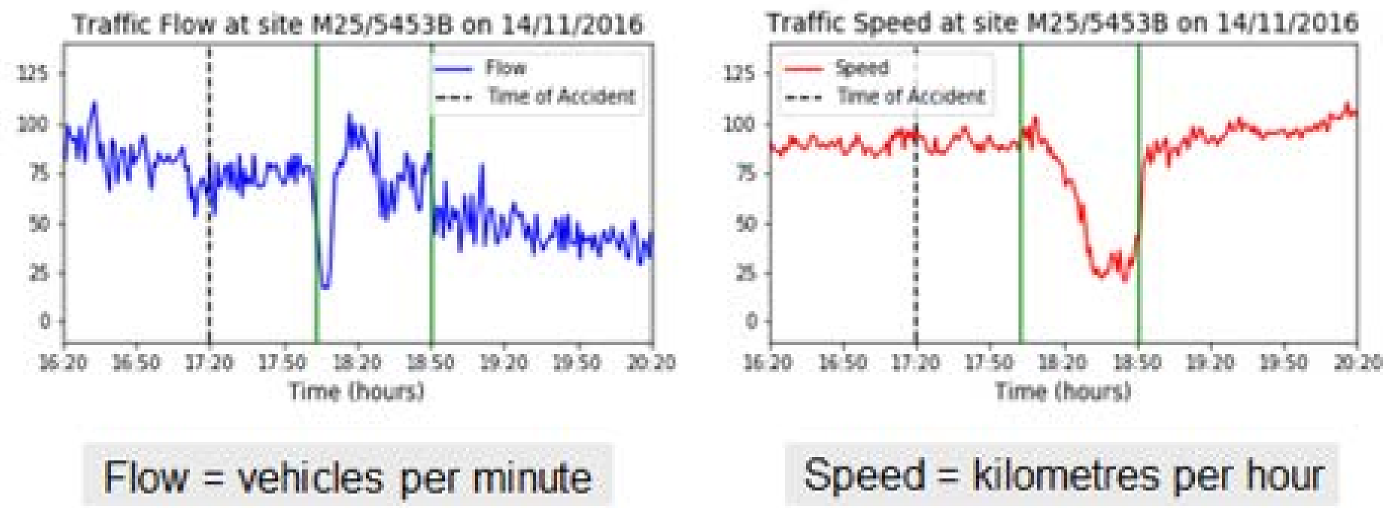
Other cutting-edge technologies had been applied to ITS solutions. For example, the UK test at un-gated stations of object-tracking technology; the use of computer vision to detect road defects; and the deployment of smart lamp posts to create an IoT network. These successful case studies demonstrated the power of advanced technologies in IoT and crowdsourced data to support the data-driven decision-making.

There were interesting new developments with big data platforms showing that they should not be seen as limited to presenting the observed data from their sensors; rather they could be the basis for performing predictions in real-time.

Forwards v Constrained

More information was being provided to road users than before. This information could be transmitted through traffic information systems such as variable message signs, navigation apps etc and reflected some important developments in transport, translated by the use of IoT, big-data platforms, and real-time AI for traffic management. However as more and more data was collected more effective and efficient ways were needed to handle the sheer volume in order to meet the requirements of users' applications. Many ITS services would like to have real-time data processing which added a cost and complexity overhead to operations.

The main constraints on the application of AI models were their reliance on accurate and consistent data sources, a requirement that was often very hard to meet. Several studies in the sessions used simulated data sets or synthetic datasets for applying their AI architectures instead of using real-life data sources. Only the work in Australia and the UK highlighted real applied data science using real-life motorway flow counts/incident records. This emphasised that incident data and flow counts were



Algorithm to predict post-accident network recovery time (Leanne Pienaar, Arup, TP 2016.)

very sensitive and not easily shared by transport agencies. Open data platforms needed to take this into account and explore ways to improve their network performance though research studies.

A presentation on the UK national traffic information service talked about the challenges and solutions when processing the big data from traffic systems to provide information about traffic conditions and events. These included volumes of data, increasing granularity, reliably detecting congestion and its extent, proving benefits, traffic profile prediction, strategic response to incidents, and traffic condition prediction.

The main constraints in terms of further deployment for some applications was the data availability and accuracy from various collection methods and most importantly privacy concerns that come with mobile or video identification.

Where might we be heading

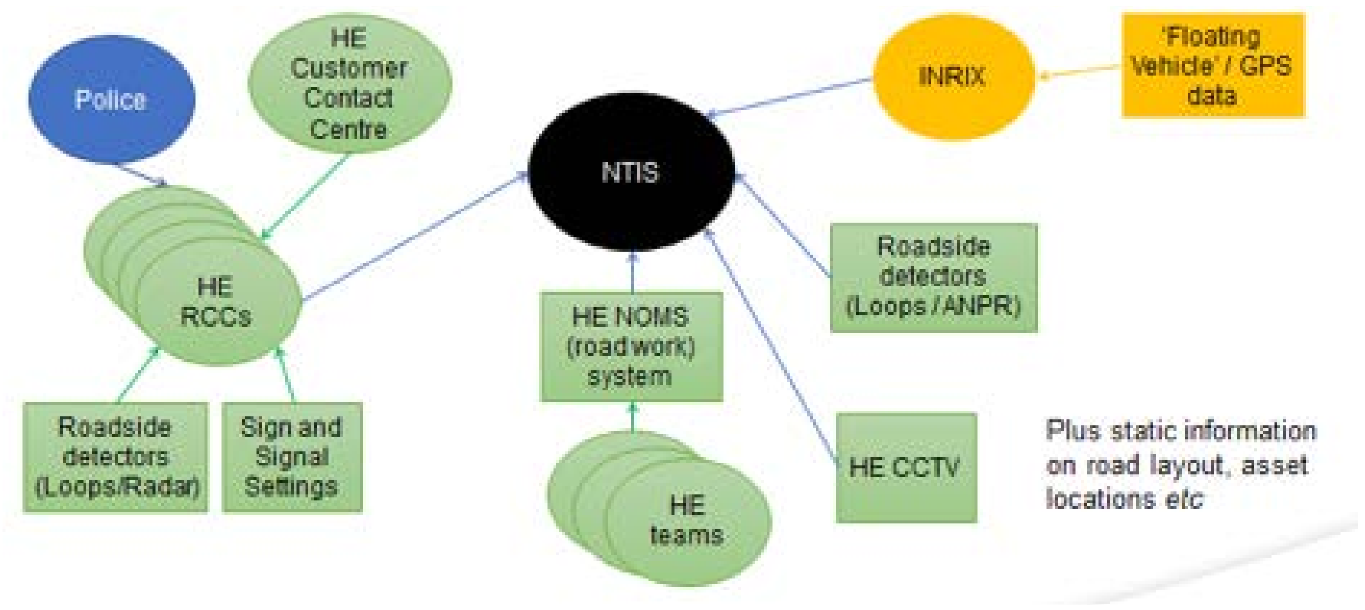
Sessions and presentations reinforced two clear messages – the complexity of data-driven modelling had increased and models that were more complicated had been developed; and second the algorithms involved needed to be more efficient and scalable which was driving studies by both researchers and front-line practitioners.

Mobile data had started to be used as a unique potential source of information which could bring massive benefits to transport agencies and it would be interesting to see in Los Angeles next year how quickly this line of enquiry developed. Similarly, Singapore saw increased emphasis on data and video analytics methods as a consequence of which there was much research activity in this area.

Researchers and practitioners were very aware of the randomness and uncertainty of daily traffic in all modes. Traffic incidents and the subsequent recovery was a popular discussion topic for city planners and traffic managers around the world and we could expect to see the results of the searches for solutions that minimise the side effects of these random traffic incidents.

Singapore saw the early signs of using the power of a range of data handling techniques to bring apparently unrelated topics together – for example the work in Japan to look at both business intelligence and data analytics. An innovative paper described finding correlations between the purchasing power of consumers using rail stations and their wider movement patterns. We could expect to see more of this type of "cross over" study linking the 'pure' ITS element to other parameters.

People today were more connected and both received and generated more data than ever before. New technologies enabled multiple channels for the information provision in our intelligent transport systems which were driving efforts to develop integrated, smart, and reliable, ways to



Overview of UK national traffic information service (Rob Kidney, NIS, TP 2223)

handle our ever-increasing connectivity. It was still a big challenge to make our transport safer and more reliable due to the uncertainty and complexity of the underpinning systems with much efforts currently being made towards a smarter city and a smarter transport system. The road was long, but we were gradually getting there.

TOPIC 3:
SUSTAINABLE SMART CITIES

The overall situation

Smart cities had featured in several World Congresses however the Singapore discussions emphasised the "Sustainable" element with the dialogues focused less on citizens'/travellers' needs and how "ready" any given city might be to becoming a "smart" city. In 2019 there was more discussion about the need for collaborative strategies among various city entities with a range of collaborative strategies described in sessions and papers. Sustainable Smart Cities was the second most popular topic with the majority of interest in traffic management tools, traffic control and operations, and electric vehicles (EVs). Cycling featured frequently as it was the obvious sustainable alternative to traditional vehicle transport, although there was mention of other mobility services, such as demand response transit and mobility on demand using automated vehicles (AVs).

The previous 3 Congresses at least had heard about proposals for deploying smart or automated shuttle systems to increase mobility within communities. However Singapore revealed a shift towards looking at the larger picture rather than just the technology. The ability to order a shuttle to take you from point A to point B was no longer seen as a sufficient success. It was clear that there was now greater recognition of the need to consider larger operational factors such as electric vehicle charging, trip supervision and business cases, accessibility, equity – and affordability.

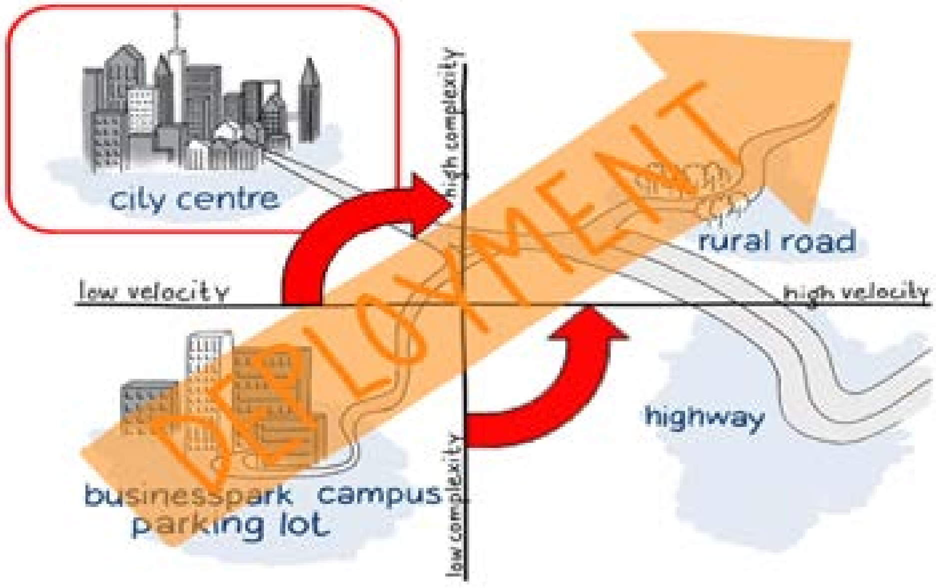
It was often noted that in recent years public transport agencies and operators around the world had faced increased competition from the boom in new mobility. As a result public transit had been losing riders to these platforms and to make matters worse, most new mobility entrants gave priority to on-demand private rides – ie not shared – which had overwhelmed cities with increased congestion."

Looking back to 2018 in Europe it was noticeable that from an EU perspective the whole range of connected and automated mobility solution deployment was moving from low velocity to high velocity, and from low complexity to high complexity, as shown below.

The topic in detail there were five popular sub-topics:

<u>Sustainable traffic management tools</u>

- "Traffic Management in the Digital Age" – the use of new technologies such as big data processing,



Possible AV deployment paths (Tom Alkim, European Commission, SIS13)

cloud computing, artificial intelligence (AI), machine learning (ML) and the use of open data platforms to improve on current management techniques

- Relocation of communication, traffic management and trip planning to mobile or in-car solutions coupled with increased connectivity to enable more central direction of networks to improve load balancing. There is also an ongoing shift in moving the analytics and computing of transport systems to the edge (local, within devices).
- On-board routing and path planning systems to allow road authorities to better utilise the available network capacity by rapid rerouting when mitigating traffic incidents."

<u>Traffic control & operations</u>

Today's systems could collect, transfer and process much more data than before. These data, combined with big data processing, real-time analytics and traditional simulation, could be used to create new traffic management plans that not only included historical data but could also consider real-time and predicted data."

- Evaluation and comparison of new real-time, adaptive and predictive traffic management systems, to maximise the capacity of the current road network without expensive upgrades.
- Evolution of current traffic management systems to integrate data from pedestrians, cyclists and other mobility services with emergency vehicle / heavy vehicle / public transport priority
- 'Green, energy-efficient, or intelligent alternatives to traffic control infrastructure (solar VMSs, energy efficient traffic signals, dynamic LED line marking etc)
- Cities around the world were realising benefits from new data sources eg connected and automated vehicles, Bluetooth and Wifi to better inform real-time optimisation control".

<u>Sustainability in transport</u>

- Integration of different travel modes, and multi-modal travel systems and hubs
- Efforts to make green options such as cycling and public transport more popular, including integrated transport systems which encourage transfers between buses and different transport modes and studies on user satisfaction with public transport
- Planning sustainable development in terms of equity among environmental, social and economic factors. Planning tools for assessing proposals for new developments, mobility services and infrastructure changes

<u>Electromobility & EV Charging Infrastructure</u>

- Electrification of public transport (especially buses) – feasibility studies, analysis of results, recommendations, strategies
- Strategies to encourage ownership and use of electric vehicles (Evs)
- Modelling energy consumption of EVs and charging infrastructure placement
- Shared Mobility & Shared Automated Vehicles
- First mile and last mile services and strategies – combination of public transport with on-demand transport, AVs or autonomous shuttles
- Fleets of AVs used in public transport service with no steward on-board

There were some surprises / disappointments regarding the less popular topics. The focus was overwhelmingly on roads with only 2 papers on rail transport and 1 each on air and sea travel. There was not a great deal on smart city infrastructure such as hardware for data collection and intelligent infrastructure systems. Given Singapore's geography there was surprisingly small focus on the use of urban space in a smart mobility future – land use, roads for autonomous vehicles, public transport and cycle ways, shared spaces for vehicles and pedestrians although this issue had some coverage in the Innovative Pricing & Travel Demand Management topic. And Singapore's status as a major port was not reflected in many discussions in this Topic around freight transport and the technology to support it.

There was a general lack of enthusiasm for recognising the need to consider accessibility and equity in the shared, automated, connected and electric future. There were numerous discussions about how autonomous vehicles will increase accessibility and provide transport for those that cannot drive, but no discussions on how this could be achieved now without autonomous vehicles.

Old v New

A number of activities were presented and described as 'New' but had been aired a number of times in the past, for example: traffic incident management; methodologies for planning how infrastructure could support active modes of commute (eg cycling and walking); and the use of AV shuttles to improve 'first km-last km' journeys for people and freight. The topic of Sustainable Smart Cities was very broad and encompassed a large variety of technologies, projects, strategies and solutions. Most ideas, solutions and projects could be classified into two groups; small local projects and large ambitious projects. Small projects were happening everywhere with exciting new ideas being developed and implemented rapidly. However, these projects were unlikely to have large impacts or revolutionise how we lived. They were often pilot projects and trials, carried out within small areas (test-sites, campuses etc). There were many papers reporting on the results of these trials for example:

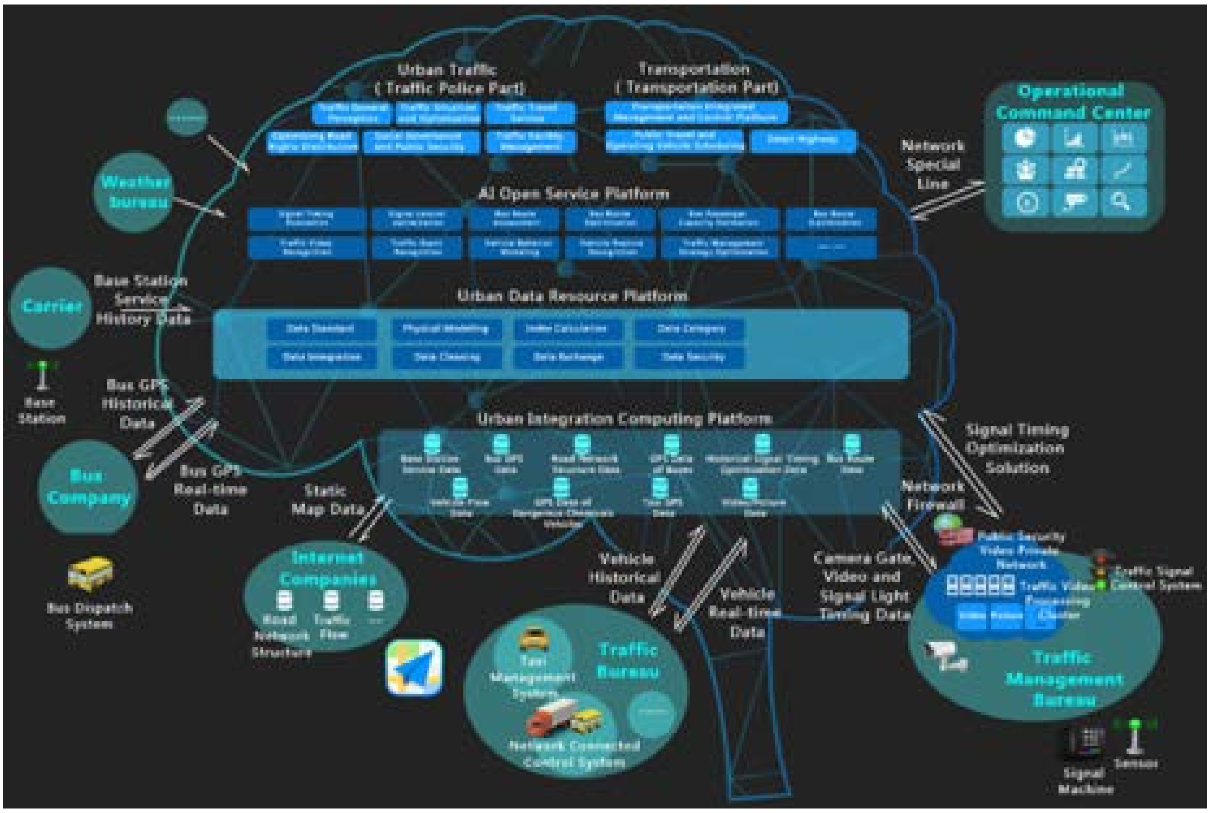
- Cycling4Trees: A gamification approach to strengthen cycling in cities based around a routeing app implemented and tested in Munich and Berlin.
- Development and field evaluation of adaptive ramp metering – a new system field tested on a northbound corridor in Minneapolis, and extended to the metro freeway network in Minnesota

Larger, more ambitious projects (with larger impacts) were seen as significantly slower moving. They were constrained by issues such as government regulation, integration, global acceptance, competition, collaboration etc. They were often proposals for national / global solutions, often based on successful results from small-scale trials:

New Ideas Included:

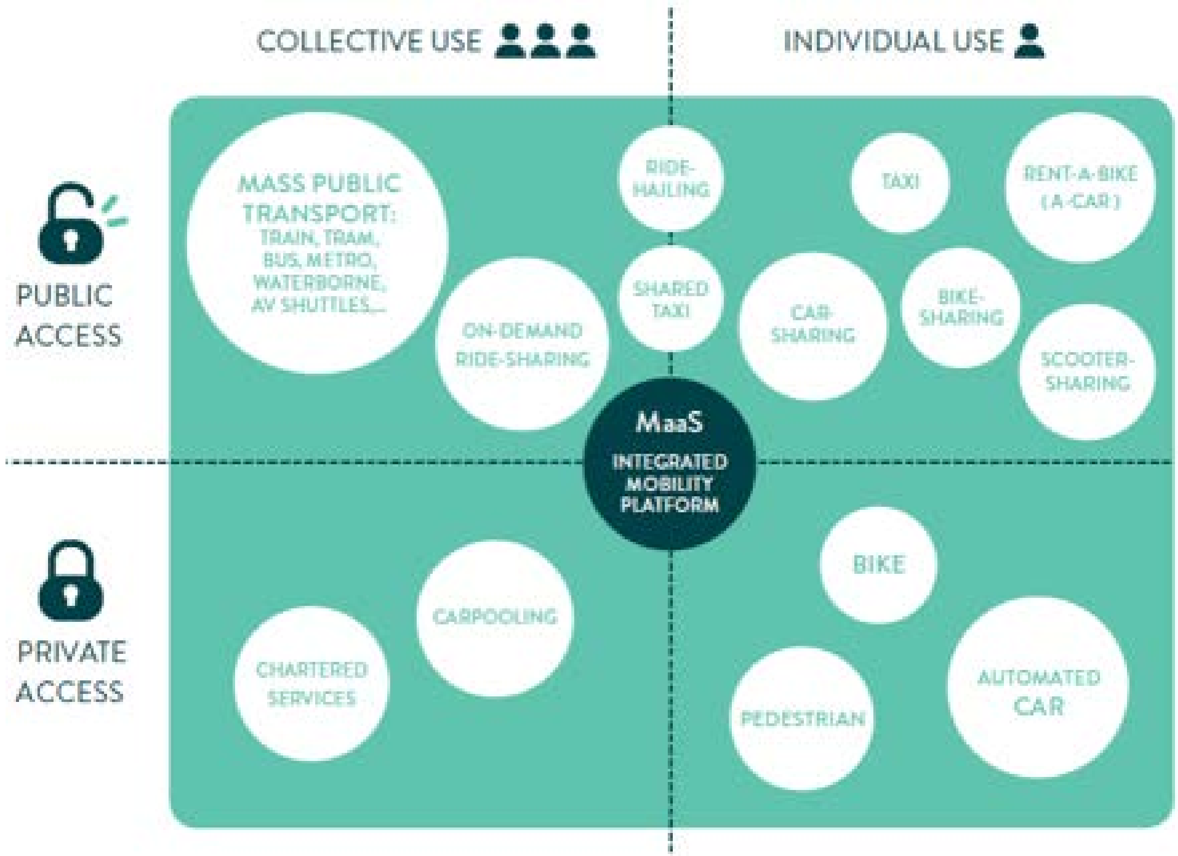
- Determining the impact of changing or uncertain working patterns on future mobility using a three-level analytic toolbox. Network operators could use the three steps together to create a consistent set of tools that would help identify what futures are relevant to assess so that resilient decisions can be made.

- A modified cell transmission model used for traffic prediction in a signalised urban network to keep track



Structure of the ET City Brain System (Yuelong Su, AutoNavi Software Co, TP1943) of vehicle route intent in order to better predict traffic flow.

- Routeing of modular electric vehicle fleets
- A "City Brain" system in China provided smart transport services based on linking real world traffic situations and balancing navigation and optimising signal timing, along with integrating services on traffic management and control and public travel.
- An event-responsive pedestrian-actuated control system to provide green time that responded quickly to audience demand and reduced the burden on police officers.
- Singapore's 2040 goal of "20-Minute Towns" – almost all journeys to the nearest neighbourhood centre on public, active or shared transport would be completed within 20 minutes; and "45-Minute Cities" where 9 in 10 peak hour journeys on public, active or shared transport to a city would be completed within 45 minutes.
- Application of deep learning to traffic signal control.
- A new methodology for optimising the traffic signal timings in signalised urban intersections, under non-recurrent traffic incidents.
- Cloud-based multiple-stakeholder communication to enable safe interaction between AVs and emergency vehicles,
- A set of indicators for human-centred impact assessments of future mobility technologies in public transport. The goal was to assess public satisfaction and identify to what extent the new mobility technology fulfilled the needs and wants of users. Three modules were defined: operator's (network) planning phase; individual usage of the public transport system; and city and societal level impacts
- A system to recommend suitable charge stations for drivers of various EV models on expressways was built using ML.
- A simulation-based methodology to derive a city-centric optimised electrification strategy for large scale public transport bus fleets.
- A methodology to measure the expected time needed to reach a suitable parking spot and then walk to a destination.
- Piloting fleets of automated vehicles in public transport service across multiple cities using a new four phase process to attract start-up companies.
- Applying deep learning to floating car data to improve traffic incident management.
- The UITP had explored redefining the term "public transport" to recognise the arrival of automated vehicle testing and a stronger focus on mobility instead of modes, and has applied the approach to the concept of cities – see diagram



Redefining Public Transport in Integrated Mobility (Guido DiPasquale, UITP, SIS13)

Forwards v Constrained

Forwards

The broad definition of this topic area meant it had a low barrier to entry and was not constrained by large technological roadblocks such as those facing AV development – individual systems could be made more sustainable or smarter without leaps and bounds in available technology. It was easy to produce small, start-up solutions within small geographic areas so we saw many projects in CBDs, university campuses etc.

Technology disruptors were driving rapid change in the transport industry. There were numerous new technologies and business cases related to the emergence of connected and autonomous vehicles, artificial intelligence, machine learning, 5G and the Internet of Things (IoT). Creating a smart city required data. The Internet of Things had enabled the collection of large amounts of data from a wide range of sources. Mobile communication was the largest technology platform in human history. 5G was an enabling technology, which would expand this system to many new industries.

In the popular topic of traffic management our decision-making was fundamentally dependent on the quality of the data we collected to inform those decisions. As technology and data sources improved the collection of data would allow for rapid advancements in control systems. As an example, loop coil detectors were currently the go-to solution for vehicle detection at intersections, but they had their downsides. Emerging data sources such as LiDAR sensors could be used to bridge the gap between existing data sources and future data sources such as vehicle-to-vehicle communications, while market penetration increased. It was also possible to merge data from multiple sources to obtain a greater understanding of traffic information.

A recurring topic within discussions about the future of smart cities was the business cases for supporting projects, and the emergence of Public Private Partnerships. It was recognised that change was driven by industry, so when the private sector saw value, things would move quickly, prompting pressures to get business to contribute more to infrastructure and transport projects.

The traffic management elements of a Mobility as a Service (MaaS) system were discussed for the first time at a World Congress. The integration of Traffic Management 2.0 (TM 2.0) and MaaS focuses on four key concepts: (1) the mobility system was not only road-based; (2) the private and public sectors needed to know how to cooperate for the benefit of all; (3) precision in origin-destination and estimated time of arrival (ETA) data was needed; and (4) seeing a bigger picture was essential for traffic balancing.

Constrained

- Lack of a definition of a "Smart City" and what one might look like, and the strategies and technologies to be included. However there were some clear suggestions:

Smart City Components (Jim Barbaresso, HNTB, SIS46)

- Small start-ups were often trying to create an impact on their own, while larger companies tended to develop all-encompassing solutions (trip planning, bookings, transport, payment etc). When developing software and apps for a smart city, interoperability was critical to avoid multiple disparate systems. This required an open architecture (not proprietary software) and structured data (not raw data).

- As discussed above, larger solutions and projects required coordination and consistency, and were constrained by issues such as government regulation, integration and global acceptance. This was complicated further by the many different players / competitors, a rather uncomfortable working relationship of the traditional automotive industry and the ITS world; and the marked discomfort and reluctance of many local authorities when faced with the trend to cooperative working

- Sharing and control of the data that powered these smart mobility systems. The big issues with data were the lack of sharing, information kept in separated silos, ownership of data and unclear policies around its use. People still considered data valuable, and so did not want to give it away without charges. One possible solution was the proposal of city-wide repositories of open data, supported by local governments. This increased collaboration and provided a 'feeding ground' for innovation.

- Route planning for electric vehicles was limited by battery life and thus the need to visit charging stations – this was improving year after year and becoming less of an issue

- One interesting constraint was not discussed very often – the lack of accountability in AI-based methods. It was difficult to explain how some AI-based methods reached their results prompting some serious concerns about lack of accountability particularly the application of AI-generated results in mission-critical areas.

- The advent of electric and automated vehicles had created dangerous situations for first responders – attending to these vehicles in incidents required disabling of the automated driving systems, and diagnosing vehicle issues remotely, for example. Also, tow companies that were dispatched to handle incidents with these vehicles needed to understand the advanced features that could require special handling.

Where might we be heading?

Many organisations were working towards a smart, sustainable future but no single body was able to change mobility alone; cooperation between all parties was required if we were to achieve this goal. The role of legislation covering autonomous vehicles and smart technologies would become a greater area of focus in the coming years. Many parts of the 'autonomous vehicle roadmap' made assumptions that legislation would not get in the way of the technology without seeing the need for a joint development with city regulators. Without sensible legislation the potential of the new technologies would not be unlocked. There were clear signs of the development of key functional components of a sustainable smart city incorporating more options for how to travel and more choices for how sustainable the method of transport would be, possibly with a focus on balancing cost, efficiency, sustainability, travel time etc. Complementing this we saw evidence for:

- A competitive industry for trip-planning apps and on-demand transport providers

- Increasingly efficient traffic management tools to predict and manage congestion, as more data are available and new ways are found to utilise it

- Development of a bus electrification strategy covering scheduling and the simulation of air quality and noise propagation models together with further integration of a multi-modal traffic model.

- Development of work streams under a travel demand management programme.

- Trials of smart ramp metering systems.

- Using AVs to increase mobility in specialised communities was recognized as a "smart" approach within not only cities, but also suburban and rural areas. Four examples were provided in the Congress: (1) First mile-last mile shared low-speed AVs serving a gated community to increase accessibility; (2) accessible hospital transport with on-demand wheelchair accessible AV shuttles; (3) a "car-lite" housing estate giving more and greener space for people, and less space for cars; (4) demonstration tests of autonomous driving on public roads.

TOPIC 4:
MULTIMODAL TRANSPORT OF PEOPLE & GOODS

The overall situation

The combination of multimodal transport of people and of freight into one stream proved to be an interesting choice, as it emphasised the fundamental differences in the application of multimodality and mobility strategies to each one. In the case of multimodal freight discussions tended to be more about the contractual arrangements where one person is responsible for the end to end journey of the goods, be it air, sea, road or rail. By contrast in multimodal people transit the practices appeared to be skewed to using more than one mode of transport, and usually without someone responsible for the end to end journey. A lot of the papers addressed planning information for a people-based multimodal journey, but there were clear signs of a shift towards "Contracted Responsibility" and universal services such as those emerging in Mobility as a Service initiatives.

The biggest visible differences between people transport and goods transport were the elements of behaviour and lifestyle-linked choice for people. Not so long ago the definition of multimodal transport of people primarily reflected the interchanges between modes of public transport. With the explosion of first and last mile solutions for both people and goods, and improved data and technology for sophisticated routeing systems, public transport is now just one part of the multimodal transport ecosystem.

The commonality between multimodal people and goods was the increasing reliance on better managed roads and corridors – bringing traffic management and transport management intelligent strategies together.

The topic in detail

The topic was fifth largest in terms of papers and sessions with "Service", "Data", "Mobile" and "MaaS" as dominant threads for session and paper titles. There was a pronounced emphasis on the movement of people rather than goods with five key themes:

- Accessible and equitable mobility
- Cybersecurity
- Digital Infrastructure
- Micro-mobility solutions
- Urban simulation and modelling

Accessible and equitable mobility

Both service providers and system managers argued for accessibility needs to be included in the development of data specifications so that descriptions of modes would be more complete and would thus enable users with a disability to tailor their trip planning and choose the options that gave them the most pleasant journey. Optimising urban mobility and successful deployment of MaaS depended heavily on a close cooperation between all stakeholders and their needs. Urban mobility must address the complexity and multimodal nature of human behaviour and a wide range of ability.

Autonomous vehicles were moving steadily closer to adoption so road service managers and both local and national governments needed to be prepared for integrating these options with other modes and vehicles to enable more accessible and equitable mobility. This was an important issue as the liveability of a city could be enhanced by its transport. Social outcomes of multimodal travel such as social equity, wellbeing and environment were increasingly being measured. One speaker gave the stark early warning that an average person was probably going to live ten years past their ability to drive so city planners needed to take note that the liveability of a city needed to be urgently considered.

Cybersecurity

Many sessions and papers punched home the message that cybersecurity was becoming increasingly important and must be designed into ITS systems at the earliest possible stages. As systems became more intelligent, digital and dispersed so the vulnerability to hackers and malware increased. The connectivity of infrastructure for autonomous and connected vehicles also raised the chance of cyber threats that could inflict significant chaos on the transport system of in a busy urban city.

With big data from intermodal journeys being used to inform better route planning, cybersecurity needed to be prioritised. Telecommunications data was also being used in conjunction with public transport data and companies could tell whether a journey was made by walking, by driving or on a bus. This movement and sharing of information needed to be properly monitored and protected to ensure that user safety was highlighted.

The trend was to edge computing, where the intelligent system processing the video analytics was in the device itself making for faster real time information. With reduced latency from localised intelligence, transit services could travel closer together safely eg trains.

Around the world 5G connectivity was being seen as a game changer for real time data exchange with particular benefit for public transport.

Digital Infrastructure

Digital infrastructure would be required to support any connected or autonomous vehicle permitted to enter a future multimodal ecosystem. Discussions stressed that adding connectivity technologies to existing infrastructure could give more immediate improvements in the way we managed multimodal journeys and road congestion than waiting for the "silver bullet" of autonomous vehicles.

For automotive companies autonomous vehicles needed to be regarded not just as a retail product but as a key part of a much larger ecosystem in which connected and autonomous vehicles used the surrounding technology of sensors, IoT, AI, deep learning in order to progress. AI and the application of machine learning for recognising the mode, vehicle or pedestrian type was also improving trip planning certainty to better facilitate multimodal journeys.

The benefits of connected and autonomous vehicles were exponentially commensurate with the density of the deployment of such vehicles and they could only operate if the digital infrastructure was in place to manage kerbside usage.

Trip planning would be a key element of future smart infrastructure which would rely on connectivity and not necessarily automation, as connectivity could be deployed today. It was important that every mode and movement in the ecosystem was treated with equal weight – not just cars and public transport but cyclists and pedestrians too. By taking this into consideration, and recognising that both physical and digital infrastructure were required to have a truly integrated and connected system, multimodal journeys could be better supported.

MaaS implementation in rural or disadvantaged communities was often not about the digital infrastructure or technology – in some cases it could be more important to prioritise physical infrastructure by engaging with the community to understand the use cases of their travel.

Micromobility solutions

A third speed of "vehicle" class was being created in the microtransit space. It was faster than walking, slower than cars and ideally would benefit from re-purposing of footpath and kerb infrastructure to provide first-mile to transit. Micromobility services like scooters and bikes would only be supported if the management of infrastructure changed. Cycling was presented as an example of a micromobility solution that had evolved to take a gamification approach to attract users.

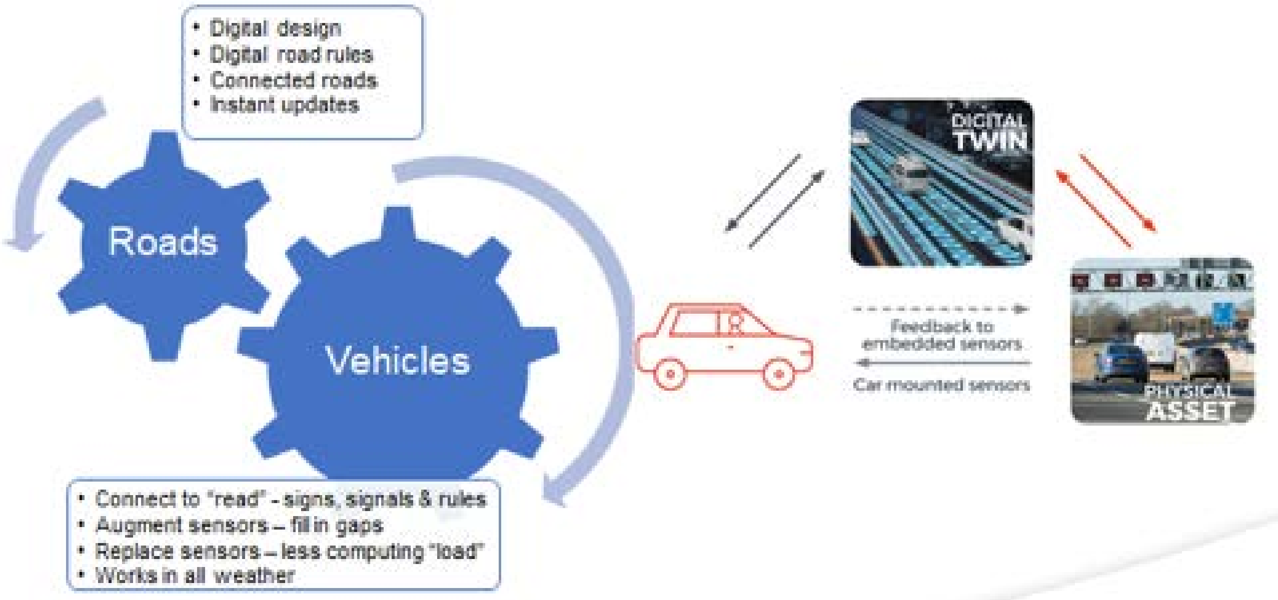
With the line between private and public transport blurring, with private cars being used for ride sharing and carpooling, and with elements of private transport being adopted by public transport, it was important to consider users' behaviour and how much they valued MaaS solutions. This would require not only implementing appropriate infrastructure to support these mobility options but also structures that emphasised the benefit of alternative modes of transport for an individual and the community. There were calls in many sessions to "reclaim the streets" by prioritising pedestrian wellbeing and focusing more on their safety and interests rather than driver convenience.

Microtransit was presented as a solution for last-mile delivery for urban freight based around a hub model. The growth in e-commerce had sparked new approaches to delivery for compliant city logistics and pressure to become more environmentally friendly through alternative transport modes like cargo bikes. As one speaker put it "this is because the new reality is we don't go to the store – the store comes to us".

Urban simulation and modelling

The concept of the digital twin was a growing trend in the intelligent transport space, where digital infrastructure could be used to improve urban traffic simulation incident management and response. Examples were presented of the importance when using models of thinking in terms of combining data from both traffic and transport services in order to get a better picture of what was happening and what interventions could reduce congestion. MaaS needed to be integrated with existing transport systems instead of considered as completely replacing them and it needed to consider the changes in travel behaviour induced by extensive adoption of these services and other disruptions. It was argued that more simulations of MaaS solutions should be commissioned to understand the wider impact of shared mobility on transport mobility on transport systems and on traffic planners.

Discussions proposed that the notion of a digital city to inform transport planning and management had to be extended to include the built infrastructure people use on a journey. This implies knowing how people travel in order to manage an incident correctly or advise people on the best journey for them to take requires. For example if the lift was not working at the railway station used by a person in a wheelchair or with a pram then they could not access their services.



Connecting to a digital twin (Ian Patey, WSP, TP 2025)

Old v New

There was a reasonable balance between bringing forward new ideas and reporting how the older ideas were performing. Research papers on the familiar topic of travel time and information presented new approaches to improving monitoring and management of: taking into account predictive time, travel time and real-time data, as well as information like traffic condition, passenger flow and bus station occupancy for better trip planning and adaptability to changing and uncertain transport and travel conditions.

There were a number of relatively new topics. Accessibility had a high profile with an Executive Session (ES 08 described earlier) debating a number of issues related to accessible and equitable mobility. A speaker in SIS 52 outlined some universal mobility solutions that were making transport more accessible eg. adaptive scooters that could be used by people with mobility issues, and non-app based solutions for bike sharing to cater for travellers without bank accounts.

Corporate MaaS emerged with examples of successful business models as MaaS providers encouraged carpooling or employee shuttles to corporate campuses. A number of companies were partnering with employers to reduce emissions and offer rewards to employees, which in return increased productivity. Corporate commuter shuttles suited the deployment of autonomous vehicles as commuter shuffle routes were relatively static.

Forwards v Constrained

Forwards

The year since the last Congress had seen many advances in automated driving for fleet management and logistics transport as well as for passenger movement. The consequent gains for services were

Sharing data and dynamic data needs (John Wall, Austroads SIS 40) increases in the flexibility of services and the possibility of serving previously unprofitable routes, as well as improvements to comfort, safety, vehicle efficiency, traffic efficiency and the effectiveness of fleet travel. The freight industry was likely to benefit from developments with connected vehicles and digital infrastructure. Data from the extended and diverse sensor networks along highways and at parking areas could help to improve the working conditions and efficiency of truck drivers due to the reduced search time for a parking spot. These improvements also increased safety on and around highways.

Growth in e-commerce has driven new approaches to delivery for compliant city logistics – focus on last mile: last mile of travel for delivery to become more environmentally friendly through cargo bikes and alternative transport modes. Cooperative deliveries and the sharing of city hubs will need to occur for B2B and B2C deliveries.

It was clear from sessions that we have started to consider users' behaviour, for example how they valued MaaS. The optimisation of urban mobility, as well as the success of MaaS, depended heavily on a close cooperation between all stakeholders and we needed a better understanding of the complex and multidimensional nature of human behaviour and the human need to control actions and thus control for mobility.

Constrained

In many cases City authorities were not connecting their thinking and planning on the management of traffic on the one hand, and the provision of parking and urban space management on the other. The perspective of, and relationship between, traffic flow and kerb-space management would need to be further explored with the rise of smaller and nimbler vehicles completing urban deliveries and the deployment of highly automated vehicles. Cities also need to assume a place-centric approach to transport technology deployment. A street was more than a part of a journey; it was a place for people and so modern city design had to stop prioritising vehicle transit when designing urban corridors. Linked to these arguments for a broader view, more discussion on innovative engagement methods by regulators and legislators would be beneficial – a constraint identified in 2018 in Copenhagen.

There was little visibility in Singapore of work on the behavioural economics of multimodal people transport. This was becoming a key topic given the significant impact it had on transport usage and the lack of understanding was likely to impact the deployment of AVs.

If B2B and B2C deliveries were going to develop as many city authorities and service providers hoped then protocols for cooperative deliveries and the sharing of city hubs would need to be put in place more rapidly than the current rate of development. It was also important to consider how cargo-cycles and these forms of microtransit would shift concerns surrounding the management of traffic and parking to kerb space management.

The perspective and relationship between traffic flow and kerb-space management would need to be further explored with the rise of smaller and nimbler vehicles

Building blocks for MaaS (Ivan Reutener, Royal HaskoningDHV, South Africa SIS 33) completing urban deliveries and travel. Smart ports were being considered as a kerb management option for freight delivery by creating flexible zones, allowing for loading zones to become something else at certain times of the day.

There were some excellent presentations and discussions in the Congress on accessibility, but more generally the subject needed to be included in the development of strategies, models and data specifications so that descriptions of modes were more complete and could help users with a disability to personalise their trip planning and improve their experience.

Where might we be heading

It was clear that the line between public and private transport was blurring, as private cars enabled ride sharing and carpooling, which had similar characteristics to shared and public mobility. Individual mobility elements usually associated with private transport, such as demand responsive transport and seat reservation, were being adopted by public transport. However, carpooling was the most appealing for people but could be considered a suitable mode of transport for those attending major events, regular hobbies and regular commuting.

Planning for MaaS would continue to increase worldwide but schemes would need to be integrated with existing transport systems instead of being considered as replacement of them. Studies on the changes in travel behaviour induced by extensive adoption of these services and other disruptions needed to be extended. Simulations of a MaaS solution were needed to understand the wider impact of shared mobility on transport systems and on traffic planning. Integrating more modes of transport in MaaS offerings meant that the MaaS accessibility and convenience could be compatible with private vehicles. It also indicated that customers could enjoy freedom of mobility without using their own vehicles.

Citizens would be able to reconsider their mobility options as new players entered the mobility market. Technology-driven factors had been changing the mobility landscape just as much as they had changed political agendas which would further emphasise issues on air quality, physical health and wellbeing. Governments would continue active development of mobility policies to favour active modes, encouraging citizens to walk and cycle more.

Discussions and presentations showed that we had made good progress in achieving symbiosis between traveller information and traffic management; this would continue as using new digital platforms would bring greater connectivity/ integration between the two systems. We should expect to see new smartphone apps for the mobility-impaired and further innovations regarding payment systems.

There was little evidence that developments with communications technologies would slow down and the adoption of 5G services would be widely welcomed and was likely to accelerate the introduction of solutions based on two-way data exchange. It was not clear what roles would be played by Blockchain and Quantum, especially in logistics.

There was a general feeling among both suppliers and regulators that they could improve how they met users' needs by better modelling travel behaviour and design systems when dealing with the explosion of new mobility services. One speaker's quote in a traffic city management session applied equally to the whole Congress – "Code is the new concrete".

TOPIC 5:
SAFETY FOR DRIVERS AND VULNERABLE USERS

The overall situation

While there were references to safety throughout the Congress safety did not feature as a headline topic in most of the executive or special interest sessions – only three direct references in 75 executive and special interest sessions. However, several of the technical papers submitted presented research focused on improving safety outcomes, especially for vulnerable road users. This was similar to the Copenhagen position and suggested that delivering improved safety was not seen as a technology challenge but a policy and regulatory concern. There was also considerable overlap between this Topic and Topics 1 and 3.

The topic in detail

Papers and sessions tended to focus on two main issues – what benefits should we expect from connected and automated vehicles and how might we best deliver them; and how can we improve safety for vulnerable road users.

Safety and connected and automated vehicles

In the connected and automated vehicles sessions the references to safety largely related to what needed to be done to get the benefits that had been promised – user acceptance was one challenge to overcome, validation of the technologies another. The need to undertake "real world testing" in order to progress to large-scale deployment, and therefore realise the benefits of connected and automated vehicle technologies, was highlighted, while still emphasising the need for the testing itself to be undertaken safely. How to test safely and integrate connected and automated vehicles was a common theme.

It was argued that it was crucial to have a shared planning framework including a harmonised approach towards safety validation and roadworthiness testing, as well as open platforms to enable data sharing. Deployment would only be possible if future users understood the basics of the new technologies and the benefits they could bring as well as the need for behavioural changes.

There was a stimulating report on the Australian ecosystem for implementing and testing connected transport technologies on a large scale and in complex urban environments.

Overall there was a greater focus on connected vehicle technology than had been seen since the 2014 Congress in Detroit, where connected vehicles dominated the programme. Many countries reported on testing V2I in live environments emphasising the point that connected vehicle technologies would bring benefits – especially for safety – much sooner than automated vehicles would ie they can be deployed today. Connected vehicle trials focused on the integration of the technology with the whole transport system, not just vehicles, so they often included speed and intersection warning use cases with a view to understanding the benefits for vulnerable users.

The potential safety benefits of the technologies appeared to be assumed although it was noted that supportive data was beginning to come from various US trials. However speakers were careful to stress that connected and automated vehicle technologies would not automatically deliver zero fatalities although the numbers of deaths and serious injuries would be reduced. To achieve really significant reductions we needed to manage the narrative because currently our acceptance of accidents involving automated vehicles was much lower than for conventional vehicles, for which we accepted many more accidents.

Safety was also discussed within the context of regulation with some presenters positing that more testing was needed before regulations could be set and others that setting the acceptance criteria was a discussion that needed to be had more broadly with society. Many countries had now amended legislation to permit testing on public roads but with the overriding criteria of 'safety first'. Included in the safety conversations were many references to how regulation of automated vehicles was a grey area and hence a barrier to deployment.

Australian Integrated Multimodal Ecosystem (Daniel Hoyne, Melbourne Uni; SIS 01)

The potential for automation to de-skill drivers and pose a safety risk was identified, as was the need to ensure that driver training was provided to maximise the benefits from vehicles that were becoming increasingly automated. Currently, some automated features were effectively being "switched off" by drivers. What was largely unclear, around the world, was a full picture of what we were doing to achieve a safe deployment regime. Many questions were still unanswered – what "living labs", deployment sites did we have or were being planned? What was their focus? How were we sharing lessons learned? How did we ensure automated vehicles would live up to promises of improved safety? How soon could we achieve this? What safety technologies were needed? Could human errors be a thing of the past? Besides technology, what other considerations were needed to ensure zero accidents?

<u>Safety and vulnerable road users</u>

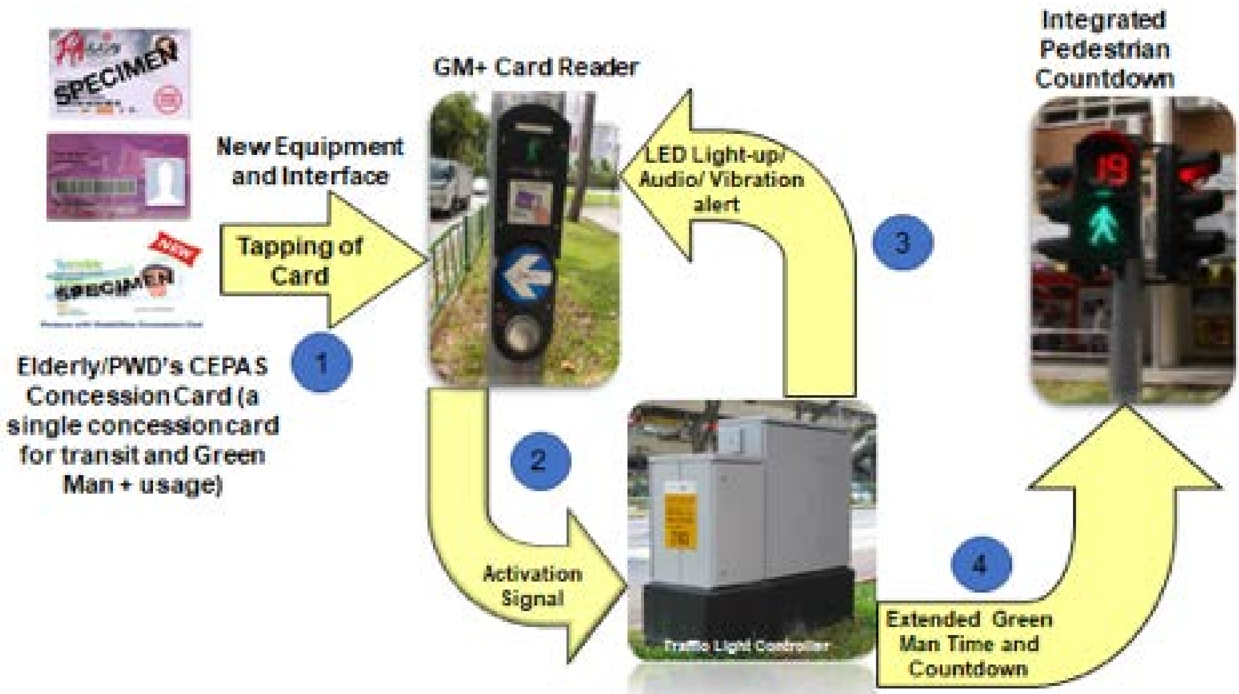
The potential for connected and automated vehicle technologies to improve safety outcomes for vulnerable users was a strong theme at the Congress, both in the sessions that presented on the testing and trialling of these technologies in real world environments, and in the safety-related technical papers. Many of the use cases being tested are those that will improve safety at intersections, such as intersection warning, speed detection and blind spot detection. All these use cases have the potential to provide greater protection for vulnerable road users such as pedestrians and cyclists.

Technical Session 50 included a presentation on Singapore's Green Man+ (GM+) initiative Singapore had a rapidly ageing population – it was estimated that by 2030 one in five residents would be elderly with reduced mobility. The GM+ scheme provided more crossing time at signalised pedestrian crossings for the elderly or anyone with disabilities who can use an RFID card to tell the crossing to allow additional "green man" crossing time. The early installations proved to be very successful with very positive feedback from users. As a result Singapore was deploying GM+ at more intersections and considering hands free devices, such as wrist bands to activate the service automatically.

Old v New

As was often the case with Congresses there were relatively few really new items; in most cases we saw the application of new techniques to relatively old problems. There was an innovative presentation in SIS 01 reviewing the developments of 5G telecoms

Artificial intelligence was seen as crucial in some areas for ensuring new technologies deliver promised health and safety benefits. In Thailand, traffic deaths are 5 times more common than fatalities from AIDS and on a par with heart disease. Traffic accident related deaths had been designated a major public health crisis. AI had been used to deal with data and treat accident location prediction as a data science problem to help to meet the political imperative in this area. Accident prediction had been deployed based on real world data including traffic volume and weather, policy evaluation and causal reference. Around 90% of Bangkok accidents happened in 5% of the road area. Understanding the data had been complex for humans but had been much simplified using AI. This had led to a reduction in field office resources by up to 90% compared to manual means as for every accident examined AI needed only 3% of resources to identify its place and time.



Making it easier for vulnerable road users to cross roads (Francis Tan, LTA, TP 1939)

Vehicle to everything connectivity (Maxime Flament, 5GAA, SIS 08)

In Nevada the 'Waycare' initiative had reduced crashes and response time through a cloud architecture that allowed multiple agencies working in the roads sector to connect. It gave advanced warning when the system thought an incident was going to happen, based on real time data input and it was estimated to lead to a 17% reduction in crashes and a 12 minute reduction in response time, by identifying crashes before they were called in through conventional means and warning other road users more quickly of their presence. It was also estimated that this analysis and prediction tool could result in Highway Patrol Officers being positioned closer to where they were likely to be needed.

Forwards v Constrained and Where might we be heading

Developments in safety were at a very interesting stage because, automated vehicles apart, there was little need for technology development in order to improve safety. The constraints on progress were nearly all policy related and reflected the difficulty many legislators faced in deciding how safe was 'safe enough' – given that "vision zero" was arguably unattainable and just about unaffordable. Difficulty was being experienced around the world in deciding the extent to which trials should be allowed on "real" roads of highly automated or fully autonomous vehicles.

The Congress presented very little in terms of new technologies to improve safety for drivers and the vulnerable. What should be considered 'new', or representative of progress, was the testing and trialling in real word environments with an emphasis on system integration and improving safety benefits for all road users – especially the vulnerable. Testing of connected and vehicle technologies was prominent. The key constraints identified were the need for more data from testing and validation, and studies on user acceptance and regulatory barriers. The lack of data sharing continued to be highlighted.

Perhaps we should start to think differently about risk by separating the probable overall gains from possible risks. This was a well-established practice with pharmaceuticals in that any prescribed medication would come with documentation explaining that a small percent of users – say, 0.1% – would experience some uncomfortable but non-threatening side effects that were listed and described. An even smaller percentage – say, 0.005% of users – would have more significant side effects requiring medical intervention. But overall the benefits for the many far outweighed the disadvantages for the few.

Could such an analysis be adopted for AVs ? There was obviously a difference in that the pharmaceutical intervention was individual so could be stopped where necessary but there was a general acceptance that deploying AVs would be a positive safety measure as it would profoundly cut (human) driver error. However user consultations reported much unease at safety being controlled by computers and a high level of distrust coloured by reports of AV accidents. But we had very many accidents on our roads now some of which could be removed by simple policy actions on eg speeding, drink-driving or by mandatory fitting of ADAS technologies. We needed to be able to say what was an acceptable level of operation and risk and that needs more trials and more evidence. Perhaps we needed to think more about the basic data – describing the current status of human driver safety in terms of crashes per distance driven, and automated system safety in terms of disengagements.

Connectivity, Automation of vehicles and Mobility as a Service schemes all represented a disruption of transport systems, cities, and societies. But they also posed a number of technological, architectural, legal, institutional, and certification challenges which could not be looked at separately. A holistic approach was needed to assess how they inter-related. The various sector players needed to work together so that all sectors shared an understanding of how transport as a whole could be managed differently and so tailored more towards the personal needs of travellers. The necessary technology was largely there. It just needed to be understood, procured, deployed, maintained, and – importantly – integrated into other systems and services. And that meant that in many places the policy makers needed to rethink why and what they were regulating and decide what was "safe enough".

Safety as one part of a larger ecosystem (Richard Harris, Real ITS Global, SIS 63)

TOPIC 6:
POLICIES, STANDARDS AND HARMONISATION

The overall situation

There had been much activity in all three areas within the topic but too much of the policy thinking had been in local, regional or national silos with the various stakeholders – telecoms companies, infrastructure owners/operators, automotive manufacturers, policy makers, regulators and "background" organisations such as insurers – usually not working collaboratively. And when stakeholder groups did get together it was rare to see any form of public end-user involvement. A universal comment was criticism of legislators and regulators for failing to understand the need to respond swiftly to technology changes; being too slow to amend legislation; and generally being risk averse as a consequence of not understanding what technology development had meant for transport planning and delivery. The continued fast pace of innovation with connected and automated vehicles had in turn put pressure on standards bodies to speed up their processes significantly.

The topic in detail

The five most visible activities within the topic were.

- Policy/planning innovations
- Harmonisation of standards for Intelligent Transport Systems (ITS)
- Technology and digitalisation in the Intelligent Transport Systems Sector
- Creating an eco-system for Autonomous Vehicles
- Smarter regulation and enforcement

Policy/planning innovations

- The use of social credits had been piloted in Chinese cities to nudge transport behaviours with early results indicating a positive effect on safety but the longer term stability of the policies had yet to be tested.
- To catalyse and sustain innovation in the transport eco-system it was necessary to have processes for co-creating or/and co-funding innovation. There had been a number of small-scale trials but the general issue had been complying with traditional procurement thinking. Maryland had experimented with a different procurement procedure for creating then building an innovative congestion management scheme and Singapore has used the "sandbox" model of fixed term but very open funding of high risk innovative solutions.

Harmonisation of standards for ITS

A number of studies reported attempts to i) improve the top-level design of Intelligent transportation standard systems at a national level; ii) internationalise national intelligent transportation technology standards; iii) promote R&D and application of core and key technologies; and iv) formulate and popularise technical standards. All of these threads needed to come together more often and to accelerate their work.

Cities in China, Denmark and in the EU had moved forward on some of these harmonisation projects. Denmark had worked on communication protocols which used internet standards like TCP/IP and were founded on open communication networks. It was hoped that such a common communication standard would be adopted by other Scandinavian countries to drive new ideas, open source, licence free use and flexibility of the protocol. The EU's FRAME NEXT project aimed at a common ITS architecture framework for interoperable intelligent transport systems.

Technology and digitalisation of the ITS transport sector

- In many countries there seemed to be a gap between top-level policy and implementation on the ground. Governments needed to do more to develop a multi-faceted view of where user demand and technology supply were taking them – perhaps by enabling more collaborative tools to handle all the data we had and supporting active engagement in testbeds to help understand the benefits of technology and contextualising it to the communities it's applied to.
- Several cities had worked on mobility master plans – sometimes as a "Smart mobility strategy" with the aim of bringing the different application areas together to provide guidance on strategy and areas of impactful investment.
- Beyond technology strategy there had been studies on business models and how small legislative changes could generate more favourable business conditions (eg Taiwan and e-scooter sharing).

Creating an eco-system for Autonomous Vehicles (AVs)

- There had been many studies into the safety and other benefits from AVs and other zero-emissions vehicles (see also Topic 3) and what changes might be needed for them to be able to run on current infrastructure/roads and leverage on existing ICT infrastructure. There were as yet no international agreements on the elements that needed to be in place for widespread adoption of AVs such as the situations requiring human monitoring of the vehicles; independent safety testing; and legal liability frameworks and insurance regimes.
- Some work was reported on steps towards independent testing (independent third-party risk assessment) and development of a set of rigorous safe standards. This was proving to be difficult. With conventional motor vehicles risk was calculated through a technical assessment of the vehicle and a view of driving behaviour (based on history and statistics). AVs were still at a relatively early stage of development and the statistical information were not available. Also, automated systems would be "retrained" frequently via new firmware and software downloads during the life of the vehicle, introducing potentially rapid rate of change to the underlying performance of the driving system. In addition different markets and regions around the world would need different styles of driving to match their local norms and behaviours and hence the scenarios needed for testing might also differ. For this to happen, the vehicle/product manufacturers and the regulators/authorities needed to work together in a collaborative manner early on so all interests (OEMs, insurers, customers, government) were fully covered.

Smarter regulation and enforcement

- Cities had come up with various approaches to smarter regulation and enforcement, often leveraging on technology. The USA and Singapore had made use of established commercial vehicle enforcement technologies such as Weigh in motion systems, cameras, V2X, and MaaS products for automated collection of real-time traffic data making decisions for safe and efficient traffic movement of commercial vehicles and for detection of illegal parking. This had enabled a shift from manual enforcement/inspection methods to more effective, targeted automated enforcement.

Forwards v Constrained

Forwards

There had been a lot of work on different aspects of standards and harmonisation as well as policy development with an interesting mixture of causes. In many cases there had been a top-down push as governments had taken very high level decisions on reducing CO_2 emissions, reducing accident rates and fatalities, or reducing congestion on roads.

Most of the papers were focused on how technology could be applied, whether in autonomous vehicles and better/smarter traffic optimisation. Some of the Special Interest Sessions staged more holistic discussions on how the boundaries between private, shared, and public transport were becoming increasingly blurred and the implications for policies, infrastructure planning and finance; and how regulations might need to adapt to support this.

Sessions organised around city issues also looked at what might need to change if / when cities looked radically different and mobility involved robo-taxis, autonomous shuttles, private autonomous vehicles, very different traffic and demand management, and, predictive maintenance of digital infrastructure.

Constrained

Upgrading infrastructure to deal with CAVs was a hotly debated issue with two key factions: the infrastructure owners/operators and the vehicle manufacturers. Significant money would be needed to upgrade road infrastructure that many jurisdictions were struggling to fund and the debate had revolved around how each party might deal with the practical realities on the ground eg what were the strategies to negotiate to what extent authorities invested in painting lane markings on the one side and what vehicle manufacturers could do with more advanced hardware and software in the vehicle on the other. These discussions were not happening quickly.

Many government organisations were not used to dealing with start-ups which operated to a different time horizon and business model. Speakers in sessions generally agreed on a need to build a better rapport so both parties could start to understand the other's concerns and constraints. The practice by some organisations of ignoring regulations when launching services then apologising for breaches afterwards was frequently criticised albeit with a little sympathy given the glacial processing of case work in some cases and the thinly disguised protection of government funded public transport in others.

The area of CAV insurance and treatment of legal liability was not moving forward as quickly as had been hoped. Current legal frameworks were able to handle liability issues up to Level 3 testing (where there was a need for a human on board) but the frameworks needed to evolve to deal with Level 4 & 5 testing. Discussing insurance, was proving difficult given the multi-variate scenarios and the paucity of data (because vehicle manufacturers have been very hawkish over data given perceived commercial interests) so the sizing of risk and liability was an on-going challenge.

Where might we be heading

Given the complexity of the landscape of players in both smarter mobility and connected and automated vehicles (authorities, infrastructure providers, vehicle manufacturers, communications players, insurers etc), one of the main constraints visible at Congresses has been finding ways of aligning their interests and effective collaboration with one another. This was critical because if we looked at what consumers wanted in terms of service offered no single party would be able to provide all the solutions and there was a critical need for all parties to collaborate. However to help collaboration the stakeholders had called for a framework for working together, with specific focus on commercially-sensitive areas like data (ie sharing data with authorities and other competitors as common source).

Another issue likely to be addressed was that while the industry players (vehicle manufacturers, communications, companies etc) had been calling for larger CAV pilots or demonstration projects there had been too little involvement with regulators about risks and safety and convincing the public especially after over-publicised safety incidents. There had been a growing appreciation of the need for better public education. In the USA and Europe there had been a lot of unrealistic hype about timescales for the adoption of AVs. A number of sessions involved discussions on ways to launch citizen dialogues to explain in understandable terms the expected benefits from different technology visions.

Cybersecurity risks had tended to be an under-developed topic and given the extensive activity in data handling and in autonomous vehicles this was also an area to watch (see Topic 8). It was also an issue requiring regulatory agencies and the various industry players to build a close partnership and share information to safeguard against threats.

Possible actions for public authorities to facilitate automated driving (Jaap Vreeswijk, SIS 50)

TOPIC 7:
INNOVATIVE PRICING AND TRAVEL DEMAND MANAGEMENT

The overall situation

in Copenhagen 2018 pricing was included in 'Mobility Services' and was not a stand-alone topic, In Singapore it was allocated a full place under the title "Innovative pricing and travel demand management" reflecting cities around the world ramping up road pricing activity as either multi-lane free-flow ETC, or congestion pricing. The issue raised in Copenhagen on fairer and equitable road use charging helping to achieve a better demand-supply balance was discussed in depth in Executive Session 12. The same issue of balance, but applied to parking, featured in technical papers describing a dynamic parking demand system and on kerb space management for ride-share services, logistics and freight. The various papers and sessions fell into three broad categories:

- managing demand for transport by pricing
- parking demand management
- technologies for pricing and tolling.

The topic in detail

<u>Managing demand for transport by pricing</u>
Designing a demand management system should start with the basic transport economics principles of why pricing was needed to address congestion management. The need to alert road users to the marginal social costs they imposed on congested traffic streams had driven the need for road tolls. Only by appropriate pricing could the externalities be minimised. Once this concept had registered then the scheme design, decisions surrounding fixed or variable pricing etc would be clearer.

Speakers in Plenary Session 02 "Promoting innovative mobility services" pressed the case for cities especially to move away from discussions about data and technology and instead focus on policy and understanding the need to change human behaviour. For example, what were the needs of the modern users and even service providers, and what might be their pain points. Very often poor public acceptance of a scheme was rooted in failure to understand or recognise the transport benefits the scheme would bring in exchange for payments. However, before setting out the benefits it might help to present the costs of congestion to the public in quantifiable terms. Public nuancing was key. Similarly, success of any Urban Vehicle Access Regulations would hinge on some levels of individual and tangible benefits for the road users and payers.

Papers and sessions reviewed the challenges of convincing the public (and/or politicians) of the benefits of road user charging in general and gaining public acceptance of schemes. It was argued that the public was not resistant to the idea of paying tolls, but to the idea of paying too much. If so, how should we determine what constituted "too much"? It was noted that public acceptance was often complicated by the prevailing political climate and associated risk appetites. Recommendations during the sessions included demonstrating the effects through a trial or actual implementation (like Stockholm); pitching it as a way of normalising fuel tax equity issues where electric cars are concerned; translating road damage and other maintenance costs per household; explaining that RUC was the most equitable source of funding; charging according to purpose of trip; and convincing that RUC would bring positive utilities to those paying and was not a means to price out car users.

Insights into land use, road user preferences and commuting trip patterns helped us understand the likely impacts of schemes at the city level and identify and quantify the benefits to different user groups. In Sydney and Melbourne people with lower income tended to live and work in the suburbs near their home, instead of in the city. They therefore lived near where they worked and tended not to travel into town. On the other hand higher-income city centre workers preferred to live in more spacious suburban houses instead of the 'shoebox' housing downtown. They therefore drove longer distances to work. European cities were mostly rather different in their urban forms and there was a great deal of concern surrounding vertical equity (equitability across social classes) with pricing schemes, as the portion of city commute trips by low income workers was generally higher.

Parking demand management

"Loading Zones are passé; microfreight deliveries are in", was quoted to illustrate how traditional kerb space was highly sought after in this era of food delivery vans and same-day retail delivery. The demand had increased but the supply had remained unchanged. Competition for kerb space had prompted dedicated ride-share pickup/drop off areas and proposals for digital dynamic kerb space reservation for retail deliveries with shoppers receiving a precise timing and kerb slot to collect their parcels.

Technologies for pricing and tolling

The issue of distance base pricing seemed to be growing acute in line with electrification. With new cars becoming increasingly fuel efficient agencies were facing the reality that fuel tax revenue was no longer sufficient to sustain road infrastructure and services. It needed to be supplemented or replaced by some form of usage base pricing.

Electronic toll collection featured heavily this year. There were papers on Japan, where tolls tended to be section specific, time-variable and dependent on day of the week as well. Another discussed the trend to deploy multi-lane free flow (MLFF) toll plazas, and cited ETCs in Chile and Sweden as examples. Other papers proposed technical enhancements to controllers to speed up transaction time and thus revenue; and one described an app or web-based service for users to understand their route choices and corresponding tolls. Maintenance downtime of gantry-based ETC systems was also addressed, as well as technology transitions in ETC systems, multilane free flow ETCs being the common thread. Authors raised valid points about importance of integration, cross-system compatibility and government regulations for ETC development success. China had plans to replace all main toll stations between provincial expressway networks with free-flow ETC between expressway interchanges instead.

The Next Generation pricing system under development by Singapore's Land Transport Authority attracted keen interest with speakers citing Singapore's extensive experience in pricing as a reference to guide RUC scheme design. Audiences were keen to learn more about LTA's intentions regarding distance base pricing in the Next Gen ERP. It was confirmed that while the new system had been designed with the technology potential for distance-based pricing, the policy for the eventual pricing strategy was still being studied.

Old v New

It was mentioned more than once that the nine core principles to guide operational design of road pricing systems listed in the 1964 Smeed Report remained relevant to many questions being asked today, and should form the cornerstone for formulating pricing policies:

Road user charging had featured in Congresses for years but with technology enabling real-time distance pricing, and some countries having intense discussions about it, several papers focused on distance pricing in various forms and its corresponding effectiveness. Different forms of pricing were deliberated reflecting that cities were recognising that not every pricing approach worked for different local issues. Time-base charging was being explored by Hong Kong to address circulating traffic caused predominantly by waiting chauffeurs, and other illegal parking problems in the city centre.

Another emerging trend on demand management more generally was innovative methods of traffic distribution, with researchers looking into real time information dissemination, dynamic modelling, and incentives to nudge drivers into using roads or time periods they would not otherwise consider. As data becomes richer and improve in resolution, and computing power continue to grow, this visionary but idealistic concept may become a reality if recommendations can be timely and accurate.

Low Emission Zones seemed to have gained more acceptance (eg the citizens in Madrid who rallied against politicians' plans to abolish their LEZ). As environmental and health benefits were perceived as more persuasive and tangible introducing an LEZ had usually been more agreeable to the public compared to other forms of RUC.

Dynamic kerb space reservation for logistics (Richard Easley, E-Squared Engineering- SIS 21)

The concept of Sustainable Urban Mobility Planning (SUMPS) has been a reference point for Europe since 2013. To help cities develop their mobility plans a second edition of the European SUMP Guidelines was published very recently this year. In particular, a UVAR topic guide was published in August 2019 under the Horizon 2020 initiative to help cities regulate their vehicle access as part of integrated mobility policies.

Forwards v Constrained

Forwards

The climate of road pricing prompted general excitement and exploration of new pricing technologies. For existing toll systems the trend was enhancement of infrastructure to enable free-flow charging and faster transactions without comprising on accuracy and enforcement. For cities and countries thinking of road pricing as a usage measure the development in Singapore of the Next Generation ERP had prompted research and studies into various forms of pricing and demand management measures.

We saw more focus than previous years on parking as a component of travel demand management. 20% of the papers this year discussed how technology and innovative engineering could be harnessed to optimally distribute parking demand, develop 3D user-centric lot-searching, integrating parking apps with transit and retail information, and even Smart Parking using IP camera detection and cloud processing.

Equitability in pricing was a new and popular discussion topic; but no one volunteered answers on how to design full equitability into a pricing system. In the first place, the term equitability was multi-dimensional. Europe's concern about vertical equity across social economic classes was shared by many cities; a study by MIT-NUS built in social welfare into its objective function for a predictive toll optimisation model. Would directing toll revenues into infrastructure or public transit funding adequately address equity concerns?

Constrained

Copenhagen had suggested the need for more serious discussions of dynamic congestion pricing. Dynamic incentives for trip making did indeed appear as an emerging thought and line of study but challenges remained such as adherence rates and incentives customisation. Model accuracy too would eventually have an impact as drivers lost or gained faith in it. Many papers were on distance pricing, but were limited to Stated Preference surveys and models, due to the lack of real data. Results were theoretical at best and constrained by model accuracy and input elasticity profiles not based on true data.

There were a number of references to marginal social costs and transport economics. However no papers this year explored computation of actual marginal social costs of individual road users in a realistic way, or defining what really constituted equitable charges. Perhaps because contribution to congestion could be presented in many forms eg distance driven on congested roads, time spent within a congested area, or pollutants from the car.

Modelling had always been a useful analytical tool in transport to simulate traffic behaviour and policy impact. With more innovative demand management schemes being considered the adoption of digital twins to facilitate engineering and policy decisions on the more untried and novel schemes continued to be seen as highly necessary. With the need to model new transport entities and obtain quick visually informative results, agent base simulations appeared to have received increased attention and were mentioned in Special Interest Sessions and generally recommended as a simulation tool to study effects of real-world scenarios. However, from the traditional transport modelling viewpoint concerns were expressed as to whether agent-based modelling was really sufficiently developed to replicate the real world. Questions remained about data resolution, calibration, vehicle mode interactions or its limitations in representing all layers of behaviour.

Where might we be heading

Using incentives to nudge travel behaviour and manage demand looked set to continue to be a lively topic for the years to come. For incentives to be useful accuracy in the back end assessment and data integrity was crucial. As the pressures for RUC built up in many regions but political resistance remained unyielding the phrases "gamification" and "incentive based pricing" were likely to become more familiar pricing concepts within the industry, especially since technology is progressively enabling it. The potential effectiveness of rewarding good transport behaviour (instead of charging) to promote user buy-in was indirectly studied by China in three provinces. Toll discounts were given on selected expressways during specific time periods to create a price differential for trucks, nudging the desired travel behaviour changes.

Japan recently proposed a tolling policy to tag toll charges to the entry-exit pair highway interchanges, regardless of routes. This appeared to be a fresh look at usage based pricing that is neither point, distance, time nor congestion based. It will be interesting to see whether and if so how this develops.

With Cooperative ITS a number of new possibilities would open up for demand management. One of them was to use dynamic travel time and congestion information to recommend routes, departure times and even modes not to help individual travel times but to achieve a network optimum, This would mean all users might not be taking their own shortest route, but one that balanced network supply and demand and generated the most optimal global trip plan measured across everyone. In fact, an ongoing Taiwan study could offer some insights into future designs of similar schemes. The study aimed to use OD information, simulation and mobile apps, to recommend optimal departure times for drivers using the highways over a selected long weekend.

This concept of network optimisation also found parallels in parking, as two of the papers proposed an innovative method of distributing parking demand from high demand areas and time periods, into under-saturated carparks (below 60%) in the vicinity by taking into account parking resources, distance and acceptable walking distance (Temporal Spatial matching).

Dynamic incentive trip making (sometimes referred to as reverse tolls) emerged as a revitalised area of study with increased viability due to technology enablers. The challenges remained adherence rates and incentives as well as accuracy of the model (a rush hour avoidance scheme), It offered monetary rewards to drivers who did not use their cars during peak hours. There were parallels with the 2017 trials in China. Technically that trial offered discounts on expressways in 3-4 provinces instead of monetary rewards as an incentive for motorists to spread out to the roads with the lower tolls; however the results indicated that it was effective.

Our ability to design relevant road user charging schemes was contingent on our possessing true insights into road usage patterns and travel behaviour. There had been concerns that, pricing regular drivers entering a city would not be effective if city congestion encountered is predominantly caused by private hire vehicles. For example a recent Northeastern study revealed that Uber and Lyft represented around 25% of trips within the city, contrary to their initial claim of serving mostly first-mile-last-mile trips. Resolving issues such this was a strong reminder of the need for more data to enable evidence-driven decisions.

GNSS remained a key technology enabler for more sophisticated road pricing schemes. In Singapore there was only one paper studying the enhancement of GNSS accuracy within this topic, recommending multi-constellation receivers augmented by vehicle speed pulse, Inertial Measurement Units and indoor positioning techniques. Positioning accuracy conversations were likely to pick up intensity in the next 2 years, especially after Singapore transferred to the highly anticipated GNSS pricing system from 2020. We were also likely to have studies on the cybersecurity vulnerability of satellite-based charging.

TOPIC 8:
CYBERSECURITY AND DATA PRIVACY

The overall situation

Although the Cybersecurity topic was Singapore's smallest it represented an increase on Copenhagen and indicated that a key problem in the past – experts not released by organisations to speak or attend – was reducing. The most common thread was overcoming hacking and malicious attacks, with a particular focus on connected and autonomous vehicles, and prevention by using smart technology. Privacy aspects tended to be dealt with in one of the other seven topics.

Speakers agreed that the key challenges in the current security landscape had expanded following the rapid development of the ITS environment and the Internet of Things. More connections, stakeholders and more networked devices meant more opportunities for security gaps. Speakers assessed the weakest links in the overall system as:

a. Connected vehicle used as an attacker.
b. ITS devices as a potential point of access
c. End point vulnerabilities from front end equipment

Tough regulations alone were no protection against cyberattacks. Individual users and vendors needed to assume more responsibility in their daily lives or regular operations to guard against threats. It was essential to extend conversations beyond the technical communities, to translate technical concerns into lay language to involve the people and operators who are the vulnerable links.

Four messages were repeated throughout the cybersecurity sessions:

- We are entering a Zero Trust era;
- When you buy a device, don't think it's safe, assume it's already compromised;
- Assume your system has already been breached – the hackers are in but just waiting;
- Secure your end-points, but assume the worst: ie they are not secure

The topic in detail

It was repeatedly stressed that incident management preparedness was crucial. It was no longer a matter of IF it happened, but WHEN. It was important to have processes in place that could help interpret the signs, prevent a threat from spreading, eradicate it if possible, and finally good incident forensics were needed to learn the lessons. From the operator standpoint the challenge was differentiating between a system fault and a real cyber threat.

Malicious and intentional hacks had tended to cause most damage because the culprits had done extensive research and studied the system closely, and possibly had already infiltrated it before the actual attack. Threats were omni-present, and attacks were unlikely to be detected through standard security information and event management software or antivirus packages. Therefore, the response procedures were particularly important.

Being prepared against attacks meant addressing supply chain vulnerability. Automotive OEMs frequently relied on specialist suppliers to deliver their products. This meant that they could not possess the technical knowledge or accreditation expertise to certify the circuit boards or system cards etc manufactured and installed in their final system that served thousands of users. This represented a serious vulnerability. It was wise to remember that the weakest links could be external suppliers and their staff, and not the actual system assets and think in terms of vulnerable access points).

There was an interesting discussion on the risks from technology obsolescence. Products and services in use today were designed 10–20 years ago; we would not be benefiting immediately from the technologies being put in today. This also meant that it would be prudent to suppose that something was flawed in today's system, instead of assuming that the people 10–20 years ago had done everything right. We should ask ourselves "how do we operate today at the most reduced risk with practical solutions?" It was healthy to have a sense of unease and always be expecting an attack.

We should think more in terms of Safety by Design and the need to eradicate silos. Typically when building a system design engineers would work on the overall concept with the cybersecurity people involved only when the designs were fairly mature. However when something went wrong the operational engineers would not be able to obtain good advice from the cybersecurity teams as neither they nor the operations people would have been involved in the system design from the beginning. The proposed solutions were simple – ensure cybersecurity and operations teams were involved in the design stage from the start. Vehicle architecture should be designed to reduce the likelihood that compromise of assets within one architectural element would result in propagation of the attack to other architectural elements.

It was important to understand that regulations were not a panacea for cybersecurity problems. Consumers needed to be educated on risks and why they should take care, and be in a position to decide if they wished to carry part of the cost for eg. cybersecurity features in the cars they purchased. Often the consumer had a choice, a more secure car or a cheaper less secure model. Governments were spending billions to protect infrastructure but the threat agents were the fleets of vehicles. A cohesive framework and co-ownership of responsibility were both important.

Despite the draft security and communications standards to protect V2X messages, a study in China had highlighted potential weak links and sought solutions to address them. It highlighted the lack of authentication processes in traditional in-car communication networks and the need for real-time verification of digital signatures in the massive transmission volumes expected from connected vehicles. The study also revealed a need to coordinate identity-authentication processes and platforms across manufacturers, operators, agencies, and insurance companies, and the difficulty of maintaining vehicle trajectory privacy in the event of an intentionally fraudulent vehicle-initiated message.

A Spanish study on connected vehicles cybersecurity was reported that was less a solutions-based approach than the development of a tool to evaluate the security of connected vehicles. Identifying vulnerabilities early would enable early intervention and mitigation.

Old v New

Copenhagen 2018 reported a lack of technical papers on cybersecurity and business models for next generation traffic management centres. This year the detailed scientific discussions and methodologies in the papers, as well as the specific authentication scenarios and verification approaches for TMCs during the experts' conversations, have somewhat bridged the gap. The concept that people were the weak links and that every additional connection could be a threat was already discussed in the key sessions in Copenhagen 2018. However, this year's discussions delved into more detail, looking at authentication scenarios and variety of access controls in both the technical papers and expert sessions.

Blockchains were becoming more visible as possible solutions to digital business processes, data management and authentication issues. One paper explored maritime port projects, and identified 3 key scenarios on which projects should be reviewed to facilitate integration of the current data management systems into distributed database technology. We will need to await Los Angeles and Hamburg to see if blockchains survived the hype and teething issues to emerge as a real contender and popular topic.

Forwards v Constrained

Forwards

Recognising the potential of cybersecurity threats was a big step towards guarding against them in future. For fully connected vehicles and V2X we were still in the relative infancy period of development so the threat scenarios and permutations of issues that could be identified were limited today. However it was clear that there was much work on looking ahead to identify possible threats and dangers so that mitigating work could be researched, and architectural integrity could be designed in earlier.

In order to get cybersecurity accepted as a crucial part of the national agenda to justify for budget, or even to induce higher personal responsibility in users, it has to be recognised and communicated in a way that non-technical people such as system users (the vulnerable access points), the political leaders or top management can understand. Personal security is important eg password control. The recent hacking attacks in New Zealand were caused by human errors. Businesses needed to think whether their recruitment and vetting processes were sound, and encourage the end users to use password protection.

Constrained

Both suppliers and users of cybersecurity needed to be more imaginative. Successful recent attacks had been mostly through unexpected vectors and had progressed beyond just networks and data. Speakers in the ITS Safety and Security workshops agreed that the industry needed to think beyond the obvious, with ingenuity to perceive potential danger in even the most innocent devices like mobile phones connected to car systems through Bluetooth, susceptibility of drones to physical tampering and control etc.

A speaker noted that cybersecurity remained a small topic in this congress. Was it perhaps being overshadowed by the autonomous topics that were seeing more visible progress and therefore represented the race every country wished to win; whereas cybersecurity remained a more abstract concern with real tangibility only to some, with many others snug in the belief that they had no need for it? Alternatively, were cybersecurity conversations being constrained by the immaturity of C-ITS, and CAVs ? Or was there a great deal of activity behind the scenes out of the public eye?

Where might we be heading

Today, humans were still leading the cybersecurity conversations and the current research trend was centred on human researchers attempting to anticipate hacking and intercept the efforts of human counterparts. However with the evolution of Artificial Intelligence and Deep

Cyber "Weather Map" (Eetu Philli - Sihvola, Traficom, AE 04 Workshop)

Learning computers had overtaken human performance in many areas. Would humans still be leading the conversations in 5-10 years' or would it be machines? With continued acceleration in digital intelligence hacking techniques using deep learning to identify and overcome human barriers could become an early reality.

On the policy front a paper from New Zealand looked into the sensitive topic of data privacy and questions of ownership and commercialisation rights. Some of the issues emerging were whether authority had the right to own more than the requisite level of data needed to deliver reasonable public services to the road users. Other questions raised were whether data legally constituted personal property, and whether government access to ITS data should be decided through market mechanisms instead of being a regulatory decision.

We can expect further attention to under-studied attack surfaces like external smart phone devices that can be penetrated by Bluetooth. We would also have to consider false road signs which was relevant now with AVs using state-of-the-art visual systems to decipher road signs during driving. An AV's knowledge base was usually based on black box machine learning approaches, and had difficult detecting deliberate forging of road signs like changing no-right-turn signs to no-left-turn signs. This sign forgery had become a popular hobby-prank for youngsters in southern Europe, but could be fatal to an AV.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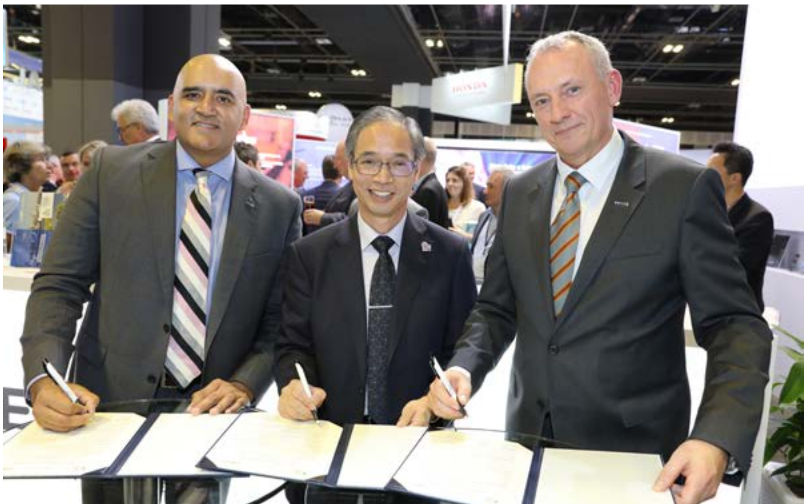


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