ITS WORLD CONGRESS 2017

Montréal | OCTOBER 29 - NOVEMBER 2

Next Generation Integrated Mobility: Driving Smart Cities

Post-Congress **Report**

Produced by

ITS AMERICA

In Conjunction with

ITS • STI CANADA

Co-organized by

ERTICO ITS EUROPE

ASIA-PACIFIC ITS

ITSWorldCongress2017.org | #THISisITS

Sponsors & Partners

PREMIER SPONSORS

SILVER SPONSORS

BRONZE SPONSORS

INDUSTRY SPONSORS

AAA/CAA

SUPPORTER SPONSORS

AECOM

Econolite

HELP, Inc.

Rohde & Schwarz

PUBLIC SECTOR SUPPORTERS

Metropolitan Transportation Commission

Utah Department of Transportation

EVENT PARTNERS

MEDIA PARTNERS

Table of Contents

Introduction

The Congress headline was “Next generation integrated mobility: driving smart cities”. This wording aimed to reflect the remarkable range of ITS products that are being deployed now by cities and urban conurbations to support population increases, sustained growth in demand for mobility, and users’ appetites for services that build on 24/7 connectivity. At the same time ITS can deliver improvements to network capacity, air quality and safety. The Congress was organized around seven key tracks:

Track Topics	page(s)
A. Connectivity and Autonomy	11 and 43
B. Infrastructure Challenges and Opportunities	10 and 46
C. Smart(er) Cities	15 and 48
D. Data, Security and Privacy	21
E. Integrated Approach: Planning, Operations and Safety	25 and 50
F. Disruption and New Business Models	31 and 51
G. Innovation, What’s Next? The New Ideas	38

The Congress Board of Directors, chaired by Claude Carette from the City of Montreal, appointed rapporteurs for each track 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, nearly 250 in total — Plenary, Executive, Special Interest, Technical, and Scientific..

Around 540 papers were presented in about 120 sessions roughly divided as follows — Track A: 120 papers; Track B: 60 papers; Track C: 95 papers; Track D 75 papers, Track E: 135 papers; Track F 35 papers; Track H. 20 papers. In the four Plenary Sessions high-level industry executives, public officials and international experts shared their perspectives and extensive experience of ITS topics encompassing policy, strategic, economic, technical, organizational and societal aspects.

There was a large, wide-ranging and very busy Exhibition involving over 200 organizations and more than 500,000 sq ft of floor space. The Exhibit Hall was complemented by a number of technical tours to local control and service centers as well as major construction sites and demonstrations. Montreal saw the largest set of technology and services demonstrations at a Congress to date, over 20 separate displays. The content was very wide-ranging.

Canadians had their first opportunity for ‘hands-on’ experience of vehicle-to-infrastructure connectivity and the link to improved safety and efficiency. There were also a number of driverless vehicles operating as automated shuttles. ITS Canada organized aVirtual Traffic Management Centre (VTMC) in the exhibit hall. It operated in real-time, to show what was happening at TMCs across the country. Live data and video feeds from several Canadian cities/agencies were displayed.

Highly automated driving depends critically on the vehicle’s knowing its exact location and also having a range of sensors to learn about its immediate environment. Different demos in Montreal illustrated the use of satellite-derived positioning, digital maps and real-time updating, techniques for precise location fixing when GNSS signals are weak or obscured, and a wide range of sensors including cameras, LIDAR and RADAR, and thermal imaging.

The lower (parking) level of the Palais des Congrès provided a very convenient place to show automated valet parking — a vehicle parking itself then returning to pick up passengers when summoned. A nearby public parking space was used to show how innovative detectors can detect, count, and size the available vehicle parking slots and also monitor occupied parking for revenue protection.

A number of communications demonstrations explained different aspects of connectivity such as V2V and V2I communication between connected vehicles and roadside infrastructure to enhance the awareness of traffic situations for drivers. These demos also showed vehicles exchanging information with control centers to improve flow,give advance warning of the aspect of traffic signals and give priority to emergency vehicles. Using a variety of techniques in combination produced a demonstration of remote asset condition management.

This Report summarizes the Congress proceedings. The first part focuses mostly on the Technical & Scientific papers and the Special Interest Sessions; the second and third parts report on the Plenary and Executive Sessions. I give my profound thanks to the main team of rapporteurs who contributed so much to this document:

Risto Kulmala	Track A
Nicolas Saunier	Track A
Peo Svensk	Track B
Carol Schweiger	Track C
Fang Chen	Track D
Darren Capes	Track E
Martin Trepanier	Track E
Catherine Morency	Track F
Luis Miranda-Moreno	Track G

I also thank Steve Dellenback, Susan Nicoletti, Janneke Poelking, and the ITS Canada, ITS America, ITS Asia Pacific and ERTICO teams for their cheerful handling of all inquiries and questions.

PROFESSOR ERIC SAMPSON
CHIEF *RAPPORTEUR* BRUSSELS February 2018

The Overall Situation

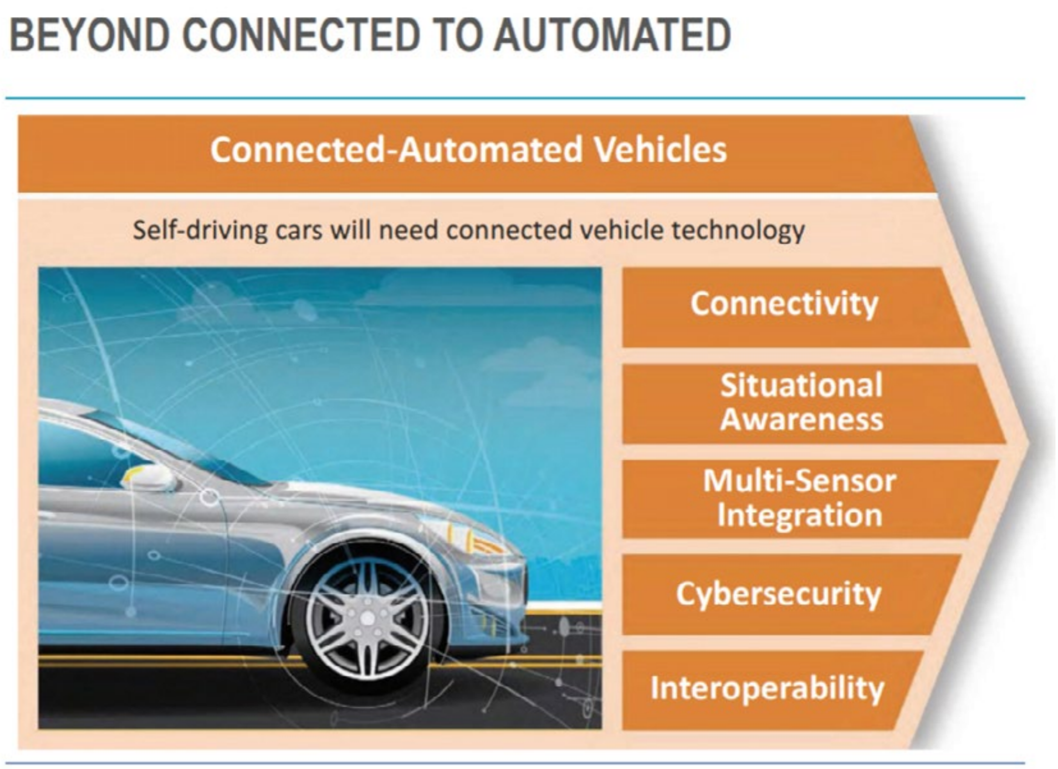
Connectivity and autonomy was one of the most popular topics in the Congress. To clarify the terminology, which was not always the case in presentations and discussions, there are different levels of "automation" as described in the popular 6 levels proposed in the SAE norm J3016, from level 0 (no automation) to level 5 (driverless). Autonomy is used here to mean not having the need for a constant short or long range wireless connection to other vehicles and road users as well as the infrastructure.

The evolution towards connectivity and automation constituted not only a disruption of transport systems and cities; it also posed a number of architectural, legal, institutional, validation, and certification challenges. One presentation described the evolution from four different angles: 1) a technological tipping point, 2) an automotive make-over, 3) infrastructure roll-out, and 4) the coming of age of the public sector. Of these, the automotive make-over is leading the way today. Tomorrow's vehicles were categorized as service-oriented, enabling adaptation *via* software changes — and thereby more future-proof than yesterday's.

While the topics were often discussed together as "connected and automated vehicles" (CAV), a large number of papers and sessions primarily addressed one or the other — connected vehicles or automated vehicles. The key question of the need for connectivity (V2V and V2I) for automated vehicles was also raised. One view was that while autonomous (*i.e.* unconnected) vehicles can operate safely, to reach similar travel speeds and efficiency levels as humanly operated vehicles connectivity will be essential. In addition to reach a <u>network</u> optimum instead of just a user optimum connectivity is needed. But on the other hand the connectivity demands of the different automation use cases vary a great deal.

From the technology aspect the topics dealt with solutions for V2X communication, their hybrid combinations, and their evolution over time. Several experts pointed out that no single communication channel or network would meet the growing demand for data communications. One presenter stated that a connected car has on average 3,000 different sensors in it. Several sessions discussed the merits of the two dominant solutions for short-range communications, the WiFi-based (DSRC, ITS-G5) and the cellular-based (LTE-V2X, C-V2X) ones. A rigorous debate about these alternatives went on in sessions, in the exhibition area, and during the breaks.

The technology discussions also dealt with the hardware components with solutions for vehicle positioning, object detection, enhanced camera and radar systems, and with



Connectivity is needed   Ken Leonard in ES07 human-machine interfaces (HMI). Many papers involved the use of artificial intelligence and in particular deep learning for detection and classification tasks. Questions on how to connect pedestrians, motorcyclists and bicyclists were also raised and solutions proposed in papers and sessions.

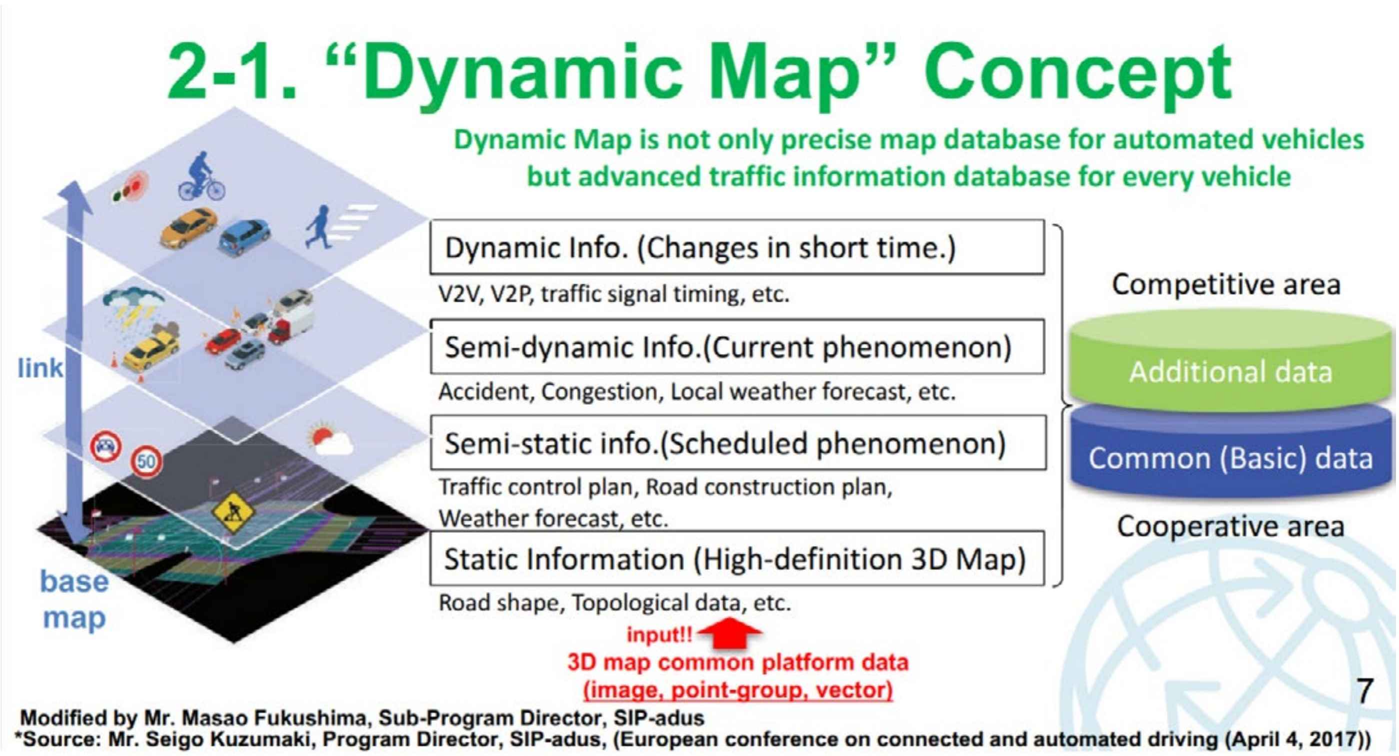
Technology was widely regarded as something that we can use to solve our transport-related challenges with a reminder that technology had not so far changed the basic physical restrictions such as the space required by a single vehicle or traveller. Many speakers reminded that the human aspect is crucial for the acceptance and use of automated vehicles.

From the technology application aspect the primary topic of papers and sessions was road safety — in particular the safety of vulnerable road users (pedestrians, bicyclists, motorcyclists) — and specific active systems such as collision avoidance. Other applications discussed included various driver assistance systems, tolling, truck platooning, parking, public transport, especially for the last mile, traffic monitoring and management (including signal control), vehicle sharing and Mobility as a Service (MaaS).

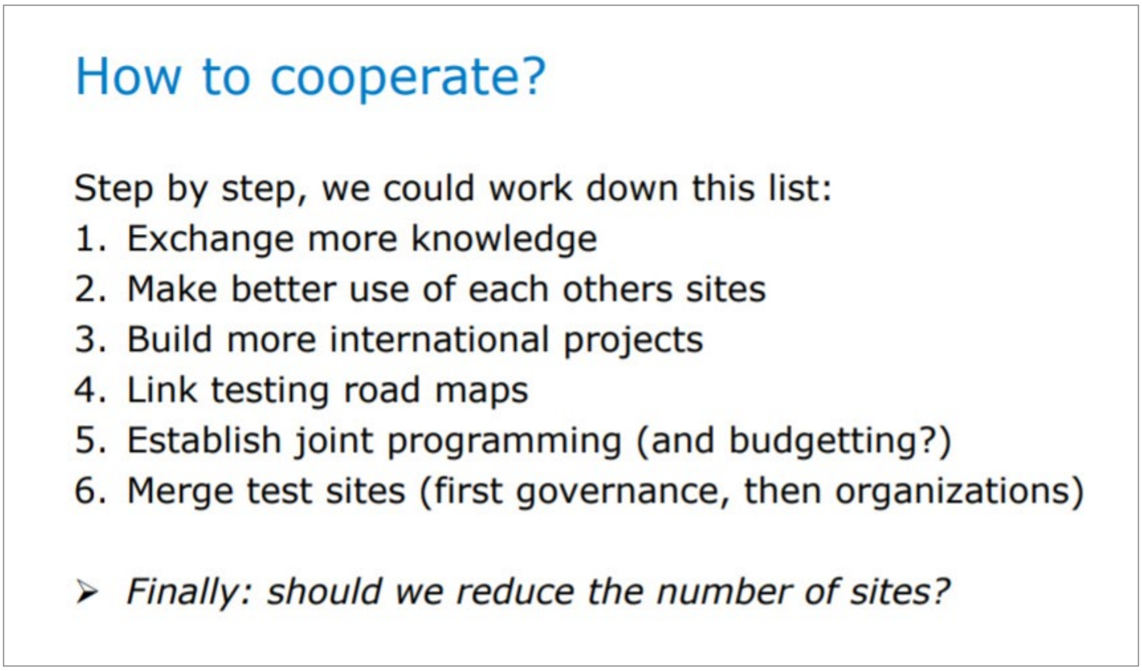
Several specific aspects of automated driving were examined. These included the acceptable safety requirements, the disengagement dilemma, the driver take-over processes, accurate positioning, how to support automated driving with an electronic horizon (or look-ahead information), car-following assistance systems, and operation in adverse weather. The concept of a dynamic map was elaborated on in many sessions. The different requirements for physical as well as digital infrastructure were discussed both in detailed and general terms.

The technical, impact and socio-economic evaluation of connected and automated driving and related ITS technologies was recognized as a crucial element. Hence several papers and sessions dealt with the current and new methods for that purpose. Testing and evaluation was under way everywhere usually in the order of simulation — test tracks — open roads. At this Congress the results were usually from simulations or test tracks.

The results of several pilot projects and evaluations from different countries were presented with a focus on technical assessment. Some countries had made major investments in road vehicle automation test sites and areas and the opportunities for cooperation and collaboration among the various sites, trials and pilots were discussed and cooperation was promoted. Everyone agreed, more or less, on data and knowledge sharing but one expert pointed out rather sadly that sharing works at a practitioner level but rarely at the executive level.



Dynamic Map Jun Shibata in SIS98.



Test site cooperation — How? Serge van Dam in SIS 49

The roadmaps from testing to piloting and then to deployment were also discussed in several sessions presenting the points of views of various stakeholders' in different countries and continents. A recommended roadmap was to go forward incrementally: test — let people try — check acceptance — if low, try new policy measures — if they work, deploy.

A convergence of both technical and regulatory standards was looked for. The regulatory challenges identified included lack of precedents, security and safety requirements, liability, record-keeping requirements *etc*. A point made strongly was that the legislation needed for the highly and fully automated cases deserved a proper research effort as the whole paradigm of what is "a legal person in control of the vehicle" was changing (levels 3 and up in the SAE classification were qualitatively different from lower levels, where responsibility for driving shifted to the vehicle, and therefore whoever had designed it).

It was also pointed out that governments were not very well set up to innovate due to their defined rules and processes, a shortage of informed decision makers, lack of resources, and lack of rewards for innovation. At the same time, with many fundamental disruptions happening concurrently, the various government agencies were looking very seriously at funding all the changes required, or at least common physical and digital infrastructure like maps that enable connected and automated vehicles, and new mobility services. Nevertheless the agencies were seen to have a key role as a facilitator and enabler of connected and automated driving. In this respect, one speaker offered the appropriate motto: "Incubate; don't overregulate".

The Old v The New

There was a reasonable balance between bringing forward new ideas and reporting on how the older ideas were performing. Simulation still played a major role in the assessment of both technical performance and impacts of connected and automated driving, but a shift was occurring towards test areas and even open road results.

5G and the Internet of Things were predicted to be the "dynamic duo" of the future and many new ideas and applications for their use were presented and proposed. Satellite communication was stressed as the way to provide connectivity everywhere and delegates were reminded that 5G encompasses both satellite and cellular communications. The new concept of hybrid communication was that of hybrid networks integrating terrestrial and satellite communications. However the more familiar hybrid concept of short-range communications and medium/long-range cellular communications was still dominant.

While most road vehicle automation use cases were related to either highways/motorways/freeways or restricted and open urban areas, presentations of low speed automated driving on rural roads, in mountainous areas or tests on snow- and ice-covered rural roads showed the need to consider other use domains.

Interesting innovative ideas presented dealt with the prediction of potential human intention using supervised competitive learning; the prediction of pedestrian motion based on current position, speed and characteristics (age) for active safety systems; and the visual assessment of lane marking deterioration from event data recorder images. New uses of V2X messaging included the sharing of vehicle profile data, basic mobility messages, and the concept of dynamically interrogative data capture, where the infrastructure stations interrogate the vehicles passing by for relevant data.

The transition phase had been in the spotlight at earlier Congresses but it was agreed that it now included areas or periods where the automation level was increased or decreased. Questions were raised on the need to adapt the infrastructure to enable connectivity and automation, and on how to operate roads in the transition period — for example whether to dedicate lanes to certain vehicles types and if so under which conditions. Simulation study results indicated that the main benefits from automated driving would materialize only for high penetration levels of automated vehicle whereas there is even the potential for disruption at low penetration levels.

Some papers brought up the consequences for, and understanding of, manual driving such as the relationship of the driving comfort of manual drivers to the ratio of automated cars, and the identification of the bio-signals, electromyography, sight information and skin temperature metrics dependent on vehicle following and gear change. Driver comfort was also addressed with a vehicle-to-infrastructure (V2I) system specifically to assist automated vehicles to adjust speed according to pavement roughness to increase driver comfort,

Different aspects of connected vehicle messaging found new uses such as tracking RSSI (Received Signal Strength Indicator) in V2V networks for collision avoidance, and utilizing DSRC data (BSM/CAM) to identify factors that impair the lane-keeping efficiency of drivers. A Long-Range Wide-Area Network (LoRaWAN) for sensors, enabling the Internet of Things, was shown to be a feasible solution for traffic monitoring. Managing massive shared fleets of automated vehicles was another major challenge for their future deployment that was highlighted for the first time.

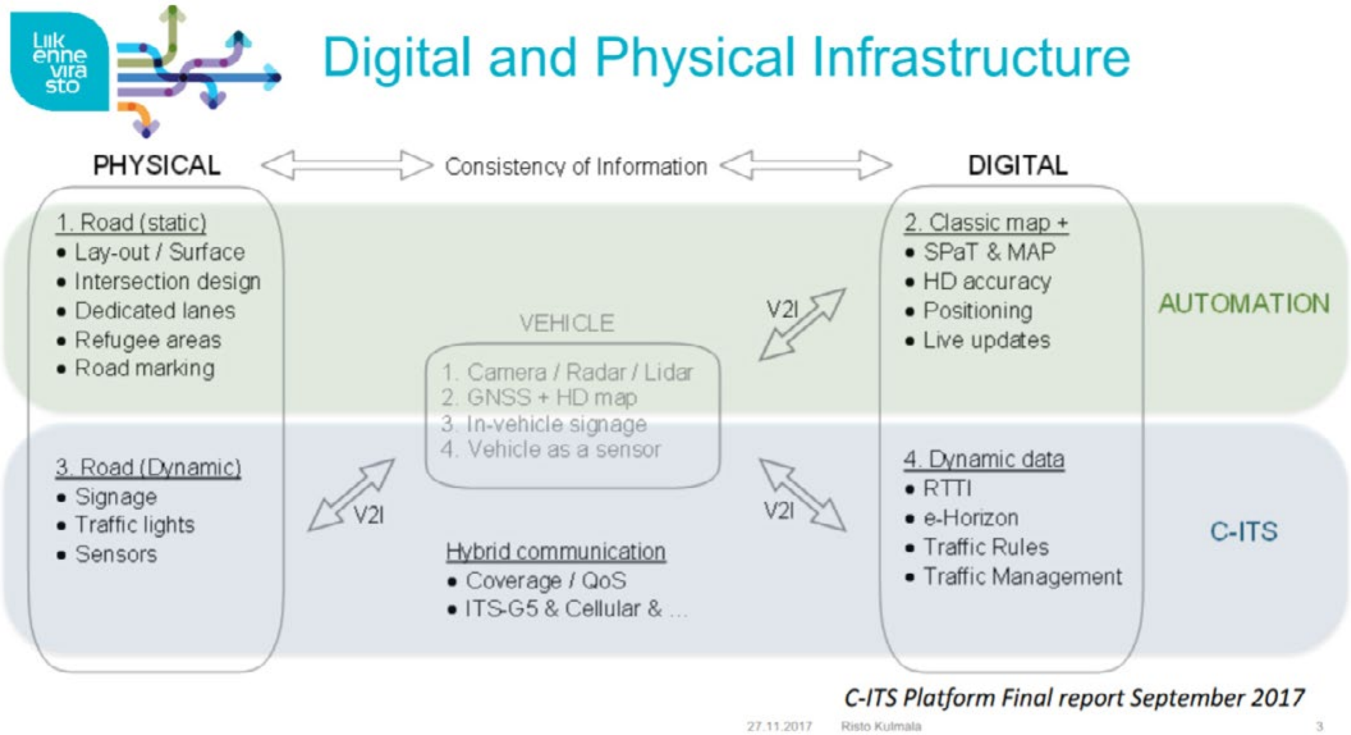
Positive and negative impacts of connected and automated vehicles were quite openly discussed in order to develop strategies adapted to a region's context and goals. The negative impacts included the reduction of capacity due to longer following headways, as shown in simulations of adaptive cruise control, and the problems due to "vehicle miles traveled going through the roof" due to the increased comfort of self-driving vehicles and the possibility of empty vehicles on the road. The latter would mostly hinge on two factors: the price of an automated vehicle, and the willingness of travelers to share cars and rides. One senior expert stressed that we should forget the "Jetson fallacy" (in the sixties' TV series, the society remained the same but only the form of transport changed to automated flying cars) as highly and especially fully automated vehicles will totally change our society.

Forwards v Constrained

Some areas were clearly moving forwards: object detection, enhanced camera sensing, trajectory forecasting, applications of artificial intelligence, cyber-security for connected automated vehicles, validation and verification processes for both communication units/systems and also automated vehicles themselves, the collaboration of test areas facilities and pilot projects to share their experience, and the utilization of connected vehicle messaging for a number of different purposes.

Less attention than before was given to user acceptance, human-technology interaction, the overall impact and socio-economic assessment. Fundamental research needs were identified for instance about the effects of highly and fully automated vehicles on social welfare, inequalities and market economies.

While many papers used the word "autonomous" when referring to the vehicle(s) being discussed, the concept of autonomous driving relying on the vehicle's own sensors alone seemed to be giving way to connected automated driving, where the vehicle makes use of a more extended electronic horizon providing information of events and conditions further along and around the vehicle's route and beyond the range of the vehicle's own sensors. However we should note that new actors in automated driving and transport services, such as Waymo (Google) or Tesla, which are actively developing and testing autonomous automated vehicles, had little to no presence in the congress.



Integration of digital and physical infrastructure   Risto Kulmala in SIS 98

The digital infrastructure was much more forward and more widely discussed in this Congress than in the previous ones. It was agreed that Artificial intelligence was likely to have a major role in interpreting the physical infrastructure but also in operating the digital infrastructure as a whole. The role and maintenance of other common elements such as maps was discussed in papers and special sessions.

There was a significant focus on bringing the technology closer to market through certification, by ensuring mutually compatible and interoperable technologies, and by establishing common frameworks and approaches which can be used across projects, systems and services. For instance cyber-security assessment guidelines were presented with the aim of national, regional and global interoperability.

The approaches of various jurisdictions to standardization and certification were presented in several sessions and emphasized the difficulties of testing software in automated vehicles, in particular since it will be updated and might even learn continuously. This pointed to a need to continue to monitor actual vehicle behaviour on the roads even after homologation.

TRACK B Infrastructure Challenges and Opportunities

The Overall Situation

Infrastructure-related issues were present in many different ITS application areas so consequently the sessions and papers in this topic covered a wide range of areas:

- Physical Infrastructure and asset management
- Procurement
- Security and integrity
- Connectivity and communication
- Simulations and new transport models
- Methods for collecting data
- Traveller information
- Mobility services especially Mobility as a Service
- Traffic management especially probe data and Big Data analytics
- Payment methods and incentives

A key question occurred frequently — is our physical infrastructure ready for automation? A well-developed infrastructure ought to help accelerate deployment but an inadequate provision would limit progress and reduce opportunities for improvements.

A large number of technical papers dealt with detector systems for various purposes *e.g.* identifying the weight of trucks (WIM is very common), classification of vehicles, identifying hazardous materials, thermal scanning, tyre anomalies *etc*. Electronic Toll Collection and the transition to distance based ETC was covered in some papers along with ITS for truck enforcement and geo-fencing.

Truck parking had been on the agenda for quite some time; an interesting new paper described using a vehicle's on-board units required for satellite-based truck tolling to get real-time information on the availability of truck parking. Another interesting topic was the potential of Big Data for asset management and improving network outcomes. ITS applications have been implemented at all levels and learning what can be done at local level and for smaller authorities was of interest to many congress delegates. Several sessions and papers covered this area and delegates could hear about a showcase on how ITS can be used for improving regional mobility.

Resilience, integrity, security and privacy are core factors when implementing ITS systems so it was especially important to raise these issues in an Executive Session as was done in ES02. The high level trends of Connectivity, Automation and Electrification mean that delivering safe and secure mobility is a real challenge when the vehicles need to sense, think and act. A rather nice catchy statement emerged from one session: "The 'Bad Guys' make a cost-benefit analysis and as a consequence the 'Good Guys' must make a Risk Analysis based on threat, vulnerability and risk assessment". Security by Design was recognized as crucial and core security principles are:

- Secure external interfaces
- Secure domain isolation
- Secure internal communication
- Secure software execution

One speaker highlighted four important questions to test the protection of assets:

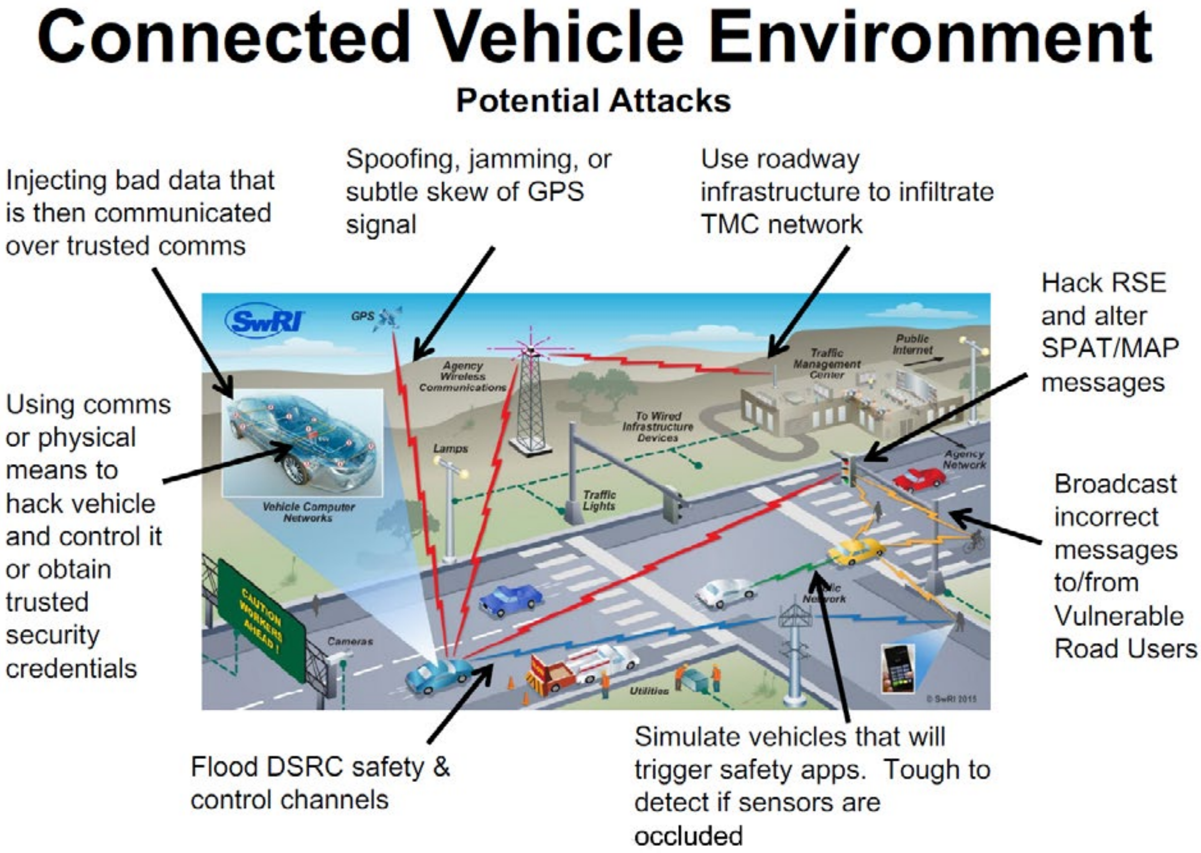
- How can someone gain unauthorized access?
- What could they do?
- How can we detect an access?
- What can be done in response to the attack?

Another key issue was how cyber attacks actually occur. In the picture on pg. 11 gives some insight regarding that.

The general issue of services for mobility featured in several sessions and MaaS (Mobility-as-a-Service) had been discussed for quite some years now. A number of pilots had begun and we had started to get some experience regarding working business models, barriers, challenges *etc*. How can cities integrate MaaS across conventional mobility services such as metro lines, rail, taxis, and buses with new services such as parking, bike share, car/ride sharing, and other services? This means more interesting MaaS presentations than on earlier congresses.

In the SIS on "Disruptive mobility services utilizing IOT big data for smart cities" we learned that authorities need to promote collaboration between public transport and private cars in order to get faster introduction of MaaS. Connection to traffic management was also necessary and resolving the best way to make payments remained a real challenge for MaaS. Cooperative Traffic Management was needed in the near future as apps and services provided by commercial service providers were the primary source for traffic information reaching travelers and vehicles. Travel behaviour depends on these factors and it was important that the industry and government worked together to provide road users with relevant and accurate transportation information and technology to facilitate travel decision making. When introducing Connected and Automated Vehicles this would be even more important.

Data collection using a variety of techniques was presented in several sessions and papers. Fixed radar-detectors and cameras are still large sources for data. Probe data from vehicles and mobile phones has increased a lot and we could also see that data can be extracted by using



Ways of attacking the connected vehicle environment Darran Anderson in ES02

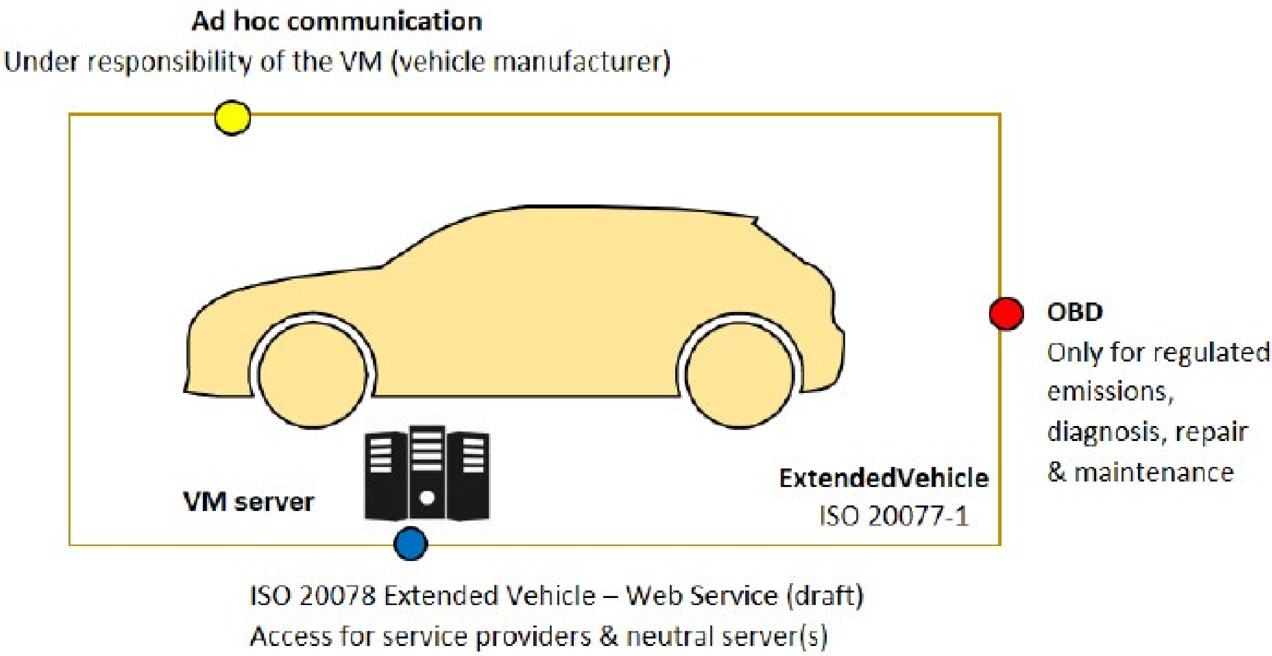
advanced sensing technology such as image processing and active sensing by either on-board or road-side units.

The interactions between vehicle sensing technologies and physical highway infrastructure were an interesting area that will need further development in order to be ready for automated vehicles. This included sensor interactions with infrastructure components such as construction signing and pavement markings. GPS probe data can be used to provide quick and low cost insight in real-time and also be applied historically to monitor, manage, and evaluate the performance of the road network. This had been known for some time now but it was important to optimize the processes of handling the data and working together with the suppliers to really benefit from the probe data. Many countries had started this work and they were beginning to learn from each other regarding this.

Combining data from different sources for all kind of purposes was also on the agenda. Many sessions covered the potential of data processing and big data analytics but not that many implemented solutions were described. One paper described the use of a cloud-based platform based on open international standards in order to make use of and integrate transport data assets from multiple local authorities in a public-private partnership. The concept of Big Data supported the use of huge amounts of heterogeneous data for road network operations; PIARC had initiated work to facilitate the dialogue between stakeholders needed to make use of these new opportunities.

Getting access to vehicle data was a hot topic especially for Europe. There were surprisingly few presentations on this but the view of the automakers and their Extended Vehicle Concept was shown. This concept generated much interest especially as it was hoped that it would be an enabler for the exchange of Probe Vehicle Data. HERE also promoted their Open Location Platform as a way to build the eco-system of data exchange and make available safety-related data from vehicles.

Modelling and simulation studies were a part of more sessions and papers than expected. One reason might be that the many and rapid changes to transport systems



The Extended Vehicle Concept   Maxime Flament in SIS13

e.g. new mobility services, connected and automated vehicles, required improvements and amendments to current models rather than radical redesign.

A key emerging question was how to ensure reliable communication between vehicles, infrastructure and servers to support future applications, and how to build a mission critical network. Some special interest sessions gathered large audiences when presenting ideas related to communication infrastructure. Connectivity is definitely seen as a pre-requisite for automated driving and the vehicle clouds as shown above are part of the solution. Technical challenges related to the communication infrastructure include:

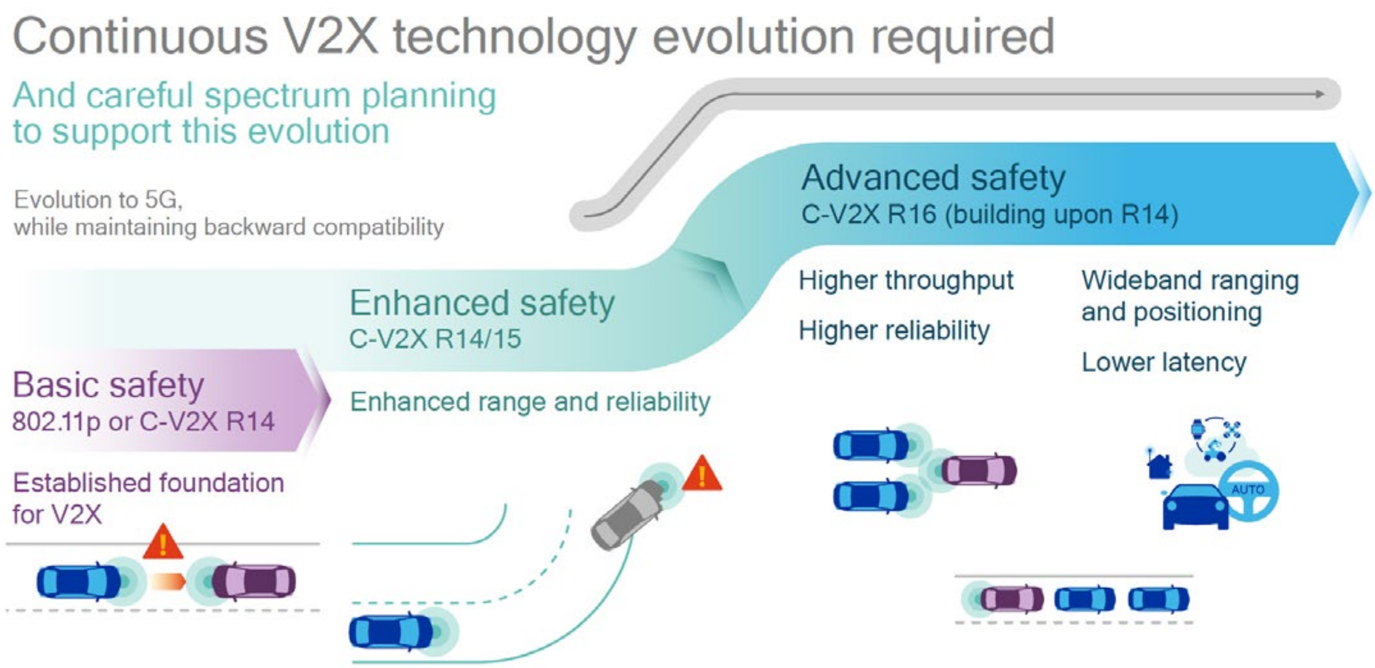
- Redundancy and seamless handover
- Interference
- Co-existence of cellular and *ad hoc* communication
- Security issues

However it was also noted that we should keep in mind that radio communication can fail.

It was agreed that hybrid communication solutions were needed using both cellular network (3G, LTE, 5G) and short range communication. Most of day 1 and day 1.5 services were not time critical and so could rely on the cellular network. For the more time critical applications with low latency requirements short range communication would probably be needed at least for V2V-services. ITS-G5 (IEEE 802.11p) had been the chosen standard for short range communication and safety applications in the 5.9 GHz-band but we now had a situation where the mobile network industry and 5GAA (5G Automotive Association) was promoting an alternative standard called Cellular-V2X (or initially LTE-V2X). The 5.9 GHz-band would probably not be enough to host both of them at least in the long run. The figure below shows the roadmap promoted by 5GAA.

Although mobile networks and wireless communication were very much prominent fixed networks and fibre along highways was still a backbone for the communication infrastructure.

Executive and Special Interest Sessions had more focus on the importance of security, resilience, privacy and integrity than we had seen before but it was a little surprising that this was not reflected in technical papers in the same way.



The evolution of V2X short range communication   Jim Misener in SIS 13

The Old v The New

As noted above on a general level many interesting topics were covered in the congress. In a number of presentations innovative ways to use ITS were described in detail *e.g.*

- The interactions between vehicle sensing technologies and physical highway infrastructure.
- Crash prediction using a neural network model to predict daily and weekly incidents.
- The development of an algorithm for traffic density estimation using probe vehicles equipped with various sensors. With the combination of high resolution 77 GHz radars, cameras, GPS, digital map aided systems, and telecommunication technologies, probe vehicles can sense current traffic conditions in their vicinity.
- A V2I system based on 920MHz as an aid to preventing crashes at small-scale crossings without traffic lights.
- Using existing city telecom fibres as sensors. Anything that moves generates strain and pressure so very small strains in the fibre can be measured and any cars moving on an equipped street can be detected.

Compared to previous congresses there was increased focus on Smart Cities. Data was even more on the agenda with presentations on the implementation of systems that can benefit from different kinds of data. Technical solutions for collecting and processing data were more in evidence than earlier. Connectivity and communication technologies were very visible along with issues related to Security, Resilience, Privacy and Integrity. At least in the Infrastructure topic the technical/scientific papers seemed to deal more with technical solutions than with organizational and business case issues.

Forwards v Constrained

There were a number of papers covering simulations and modeling for purposes such as analyzing the relationship between internet search data and traffic conditions in order to develop a model to predict traffic conditions. Modeling of lane merging was described in one paper. This is extremely difficult but it will be necessary to understand it in order to implement lane merging in autonomous vehicles. Using incentives and rewards to influence the behaviour of travelers *e.g.* by points-based loyalty schemes was a growing area and we will probably see more of this at future congresses. Technologies and software packages for using large amounts of data will also continue to develop.

Connectivity was highlighted as a key subject on the congress and we will need many more discussions related to communication infrastructure. It was agreed that as a consequence of the high level automotive trends of Connectivity, Automation and Electrification issues of security, resilience, privacy and integrity are really core when implementing ITS systems. They were high on the agenda for both the automotive and ITS industries as demonstrated by the Executive and Special Interest sessions.

Multimodal aspects were not very common and public transport actors seemed to be less visible than at European congresses. Infrastructure for electric vehicles was anticipated and would fit well in this topic, but there wasn't any paper on that. Cooperation had been a key area of interest at earlier congresses but at least among the technical/scientific papers on topic Infrastructure, cooperation seems to be less in focus. Cooperation is needed to benefit from the expanding eco-system of data exchange and to overcome fragmentation and silos. More discussions regarding actors and roles would have been interesting also in this topic.

We had a lack of papers covering ITS and infrastructure for cyclists. The use of bikes is increasing rapidly in many cities and one can expect increasing need of data from this area for analyzing and planning and also for services to bicyclists. Perhaps authors are saving themselves for Copenhagen in 2018.

TRACK C Smart(er) Cities

The Overall Situation

The "Smart(er) Cities" track was organized around 50+ sessions linked to the following key topics:

- Air quality strategies
- Traffic management
- Managing city space for freight as well as passengers
- Integrating transport, energy, telecoms, waste and water systems
- Modernizing parking management
- Business models for urban mobility
- Getting a mode shift and a bigger role for transit
- Pedestrians/cyclists in the evolving city
- More liveable cities
- Transport in a digital city

There have been numerous definitions of a Smart City and there was no shortage of discussions in Montreal about what really constitutes a Smart City. While no one can agree an exact definition, generally the literature covers what makes cities smart (its people), and advancing the deployment and integration of smart city technologies. These thoughts were reflected in several Congress presentations but less so in written papers. There was a variety of sub-topics demonstrating some clear overall themes:

- Traffic management in smart cities requires new technologies and techniques;
- Improving the transport of both goods and people is critical to a city's being "smart;"
- The challenges of seamlessly integrating single and isolated ITS applications;
- The role of partnerships between public and private entities;
- Incentivising travelers to make better decisions regarding mode and route selection;
- Understanding behaviour when real-time information and guidance is accessible;

Overall, the most popular discussion subjects were:

- ITS-based traffic management tools and techniques
- Using open, flexible, secure and interoperable software and hardware platforms
- Fusion of public and private open data in next generation traffic management
- Incentivising individuals to make better mobility choices
- Forming partnerships to establish a Smart City

Two Executive sessions and one Plenary provided a broader perspective on the most relevant topics within the track including integrated mobility, liveability and connected cities. There was also the Smart Cities Educational Pavilion, which had numerous presentations and panel discussions around how policy can advance the future of integrated mobility, how the Internet of Transportation (IoTr) is critical to a Smart City, planning for automated vehicles, and how technological solutions and the Internet of Things (IoT) are rapidly changing cities around the world. Contributions in this track were not uniformly distributed; there was a concentration on next generation traffic management and a dip for air quality strategies, business models for urban mobility and pedestrians/bicycles in an evolving city.

The shift in focus to people in smart cities was discussed at the Melbourne 2016 Congress and continued in Montreal. Fundamentally a smart city is one that has been able to look internally and identify what its challenges are — what its people and residents need to have the quality of life they want to have — and to craft unique solutions that enable the city and the community to deal with those challenges. Many of the papers covered specific smart city technologies and their potential and initial deployment but descriptions of more mature deployments and integration of the technologies were minimal.

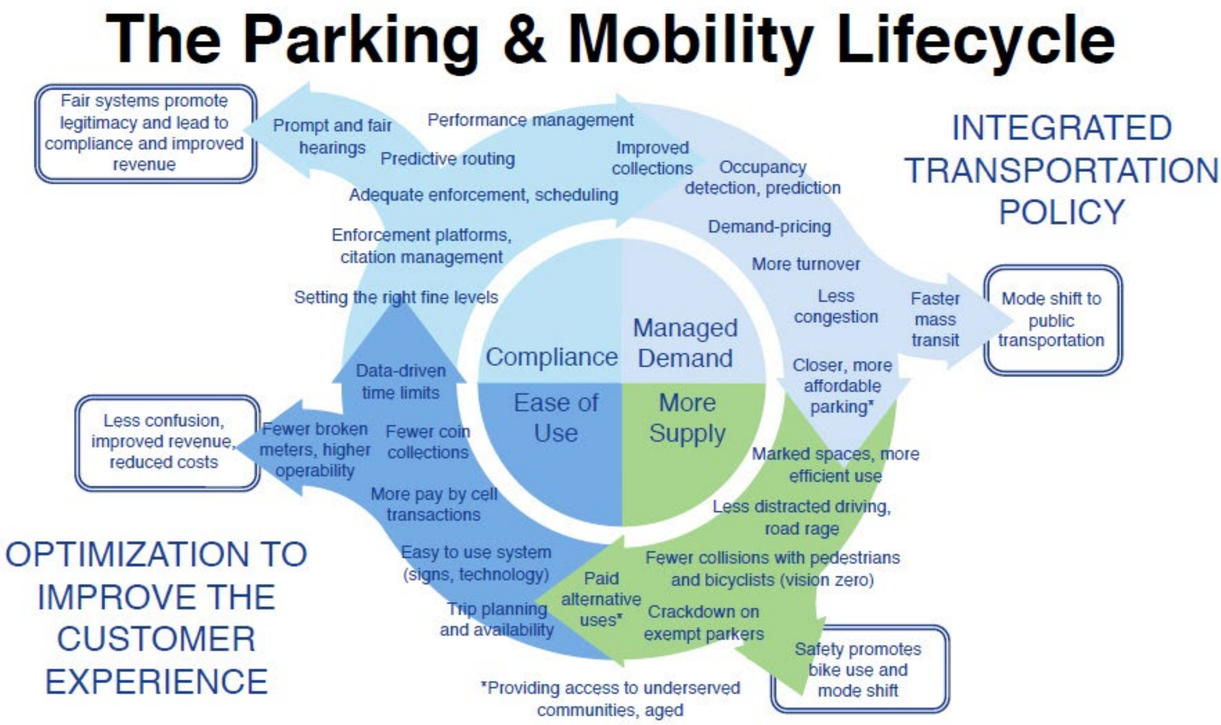
Two key themes were visible across all of the Smart Cities presentations at the Congress:

- **Data** — without data and analytics, Smart Cities cannot exist. Data is a fundamental pillar of a smart city's economy and key to the evolution of the new mobility in cities
- The focus must be on **citizens and their needs** — the availability for citizens of technologies that will drive Smart Cities so that they can improve their quality of life.

It was clear from a number of discussions that an integrated mobility management platform was almost essential for a smart city and should provide, at reasonable cost:

- Integrated situational awareness
- High level operation of all traffic control and ITS systems
- Events and incidents management with automated response plans
- Data centralization and analytics
- Coordination between agencies
- Multi-modal integration
- Dissemination of information to citizens

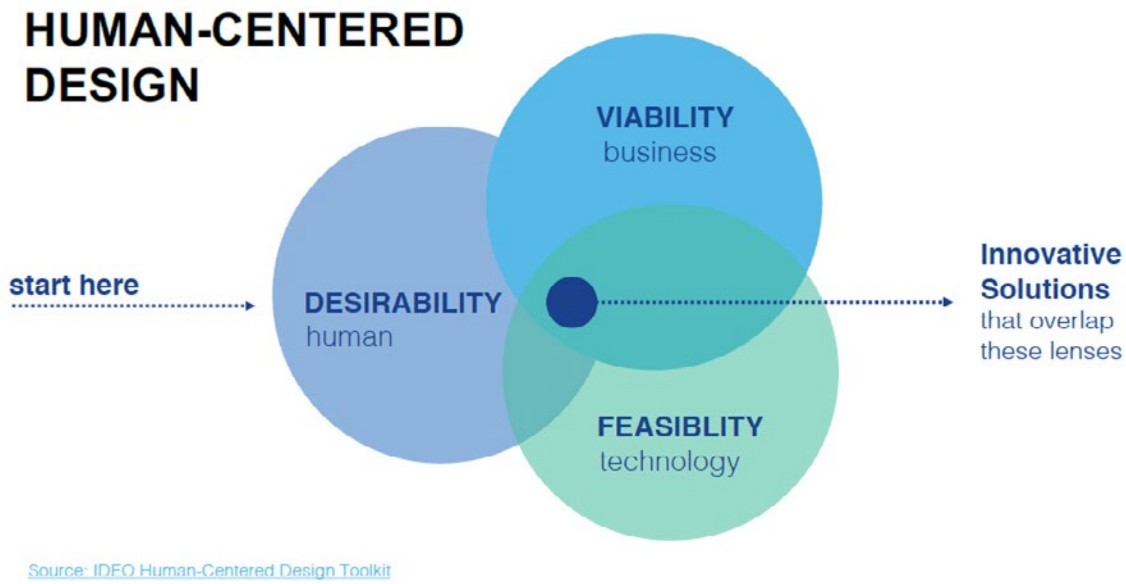
A number of key points were made in Special Interest Sessions. Many speakers argued that not enough attention



The Parking and Mobility Lifecycle   Vincent Valdez in SIS54

was being paid to the impact of freight/package deliveries on a city and we might benefit from MaaS for goods as most MaaS projects to date had focused on the traveller even though it was claimed that they covered goods. City parking had also tended to be forgotten when considering ITS applications and innovative multi-modal solutions.

Most drivers navigate to their final destination rather than towards the parking space that they will need before reaching their final destination. New in-vehicle systems can now navigate automatically to the closest managed spaces or curbside parking when the driver enters a final destination. It was pointed out that "Every vehicular trip



Human-Centred Design   Lenae Boykin Storey in SIS 60 begins and ends with parking" — a memorable quote but unfortunately we don't usually think enough about the significant impact parking has on cities.

One presentation defined a Maturity Level of Transportation for qualifying as a smart city:

Level 0	business as usual with a public transport authority
Level 1	single modes of travel
Level 2	new modes added
Level 3	integration of modes into a multimodal network
Level 4	integration of ITS and traffic management with the multimodal network
Level 5	a fully integrated multimodal network

The process for developing integrated mobility networks was also examined and one speaker outlined how to use human-centered design and design thinking when approaching transport to put the focus on the human behaviors we want to create and then using technology to enable those changes.

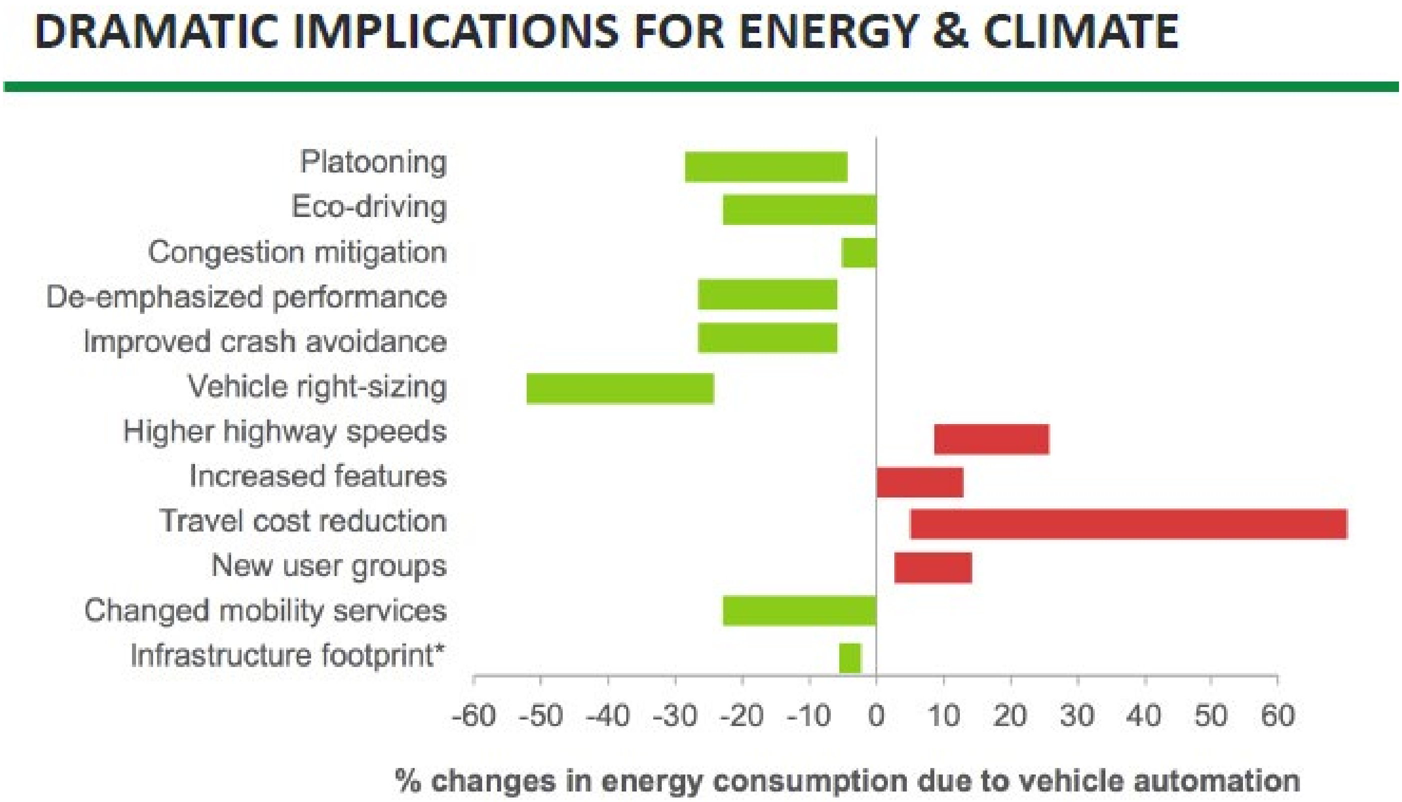
The Old v The New

We learned about several new ideas in this track. The US Department of Energy has the Systems and Modeling for Accelerated Research in Transportation (SMART) Mobility Program to integrate science, technology and policy to improve people's lives and society. Working with the US Department of Transportation this program supports maximum mobility using minimum energy for the future of urban areas.(see diagram)

The ACCRA project (Autonomous and Connected vehicles for CleaneR Air) described a system using connected autonomous vehicle technology to address the issue of poor air quality due to vehicle emissions. ACCRA links hybrid internal combustion engine and electric vehicles to a city's traffic control system to allow responses to pollution violations and modification of emissions strategies. Other traffic management innovations included:

- Predicting traffic delays by pattern and data from probe cars
- A public Traffic Congestion Index derived from on-road camera surveillance networks
- Using Internet of Things (IoT) technologies in a fully automated and integrated system that collects, analyses and broadcasts traffic conditions in real-time
- In Copenhagen smart systems to evaluate conditions on the network in relation to politically-decided service goals; facilitating and giving information to travelers including variable message signs for cyclists to stimulate green mobility and dynamic usage of parking spaces and street space.
- The "TM 2.0" concept of interactive traffic management, which aligns objectives among the various stakeholder groups that typically have conflicting objectives, by exchanging traffic data and traffic control data based on a common traffic management strategy.
- Life First Emergency Traffic Control (LIFE) — using a microsimulation model to improve emergency vehicle response time and reduce costs, whilst assessing mitigation strategies to reduce other impacts such as residual congestion.

US Department of Energy Mobility Engagement Approach in SIS63



Impact of vehicle automation on Energy Consumption; National Renewable Energy Laboratory

New ITS services and technologies can have dramatic implications for energy and climate:

The sensitive issue of allocating sufficient network capacity for managing freight alongside passenger traffic was frequently aired. An intriguing trial in Bilbao was using IoT and Smart City developments to automate the monitoring of freight loading zones and the associated enforcement. A Canadian trial was using crowd-sourcing to measure travel time reliability to measure performance on goods movement routes in Calgary. The crowd-sourced data technique was capable of measuring speeds and travel times on lengthy stretches, and determining congestion and bottlenecks.

Many cities talked about ways to get a mode shift and a bigger role for public transport and a wide range of solutions was described:

- Determining the relative priority of vehicles approaching an intersection using an interface between the passenger counting system and the onboard computer-aided dispatch (CAD)/automatic vehicle location (AVL).
- Using a retail 'points-based loyalty' scheme in a northern UK city to encourage a modal shift to public transport.
- Multiple Passenger Ridesharing was being researched in Barcelona using microscopic simulation emulating real-time traffic information and interaction with a Decision Support System to determine the feasibility of this mobility concept.
- A first and last mile pilot program in Colorado involved the use of either the Lyft app or the Go Denver app to book a fully-subsidized Lyft ride in a pre-defined service area.
- Encouraging public transit use by using data, such as movement, air quality, noise and illumination, from a mobile device's sensors to determine the impacts of comfort and safety elements for urban transit journeys.
- A deep learning methodology for bus arrival time prediction was being trialled in Bangkok based on only bus location data.
- An innovative real-time multi-modal journey planner available through a single integrated web site and mobile app integrates both pre-defined and real-time data for all modes of public transport and driving, walking and cycling.

One of the key Smart City tests was progress with integrating transport, energy, telecoms, waste and water systems. An interesting new qualitative approach to exploring the degree of "fit" between current business models and needs of varying stakeholders was presented. This theoretical representation demonstrated a new way forward for integrated travel based on social enterprise business models and an assumption that smart cities do not necessarily consider people, societal value or societal challenges. Using a synergistic approach to existing transport infrastructure not only delivered significant cost savings, but had a further direct impact on health & well-being and social objects.

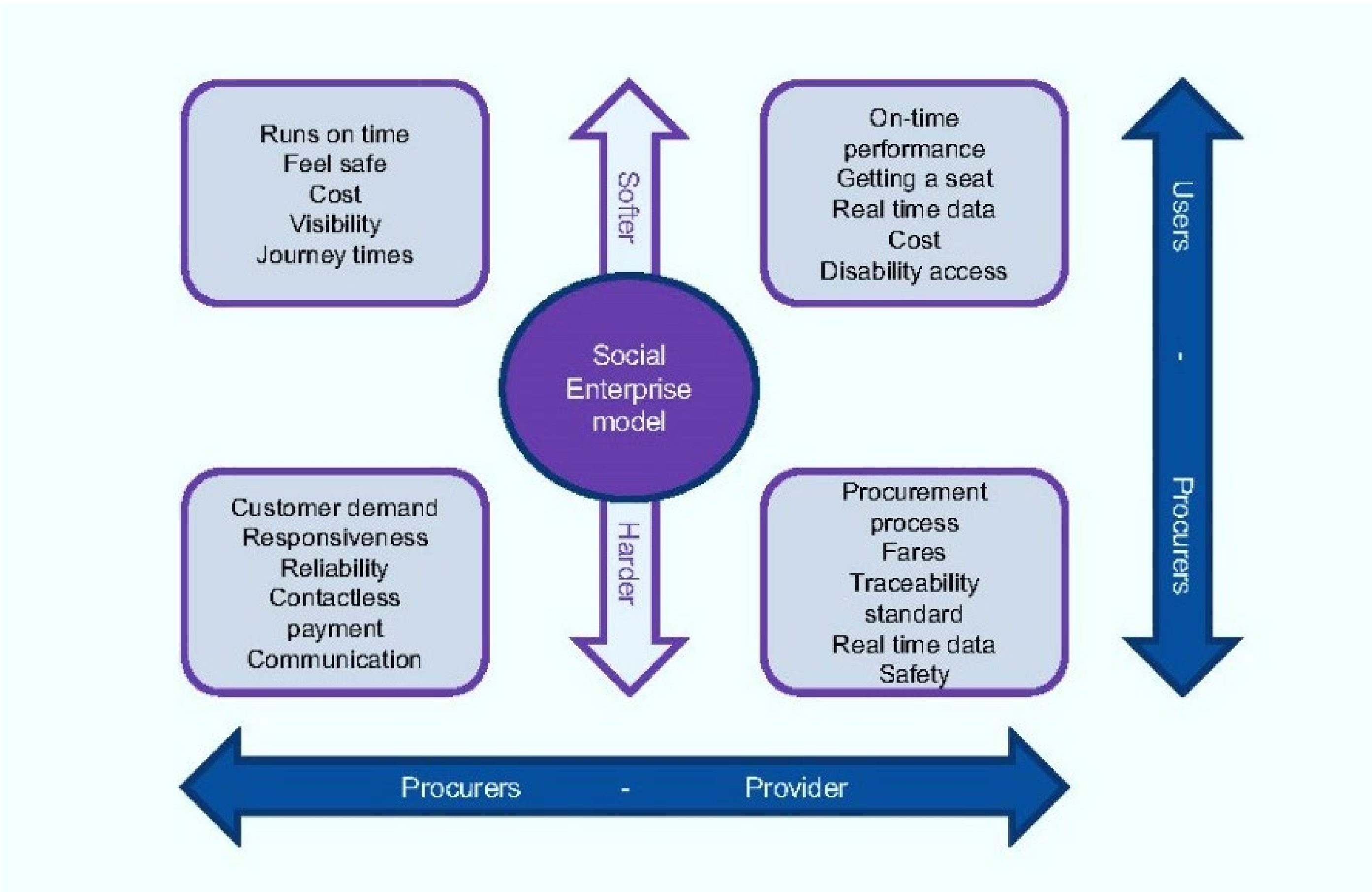
There were also some not-so-new ideas, particularly in the area of traffic control, receiving a new lease of life as a result of being applied in the area of Smart(er) Cities:

- Experience with various on-street parking occupancy technologies had assisted in identifying solutions to urban challenges inherent in the District of Columbia (US). On-street occupancy detection technologies examined included in-ground sensors, portable closed-circuit television, time-lapse cameras, cameras with GPS, manual counts, payment data, dome-mounted sensors, fixed cameras, license plate recognition, and crowd-sourcing applications.

The City of Montreal has approximately 170 intersections equipped with universally accessible technology adapted to the needs of the visually impaired that requires no special equipment for use.

Forwards v Constrained

Last year's Congress recognized a fundamental shift in the definition of Smart Cities. Rather than thinking of multiple technologies and smartphone applications we now think of a city that has deployed integrated technology to meet the needs of citizens. Numerous conferences around the world have discussed what constitutes a smart city, and how public and private agencies must work with citizens to determine what is needed. Consequently we saw much more citizen involvement in Montreal.



Smart City Social Enterprise Model   Liam Fassam in TS07

We also saw changes from another issue identified last year in Melbourne — the fact that while the ITS community is in a position to help cities get smarter in many cases some current regulations were stopping cities. Fortunately, in many countries regulations are being relaxed — for example to permit demonstrations of Mobility on Demand/ Mobility as a Service. Discussions tended to be focused on mobility, rather than on individual travel modes. As part of this trend public transport is being redefined so it now covers more of the transport ecosystem, particularly what were traditionally called "private services" such as transportation network companies, microtransit providers, shared-ride services, and autonomous (self-driving) vehicles.

Mobility as a Service (MaaS) was now being deployed and there is more material in the Disruption and New Business Models Track. However it was clear that some aspects of MaaS are not yet completely understood, such as how a city or town procures MaaS. The MaaS Alliance reported how it was developing guidance to assist entities that want to plan for and deploy MaaS.

We should also note some issues which were visible but probably insufficiently addressed by the sessions and papers:

- The role of data in smart cities;
- Engaging citizens to determine Smart City needs and expectations;
- Business models for improved mobility in urban, suburban and rural locations;
- Impact of freight transport on Smart(er) Cities;
- The willingness of people to use shared mobility (including automated vehicles);
- Planning for shared, electric, automated and accessible vehicles.

The Overall Situation

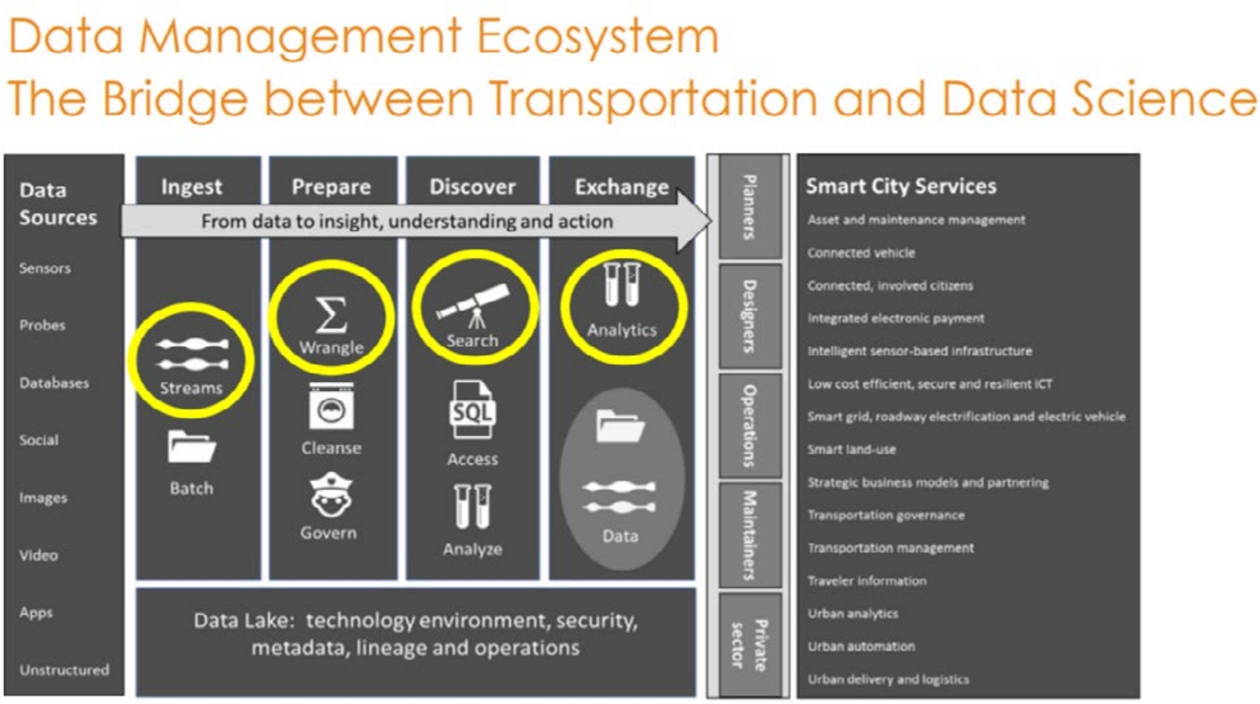
Data, Security and Privacy track covered a wide range of sessions including management of Big Data, open and shared data, ride sharing, connected vehicles along with the corresponding cyber security and deployment issues. It also included popular traffic data analysis sessions *e.g.* travel speed prediction, congestion condition estimation and machine learning (ML) for transport analysis.

The systems presented for ITS big data management were mainly linked to central storage for multiple ITS data sources (*e.g.* freeway/arterial condition data; ITS operations data and performance measures and traffic events) rather than targeted on big data processing. The use of cloud storage was mentioned but it is still not a new implementation. ITS data quality sessions recommended the best technology and data sources to be used based on traffic condition to allow the data fusion process to be constructed to maximize the contribution of each data source when it is strongest and avoid many of the weaknesses.

An open location platform to enable an ecosystem to turn big data into Insights for Smart Mobility was presented; as one of the most advanced and popular platforms it had real-world applications in car companies for CAV development and in cities for advanced traffic management. The US DOT/JPO's Operational Data Environment (ODE) was also presented as a scalable, open source, open build, and modular data sharing framework. This system stores data from connected vehicles, personal mobile devices, infrastructure components and road sensors.

There were quite a few papers on estimating and measuring congestion conditions including queue detection using FCD or comparing multiple data sources for congestion detection/cost estimation. However most authors just reviewed or applied available methods rather than develop new approaches. An interesting finding was that the excess delay cost estimates based on probes and Bluetooth were 55% and 54% higher than those from inductive loops respectively.

Data analytics was increasingly being applied to transit operations to enhance efficiency and quality. A case study carried out in Singapore had shown that a data analytic approach could improve operators' ability to manage bus services such as journey speed monitoring and congestion spot investigation. In Taiwan a smart bus operation management system had been developed to help operators to improve service quality and efficiency. The 'service irregularity problem' had also attracted researchers' attention. A study demonstrated that automated vehicle location data was a useful data source for diagnosing transit irregularity.



The use of Big Data analytics   Peeter Kivestu in SIS 14

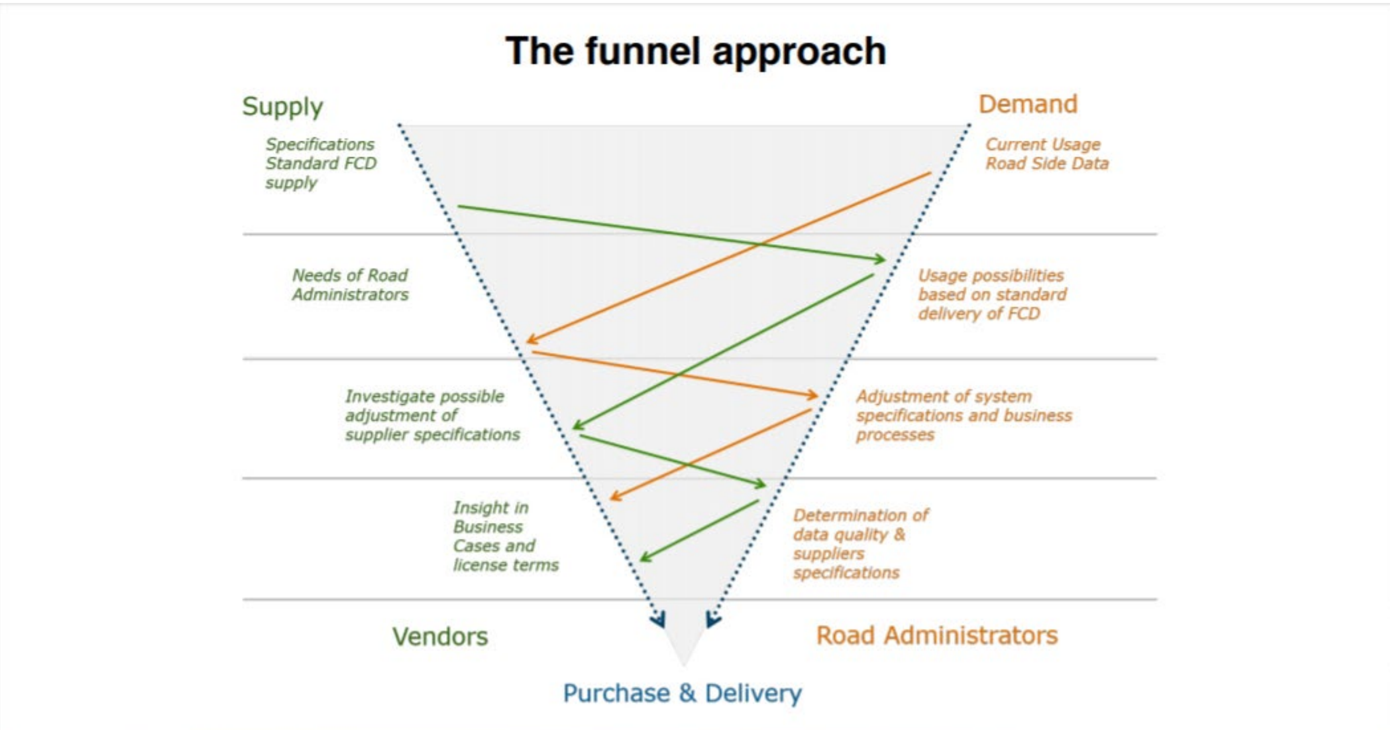
It was clear that with the advance of technologies for data acquisition data analytics was becoming a useful tool in transit operations. In an SIS a detailed visualization and diagnosis for a road bottleneck was presented along with queue propagation, bottleneck capacity and dynamics analyses. One project to reduce congestion was presented that integrated real-time data Into Mobile Map Applications (Waze, Here, Broadcast Media and official incident information from Transport Management Centers) to enhance the situation awareness capability for road users and travelers.

Real-time traffic information for road users also featured and speakers from Japan mentioned the use of a dynamic map which included several layers: static base map, semi-static (traffic regulation, road construction, weather *etc*.), semi-dynamic (accidents, traffic jams, detailed weather *etc*.) and dynamic data (movement of vehicles, status of pedestrians, traffic signals *etc*.). However the data quality needed to be evaluated and considered for individual sources and a speaker noted that probe speed data could be very noisy and sparse, loop detector volume could be miscoded and missing, and loop detectors can be faulty.

Shared mobility had recently become a very hot topic around the world. It had brought fundamental changes in the way people travel and also had a great impact on their finance and lifestyle. In this sub-topic a study had showed that using shared mobility rather than conventional transport service provision governments could reduce costs and save space. Researchers studying data from the EVCard car sharing system in Shanghai had found that there were macroscopic demand patterns and microscopic user choice factors. Another Shanghai paper had analyzed the GPS data generated by a bicycle sharing system and discovered interesting spatial-temporal patterns such as distribution of travel time, travel distance and tax revenue.

A research project had proposed a new concept of environment values such as energy, excursion, experience *etc* which could be used for moving demand prediction before the big data are accumulated. Interestingly a paper presented a methodology for modeling the design and operations of shared vehicle systems. In general, the papers presented in this section suggested that ride-sharing has attracted more and more attention and has becoming an innovative supplement to existing transport services.

It was clear from many presentations that Connected Vehicle (CV) studies had attracted huge attention around the world and were becoming increasingly popular in the ITS community. Research had flourished in this area. CVs had been integrated into traffic data collection at an early stage through probe vehicles and commercial vehicles and many commercial suppliers were using CV techniques to enrich their data sets. Presentations reported on several collaborative efforts for a global connected car project. It was recognized that it is an opportunity as well as a



From data to Big Data   Edoardo Felici in SIS 76 challenge to take advantage of CV data as one of the key deployment challenges is the cyber security issue. However, most papers in cyber security sessions mainly reviewed available systems and recommendations to secure AV technologies rather than introducing new methods.

The Old v The New

In general it was difficult to find very innovative ideas or research directions in this topic as most of the technical papers presented reflected continuous discovery and improvement from previous systems and methods. However there were some new ideas summarized below:

- Enhancing cyber security by adding physical devices for enrollment/registration service to current systems.
- Introducing a public key infrastructure for the communications between automotive back-end systems and vehicles based on specific security goals for entity authentication, integrity and confidentiality.
- A practical application of machine learning used to discover the association between heart rate, thermal sensation and cabin temperature change used for automatic control of a car's air conditioning.
- Integrating CV data into traffic signal central systems to complement high-resolution traffic signal data performance measures.
- CV data can be introduced into safety warning messages (such as end of ramp deceleration, emergency electronic brake light, and forward collision warning) and adjustable traffic control (such as transit signal priority and pedestrian priority).
- A new method for car platoon detection was described based on signal pattern correlation on subsequent detectors.
- Traffic state estimation using traffic measurement from the opposite lane.
- Case studies were presented on the use of big data platforms to integrate datasets and develop analytic insights on transport management for special events *e.g.* F1 race days, English Premier League matches etc in U.K.
- A methodology for modeling the design and operations of shared vehicle systems along with investigating the financial impact of shared mobility.
- Studying the factors that influence users' choices in shared vehicle and spatial-temporal patterns for supporting dynamic deployment of shared vehicles.
- Impact assessment using CO2 reduction for better speed control
- Using best practices from health data sharing to broker authorization of access to sensitive data, including from the private sector and public-funded field tests.

Forward v Constrained

Many sessions illustrated the great potential of CV techniques with many applications in a testing phase. However CV data brings practical challenges such as finding innovative data parsing and fusion methods, data transfer techniques, and data mass processing techniques. Moreover cybersecurity for CV looked to be constrained by established standards and recommended systems.

Various concerns were raised and debated on the shifting risk and liability landscape as the vehicles automation processes develop from Level 2 to Level 4. Various studies were focusing on the study of semi-autonomous vehicles (SAVs) which were believed to be able to generate enormous amounts of telematics data from a suite of sensors and communication channels. In order to address this problem an innovative approach this year was applying machine learning methods and anomaly detection algorithms to identify deviations from normal driving patterns. On-line machine learning methods can be further used to continuously update SAV accident likelihood rates given the constant flow of data on driving, near miss and accident events.

Many public authorities were still reluctant to fund shared mobility services. We expected to see more studies on how shared mobility can save public spending and benefit the local communities to encourage budget shift towards shared mobility services. We learned that factor analysis and pattern discovery had been used for identifying influence factors and usage patterns. We look forward to learning how the identified factors and patterns might be used for demand prediction and dynamic supply.

A number of studies were presented on the use data analytics to improve transit operations. They showed the potential of data analytics in many areas such as journey speed monitoring, congestion spot detection, driving safety indexing, incident tracking, fuel consumption analysis, and irregularity investigation. Unfortunately we did not see any applications in transit demand analysis which is significant to transit operations. Furthermore it was argued that we still wait for a programmatic way to move the right data to the right apps at the right time for real-time traffic situation awareness.

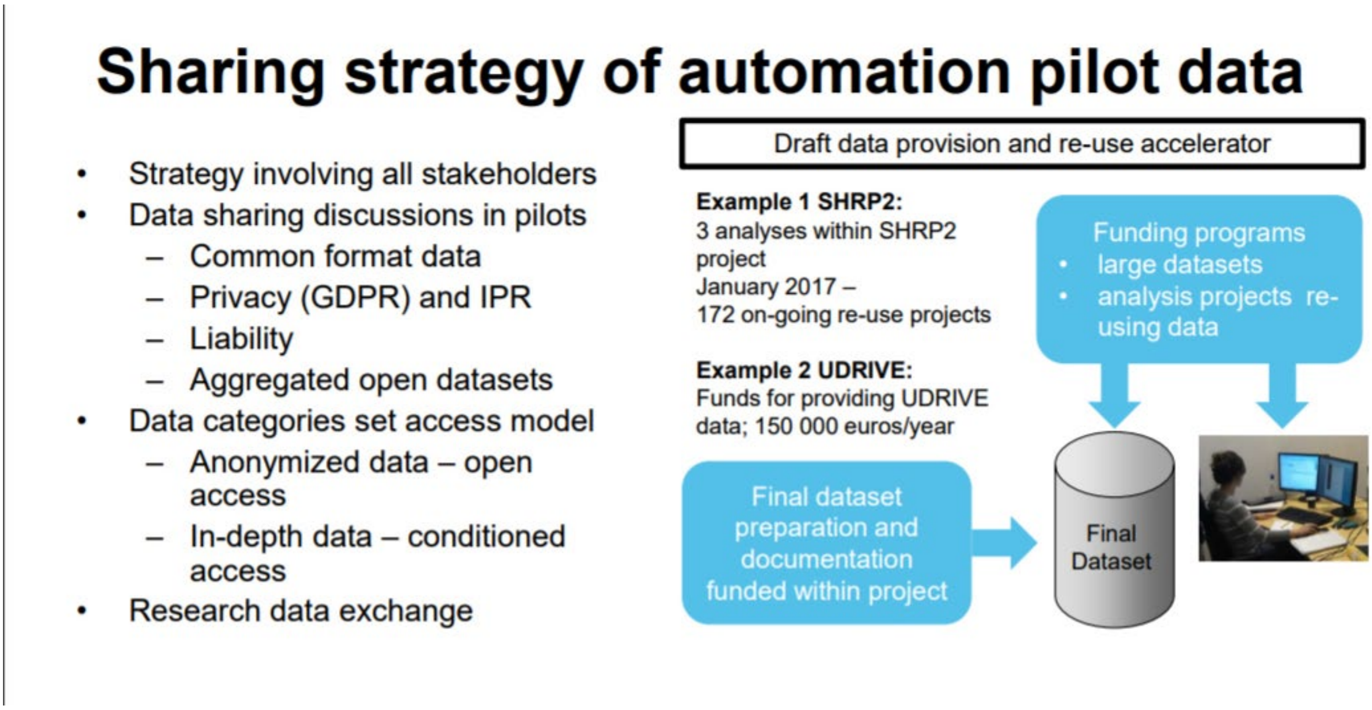
The public and private sectors were collaboratively developing the ecosystem for the Open and Shared Data in transport. A common reckoning amongst the participants was the need to break data silos and establish a market place for data sharing, exchange and standardization. An example of such collaborative efforts was the oneTRANSPORT platform (conceptual framework was introduced in ITS2016). The platform is an open, standardized, cloud-based platform which enables transport data suppliers to publish data on the platform/marketplace. Such data is then provided through a unified interface to data consumers.

The ability of the platform to provide open and common interfaces to multiple datasets was due to the use of the oneM2M international standard. The oneM2M is a Service Enablement Layer standard designed to provide a set of service capabilities that enable manageable data sharing for new services and application development from multiple parties. Studies show that the benefits of Open and Shared Data in transport would be transferred to the travelers in the form of reduced time to find parking, optimized public transport journey decisions and enhanced safety.

The common trend from many special interest sessions was that people continue to connect available data sources as well as investigating more data sources and the balance between business and public data. A few survey results for user acceptance and expectation for CAV and related cybersecurity issues were presented (*e.g.* SIS 55) with a special focus on risk *v* social benefit concerns.

There was much ongoing work to establish standards for cooperative ITS platform. For example Europe presented the Cooperative ITS Platform initiative which includes establishment of a single common trust model; common certificate policy; setting up a legislative framework; and identification of roles, financing and standardization. Using data fusion on multiple data sources was a new movement as most studies use multiple types of data from different sources. Another change was the use of open data sources which indicates that open data has attracted more and more attention.

Traditional machine learning methods (*e.g.* random forest, neural network and SVMs) were continuously applied to analyze transportation data in order to support trip survey or automatic transport mode detection. We should expect to see more studies reported in Copenhagen on implementations of “deep learning” approaches. Similarly Montreal only saw one research report on the development of a Long Short-Term Memory neural network (LSTM) to predict travel speed from point-to-point which is also not new in transport. On the other hand in Montreal we saw real-life data analytics applications used in transit operations.



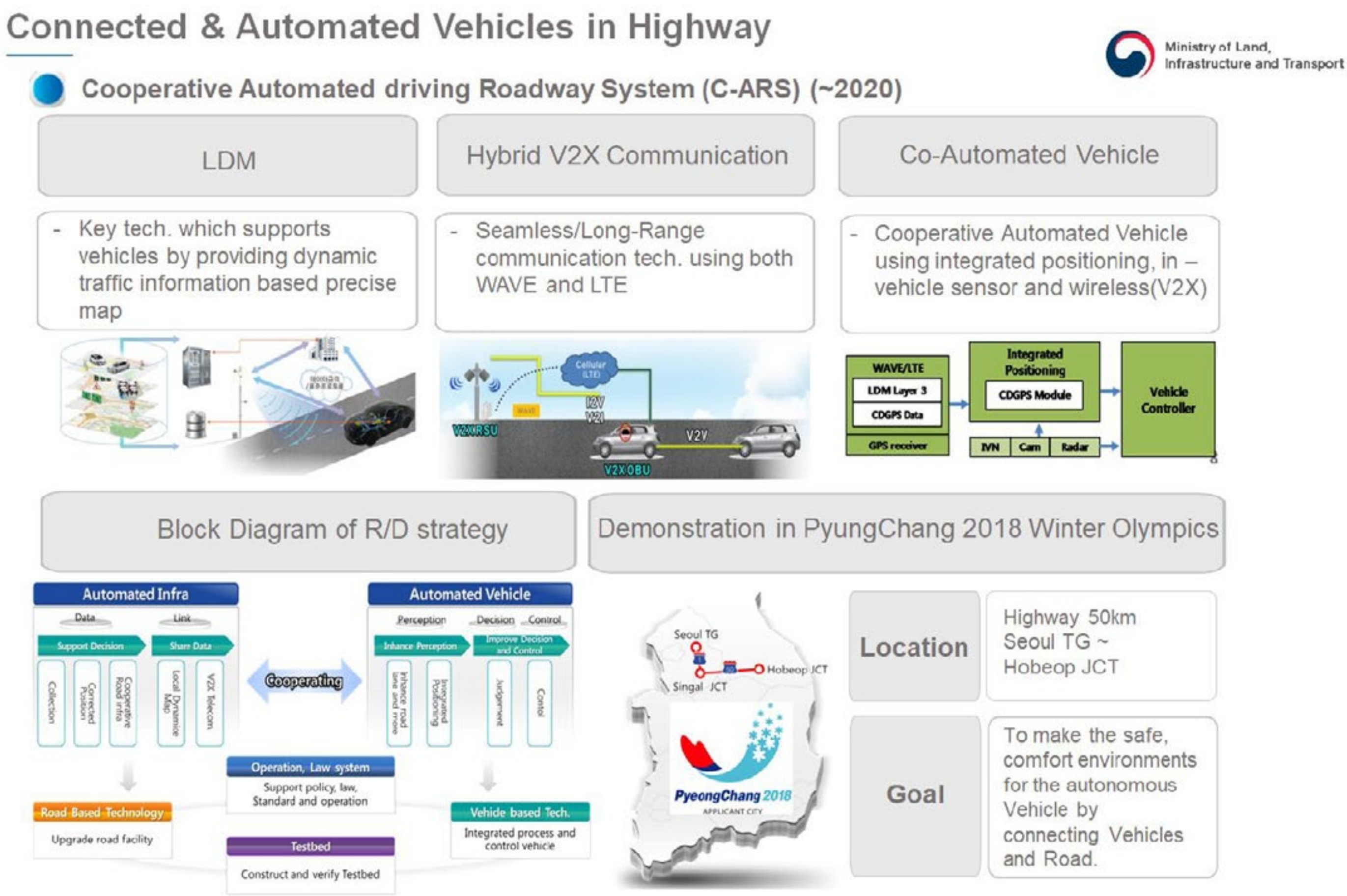
Data collection and data sharing   Helena Gellerman in SIS 59

The Overall Situation

The various special interest and technical sessions that comprised this Track covered a wide range of applications of ITS technology particularly Connected-ITS. As the title 'Integrated approach: planning operations and safety' suggests an underlying thread of pragmatic uses of ITS and integration into real world situations ran through many of the issues discussed. Most papers and presentations focused on practical uses of C-ITS to solve current, and often pressing, safety and operation issues. Many of the papers reflected the growing maturity of C-ITS technologies and discussed implementation and operational experience from actual systems, as opposed to the trials and theoretical uses that have been the case in the past.

The Ministry of Land and Transport in South Korea envisaged a goal of commercializing C-ITS and CAV research and the Government plans full-scale deployment by 2020. The current C-ITS master plan involved a trial that included over 3000 OBUs providing 15 services, or use cases that are similar to the EU CIMEC connected vehicle/connected infrastructure uses cases. After the trials the government will prioritize the order in which services are rolled out more widely across the Country. The 'Cooperative — Automated driving Roadway System' C-ARS was developing a local dynamic map (LDM) to complement these systems and provide road state and operational data in vehicles which will be trialled during the Pyungchang 2018 Winter Olympics.

South Korea's advanced traffic signal 'Connected and Automated Vehicles in Urban Road System' was using a variety of data sources (detectors, mobile phones) that are taken into cloud storage and then used for CAV based signal operation. This will also deliver a vulnerable road user discovery sub-system that uses the newly available capabilities of C-ITS technologies to address the safety of a wider range of road users. South Korea was also working on an Emergency Call system as part of this as a national, multi-disciplinary project involving data and service sharing across all relevant areas of Government. Addressing one of the clear themes of this track, the Government was aiming for zero traffic fatalities by 2022 starting with increasing ITS based road traffic safety and detection systems.



Korea implementation plan for CAV Hang Seon Lee in ES10

For C-ITS in Europe the European Commission was working towards getting the infrastructure ready; this involved getting the physical infrastructure ready for CAVs where possible and assessing if all roads are CAV capable, (or not). This work was also driving the development of digital infrastructure. The physical work involved ensuring traffic signals, VMS and other on-street devices were ready for CAV operation and its particular uses, (such as platooning). In a development that echoed the work underway in South Korea and further demonstrated the breadth of international effort that was driving towards similar goals, the EU was also working towards full digital Infrastructure including the development of a LDM standard to include road, legal and right-of-way information available in a two-way infrastructure that CAVs can interface with.

Across Europe interest was growing in smart infrastructure and developing opportunities to use a wide range of city equipment to support Smart technologies and principles. In terms of smart mobility Europe was developing the Traffic Management 2.0 (TM2.0) platform to promote technology driven traffic management centers and adaptive management. However. in order for cities to be really smart the principles of TM2.0 and Adaptive Management needed to be developed much further. Such developments would allow public authorities more control over how they meet their policies and give the correct weight to walking, cycling and other policy needs whilst still operating the network as efficiently as possible. This would encompass technologies such as signal phase and timing (SPAT) and green light optimal speed advice (GLOSA) as part of an overall Smart Mobility solution; and could break down the barriers of traffic management systems where they are based on historic data and so allow them to become much more reactive.

The EU MAVEN project was looking to address the challenge of managing automated vehicles, as this will enhance network operation and utilization and deliver safety improvements. Similarly, the management of electronic traffic Regulations (METR) that was about to commence was a crucial piece of work to arrive at an EU wide standard. Motorcycles and vulnerable road users are an important but difficult to deal with element and all actors (OEMs, authorities, suppliers) must increasingly work together.

From the USA a different perspective was presented that focused on the abilities of C-ITS to address issues with asset maintenance and the ownership costs of highway technology that are increasingly hard to resource. Washington State DOT (WSDOT) exemplified this approach in the work it was undertaking to squeeze the maximum usage out of current infrastructure. As with many road authorities across the world pressure was growing to maximize infrastructure use whilst reducing operational costs and prepare for new technological and social challenges. This might be addressed by decommissioning elements of infrastructure to reduce ongoing costs, so authorities were seeking to assess whole life costs of infrastructure and decide what could be removed. WSDOT, for example, were adding around 7% to their ITS estate annually but had concerns about the effects this could have on budgetary and staff resources.

In large parts of North America road authorities were developing different types of metric to assist in assessing the utility of current infrastructure technologies and potential new deployments, reflecting the generally less urbanized and more private car focused nature of travel. WSDOT's aim for their interstate network was achieving an average vehicle speed of 45 mph for 95% of the time during the peak period. It was widely accepted that reaching this goal in a safe and efficient manner would depend on current and emerging ITS systems. Achieving and sustaining network performance at this level would be main driver for the types of C-ITS systems that State Departments of Transportation aimed to roll out.

Japan was rolling out ETC 2.0, the latest generation of electronic tolling collection and was finding it around ten times as efficient as cash collection [it operated at over 1400 users per hour compared to under 150]. An incidental benefit was that Japan had over 3600 roadside units using V2I technology and over 2M connected vehicles using the system. This gave the country a very high level of vehicle connectivity from which to explore many of the use cases and applications that were being discussed elsewhere in theoretical terms. The probe data collected by ETC 2.0 was now being used beyond the tolling systems for real V2I uses, to identify, (for example) areas of heavy braking, leading to better prioritization of road improvement engineering. Probe data is also being used for smarter toll pricing that can be used to nudge users to use the routes the authorities prefer and hence assist in actively reducing or balancing out congestion.

ETC 2.0 was also being used to provide probe data to freight and logistics companies to help to increase the productivity of logistics operations and identify poor driving behaviour. The data feed was also being used to respond to earthquakes by quickly establishing whether routes were passable or blocked by earthquake damage. It was a also firm Japanese view that it will not be possible for CAVs to fully understand their surroundings solely from on-board sensing equipment and so ETC 2.0 data will be essential to providing live driver data into vehicles. Japan was about to start a public — private project to develop such systems. Although primarily a toll collections system ETC 2.0 was seen as the 'vehicle' by which the CAV data platform would be developed and on which it would be based.

The Old v The New

The theme that resonated strongly in this Topic was that of the use of C-ITS technologies to address real world problems and maximize operational effectiveness of road networks. In this respect, this Topic had a less theoretical and academic feel to it than some others, and focused heavily on examples from around the world of C-ITS systems in use today. Many examples of this reflected the need to reduce road collisions and associated casualties and areas that in the past have been very difficult to manage, such as wrong-way driving on dual carriageways can now be addressed using available technology. In this particular case, authorities were using technology to answer the question 'Is there a better way of detecting wrong-way drivers in real-time (*i.e.* better than waiting for 911 / 999 calls)?'

Turning to safety Arizona described 245 wrong-way crashes of which 62 involved fatalities over an 11 year period. However, it was not as one would suspect a problem of older confused drivers but primarily 16-35 age men traveling between 02:00 and 04:00. This suggested alcohol as the probable cause linked to disorientation caused by temporary impairment, and not an age-related reduction in the ability to understand the layout of the network. This meant that systems that better detect wrong-way vehicles, warn the few other drivers likely to be on the roads at such quiet times of the day, and try to 'shock' wrong-way drivers into realization of their error, were likely to be successful.

The use of thermal cameras on 'off' ramps and on the mainline of Freeways at 1 mile intervals allowed ramp-monitoring signs to be set to red to stop more vehicles entering the ramp and VMS/CCTV on the mainline to be deployed. Across the USA on average wrong-way collisions were 0.02% of all crashes but 2.8% of all fatalities. Simple mitigations including reflectors that show white in the right direction and red in the wrong direction, or larger road-signs, or better off ramp pavement delineation had reduced wrong-way incidents in California, but because alcohol impaired drivers were the most likely group to offend means this is only partially effective. Caltrans was tackling this issue by commencing the use of a C-ITS systems utilizing a zone triggered Video Image Processing System (VIPS) to detect wrong-way driving.

Toolbox of Technologies

Technology Option	Current Use	Potential Use
WRONG-WAY DRIVER		
Illuminated sign at off ramp	N/A	Sign triggered by the wrong-way driver giving them information that they are traveling in the wrong direction
Audible Signal	N/A	Triggered by wrong-way driver
In-Pavement Lights	N/A	Triggered by the wrong-way driver
RIGHT-WAY DRIVER		
Lights along mainline	N/A	Lights along the mainline to warn right way drivers when wrong-way driver is detected in rural applications
Ramp Meter	Currently used to adjust traffic flow onto the freeways, was in the vicinity	Set to solid red when a downstream detector is triggered. This would stop freeway entries when a wrong-way driver is in the vicinity
DMS	Currently used to provide traveler information and notification of a wrong-way driver in the vicinity	Could be programmed to automatically display a predetermined message if a detector senses a wrong-way vehicle in the vicinity of the DMS
Emergency Alert System	N/A	Could be used to broadcast the location and direction of a wrong-way vehicle

Detection & Warning System for Wrong-Way Driving Sarah Simpson in SIS 85

Drowsiness was another pressing road safety issue that C-ITS could help to alleviate. In this case it was not just about ensuring drivers stay awake during manual driving, which was the current problem with motorway and interstate driving, it was also essential for Level 3 CAV operation. A vehicle would need to be able to assess the current cognitive state of the driver (degree of drowsiness) before attempting to hand back control at the end of the AV mode driving session. It was considered likely that vehicles would require some form of driver monitoring system to be in operation at all times during AV driving to detect driver drowsiness and eliminate it by a driver attention device, in order to allow safe hand back.

The complexity that researchers were currently examining centered on developing machine detectable traits associated with 'awake state' conscious and unconscious eye activity, and identifying behaviour that indicated the early onset of drowsiness. The key issue with this emerging technology, above the basic ability to reduce road collisions associated with driver drowsiness, was the necessity of drowsiness detection for CAVs operating in SAE level 3 & 4. Vehicles operating in these modes cannot be allowed to attempt to hand back control to a driver who does not have adequate capacity, (through being asleep or drowsy for example).

In terms of protection of workers and the emergency services, the US described the 'National Traffic Incident Management Program' vision and business case. The *Every Day Counts* (EDC) initiative had been developed as part of this to track performance and identify areas for improvement in road-worker and first responder safety when working on the highway and C-ITS technologies was being trialled to assist in delivering this. There were risks posed to emergency responders if their own driving became distracted. Efforts were being made to use technology to reduce clutter and distraction for emergency vehicle drivers in their user environment to make it easier for them to send and receive updated data while driving without being unnecessarily distracted.

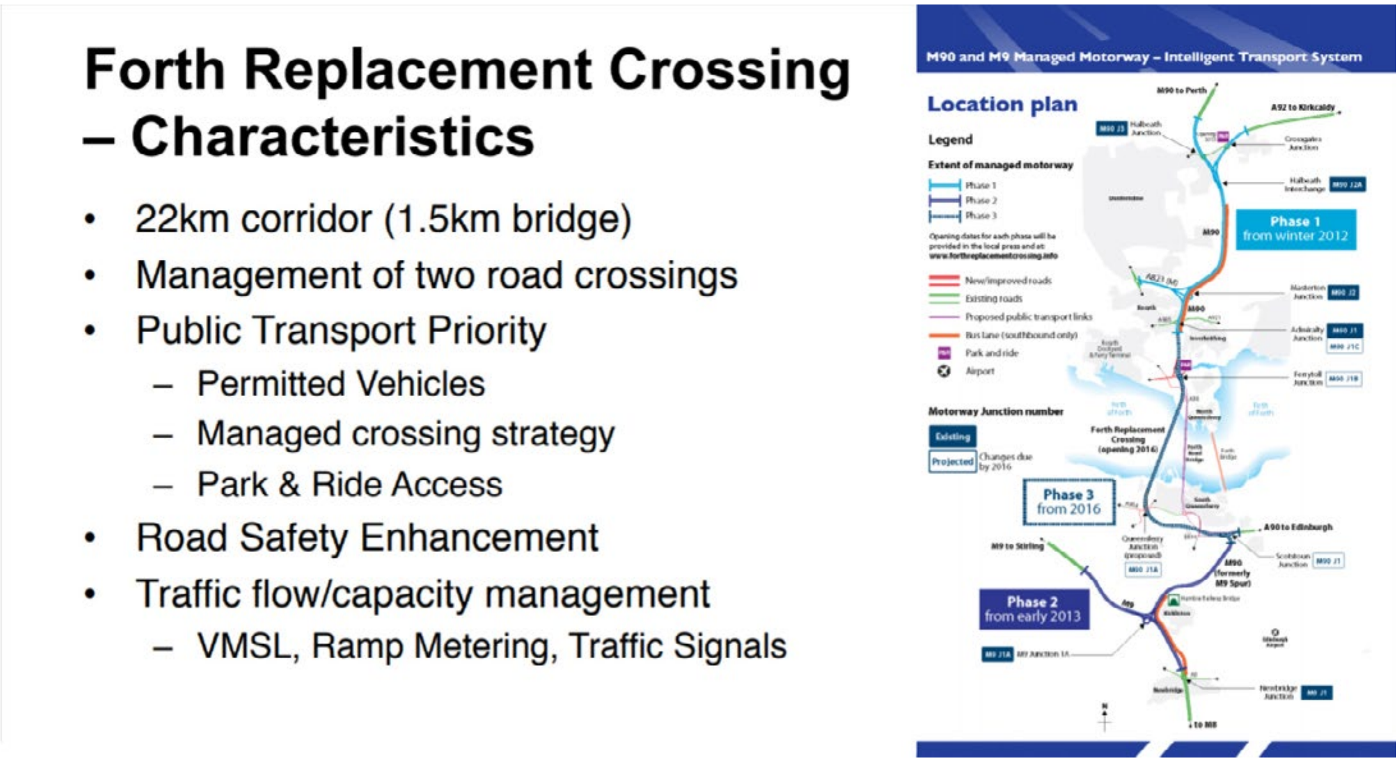
The use of connected vehicle data to warn other vehicles of approaching emergency services vehicles was also under trial. This was viewed as important both in the US as part of the EDC initiative and also in Europe where it had been identified as an important use case for the adoption of connected vehicle technologies. This approach also extended to the use of connected vehicle technology in emergency vehicles at incident sites to warn approaching vehicles of the hazard and the possibility of emergency services vehicles and staff to be in the roadway.

Research in the US had shown technology in a connected truck that can warn the driver and disable cruise control on the approach to an incident scene. This was aimed at increasing the safety of first responders operating on the highway near moving traffic. As an illustration of the pressing nature of the problems C-ITS can contribute to solving, research by Maryland DOT had shown that for every one minute a lane of a freeway is closed, the chance of a secondary collision increases by 2.9%.

A number of groups described work to develop the principles of C-ITS technologies and tools as part of integrated corridor management (ICM) initiatives. This built on a key element of the title of this track, the "Integrated Approach", in that it focused on the 'joining up' of individual technologies into wider schemes with wider benefits. In areas where the decision had been made not to try to build additional capacity, concentrating on demand management offered an attractive alternative. The adoption of ICM in New Jersey had seen a multi-disciplinary program between the various public transport bodies and turnpike operators. It aimed to ensure effective efficient management of the main road network throughout NJ with increased collaboration and real-time data and information sharing. Joint working on documentation and planning allowed all partners to fully understand the corridor being managed and had led to a series of strategies being implemented across the various stakeholders in the project. This structure also allowed linkages with neighboring ICM projects in New York, State which in turn generated cost savings and better joint working and planning.

In the UK the replacement crossing at Queensferry Bridge and realignment of the approaches had demonstrated that ICM can be used as part of the construction phase of a major project, This involved developing a public transport focused policy around permitted vehicles, managed crossing strategies, and Park & Ride access. The old Forth crossing had been converted to bus only, with general traffic using the new bridge. The old site is susceptible to high winds so there is a strategy to allow the hard shoulders of the new bridge to be opened up for public transport use when the old bridge is not usable due to winds.

On the US/Canada border NITTEC, the Niagara International Transportation Technology Coalition was leading cross-border working and development of ICM in western New York and Southern Ontario. This was believed to be the only bi-national coalition of its kind in the US/Canada and demonstrated the possibilities for international C-ITS projects when both the data and political standards can be agreed. NITTEC was aiming to increase the efficiency of



Integrated Corridor Management case study Tim Gammons in SIS 121

cross border traffic and travel and operated centralized regional operation functions on behalf of the member organizations in each jurisdiction. This allowed for cross border coordination of events affecting highway operation. One of the benefits of this was actively managing traffic between the three Canada & US border bridges to balance demand and congestion. A mesoscopic model had been developed to test the strategies that are used, taking data both from NY and Ontario to build a single cross-border model and strategy.

Forwards v Constrained

In Europe the principle of CCAM (Connected and Cooperative Automated Mobility) was becoming increasingly established as the vision defining the connected vehicle future. It was the view of the EU that the future would require *Connected and Cooperative Mobility* to move forward, not just be cleverer on-vehicle systems. In terms of safer and smarter Infrastructure the EU shared South Korea's vision for zero road fatalities, aiming to have fatalities halved by 2030 and reduced to zero by 2050. This longer time frame reflected the greater complexity and ambition of delivering this goal across the 25+ different nations that make up the EU. The EU had a clear road-map for moving towards CCAM and a growing understanding of the governmental and technical steps that would be required between now and 2045 to get there. The EU Stakeholder platform was moving from the launch of the C-ITS Strategy in 2014, through the C-ROADS program towards full autonomy by 2045.

North American authorities were increasingly looking to demand management as a cheap and effective solution for maintaining network performance, rather than adding capacity. As a result of this trend they were also recognizing CAV development as a move to reduced car use rather than the more traditionally held North American view that CAV technology was about replacing the driver with autonomy to increase safety (but not necessarily about reducing car use). However this still differed from the European and Asia Pacific philosophy in that it continued to see this as a route to reducing infrastructure requirements rather than the more common EU view that it was ultimately about environmental and land use benefits.

The issue of whether public bodies should continue to be an information provider to the public, or whether the future lies more in working with private sector companies, was being widely considered. This subject was relevant to all aspects of the roll-out of C-ITS systems in virtually every country as the data and information they generate clearly has a value. Many public bodies were seeing a need to become a 'data provider of choice' and trusted partner to the large commercial bodies that will probably dominate the public's consumption of data and information in the future. Concerns around the budgetary and resource implications of highly technical systems were highlighted by experience in North America where there is a growing need find an effective relationship between public bodies as data generators and the private sector as experts in its dissemination.

On the subject of matching assets to their utility, many US authorities were developing strategies to ensure they can maintain a state of good repair on existing critical assets and continue to work towards the performance metrics discussed earlier. It was assumed that authorities require annually around 7.5% of the total value of their assets in order to resource effective maintenance and renewal. However for most authorities the annual funds available amount to about one tenth of this figure, which is clearly not sustainable. To combat this ongoing shortfall in maintenance funding many were establishing decommissioning plans to reduce to an asset base that reflected critical needs and met the desired metrics but was also maintainable within the budget available.

TRACK F Disruption and New Business Models

The Overall Situation

The "Disruption and New Business Models" track was organized around 3 Executive and 16 special interest sessions together with some 30 technical papers covering 8 sub-topics. Presentations were skewed towards Mobility as a service (MaaS) which appeared to be a key component of the entire congress, attracting discussion on issues as varied as regulation, public/private partnerships, financing, operational issues, infrastructure development, equity and information provision. The MaaS focus came as no surprise since it was one of the important concepts being put forward at the 2016 Melbourne World Congress coupled with the launching of the MaaS Alliance.

These SIS on MaaS addressed several aspects such as their application in remote areas or with low transport demand, the definition of a common approach for regulation of MaaS, the required new business models and the changing role, responsibility and interaction between public and private contributors, the challenges related to the personalization of service and the identification of the best information to provide to users as well as developments in business, service and policy aspects. Four sessions were organized as a continuous discussion regarding Freight. These sessions were welcomed in the topic as we rarely have a structured and coherent discussion around the important and sometimes delicate issue of "Moving Freight in a Digital World" with consideration of how this system can benefit from the innovations and how it should adapt to the changing global system of mobility.

The SISs on Managing Innovation brought the opportunity to discuss selecting and pushing forward processes such as financial tools, demonstration projects, incentives and renewed procurement models to make sure next generation technology can be deployed in cities as part of regular projects. Sessions linked to Shared Mobility reviewed how self-driving cars may reshape shared mobility and what impacts such autonomous shared vehicles systems might have on urban mobility and cities. There were also discussions on the interaction between public transport and how shared mobility and MaaS might impact business models as well as an opportunity to address the question of public acceptance as well as the available tools and incentives to promote changes in behaviors.

Key messages from the overall discussion within this topic were:

- The borders between public and private transport, and between passengers and freight transport, were fading and the planning, management, regulation and operation of these elements must be addressed as one system. It wasn't clear yet whether special infrastructure, physical or technological, is required for MaaS.

- The Mobility as a Service (MaaS) theory had become a mainstream concept. It had the potential to break the traditional link between mobility and vehicle ownership, pushing people more and more towards being service consumers. It needed to be tested in a variety of contexts, including rural areas. It was challenging the current public transport (transit) operators and the current operation and regulation practices. MaaS would not replace transit but would change the ways in which networks were organized, making them more efficient in the heavy corridors and helping to ensure services in low-demand areas.

- Autonomous and connected vehicles (ACV) were becoming a game changer in the mobility of the future, for both passenger and freight travel. For passengers we needed to succeed with MaaS before the advent of automated-MaaS. For freight the policy issues (*e.g.* standardization) were even more important to ensure that crossing borders would be seamless. We don't know yet how people will use the technology !

The Old v The New

Mobility as a service (MaaS) had gained so much interest in the community that we should expect an increase in the trials and researches under way. In Montreal many elements came back to the MaaS concept and the implications for the current service provision. There was discussion on many aspects:

- Applicability of MaaS in remote areas or where travel demand is low. Classical transit services struggle to be efficient in such areas so MaaS has the potential to revolutionize mobility there. Some speakers suggested that there were fewer obstacles for electric, connected, autonomous and shared vehicles in rural areas and that service providers should test in such places where we will find less resistance.

- The importance of organizing MaaS within a bundle of services in case things go wrong.

- Standardization of MaaS provision in the context of the increasing amount of interested parties as well as diversification of supply. This covered business, service, and policy aspects of MaaS. Formalizing MaaS and agreeing a single definition was often argued. Such typology is mainly based on the integration of various components such as integrated information, integrated booking and payment and service management and policy and governance see below)

- The respective role and responsibility of public and private providers as well as the most efficient collaboration approaches with respect to business models, funding (service and infrastructures). The important and delicate issue of data sharing was clearly formulated: both parties need to be ready to share data to make sure an integrated view of the system can be constructed.

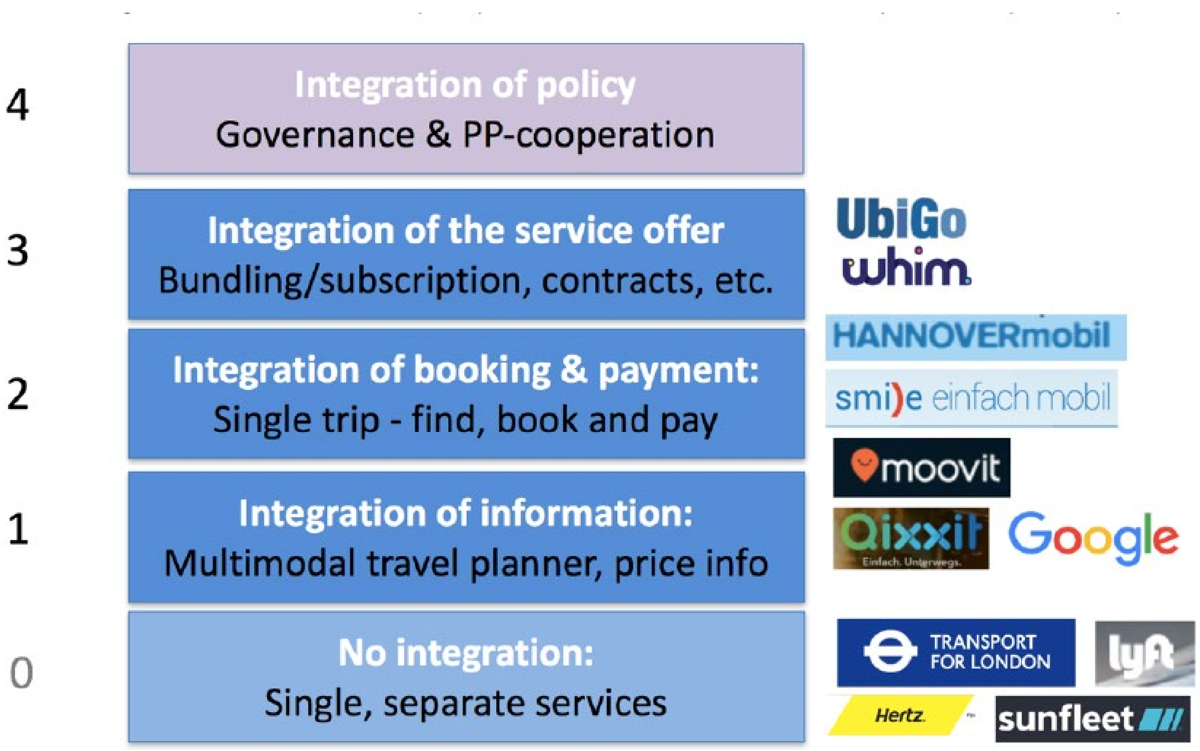
- Changing the point of view when designing services since with MaaS services will be tailored to fulfill individual needs, accounting for preferences.

- The changing relationship between mobility and car ownership which is already being challenged with car sharing and more generally by the Sharing Economy movement and which is even more questioned with MaaS.

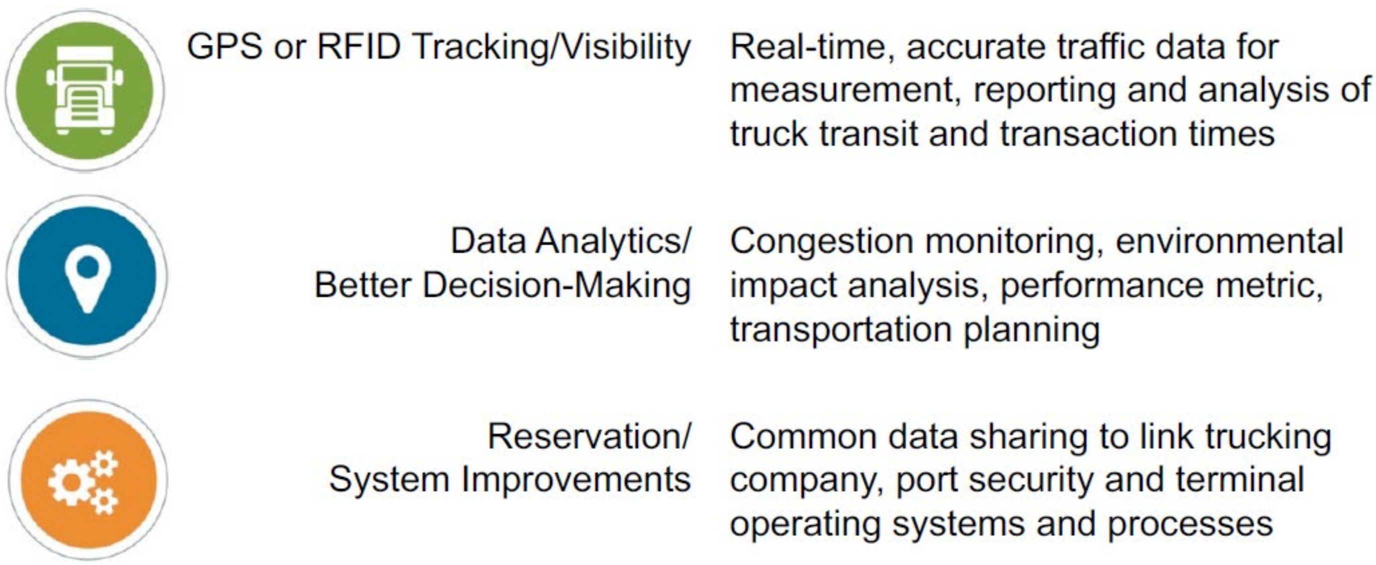
Freight transport received much attention within the workshop-style four SIS sessions: it is a highly strategic component of urban mobility and could benefit highly from the relevant inclusion of new technology and innovation in its planning and operation. The following elements were discussed:

- Safety issues related to new technologies such as platooning systems, delivery drones, unmanned inspection systems. It was argued: “It’s unsafe until it’s very safe”, echoing the very high safety expectations regarding trucks and the ultimate aim to have machine drivers much safer than human drivers.

- Studies have been conducted on truck platooning systems to assess their performance based on features such as distance, speed, and technologies such as cruise control, and how these



Proposed typology of Maas with examples Jana Sochor in TS85



Clean Transport Initiative for Port Trucking   Ryan Klomp in SIS 50

performances may change in various situations (merging vs non-merging situations for instance). The importance of testing in all sorts of weather conditions was noted.

- The use of new technologies for more efficient and sustainable freight transport as well as increased productivity. A key point in improving the efficiency of the freight industry was the use of high capacity vehicles, allowing reductions in the numbers of trucks and increasing the capacity of fleets. This idea raised many issues such as the necessity for a new business model and task force management (as fewer trucks will reduce the number of drivers required, an ambiguous outcome depending on the market).

- The challenge for the freight industry of reducing its GHG footprint in the context of electric truck options still being too risky especially in areas with cold weather which rapidly degrades the expected range.

- Perception and trust of drivers, fleet operators and managers regarding cooperative freight transport services;

- The opportunity to use small automated vehicles (drone-type) for first/last mile deliveries.

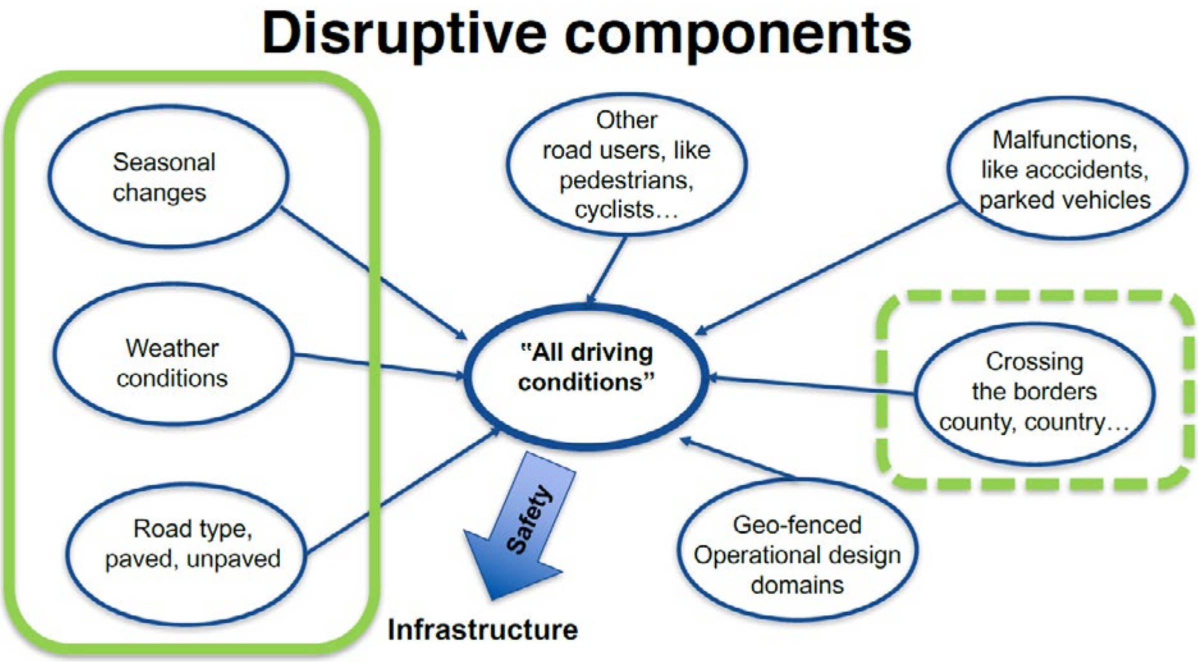
- The challenge of this industry when it comes to border crossing and the importance of harmonizing regulation to ensure public safety (the case of Europe for instance). Procedural challenges to make sure similar (at least compatible) policies are adopted across borders were discussed.

Self-driving vehicles (autonomous technology) prompted much debate and were often used as a “what if?“ question in other discussions. They will undoubtedly be a game changer but there was still uncertainty on how they will be accepted and used by drivers. There were no challenges to their being a part of future mobility; the arguments were about <u>when</u> they will significantly occur. Other key issues were :

- The impact on logistics chains and the reorganization of manufacturing.

- What digital infrastructures will be required for self-driving vehicles.

- Studying the acceptance and operational feasibility of self-driving vehicles in real settings. Pilot projects were identified as important milestones to learn about self-driving cars in real-setting but the



Disruptive components in the context of automated driving   Antti Vehvilainen in SIS 86

fact that in most cases they were not operating in 100% of the "real" situation had to be recognized. The diagram following illustrates some of the disruptive components that are putting self-driving cars to the test and that need to be addressed to generalize their usability in real-life situations.

New business models were discussed for both passenger and freight transport as well as for both combined. Many questions were asked about this issue but with few answers since most areas were still struggling to make progress. Some speakers suggested that we were more or less done with technology development and that all we needed was disrupting business models meaning that changes on this part of the equation were slower to materialize and probably more complex. More specific questions were:

- How are the changes affecting our traditional business models? Are we clear on Electromobility v fuel tax; self-driving car v regular bus service and freight deliveries; sharing instead of owning?

- How should we move towards building new business models? An example was provided in the context of the management of a port where the lessons learned included the importance of communicating the project differently to each stakeholder; the need to find and engage multiple project champions; the usefulness of scenario-based examples to facilitate the definition or project scope and components; the need to assess the level of organizational readiness and to account for its importance.

- How will the finance part of the model be addressed? For instance, will the subsidy to public transport be transferred to private partners? Will private providers be asked to support infrastructures financially as well? How will equity be addressed by private-public service providers?

The concept of user-centric mobility represents a change in perspective driven by the availability of more and more mobility options aiming to meet the changing and diversified needs of people. It applies to individual, shared and public transport modes and it aims to provide a personalized experience to travelers. For this move to succeed operators and service providers must provide more relevant data to users and these data need to be packaged into a coherent tool.

It will also be necessary to transform public transport into a more personal mobility service (in collaboration with other service providers) which means operators must understand the entire travel need (from O to D); this will probably lead to the reduction of the share of pure transit share for the benefit of a higher share for the pool of mobility options.

The future of mobility is about choices and empowering travelers — they need good information and will help developers by sharing their own data. The next generation of mobility options will improve user experience by adjusting services to specific needs and preferences. A concept of maturity levels for city transport systems was proposed and shows the various steps leading to the highest level, with inclusion of active and shared modes as well as ITS tools and combination of fixed/on-demand services.

Some of the ideas discussed during sessions were newer (or at least refreshing) in the track:

- MaaS was a mainstream topic but typologies of MaaS services were proposed to facilitate comparison between systems. This would also allow a better assessment of the impact of such services. This was relevant and pragmatic and should help structure the upcoming trials.

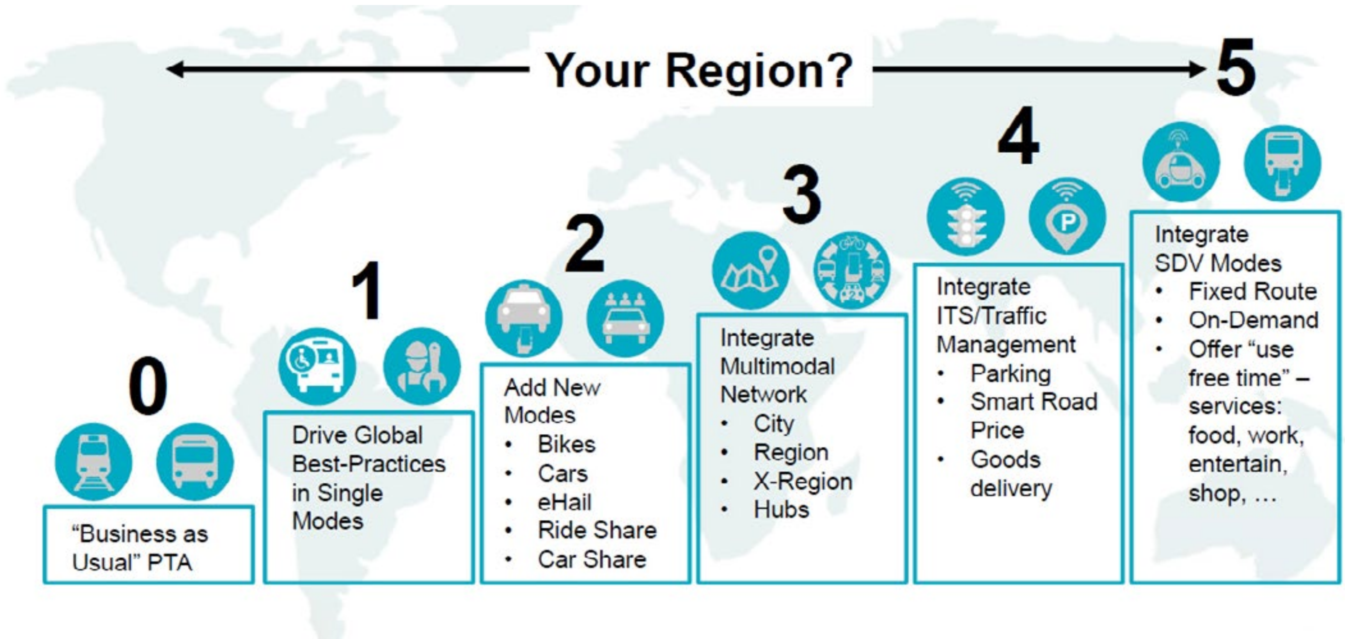
- Few people have managed to focus discussions of technology on the purpose of having the technology rather than on the technology per se. Focusing on the objective of enhancing quality of life and creating livable cities is actually key in all the deployment currently ongoing and should become even more important in the current race for smarter cities.

- New procurement models for accelerating innovation in transport were presented. Many raised the problem that current practices were not suited to innovation and so limited the scope to try new things. New models were being tested — but the way requests for proposal are structured may also limit the possibility of innovation.

Forwards v Constrained

With the mainstream interest towards mobility as a service we saw much reduced interest in the study of single transport systems; and we heard less about transport systems than about "mobility". The operational challenges that single operators face were being replaced by issues of integrated operations, even if transport supply still relied on a set of unconnected providers in most locations. It seemed the theoretical concepts were a few steps ahead of what was still happening in cities. MaaS and Integrated Mobility were in the light and there were high expectations that their clear formalization and regulation would help planners get a grip of the demands placed on their infrastructures and networks.

Open data seemed like a never-ending question. Clearly, integrated planning and service provision requires an understanding of both the demand and supply side of the mobility equation but there are still challenges with respect to data standards and data sharing among public/private stakeholders. It was clear that much effort was still required in this direction although regulation would probably force both sides to interact for the benefit of widespread implementation of integrated services. Hence

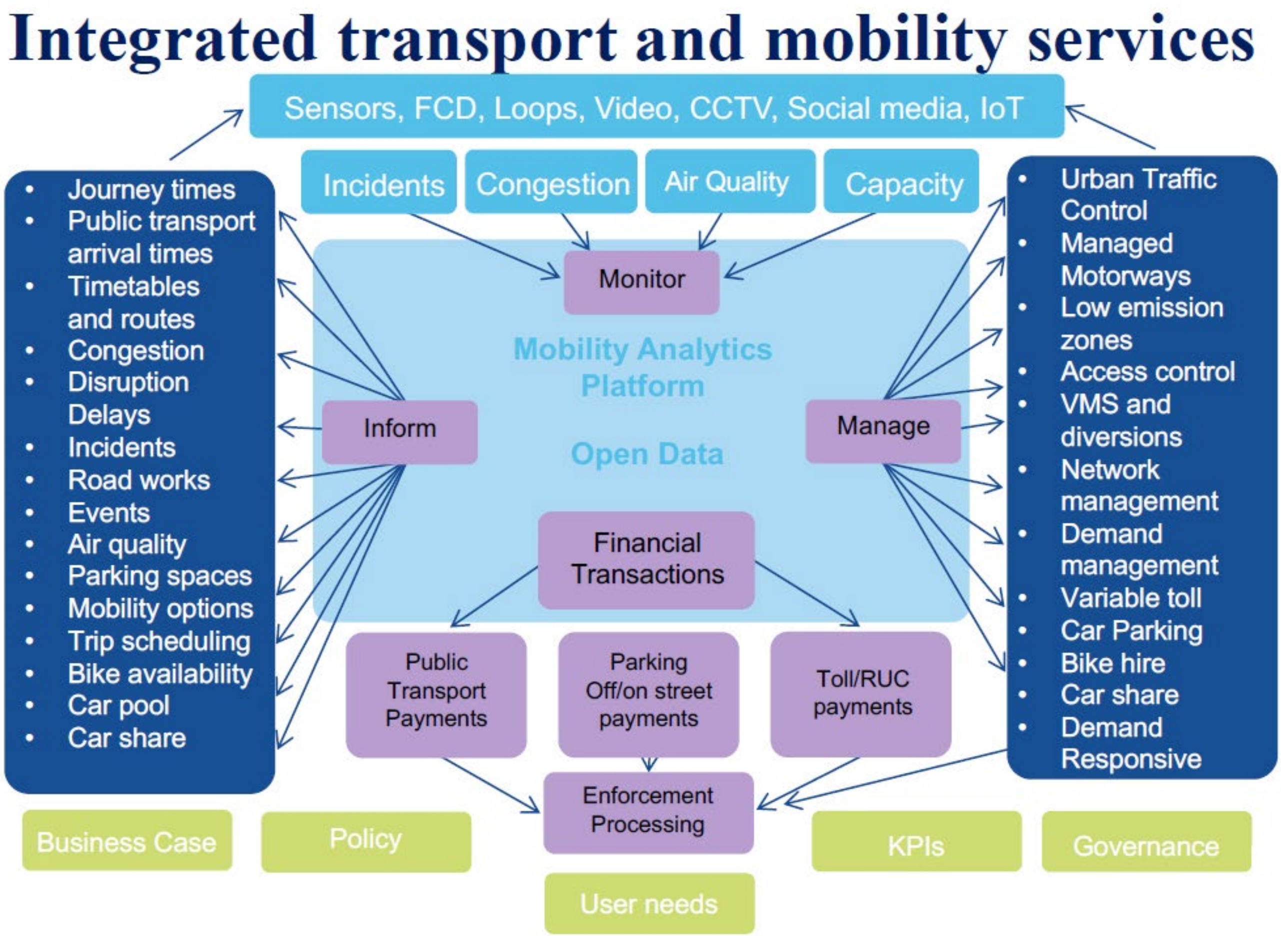


Maturity Levels of City Transport System   Thi Mai in SIS53 many participants had the opinion that public authorities should own the data regarding user mobility.

Data privacy was discussed but with no innovative solutions. It remained an issue needing to be addressed and one that will probably become even more complex with the diversification and ever-increasing load of data collected with technology. Providing integrated transport and mobility services to travelers was recognized as an ambitious goal but it is the target of most urban areas and represents an important time and money investment. As illustrated below it all starts with Open Data combined with efficient data analytics; it requires a number of indicators and must account for a wide variety of events and contexts.

Some issues were insufficiently addressed by the sessions and papers included in this track although they may have been covered as part of another; such as:

- The IoT (Internet of things) will impact on data volumes and will affect the potential to optimize services. The way it will affect service provision and how it will interact with on-demand transport needs to be addressed.
- Space-time sharing in cities will need to be re-visited as self-driving cars and other technologies will prompt changes in urban space use especially parking.
- How will governments support transport expenditures in a sharing economy and what will be the contribution of private stakeholders.
- What are the roles and requirements for active transport modes within the pool of innovative mobility services and in MaaS.
- The potential of big data analytics and its various applications.
- The role of gamification in changing individual behaviors.
- Exploring how systems should address the needs of users with disabilities and give access to the same level of diversified mobility options as the rest of the population.



Integrated transport and mobility services   Richard Harris in SIS 114

Several key messages were captured from the presentations and the discussions including:

- Mobility as a Service requires an unprecedented collaboration between the public and private sectors, both on infrastructure and the operational sides.
- *"The autonomous car is about to do to transport what the internet did to communication"*
- *"Sometimes we forget — technology is meant to serve people and not the opposite".*
- A smart city is not about vehicles, it's about mobility and moving people and goods.
- We need to think "out of the box" for funding as well.
- Lifelong training will be required if we don't want to leave people behind.
- It is important to do pilot projects and learn from them as quickly as possible.

TRACK G Innovation, What's Next? The New Ideas

The Overall Position

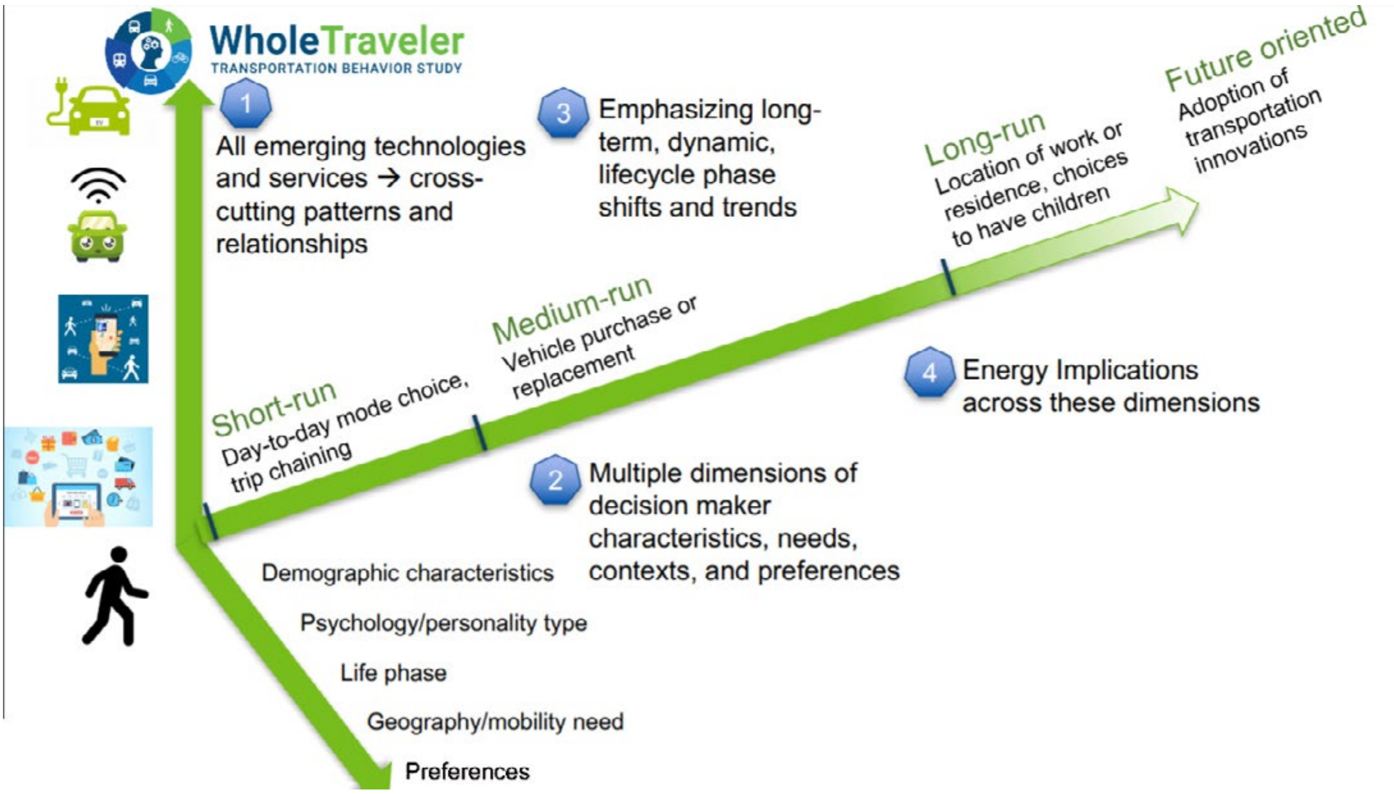
The thinking behind the Track "Innovation — what's next? the New Ideas" was grouping together a range of papers with different sub-topics dealing with alternative technologies, experimental applications, controversial theories *etc*. In the event many authors preferred to sit alongside the more traditional material in the different fields so this became the smallest of the seven tracks. Many of the papers presented were related to smart road infrastructure and ways to improve the automated data collection and monitoring of the different components of the system: traffic in general, pavement surfaces, vehicles and travelers. Some papers described new ideas about implementing and integrating ITS solutions in the context of smart cities using new concepts such as crowd-sourcing and low-cost travel information systems based on smartphone applications.

From the technology point of view the topics dealt with various sensing solutions such as WiFi - Bluetooth and specialized RFID vehicle identification systems for traffic monitoring, radar sensors for three-dimensional positioning of vehicles on sloping roads and depth sensors for automated pavement condition inspections. Road safety innovation has always been well received at congresses and ideas presented included the use of fibre optic for Incident detection, the use of advanced warning systems for actuating signs on road with low traffic volumes, and thermal imaging systems for tire anomaly detection and identification of hazardous materials.

From the application point of view the papers and session presentations covered monitoring of vehicular traffic and road surface conditions, road safety applications (warning devices and incident detection systems), monitoring of buses and commercial vehicles and the performance of specific vehicle components. Some papers examined the integration of technologies as part of smart city concepts and crowd-sourcing. One particular paper also discussed driver licensing in the context of autonomous vehicles. Some papers addressed very specialized concerns such as the use of ITS to help monitor flooding, ITS in the context of multiple rail freight networks, and the benefits of advanced travel information systems for dealing with very large or critical events. A speaker in a special interest session focused on understanding the innovation process:

The Old v The New

In a way this entire track was about new ideas. Some papers presented new ideas in the sense of new concepts but others described the application of emerging technologies to old problems and testing feasibility of the



Mobility Decision Science Anand Gopal in SIS 63 solutions through pilot projects. Examples included the automated monitoring of traffic conditions using underground induction antenna for vehicle identification; the automated data collection of pavement conditions for monitoring the quality of road surface using depth sensors; the use of pulsed laser-light in optical fibres for automated real-time detection of incidents.

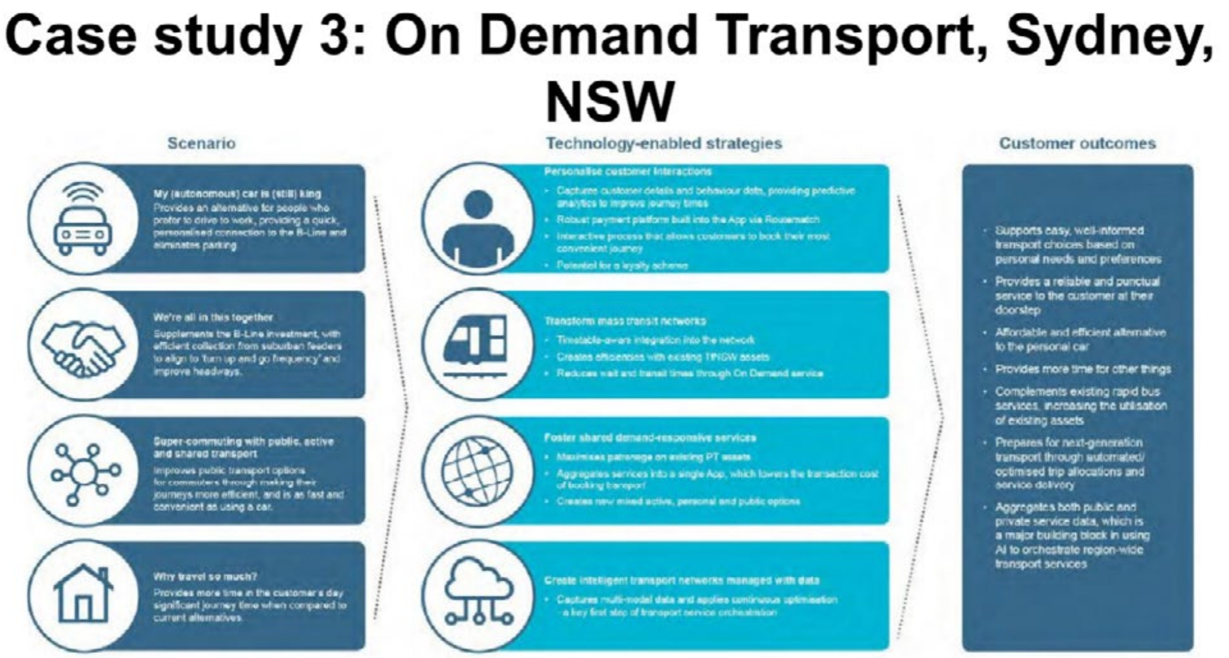
A Special Interest Session focused on the experiences of 4 start-up companies that included a computer vision company looking at automated video analytics for pedestrian and vehicle traffic analysis; a company specializing in Bluetooth sensors for real-time monitoring of the travel demand in a network; an app-based solution to facilitate the offer of shared mobility services; and a consultancy in block chain technologies and crypto-currencies with some transport applications. Discussion ranged very wide including questions on building a company; the main issues that a start-up in the transport was likely to face? How can a new solution be scaled up?

There were some key conclusions — in the initial stage the start-up needs to be very flexible in order to identify and adapt quickly to actual market needs; it is very important to find business cases to show how the proposed solution could go from concept to real applications. The importance of having specialized and experience people as mentors was also highlighted. Many speakers argued that while the development of the technology elements was important it is the delivery of the full solution that is fundamental for the success of a start-up, particularly when it involves multiple suppliers and integrators.

Similarities and differences among regions could add difficulties to the scaling process. Startups in different countries and regions might need to operate in different ways. In the transport sector the sales cycle was an important point to consider. It could be up to a year in less mature markets like Latin America; however in mature markets such as Europe it could be considerably faster. Cities were often open to field tests (pilot projects) to explore the use of a new technology. However large scale projects were much more difficult to obtain.

Forwards v Constrained

Some areas were clearly moving forwards. In particular we could see the current interest and need for traffic conditions of particular vehicles or surface conditions as well as the monitoring of specific vehicle components such as tyres and dangerous goods. It was interesting to see the recent developments of systems for monitoring commercial vehicles and buses and the development of three-dimensional position sensing systems for navigation in more complex urban environments with critical slopes and deteriorated surface conditions.



Innovation delivery framework   Henry Wu in TS 22

There were also some interesting new concepts that could help accelerate the adaptation of public transport such as the use of bus toll lanes and crowd-sourcing smart cities concepts that could help with the development of open platforms. Solutions regarding road safety are a continuing transport issue and speakers demonstrated some progress through pilot studies for the automated detection of incidents and the use of actuated warning systems.

A presentation in a Technical session looked at a framework for enabling and accelerating the integration of ITS innovations with examples from three case studies. The focus was on the assessment of alternative methodologies and the steps taken to minimize risks, maximize success, and ensure a smooth delivery of the ITS systems. The three cases studies included the use of a fibre optic cable to detect acoustic signals from passing vehicles; an ITS application for automatic incident detection in Victoria, Australia and an app- based system for travel demand management. This presentation finished with a short discussion on the issues and future directions on the integration of ITS solutions.

PL01 - Integrated Mobility with Urban Cities

Moderator
John Barton, Texas A&M University, United States

Speakers
Christopher Hart, National Transportation Safety Board, USA
Michel Schilling, City of Copenhagen, Denmark
Aref Salem, City of Montreal, Canada
Lianne Dalziel, Christchurch, New Zealand
Lam Wee Shann, Singapore

CH gave a keynote address on safety with comparisons between aviation and (road) surface transport. There was fervent hope that the introduction of highly automated vehicles would dramatically cut road fatalities by reducing or even removing the scope for human error. There would be associated benefits from reduced environmental impact and improved network efficiency. Experience from the aviation industry suggested a more cautious approach as accidents had taught the need to match automation to human skills. The critical area was transfer of control if the automation failed for whatever reason or encountered a new situation and asked for human intervention. It was a common challenge to keep drivers/pilots engaged and alert. For both air and land it was also essential to design a 'graceful exit' from automated operation.

The panel discussed ways to connect mobility to city planning more strongly. Christchurch had suffered an earthquake that destroyed a lot of infrastructure and communications so a very open approach to innovation was unavoidable during recovery. This had permitted trials of a number of immature systems and had imprinted a message "the future is coming whether you are ready or not so be open to change". Montreal was concentrating on data and real-time information services and that required a communications program to explain to citizens what was available, what was wanted and the mutual benefits from sharing. Singapore's problems were dominated by shortage of space so a top priority was getting people out of cars into conventional and innovative public transport. Copenhagen had ambitious 'green' targets that had been set after extensive public consultation. Meeting them meant reduced car use and this in turn meant priority for the alternative modes and a constant information campaign reporting what was happening and the progress.

The moderator asked speakers if they could give a simple short piece of advice — "be risk averse as you learn much more from mistakes" (LD); "get everyone joined together and involved and don't forget to join up the government departments (LWS); "communication both up and down so everyone is aware of goals and problems" (MS); "political vision that recognizes that established things have to be changed" (AS).

PL02 - The Evolution of Transport Within Our Society

Moderator
Mark Garneau, Minister of Transport, Canada

Speakers
Cees de Wijs, Dynniq, Belgium
Rupert Soames, Serco Group, UK
Paul Gray, Cohda Wireless, Australia
Rick Snyder, Governor, Michigan, USA
Stephen Carlisle, General Motors of Canada, Canada

In a keynote address MG commented that one of the hardest decisions for a politician was recognizing that the future for transport was public-private partnerships, a very different range of infrastructure and vehicles, and the need to support initiatives with a new and different set of regulations and skills.-Politics tended to evolve slowly but it was obvious to all that change was happening very quickly so it was essential to 'expect the unexpected'. New policies had to be designed and adopted — and if necessary changed — much more quickly than in the past.

The panel addressed a series of questions from the moderator — "New transport technologies are coming how do we get economic and social benefits?". Points made in response included making the most of what we already have and understand in order to improve traffic flows and reduce emissions; speed up the deployment of connected vehicles to get better real-time information on the state of the network; set clear targets such as emissions reduced by x% by a fixed date then work back to design the policies and deployment strategies to hit those targets.

"We expect connected and automated vehicles (CAVs) to transform mobility; what infrastructure changes will be needed?" Some of the panel responded 'none' on the grounds that an autonomous vehicle was just that — one that carried all the necessary sensors, information and intelligence itself. Others argued that while a great deal of benefit was expected from a 'pure' autonomous vehicle there was significantly more from one that was connected. Links to systems for traffic management, parking, travel information would bring obvious gains and using CAVs as probe vehicles brought a universal benefit.

PL03 - Conducting Business Within Our Transportation Industry

Moderator
Kirk Steudle, Michigan Department of Transportation, USA

Speakers
Giles Gherson, Ministry of Economic Development and Growth, Province of Ontario, Canada
Chris Murray, Kapsch TraffiCom North America, United States
Mika Rytkönen, HERE, Finland
Malcolm Johns, Christchurch International Airport, New Zealand

GG made a keynote speech on the importance of re-educating both the supply side and the demand side for transport of the future. We had put massive effort into teaching cars to think in order to have a cleaner, safer smarter mobility but we needed to follow through with planners, regulators and politicians. For example were we clear on the content of the driving test after, say, 2025? Would future cars be taken to 'software mechanics' in which case did we have training programs in place for them?

MR said that CAVs were already doing to transport what GSM telephony did to social habits in 1990. We needed to identify and better understand a new business world based around smart cities, Mobility as a Service, abundant data and machine-to-machine exchanges. For Europe with 28 member states there were potential barriers to business — data formats, ownership and availability had to be resolved or there would be no progress.

CM agreed that CAVs were big disrupters but they were likely to bring with them much enhanced consumer demand provided that the Big Issues could be resolved — cybersecurity, privacy, and data ownership and availability. A single CAV could generate Terabytes of data a day but how much would be the property of the driver? How much could be anonymized and put in the public domain to enhance safety and information about the operation of networks? There was significant risk of data monopolies developing.

MJ agreed that understanding and using data was key. As an airport operator he saw his customers for 30-90 minutes and so had to present his business offerings very quickly. He was keen to develop a much better data profile of his customers and argued that we had to re-think our target markets; for example we might sell to 'personalities' rather than socio-economic groups. We also needed to recognize the rapid move to a digital economy fueled by data and it was very age-dependent. In his experience under 25s were rarely concerned by privacy worries.

Executive Sessions by Track

Four ESs were grouped under the **Connectivity and Autonomy Track**, numbers 1, 5, 7 and 11. Their topics and speakers were as follows:

ES01 - Breaking Silos to Pave the Way to Automated Vehicles

Moderator
Shelley Row, Eberle Design Inc., United States

Speakers
Leslie Richards, Pennsylvania Department of Transportation, USA
Naohiko Kakimi, Ministry of Economy, Trade and Industry, Japan
Paul Campion, Transport Systems Catapult, United Kingdom
Walter Nissler, United Nations Economic Commission for Europe (UNECE), Switzerland

ES05 - Practical Aspects of Deploying Connected and Automated Vehicles

Moderator
Angelos Amditis, ICCS, Greece

Speakers
Kenji Sato, MLIT Japan
Shailen Bhatt, Colorado Department of Transportation, USA
Andrew McKellar, FIA, France
Andrew Mehaffey, HMI Technologies Ltd, Australia
Brian Negus, RACV, Australia
Klaus Schierhackl, ASFINAG, Austria

ES07 - ITS Deployment Policies

Moderator
Atsushi Yano Sumitomo Electric Industries, Japan

Speakers
Koji Hachiyama, Cabinet Secretariat, Japan
Kirk Steudle, Michigan Department of Transportation, United States
Xiaojing Wang, China ITS Industry Alliance, China
Kenneth Leonard, Department of Transportation, United States
Claire Depré, DG MOVE European Commission, Brussels

ES11 - Communication Options for Connected, Cooperative and Automated Transport

Moderator
Young-Jun Moon, Korea Transport Institute, Korea

Speakers
Gaku Nakazato, Ministry of Internal Affairs and Communications, Japan
Ming-Whei Feng, Institute for Information Industry, Chinese-Taipei
Joaquín Torrecilla, DEKRA Testing and Certification, Spain
Brian Tossan, General Motors of Canada, Canada

Discussion in **ES01** focused strongly on "How?" rather than the "If" or "When?" aspects of connected and automated vehicles. The Panel agreed that although the goal of 'driverless driving' was simple to describe achieving it was immensely complex and above all demanded a multi-disciplinary approach by the stakeholders concerned. Vehicles and Infrastructure were equally important — neither sector could succeed alone. The various types of organization involved (automotive, IT, telecoms, insurance, standards, regulators, security, infrastructure suppliers and operators, national and local governments) needed to remember that internal collaboration was just as important as external collaboration.

The key success factors — safety, security, user acceptance, standards and interoperability — were highly interdependent. Japan had launched a centrally-coordinated program of trials and demonstrations with the aim of deployment for visitors to the 2020 Olympics. The session title was exactly right — successful deployment would not come from operating in silos.

Session **ES05** emphasized the need to re-think business models and customer experiences for a connected and automated world. Interoperability was essential — connected services did not recognize local, regional, or even national boundaries and users would expect effortless roaming in the same way as with mobile telephony. Interoperability had to be designed in from the beginning even if this sort of 'open' approach was anathema to many businesses.

The list of potential beneficiaries was very long: traveling members of the public, network operators, emergency responders and incident management teams, weather forecasters, value-added service providers *etc.* However we needed to think carefully about our deployments as there might well be unintended consequences: for example improved traffic flow would lead to higher road capacity but that in turn might induce new traffic resulting in reduced capacity. Similarly using connected, cooperative and automated transport to optimize an individual's driving time might well conflict with procedures to optimize collective driving time for all travelers.

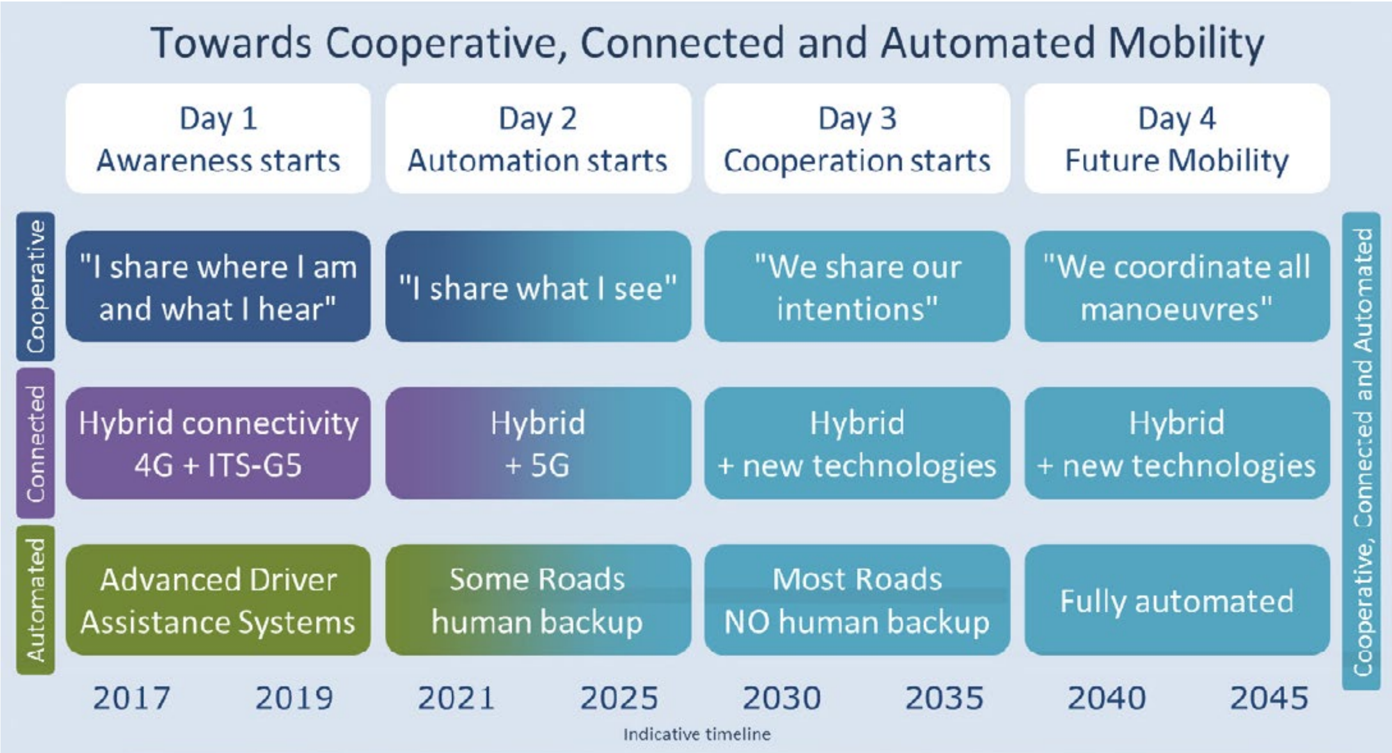
ES07 looked in detail at deployment policies from different regions. Japan's approach was driven by an aging population, a shortage of truck drivers, and a drive to improve mobility in rural areas. There was a general aim of safer and smoother road transport — reducing accidents and alleviating traffic congestion — combined with an industrial policy of enhancing the competitiveness and efficiency of transport-related Industries and promoting the competitiveness and efficiency of the transport, logistics and automobile-related industries.

China was still undergoing rapid change as a consequence of extensive motorization and a wish to develop better public transport for the rural areas as well as the mega-cities. The over-riding polices were: supporting an integrated transport system by interconnection and coordinated operation; installing intelligent transport infrastructure incorporating smart sensor networks and communication systems; developing ow carbon and intelligent vehicles; and intelligent decision-making based on big data.

In the USA connected vehicles were expected to deliver early gains from reducing fatalities, improving fuel consumption and making travel generally easier, more enjoyable and more efficient. Highly automated vehicles were seen as a logical extension of the variety of driver assistance technologies already available. A key element was developing a light but appropriate regulatory regime to ensure safe operation in practice and that rested on an intensive program of trials and demonstrations. A particular benefit was expected from streamlining border crossings for freight traffic.

Europe shared the US view that connectivity would bring affordable and rapid gains; the key issue was interoperability to ensure seamless passage across the 28 Member States. A future transport world was likely to be a mix of 'conventional' vehicles, connected, highly automated and fully autonomous. This was potentially a difficult and complex scenario which demanded a multi-disciplinary approach by the stakeholders working together in a range of public — private partnerships.

ES11 looked at Communication options for connected, cooperative and automated mobility. The session aimed to explore the communications challenges and opportunities presented by connected and automated systems. It was noted that telecommunications are just one element in the complex world of the connected vehicle ecosystem with three primary challenges. The first one contained interoperability and standards, especially for the safety-related functions. Standards were fragmented across the globe preventing true interoperability. Standards were badly needed also for other than safety related use cases, such as dynamic maps. The second challenge was data management and subsequent use — a connected vehicle could easily provide data of 25 GBytes/hour, and there were increasing numbers of connected vehicles to serve. The mobile network evolution was providing higher transmission rates with lower latency. The third challenge was cybersecurity



Claire Depré in ES 07

because a connected vehicle ecosystem had several vulnerable points potentially putting the lives of people in risk.

We should aim to preserve an open attitude to communication options, and the many other processes associated with them, for as long as possible. The Internet of Things was bringing causes new challenges and the communications needed to integrate the different sectors not only horizontally but also vertically. There were also difficult challenges related to cybersecurity and privacy. The move towards automated and autonomous driving required extending technology capabilities into new and unfamiliar where clouds, big data, and especially AI would have an increasing role. Tomorrow's vehicles would be very service-oriented, enabling adaptation and amendment *via* software changes.

The Panel considered the fundamental role of communications in delivering just about every transport policy. The ongoing transport technology revolution was addressing the challenges of climate change, safety and traffic congestion and the triple vision of zero crashes, zero emissions and zero congestion was compelling. Electric vehicles utilizing advanced battery and hydrogen fuel cell solutions would only be successful following close stakeholder collaboration and resilient V2I linkages. Zero crashes would only be reached using self-driving vehicles requiring resilient V2I and V2V links at minimum.

Self-driving provides also for ride-sharing and mobility as a service and is coming more quickly than we might think. Shared mobility is also a major factor in reaching the zero congestion goal. Smart cities will need smart infrastructure, including the smart communication infrastructure. As well as V2V and V2I we needed to incorporate V2N(etwork) and V2P(edestrian). 5G has a lot of potential for automated driving and a number of trials were underway for instance for truck platooning.

The Panel agreed that 5G will play a major role in future communications for transport but may also bring some problems. We need to verify the applicability of 5G in various ITS use cases because the connectivity demands of the different use cases vary a lot. However a bigger problem may be who is going to carry the costs of 5G. The costs of providing the framework for enabling automated transport, and the related digital infrastructure are likely to be huge, not least as the infrastructure will also be needed outside the big cities and in rural areas. The standards for 5G are likely to be available in December 2019 and the chipsets 18 months later. The actual deployment of 5G infrastructure will take several years.

The ownership of data was another major issue, related to much more than automated driving, and one requiring government-level policy solutions. It was noted that the

EU was already looking into this issue. The role of the different stakeholders for the new communication technologies and their roles in take-up were still unclear and the government sector needed to agree on the big picture. Challenges related to topics such as privacy needed the involvement of consumers to find a working solution. Each challenge required various roles, perhaps. Interoperability requires commitment from all relevant stakeholders. Cybersecurity needed specific attention immediately. The Panel warned that in communications, as in many areas of transport, technology disruption will need new thinking in general and especially on the roles of the stakeholders which would change from what was traditionally expected.

The **Infrastructure Challenges & Opportunities Track** had two ESs:

ES02 - Securing Critical ITS Infrastructure in a Connected World

Moderator
Michael De Santis, ITS Canada, Canada

Speakers
Darran Anderson Texas Department of Transportation, United States
Woo-Seok Choi, Ministry of Science, ICT and Future Planning, Korea
Maurice Geraets, NXP, Netherlands
Brian Ness, Idaho Transportation Department, United States

ES09 - Better Traveller Information Technology and Institutional Issues for Automated Driving

Moderator
Takashi Oguchi, The University of Tokyo, Japan

Speakers
Yuko Sano, National Police Agency, Japan
Judith Zielke, Federal Department of Infrastructure and Regional Development, Australia
Phil Blythe, Department for Transport, United Kingdom
Susan Mulvihill, Minnesota Department of Transportation, United States

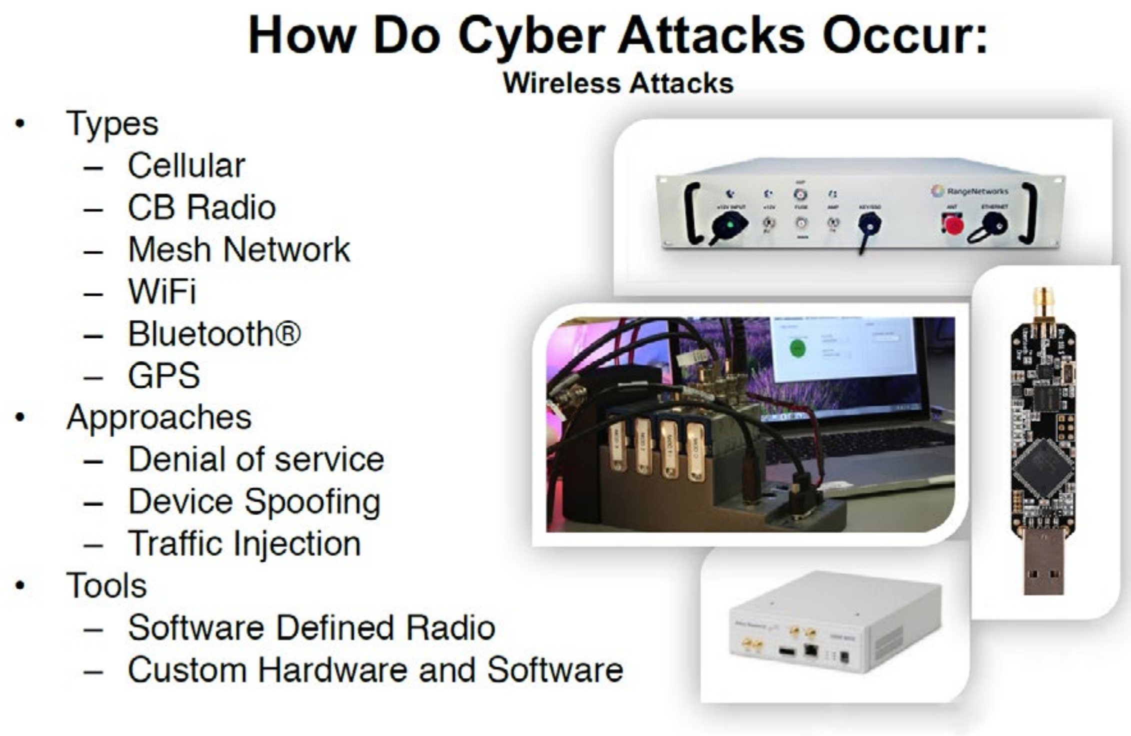
The Panel discussion on **ES02** recognized a number of potential threats to infrastructure: damage resulting from component or system failure; damage caused by deliberate attack, and damage from severe weather events. The impacts might be safety-related, financial, personal such as loss of data privacy, and reputational. The rapid shift to a connected world added to problems as a connected vehicle offered a number of potential entry points for deliberate or accidental security attack and the wireless links meant that physical closeness was not necessary for an attack.

It was essential to conduct a vulnerability audit and ask pointed questions regarding values and risks. Organizations needed to decide how much to pay for security — the answer was usually "not a lot" until there had been a compromising incident. Like all technology solutions, a balance had to be reached based on funding, accessibility and reality (risk assessment). Every organization had to decide the level of "acceptable risk. It was also essential to analyze the overall regime:

- How might someone gain unauthorized access?
- What could they do?
- How would we detect that an access had occurred?
- What could we do in response to an attack?

Providing reliable cybersecurity was not easy but barriers could be put in place at sensible costs; it was essential to remember that cybersecurity in practice meant defending more than one potential entry point. As one speaker put it: the "Bad Guys" make a cost-benefit analysis and as a consequence the "Good Guys" must make a Risk Analysis based on threats, vulnerability and risk assessment.

The focus in **ES09** was on how industry and government could work together to provide relevant and reliable services to facilitate decision making for travelers and help



Darran Anderson in ES 02

raise the productivity of networks. A key issue was a better understanding of behaviour, especially drivers' responses to the provision of information. Numerous countries were investing in programs leading towards automated driving but there was still a great deal to learn and understand regarding the situation with a non-driving 'driver' in a vehicle.

The regulatory and testing regimes were not at all clear and results from trials were awaited. Most automated driving programs were examining three classes of challenge. There were the social issues such as managing disruptive transport services, the impact on labour markets, gaining users' acceptance, sharing the productivity benefits, ensuring accessibility for aging or mobility-limited drivers, and ensuring that rural areas were not left behind.

There were infrastructure challenges such as space sharing, removing telephony blind spots, pavement markings, roadside signs, lane widths, optimizing the existing network and learning how to turn 'private' information from connected vehicle into a 'public' benefit.

Institutional challenges included multiple jurisdictions, developing a combined effort from federal and state governments, and of course funding.

The Panel concluded that although automated driving represented a very good case study the problems described were typical of any program aimed at introducing very innovative technologies.

There were two ESs under the ● **"Smart(er) Cities" Track**:

ES03 - ITS Delivering Liveability

Moderator
Delphine Krieger, Eurometropolis of Strasbourg, France

Speakers
Randell Iwasaki, Contra Costa Transportation Authority, United States
Steffen Schaefer, HMI Technologies — Global, New Zealand
Morten Kabell, Mayor of Technical and Environmental Affairs, Copenhagen, Denmark
Jeff Brandes, Senator, The Florida Senate, United States

ES06 - Smart Connected Cities Promote Smart Mobility

Moderator
Jane Lappin, Toyota Research Institute, United States

Speakers
Tan Kok Yam, Smart Nation Program Office, Prime Minister's Office, Singapore
Hermann Meyer, Continental Automotive GmbH/Regensburg, Germany
T. Russell Shields, Ygomi, USA
Klaus Kröll, Kapsch TrafficCom AG, Austria

ES03 on Delivering liveability emphasized the fact that cities and metropolitan areas are going through major changes especially with respect to population increases and aging, both of which put more pressure on finding integrated and adaptable solutions. The Panel agreed that new technologies can make cities more livable but it is vital to plan how those technologies will be trialled and deployed which in turn requires exploring how they are accepted by the general public as well as a thorough post-implementation evaluation.

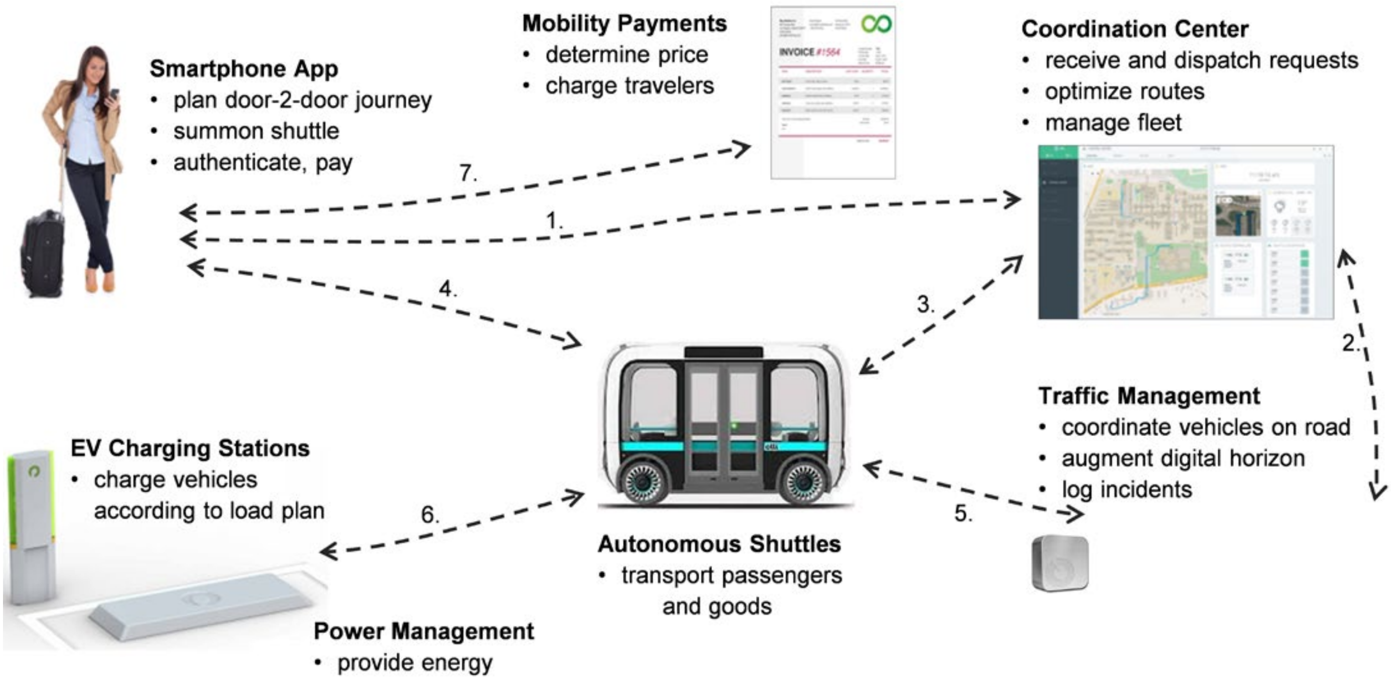
In the Contra Costa Transportation Authority the priority was improving mobility and reducing congestion. Their main challenges were the first and last mile; they also wanted to make the streets more walkable and bikeable. The region was involved in a number of tests of autonomous vehicles with the associated issues of amending the approach to transport planning as well as procurement and maintenance procedures.

The New Zealand Transport Agency was re-thinking the concept of Urban Mobility which in future was likely to be fleets of autonomous shuttles connected to other transport modes and intelligent roadside devices, real-time backend services, and smartphone app. When planning it was essential to remember that transport generally, and urban mobility especially, is a system of systems that interact mostly wirelessly and mostly in real-time.

The City of Copenhagen argued that a livable city is not just a more technological city. 40% of Copenhagen's population used bikes and a further 25% used public transportation. The new local challenge was managing bicycle traffic flow. The city also has the goal of zero emissions by 2025 and to move towards that they were implementing 'eco-driving' policies, for example helping truck drivers maintain a speed to avoid stopping for red lights, so using less fuel and lowering emissions.

The State of Florida was also aiming to increase liveability and this rested on understanding or at least coming to terms with a number of fast-changing factors such as the sharing economy and pervasive artificial intelligence. These in turn raised challenges for administrators: ensuring the flow of electric vehicles as the population increased; ensuring the provision of electricity supply using "new electricity"; and ensuring connectivity for autonomous vehicles.

The ways forward were not exclusively technological: it was essential to understand traveller behaviour and how to change it (*e.g.* the Copenhagen truck drivers) and preparing an integrated deployment plan to ensure collaboration between the actors. The session closed with discussion on the question "When do we expose people to autonomy?"



Steffan Scaheffer in ES03

ES06 explored how to promote smart mobility. Speakers concurred that there was no single definition of a Smart City; rather there was a broad high-level objective and a variety of elements in the deployment packages. Two common factors were data (because without data and analytics smart cities cannot exist) and the need to focus on citizens and their needs. Data was a fundamental pillar of a smart city's economy and key to the evolution of new mobility solutions. Citizens will accept deployment of new, possibly disruptive, technologies in cities if it is made clear how they will improve their quality of life. As one speaker put it: "The motivation for Smart Cities is people".

Singapore was following the principles that "a smart nation is about exploiting digital technology to close distances" and "a Smart City is one that enables fulfilled living and provides opportunities for all." Physical space was a major problem for Singapore so the transformation of public transport would be critical. Other speakers emphasized the points about data and also called for a "reality check" in terms of when and how automated vehicles would transform cities, questioning the various promises that had been made and the expected benefits claimed for automated vehicles.

A number of key points were made during the session including:

- Five trends are driving smart cities: technology; politics; society; commerce; behaviour.
- It's necessary to determine key performance factors based on things that affect people and businesses *e.g.* how reliable is public transport? Assessing performance was not straightforward — for example there are a variety of thoughts about how to measure the Return on Investment of a Smart City.
- The performance goals need to go up steadily or we not improve — there's no gain from measuring the things we did in the past.
- A key measure of "digital success" was adoption by citizens: do they find our digital initiatives useful?

The ● **Integrated Approach: Planning, Operations, Safety Track** linked to just one ES:

ES10 - Resilient, Safe and Smart Infrastructure

Moderator
Sorawit Narupiti, Chulalongkorn University, Thailand

Speakers
Takashi Nishio Ministry of Land, Infrastructure, Transport and Tourism, Japan
Sang Heon Lee, MOLIT, Korea
Klaas Rozema, Dynniq, The Netherlands
Roger Millar, Washington State Department of Transportation, United States
Stephanie Leonard, European Commission — DG MOVE, Belgium

This session aimed to look at different strategic approaches to the concept, design, structure, funding, operation and evaluation of smart and resilient infrastructure. Korea was taking a 'top down' approach based around the design and deployment of a standard on-board unit as part of a C-ITS network that would be expected to develop a complementary capability for autonomous driving. The overall project included specification of maps, telecoms standards, and data from a variety of sources, (detectors, mobile phones) taken into cloud storage and then used for signal operation and similar services. Some sub-systems of the design would be trialled during the Pyungchang 2018 Winter Olympics.

In Europe the European Commission believed that we will need both connected and cooperative mobility to move forward as holistic concepts, and not look narrowly at on-vehicle systems. In terms of safer and smarter infrastructure the EU shared a vision of zero road fatalities by 2050. There was a clear road-map for moving towards full connected, cooperative and automated mobility (CCAM) which had started in 2014 with the launch of the C-ITS Strategy in 2014 and the C-ROADS program in 2016. A key activity was getting the physical and digital infrastructure ready including the development of digital mapping standards to include road, legal and right-of-way information available so that future vehicles of all classes can interface with.

Roger Millar in ES 10

Funding was a common challenge for many US State Departments of Transportation. Demand for services was increasing, especially in cities, and technology costs were rising; at the same time budgets were being reduced. Some states (*e.g.* Washington State) were looking to squeeze additional productivity from current infrastructure but were also considering decommissioning parts of their infrastructure to reduce costs. Improving efficiency and effectiveness was not exclusively a technology issue: Washington had shown that getting the best output from ITS systems was helped by using social media to disseminate data and information to travelers. Many States were concerned with system resilience and were investing heavily in building redundancy and resilience into the delivery of ITS. This was essential for the use of ITS as a tool for emergency response, a point of additional value for states located in earthquake zones.

Japan also had a 'top down' approach with an overall strategy built up from the roll-out of the latest generation of electronic tolling collection (ETC 2.0) and in-vehicle information systems. There were over 3600 roadside units using V2I technology and over 2M connected vehicles using the system. The probe data collected by ETC 2.0 was being used for traffic management and better prioritization of road improvement engineering. There was common ground with the USA in that ITS services were invaluable in emergencies such as earthquakes by quickly establishing which routes were passable and which were blocked by earthquake damage.

Europe was also concentrating on deploying smart infrastructure and associated services and technologies in cities., The Traffic Management 2.0 (TM2.0) platform was a key basis for this with its link to traffic control centers and adaptive management techniques. Work is under way to take adaptive management to the next level to allow public authorities more options for meeting their policies and enabling additional weight for walking, cycling *etc* while still operating the network. These developments will avoid the present barrier that traffic management centers rely too much on historic data and will allow them to become much more reactive.

The ● **Disruption and New Business Models Track** was covered by three ESs 04, 08, 12

ES04 - Freight Technology: How Do We Ensure Public Safety

Moderator
Richard Easley, E-Squared Engineering, USA

Speakers
Peter Sweatman, CAVita LLC, USA
Paul Retter, National Transport Commission, Australia
Bill Panos, Wyoming Department of Transportation, USA
Catherine Trautmann, Strasbourg Eurometropolis and Strasbourg Autonomous Port, France

ES04 looked into the operations of freight companies who anticipate considerable benefits from new technologies but there are associated impacts on public safety. Platooning systems for private truck fleets were emerging, drone deployments were becoming a reality, and unmanned vehicle inspection systems were being deployed to reduce delays to scheduled delivery times, and make supply chains cheaper. The new technologies affect operations, change the role of drivers and change the interactions between shippers, planning and regulatory agencies and technology companies. Public agencies needed to engage with the freight industry to ensure safety was maintained while not unduly inhibiting efforts to improve freight movements. This session saw a vigorous panel discussion that aimed to explore how the various sector stakeholders could work together to improve both operations and safety.

There were many steps leading to deployment of full CAV (connected and automated vehicles) in the freight industry and the idea of convergence was proposed to identify the various steps leading to this level. It would be necessary to plan the interactions between deployment of the connected components (pilot projects, implementation of rules and required infrastructures, testing of V2V and V2I) and the automated components (trials of automated features, inclusion in the smart cities framework and mobility services as a coherent system).

A key issue related to the conversion to full autonomy is the fact that in the freight industry all technologies need to be highly safe and will be acceptable only if the "machine" manages to be much safer that the human. The view is that there is no place for technology errors and that "it's unsafe until it's very safe". Hence, freight technologies cover a wide spectrum of both societal and business issues. On the one side they are an important component of a sustainable development vision (including public safety and quality of life in urban areas) and large gains are expected to come from changes in the freight movement industry. On the other side there are gains from technology making transport more efficient including the optimization of itineraries, the combination of flow and improved customer satisfaction (delivery time and cost).

Three main drivers of transport change were identified for this industry: new technology, consumer demand and market structure. Regarding the new technology component, the digitalization of transport marketplaces had gone through various phases, from on-line interactions to apps and then the internet of things to block chains. This evolution had facilitated the movement of goods and the associated traceability and monitoring. But to take full benefit from the potential of the available and rapidly evolving technology the way the industry was regulated needed to be re-examined. In the current era of rapid change, regulation had to be responsive and flexible, performance-based, less prescriptive so as to encourage innovation, while always keeping the networks safe and sustainable.

Freight transport often faces specific challenges in particular situations and the contributions of new technologies need to be assessed for each one. It is likely that in corridors faced with high rates of incidents due, for instance, to remoteness and rigorous climate technologies such as connected vehicles could bring significant contributions to improving the driving conditions and reducing the occurrence of incidents. In such cases technology adoption is driven by the need to improve safety levels of both truck drivers and private car drivers. Connected technologies are promising since vehicles will share knowledge and interact more smoothly in hazardous conditions; they will also help to reduce response times and consequently reduce the impacts of incidents when they occur.

One example of such an implementation was presented during the session: Interstate 80 crosses the USA from west to east and experiences multiple disruptions and closures throughout the year. It is the site for a pilot project on connected vehicles lasting 18 months and demonstrating in a real-world context with 400 vehicles. The project also includes evaluation such as benefit assessment and the maintenance of the required infrastructures as well as recommendations for future deployment.

The questions of regulation harmonization between systems were also discussed in the context of deployment across multiple jurisdictions, as it is the case in Europe. It is very challenging to adopt the same policies across borders but it is an a priori condition for efficient and optimal deployment of technologies and especially in the freight sector. A number of challenges were identified as requirements in the aim to improve public safety and the national and local levels such as anticipating logistics needs in urban planning policies and the development of infrastructures, and the sharing of real-time information on containers and contents. Sharing information raised questions since the targeted information might well be sensitive and so privacy needed to be ensured.

There are still some big questions pending: can we combine passengers and goods in the same vehicle? Can we rely on individuals to transport small packets? In the context of connected vehicles will drivers enter the platoon or not? How generally will people use the available technologies? How much safer than human does the technology need to be? Do we need coercive of incentive measures to move technology forward in the freight industry?

ES08 - Mobility as a Service

Moderator
Jacob Bangsgaard, ERTICO - ITS Europe, Belgium

Speakers
Muhan Wang, MOTC, Chinese-Taipei
Thomas Sedran, Volkswagen, Germany
Alex Mackenzie-Torres, Toyota Research Institute, United States
Anita Curnow, VicRoads, Australia

In theory Mobility as a Service (MaaS) can break the traditional link between mobility and vehicle ownership so that travelers are offered journeys on demand for all modes of transport. But delivering MaaS is complex as service providers need to offer responsive services using collective or shared transport that will compete with private cars. MaaS will require different business models and different regulatory regimes with many vested interests defending the status quo. Around the world most cities share identical problems: roads dominated by single-passenger car mobility; extensive urban sprawl but little space (or funding) for new infrastructure; excess demand for public transport.

It was useful to think of transport provision in a different way: a graph plotting different modes using axes of decreasing personalization against levels of government intervention. This helped to locate the barriers to modes such as inadequate infrastructure but it also identified social issues such as inconsistent information, technology disadvantage and privacy concerns. There was a vital role for governments to stand back from traditional roles as public transport providers and look to a more enabling, facilitating and integrating function.

In Taiwan the government was acting as the facilitator with technology providers offering sets of delivery options. Services for all modes were integrated in an app-based platform that also included e-ticketing and on-line payment. The MaaS service concept was aimed at using ICT & AI technologies to improve travelers' needs for personal mobility in the long term. He presented the case study of MaaS in Taiwan.

In Finland the government had sponsored the development of a general data platform to integrate MaaS operators working in logistics & freight, e-commence, public transport, e-mobility as well as aviation and maritime transport. A key issue to be addressed was thinking through the need for different data flows as well as weaning suppliers from the traditional ways — building and operating mobility in separated silos. The platform was designed to increase market accessibility and provide more room for innovation by streamlining across business models and services, and adopting technology neutral rules.

As part of a general discussion involving the panel a number of questions were addressed: How to incorporate public-private initiatives and government subsidies to service providers? How quickly should systems be expected to become economically sustainable? Will public transport services have to change/adapt? [Answer: Yes, there will be no choice, they need to move away from fixed routes towards on-demand services with a big increase in flexibility].

Some behavioral change would be achieved through education, and media &marketing campaigns, targeting both the public and private sector providers. A large percentage of users were likely to change behaviour through improvements in systems and services.

Another key question was: how will the automotive industry participate and share data? This was seen as still an open question with no clear answer.

ES12 - New Business Models

Moderator
Krista Huhtala-Jenks, Ministry of Transport and Communication, Finland

Speakers
Patrick F. McGowan, Serco Inc., USA
James Barna, Ohio Department of Transportation, United States
Martin Matthews, HMI Technologies, New Zealand
Michael Hurwitz, Transport for London, United Kingdom

ES12 discussed how typical business models were being questioned and impacted by the increasing availability of a wide range of technology and transport services. Business models that had been around for many years were being disrupted by rapidly changes of supply and demand for the movement of both people and goods. The topic was addressed through a set of questions aiming to unravel some of the key resistance points and opportunities.

On licensing and regulation it was felt that organizations should engage with all the parties potentially involved before launching any new option as both the regulator and the public need to engage in the development of a new approach if sustainable and long-term solutions were wanted. The challenge that regulations currently do not facilitate innovation was discussed. Innovating within existing regulations designed for a different world is often too limiting and therefore we have seen various new mobility players propose services at the frontier or clearly outside existing rules. Regulators must create a space where private sector innovators can experiment and try things so that both private and public parties have a view of how the users react to new services and can agree to learn and adjust together. Such approach should be preferred to the "launch and defend" strategy often observed.

It was suggested that the concept of private-public partnerships should be redefined and redeveloped to meet the needs and expectations of MaaS. Public authorities have tended to view themselves as the dominant players and it was clear that they were not always embracing the different concepts and opportunities of Maas. They needed to learn how to engage differently with private partners and identify ways to link all services into a more coherent system. Without such positioning the roles of States will just be managing competitors instead of defining and supporting an integrated mobility setting. The Panel thought it was important to identify ways to support a transition from the current world to the upcoming one but had no clear and simple answer to the question "Can public authorities 'self-disrupt'?". Perhaps a solution is reshaping the risk appetite to make sure that institutions are not future-proof but future-ready.

The need to reskill organizations to allow them to manage non-traditional means such as new funding sources was formulated. Mobility as a service requires new pricing strategies, one of the options being to embed the charges within a network use charge. Charging strategies to incentivise the right way to travel were also suggested, namely through charges aimed at polluting vehicles. Other concerns on this topic were that with automated vehicles people might think it less of a burden to let their car go around empty instead of paying for parking — charging seemed to be an obvious solution to limit this very inefficient way to use space.

Combining the movement of people and goods was an interesting challenge to current business models. With automated and connected vehicles it could be possible to optimize the use of the on-board space and to develop systems for both needs (particularly for first and last mile problem). While no market-ready solutions where provided, it seemed like an attractive theoretical opportunity that should be further explored and conceptualized since it is bringing a quite diverse set of challenges, along with the definition of possible business models, partnerships, responsibility, monitoring and safety concerns.

The concept of accessibility was also discussed since some population segments may be left out of the current MaaS trend. Accessibility for all population segments, which has an important price tag, is fundamental in the sustainable development framework. Many countries are facing rapidly aging populations that have to be considered in planning. The importance of developing and providing more products in the space of universal accessibility was raised, on the aspect of multimodal services and information availability for instance.

The panel discussed the main drivers for change and the most important business model disrupters. The first and most important one to be identified was shared services and everyone agreed that they were going to happen (it is already the case in many cities). The money spent to have a car parked was also mentioned as well as the changing perspective of millennials that are much smarter in the way they choose their travel options while opting for the best combination of cost *v* speed (faster and cheaper). They also agreed on the fact that whatever was coming along in terms of mobility options would challenge governments, echoing the initial discussion regarding the necessity to change the way they regulate to allow for experimentation. Planners, regulators, operators at all levels must adjust to the new view that it’s not about cars anymore — it’s about mobility.